

Debugging with GDB

The GNU Source-Level Debugger

Ninth Edition, for GDB version 7.2

(GDB)

Richard Stallman, Roland Pesch, Stan Shebs, et al.

(Send bugs and comments on GDB to <http://www.gnu.org/software/gdb/bugs/>.)

Debugging with GDB
T_EXinfo 2007-06-20.13

Published by the Free Software Foundation
51 Franklin Street, Fifth Floor, Boston, MA 02110-1301, USA
ISBN 1-882114-77-9

Copyright © 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010 Free Software Foundation, Inc.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with the Invariant Sections being “Free Software” and “Free Software Needs Free Documentation”, with the Front-Cover Texts being “A GNU Manual,” and with the Back-Cover Texts as in (a) below.

(a) The FSF’s Back-Cover Text is: “You are free to copy and modify this GNU Manual. Buying copies from GNU Press supports the FSF in developing GNU and promoting software freedom.”

This edition of the GDB manual is dedicated to the memory of Fred Fish. Fred was a long-standing contributor to GDB and to Free software in general. We will miss him.

Table of Contents

Summary of GDB

The purpose of a debugger such as GDB is to allow you to see what is going on “inside” another program while it executes—or what another program was doing at the moment it crashed.

GDB can do four main kinds of things (plus other things in support of these) to help you catch bugs in the act:

- Start your program, specifying anything that might affect its behavior.
- Make your program stop on specified conditions.
- Examine what has happened, when your program has stopped.
- Change things in your program, so you can experiment with correcting the effects of one bug and go on to learn about another.

You can use GDB to debug programs written in C and C++. For more information, see [\(undefined\) \[Supported Languages\], page \(undefined\)](#). For more information, see [\(undefined\) \[C and C++\], page \(undefined\)](#).

Support for D is partial. For information on D, see [\(undefined\) \[D\], page \(undefined\)](#).

Support for Modula-2 is partial. For information on Modula-2, see [\(undefined\) \[Modula-2\], page \(undefined\)](#).

Debugging Pascal programs which use sets, subranges, file variables, or nested functions does not currently work. GDB does not support entering expressions, printing values, or similar features using Pascal syntax.

GDB can be used to debug programs written in Fortran, although it may be necessary to refer to some variables with a trailing underscore.

GDB can be used to debug programs written in Objective-C, using either the Apple/NeXT or the GNU Objective-C runtime.

Free Software

GDB is *free software*, protected by the GNU General Public License (GPL). The GPL gives you the freedom to copy or adapt a licensed program—but every person getting a copy also gets with it the freedom to modify that copy (which means that they must get access to the source code), and the freedom to distribute further copies. Typical software companies use copyrights to limit your freedoms; the Free Software Foundation uses the GPL to preserve these freedoms.

Fundamentally, the General Public License is a license which says that you have these freedoms and that you cannot take these freedoms away from anyone else.

Free Software Needs Free Documentation

The biggest deficiency in the free software community today is not in the software—it is the lack of good free documentation that we can include with the free software. Many of our most important programs do not come with free reference manuals and free introductory texts. Documentation is an essential part of any software package; when an important free software package does not come with a free manual and a free tutorial, that is a major gap. We have many such gaps today.

Consider Perl, for instance. The tutorial manuals that people normally use are non-free. How did this come about? Because the authors of those manuals published them with restrictive terms—no copying, no modification, source files not available—which exclude them from the free software world.

That wasn't the first time this sort of thing happened, and it was far from the last. Many times we have heard a GNU user eagerly describe a manual that he is writing, his intended contribution to the community, only to learn that he had ruined everything by signing a publication contract to make it non-free.

Free documentation, like free software, is a matter of freedom, not price. The problem with the non-free manual is not that publishers charge a price for printed copies—that in itself is fine. (The Free Software Foundation sells printed copies of manuals, too.) The problem is the restrictions on the use of the manual. Free manuals are available in source code form, and give you permission to copy and modify. Non-free manuals do not allow this.

The criteria of freedom for a free manual are roughly the same as for free software. Redistribution (including the normal kinds of commercial redistribution) must be permitted, so that the manual can accompany every copy of the program, both on-line and on paper.

Permission for modification of the technical content is crucial too. When people modify the software, adding or changing features, if they are conscientious they will change the manual too—so they can provide accurate and clear documentation for the modified program. A manual that leaves you no choice but to write a new manual to document a changed version of the program is not really available to our community.

Some kinds of limits on the way modification is handled are acceptable. For example, requirements to preserve the original author's copyright notice, the distribution terms, or the list of authors, are ok. It is also no problem to require modified versions to include notice that they were modified. Even entire sections that may not be deleted or changed are acceptable, as long as they deal with nontechnical topics (like this one). These kinds of restrictions are acceptable because they don't obstruct the community's normal use of the manual.

However, it must be possible to modify all the *technical* content of the manual, and then distribute the result in all the usual media, through all the usual channels. Otherwise, the restrictions obstruct the use of the manual, it is not free, and we need another manual to replace it.

Please spread the word about this issue. Our community continues to lose manuals to proprietary publishing. If we spread the word that free software needs free reference manuals and free tutorials, perhaps the next person who wants to contribute by writing documentation will realize, before it is too late, that only free manuals contribute to the free software community.

If you are writing documentation, please insist on publishing it under the GNU Free Documentation License or another free documentation license. Remember that this decision requires your approval—you don't have to let the publisher decide. Some commercial publishers will use a free license if you insist, but they will not propose the option; it is up to you to raise the issue and say firmly that this is what you want. If the publisher you are dealing with refuses, please try other publishers. If you're not sure whether a proposed license is free, write to licensing@gnu.org.

You can encourage commercial publishers to sell more free, copylefted manuals and tutorials by buying them, and particularly by buying copies from the publishers that paid for their writing or for major improvements. Meanwhile, try to avoid buying non-free documentation at all. Check the distribution terms of a manual before you buy it, and insist that whoever seeks your business must respect your freedom. Check the history of the book, and try to reward the publishers that have paid or pay the authors to work on it.

The Free Software Foundation maintains a list of free documentation published by other publishers, at <http://www.fsf.org/doc/other-free-books.html>.

Contributors to GDB

Richard Stallman was the original author of GDB, and of many other GNU programs. Many others have contributed to its development. This section attempts to credit major contributors. One of the virtues of free software is that everyone is free to contribute to it; with regret, we cannot actually acknowledge everyone here. The file ‘ChangeLog’ in the GDB distribution approximates a blow-by-blow account.

Changes much prior to version 2.0 are lost in the mists of time.

Plea: Additions to this section are particularly welcome. If you or your friends (or enemies, to be evenhanded) have been unfairly omitted from this list, we would like to add your names!

So that they may not regard their many labors as thankless, we particularly thank those who shepherded GDB through major releases: Andrew Cagney (releases 6.3, 6.2, 6.1, 6.0, 5.3, 5.2, 5.1 and 5.0); Jim Blandy (release 4.18); Jason Molenda (release 4.17); Stan Shebs (release 4.14); Fred Fish (releases 4.16, 4.15, 4.13, 4.12, 4.11, 4.10, and 4.9); Stu Grossman and John Gilmore (releases 4.8, 4.7, 4.6, 4.5, and 4.4); John Gilmore (releases 4.3, 4.2, 4.1, 4.0, and 3.9); Jim Kingdon (releases 3.5, 3.4, and 3.3); and Randy Smith (releases 3.2, 3.1, and 3.0).

Richard Stallman, assisted at various times by Peter TerMaat, Chris Hanson, and Richard Mlynarik, handled releases through 2.8.

Michael Tiemann is the author of most of the GNU C++ support in GDB, with significant additional contributions from Per Bothner and Daniel Berlin. James Clark wrote the GNU C++ demangler. Early work on C++ was by Peter TerMaat (who also did much general update work leading to release 3.0).

GDB uses the BFD subroutine library to examine multiple object-file formats; BFD was a joint project of David V. Henkel-Wallace, Rich Pixley, Steve Chamberlain, and John Gilmore.

David Johnson wrote the original COFF support; Pace Willison did the original support for encapsulated COFF.

Brent Benson of Harris Computer Systems contributed DWARF 2 support.

Adam de Boor and Bradley Davis contributed the ISI Optimum V support. Per Bothner, Noboyuki Hikichi, and Alessandro Forin contributed MIPS support. Jean-Daniel Fekete contributed Sun 386i support. Chris Hanson improved the HP9000 support. Noboyuki Hikichi and Tomoyuki Hasei contributed Sony/News OS 3 support. David Johnson contributed Encore Umax support. Jyrki Kuoppala contributed Altos 3068 support. Jeff Law contributed HP PA and SOM support. Keith Packard contributed NS32K support.

Doug Rabson contributed Acorn Risc Machine support. Bob Rusk contributed Harris Nighthawk CX-UX support. Chris Smith contributed Convex support (and Fortran debugging). Jonathan Stone contributed Pyramid support. Michael Tiemann contributed SPARC support. Tim Tucker contributed support for the Gould NP1 and Gould Powernode. Pace Willison contributed Intel 386 support. Jay Vosburgh contributed Symmetry support. Marko Mlinar contributed OpenRISC 1000 support.

Andreas Schwab contributed M68K GNU/Linux support.

Rich Schaefer and Peter Schauer helped with support of SunOS shared libraries.

Jay Fenlason and Roland McGrath ensured that GDB and GAS agree about several machine instruction sets.

Patrick Duval, Ted Goldstein, Vikram Koka and Glenn Engel helped develop remote debugging. Intel Corporation, Wind River Systems, AMD, and ARM contributed remote debugging modules for the i960, VxWorks, A29K UDI, and RDI targets, respectively.

Brian Fox is the author of the readline libraries providing command-line editing and command history.

Andrew Beers of SUNY Buffalo wrote the language-switching code, the Modula-2 support, and contributed the Languages chapter of this manual.

Fred Fish wrote most of the support for Unix System Vr4. He also enhanced the command-completion support to cover C++ overloaded symbols.

Hitachi America (now Renesas America), Ltd. sponsored the support for H8/300, H8/500, and Super-H processors.

NEC sponsored the support for the v850, Vr4xxx, and Vr5xxx processors.

Mitsubishi (now Renesas) sponsored the support for D10V, D30V, and M32R/D processors.

Toshiba sponsored the support for the TX39 Mips processor.

Matsushita sponsored the support for the MN10200 and MN10300 processors.

Fujitsu sponsored the support for SPARClike and FR30 processors.

Kung Hsu, Jeff Law, and Rick Sladkey added support for hardware watchpoints.

Michael Snyder added support for tracepoints.

Stu Grossman wrote gdbserver.

Jim Kingdon, Peter Schauer, Ian Taylor, and Stu Grossman made nearly innumerable bug fixes and cleanups throughout GDB.

The following people at the Hewlett-Packard Company contributed support for the PA-RISC 2.0 architecture, HP-UX 10.20, 10.30, and 11.0 (narrow mode), HP's implementation of kernel threads, HP's aC++ compiler, and the Text User Interface (nee Terminal User Interface): Ben Krepp, Richard Title, John Bishop, Susan Macchia, Kathy Mann, Satish Pai, India Paul, Steve Rehrauer, and Elena Zannoni. Kim Haase provided HP-specific information in this manual.

DJ Delorie ported GDB to MS-DOS, for the DJGPP project. Robert Hoehne made significant contributions to the DJGPP port.

Cygnus Solutions has sponsored GDB maintenance and much of its development since 1991. Cygnus engineers who have worked on GDB fulltime include Mark Alexander, Jim

Blandy, Per Bothner, Kevin Buettner, Edith Epstein, Chris Faylor, Fred Fish, Martin Hunt, Jim Ingham, John Gilmore, Stu Grossman, Kung Hsu, Jim Kingdon, John Metzler, Fernando Nasser, Geoffrey Noer, Dawn Perchik, Rich Pixley, Zdenek Radouch, Keith Seitz, Stan Shebs, David Taylor, and Elena Zannoni. In addition, Dave Brolley, Ian Carmichael, Steve Chamberlain, Nick Clifton, JT Conklin, Stan Cox, DJ Delorie, Ulrich Drepper, Frank Eigler, Doug Evans, Sean Fagan, David Henkel-Wallace, Richard Henderson, Jeff Holcomb, Jeff Law, Jim Lemke, Tom Lord, Bob Manson, Michael Meissner, Jason Merrill, Catherine Moore, Drew Moseley, Ken Raeburn, Gavin Romig-Koch, Rob Savoye, Jamie Smith, Mike Stump, Ian Taylor, Angela Thomas, Michael Tiemann, Tom Tromey, Ron Unrau, Jim Wilson, and David Zuhn have made contributions both large and small.

Andrew Cagney, Fernando Nasser, and Elena Zannoni, while working for Cygnus Solutions, implemented the original GDB/MI interface.

Jim Blandy added support for preprocessor macros, while working for Red Hat.

Andrew Cagney designed GDB's architecture vector. Many people including Andrew Cagney, Stephane Carrez, Randolph Chung, Nick Duffek, Richard Henderson, Mark Kettenis, Grace Sainsbury, Kei Sakamoto, Yoshinori Sato, Michael Snyder, Andreas Schwab, Jason Thorpe, Corinna Vinschen, Ulrich Weigand, and Elena Zannoni, helped with the migration of old architectures to this new framework.

Andrew Cagney completely re-designed and re-implemented GDB's unwinder framework, this consisting of a fresh new design featuring frame IDs, independent frame sniffers, and the sentinel frame. Mark Kettenis implemented the DWARF 2 unwinder, Jeff Johnston the libunwind unwinder, and Andrew Cagney the dummy, sentinel, tramp, and trad unwinders. The architecture-specific changes, each involving a complete rewrite of the architecture's frame code, were carried out by Jim Blandy, Joel Brobecker, Kevin Buettner, Andrew Cagney, Stephane Carrez, Randolph Chung, Orjan Friberg, Richard Henderson, Daniel Jacobowitz, Jeff Johnston, Mark Kettenis, Theodore A. Roth, Kei Sakamoto, Yoshinori Sato, Michael Snyder, Corinna Vinschen, and Ulrich Weigand.

Christian Zankel, Ross Morley, Bob Wilson, and Maxim Grigoriev from Tensilica, Inc. contributed support for Xtensa processors. Others who have worked on the Xtensa port of GDB in the past include Steve Tjiang, John Newlin, and Scott Foehner.

Michael Eager and staff of Xilinx, Inc., contributed support for the Xilinx MicroBlaze architecture.

1 A Sample GDB Session

You can use this manual at your leisure to read all about GDB. However, a handful of commands are enough to get started using the debugger. This chapter illustrates those commands.

In this sample session, we emphasize user input like this: **input**, to make it easier to pick out from the surrounding output.

One of the preliminary versions of GNU `m4` (a generic macro processor) exhibits the following bug: sometimes, when we change its quote strings from the default, the commands used to capture one macro definition within another stop working. In the following short `m4` session, we define a macro `foo` which expands to `0000`; we then use the `m4` built-in `defn` to define `bar` as the same thing. However, when we change the open quote string to `<QUOTE>` and the close quote string to `<UNQUOTE>`, the same procedure fails to define a new synonym `baz`:

```
$ cd gnu/m4
$ ./m4
define(foo,0000)

foo
0000
define(bar,defn('foo'))

bar
0000
changequote(<QUOTE>,<UNQUOTE>)

define(baz,defn(<QUOTE>foo<UNQUOTE>))
baz
Ctrl-d
m4: End of input: 0: fatal error: EOF in string
```

Let us use GDB to try to see what is going on.

```
$ gdb m4
GDB is free software and you are welcome to distribute copies
of it under certain conditions; type "show copying" to see
the conditions.
There is absolutely no warranty for GDB; type "show warranty"
for details.

GDB 7.2, Copyright 1999 Free Software Foundation, Inc...
(gdb)
```

GDB reads only enough symbol data to know where to find the rest when needed; as a result, the first prompt comes up very quickly. We now tell GDB to use a narrower display width than usual, so that examples fit in this manual.

```
(gdb) set width 70
```

We need to see how the `m4` built-in `changequote` works. Having looked at the source, we know the relevant subroutine is `m4_changequote`, so we set a breakpoint there with the GDB `break` command.

```
(gdb) break m4.changequote
Breakpoint 1 at 0x62f4: file builtin.c, line 879.
```

Using the `run` command, we start `m4` running under GDB control; as long as control does not reach the `m4_changequote` subroutine, the program runs as usual:

```
(gdb) run
Starting program: /work/Editorial/gdb/gnu/m4/m4
define(foo,0000)
```

```
foo
0000
```

To trigger the breakpoint, we call `changequote`. GDB suspends execution of `m4`, displaying information about the context where it stops.

```
changequote(<QUOTE>,<UNQUOTE>)

Breakpoint 1, m4_changequote (argc=3, argv=0x33c70)
  at builtin.c:879
 879     if (bad_argc(TOKEN_DATA_TEXT(argv[0]),argc,1,3))
```

Now we use the command `n` (`next`) to advance execution to the next line of the current function.

```
(gdb) n
882     set_quotes((argc >= 2) ? TOKEN_DATA_TEXT(argv[1])\
: nil,
```

`set_quotes` looks like a promising subroutine. We can go into it by using the command `s` (`step`) instead of `next`. `step` goes to the next line to be executed in *any* subroutine, so it steps into `set_quotes`.

```
(gdb) s
set_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
  at input.c:530
 530     if (lquote != def_lquote)
```

The display that shows the subroutine where `m4` is now suspended (and its arguments) is called a stack frame display. It shows a summary of the stack. We can use the `backtrace` command (which can also be spelled `bt`), to see where we are in the stack as a whole: the `backtrace` command displays a stack frame for each active subroutine.

```
(gdb) bt
#0 set_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
  at input.c:530
#1 0x6344 in m4_changequote (argc=3, argv=0x33c70)
  at builtin.c:882
#2 0x8174 in expand_macro (sym=0x33320) at macro.c:242
#3 0x7a88 in expand_token (obs=0x0, t=209696, td=0xf7ffa30)
  at macro.c:71
#4 0x79dc in expand_input () at macro.c:40
#5 0x2930 in main (argc=0, argv=0xf7ffb20) at m4.c:195
```

We step through a few more lines to see what happens. The first two times, we can use `'s'`; the next two times we use `n` to avoid falling into the `xstrdup` subroutine.

```
(gdb) s
0x3b5c 532     if (rquote != def_rquote)
(gdb) s
0x3b80 535     lquote = (lq == nil || *lq == '\0') ? \
def_lquote : xstrdup(lq);
(gdb) n
536     rquote = (rq == nil || *rq == '\0') ? def_rquote\
: xstrdup(rq);
(gdb) n
538     len_lquote = strlen(rquote);
```

The last line displayed looks a little odd; we can examine the variables `lquote` and `rquote` to see if they are in fact the new left and right quotes we specified. We use the command `p` (`print`) to see their values.

```
(gdb) p lquote
$1 = 0x35d40 "<QUOTE>"
(gdb) p rquote
$2 = 0x35d50 "<UNQUOTE>"
```

`lquote` and `rquote` are indeed the new left and right quotes. To look at some context, we can display ten lines of source surrounding the current line with the `l` (`list`) command.

```
(gdb) l
533             xfree(rquote);
534
535             lquote = (lq == nil || *lq == '\0') ? def_lquote\
: xstrdup (lq);
536             rquote = (rq == nil || *rq == '\0') ? def_rquote\
: xstrdup (rq);
537
538             len_lquote = strlen(rquote);
539             len_rquote = strlen(lquote);
540         }
541
542     void
```

Let us step past the two lines that set `len_lquote` and `len_rquote`, and then examine the values of those variables.

```
(gdb) n
539             len_rquote = strlen(lquote);
(gdb) n
540         }
(gdb) p len_lquote
$3 = 9
(gdb) p len_rquote
$4 = 7
```

That certainly looks wrong, assuming `len_lquote` and `len_rquote` are meant to be the lengths of `lquote` and `rquote` respectively. We can set them to better values using the `p` command, since it can print the value of any expression—and that expression can include subroutine calls and assignments.

```
(gdb) p len_lquote==strlen(lquote)
$5 = 7
(gdb) p len_rquote==strlen(rquote)
$6 = 9
```

Is that enough to fix the problem of using the new quotes with the `m4` built-in `defn`? We can allow `m4` to continue executing with the `c` (`continue`) command, and then try the example that caused trouble initially:

```
(gdb) c
Continuing.

define(baz,defn(<QUOTE>foo<UNQUOTE>))

baz
0000
```

Success! The new quotes now work just as well as the default ones. The problem seems to have been just the two typos defining the wrong lengths. We allow `m4` exit by giving it an EOF as input:

```
Ctrl-d
Program exited normally.
```

The message ‘`Program exited normally.`’ is from GDB; it indicates `m4` has finished executing. We can end our GDB session with the GDB `quit` command.

```
(gdb) quit
```

2 Getting In and Out of GDB

This chapter discusses how to start GDB, and how to get out of it. The essentials are:

- type `'gdb'` to start GDB.
- type `quit` or `Ctrl-d` to exit.

2.1 Invoking GDB

Invoke GDB by running the program `gdb`. Once started, GDB reads commands from the terminal until you tell it to exit.

You can also run `gdb` with a variety of arguments and options, to specify more of your debugging environment at the outset.

The command-line options described here are designed to cover a variety of situations; in some environments, some of these options may effectively be unavailable.

The most usual way to start GDB is with one argument, specifying an executable program:

```
gdb program
```

You can also start with both an executable program and a core file specified:

```
gdb program core
```

You can, instead, specify a process ID as a second argument, if you want to debug a running process:

```
gdb program 1234
```

would attach GDB to process 1234 (unless you also have a file named `'1234'`; GDB does check for a core file first).

Taking advantage of the second command-line argument requires a fairly complete operating system; when you use GDB as a remote debugger attached to a bare board, there may not be any notion of “process”, and there is often no way to get a core dump. GDB will warn you if it is unable to attach or to read core dumps.

You can optionally have `gdb` pass any arguments after the executable file to the inferior using `--args`. This option stops option processing.

```
gdb --args gcc -O2 -c foo.c
```

This will cause `gdb` to debug `gcc`, and to set `gcc`'s command-line arguments (see [\(undefined\) \[Arguments\], page \(undefined\)](#)) to `'-O2 -c foo.c'`.

You can run `gdb` without printing the front material, which describes GDB's non-warranty, by specifying `-silent`:

```
gdb -silent
```

You can further control how GDB starts up by using command-line options. GDB itself can remind you of the options available.

Type

```
gdb -help
```

to display all available options and briefly describe their use (`'gdb -h'` is a shorter equivalent).

All options and command line arguments you give are processed in sequential order. The order makes a difference when the `'-x'` option is used.

2.1.1 Choosing Files

When GDB starts, it reads any arguments other than options as specifying an executable file and core file (or process ID). This is the same as if the arguments were specified by the ‘-se’ and ‘-c’ (or ‘-p’) options respectively. (GDB reads the first argument that does not have an associated option flag as equivalent to the ‘-se’ option followed by that argument; and the second argument that does not have an associated option flag, if any, as equivalent to the ‘-c’/‘-p’ option followed by that argument.) If the second argument begins with a decimal digit, GDB will first attempt to attach to it as a process, and if that fails, attempt to open it as a corefile. If you have a corefile whose name begins with a digit, you can prevent GDB from treating it as a pid by prefixing it with ‘./’, e.g. ‘./12345’.

If GDB has not been configured to include core file support, such as for most embedded targets, then it will complain about a second argument and ignore it.

Many options have both long and short forms; both are shown in the following list. GDB also recognizes the long forms if you truncate them, so long as enough of the option is present to be unambiguous. (If you prefer, you can flag option arguments with ‘--’ rather than ‘-’, though we illustrate the more usual convention.)

```
-symbols file
-s file      Read symbol table from file file.

-exec file
-e file      Use file file as the executable file to execute when appropriate, and for examining
              pure data in conjunction with a core dump.

-se file     Read symbol table from file file and use it as the executable file.

-core file
-c file     Use file file as a core dump to examine.

-pid number
-p number
              Connect to process ID number, as with the attach command.

-command file
-x file     Execute commands from file file. The contents of this file is evaluated exactly
              as the source command would. See \(undefined\) \[Command files\], page \(undefined\).

-eval-command command
-ex command
              Execute a single GDB command.

              This option may be used multiple times to call multiple commands. It may also
              be interleaved with ‘-command’ as required.
              gdb -ex 'target sim' -ex 'load' \
                -x setbreakpoints -ex 'run' a.out

-directory directory
-d directory
              Add directory to the path to search for source and script files.
```

-r
-readnow Read each symbol file’s entire symbol table immediately, rather than the default, which is to read it incrementally as it is needed. This makes startup slower, but makes future operations faster.

2.1.2 Choosing Modes

You can run GDB in various alternative modes—for example, in batch mode or quiet mode.

-nx
-n Do not execute commands found in any initialization files. Normally, GDB executes the commands in these files after all the command options and arguments have been processed. See [\[Command Files\]](#), page [\[undefined\]](#).

-quiet
-silent
-q “Quiet”. Do not print the introductory and copyright messages. These messages are also suppressed in batch mode.

-batch Run in batch mode. Exit with status 0 after processing all the command files specified with ‘-x’ (and all commands from initialization files, if not inhibited with ‘-n’). Exit with nonzero status if an error occurs in executing the GDB commands in the command files. Batch mode also disables pagination, sets unlimited terminal width and height see [\[Screen Size\]](#), page [\[undefined\]](#), and acts as if *set confirm off* were in effect (see [\[Messages/Warnings\]](#), page [\[undefined\]](#)).

Batch mode may be useful for running GDB as a filter, for example to download and run a program on another computer; in order to make this more useful, the message

```
Program exited normally.
```

(which is ordinarily issued whenever a program running under GDB control terminates) is not issued when running in batch mode.

-batch-silent
 Run in batch mode exactly like ‘-batch’, but totally silently. All GDB output to `stdout` is prevented (`stderr` is unaffected). This is much quieter than ‘-silent’ and would be useless for an interactive session.

This is particularly useful when using targets that give ‘Loading section’ messages, for example.

Note that targets that give their output via GDB, as opposed to writing directly to `stdout`, will also be made silent.

-return-child-result
 The return code from GDB will be the return code from the child process (the process being debugged), with the following exceptions:

- GDB exits abnormally. E.g., due to an incorrect argument or an internal error. In this case the exit code is the same as it would have been without ‘-return-child-result’.
- The user quits with an explicit value. E.g., ‘quit 1’.

- The child process never runs, or is not allowed to terminate, in which case the exit code will be -1.

This option is useful in conjunction with ‘-batch’ or ‘-batch-silent’, when GDB is being used as a remote program loader or simulator interface.

-nowindows

-nw “No windows”. If GDB comes with a graphical user interface (GUI) built in, then this option tells GDB to only use the command-line interface. If no GUI is available, this option has no effect.

-windows

-w If GDB includes a GUI, then this option requires it to be used if possible.

-cd *directory*

Run GDB using *directory* as its working directory, instead of the current directory.

-fullname

-f GNU Emacs sets this option when it runs GDB as a subprocess. It tells GDB to output the full file name and line number in a standard, recognizable fashion each time a stack frame is displayed (which includes each time your program stops). This recognizable format looks like two ‘\032’ characters, followed by the file name, line number and character position separated by colons, and a newline. The Emacs-to-GDB interface program uses the two ‘\032’ characters as a signal to display the source code for the frame.

-epoch

The Epoch Emacs-GDB interface sets this option when it runs GDB as a subprocess. It tells GDB to modify its print routines so as to allow Epoch to display values of expressions in a separate window.

-annotate *level*

This option sets the *annotation level* inside GDB. Its effect is identical to using ‘set annotate *level*’ (see [\[Annotations\]](#), page [\[undefined\]](#)). The annotation *level* controls how much information GDB prints together with its prompt, values of expressions, source lines, and other types of output. Level 0 is the normal, level 1 is for use when GDB is run as a subprocess of GNU Emacs, level 3 is the maximum annotation suitable for programs that control GDB, and level 2 has been deprecated.

The annotation mechanism has largely been superseded by GDB/MI (see [\[GDB/MI\]](#), page [\[undefined\]](#)).

--args

Change interpretation of command line so that arguments following the executable file are passed as command line arguments to the inferior. This option stops option processing.

-baud *bps*

-b *bps* Set the line speed (baud rate or bits per second) of any serial interface used by GDB for remote debugging.

-l *timeout*

Set the timeout (in seconds) of any communication used by GDB for remote debugging.

- tty device**
-t device Run using *device* for your program's standard input and output.
- tui** Activate the *Text User Interface* when starting. The Text User Interface manages several text windows on the terminal, showing source, assembly, registers and GDB command outputs (see [\[GDB Text User Interface\]](#), page [\(undefined\)](#)). Alternatively, the Text User Interface can be enabled by invoking the program 'gdbtui'. Do not use this option if you run GDB from Emacs (see [\[Using GDB under GNU Emacs\]](#), page [\(undefined\)](#)).
- interpreter interp**
 Use the interpreter *interp* for interface with the controlling program or device. This option is meant to be set by programs which communicate with GDB using it as a back end. See [\[Command Interpreters\]](#), page [\(undefined\)](#).
 '--interpreter=mi' (or '--interpreter=mi2') causes GDB to use the GDB/MI interface (see [\[The GDB/MI Interface\]](#), page [\(undefined\)](#)) included since GDB version 6.0. The previous GDB/MI interface, included in GDB version 5.3 and selected with '--interpreter=mi1', is deprecated. Earlier GDB/MI interfaces are no longer supported.
- write** Open the executable and core files for both reading and writing. This is equivalent to the 'set write on' command inside GDB (see [\[Patching\]](#), page [\(undefined\)](#)).
- statistics**
 This option causes GDB to print statistics about time and memory usage after it completes each command and returns to the prompt.
- version** This option causes GDB to print its version number and no-warranty blurb, and exit.

2.1.3 What GDB Does During Startup

Here's the description of what GDB does during session startup:

1. Sets up the command interpreter as specified by the command line (see [\[Mode Options\]](#), page [\(undefined\)](#)).
2. Reads the system-wide *init file* (if '--with-system-gdbinit' was used when building GDB; see [\[System-wide configuration and settings\]](#), page [\(undefined\)](#)) and executes all the commands in that file.
3. Reads the init file (if any) in your home directory¹ and executes all the commands in that file.
4. Processes command line options and operands.
5. Reads and executes the commands from init file (if any) in the current working directory. This is only done if the current directory is different from your home directory. Thus, you can have more than one init file, one generic in your home directory, and another, specific to the program you are debugging, in the directory where you invoke GDB.

¹ On DOS/Windows systems, the home directory is the one pointed to by the HOME environment variable.

6. Reads command files specified by the ‘-x’ option. See [\(undefined\) \[Command Files\]](#), page [\(undefined\)](#), for more details about GDB command files.
7. Reads the command history recorded in the *history file*. See [\(undefined\) \[Command History\]](#), page [\(undefined\)](#), for more details about the command history and the files where GDB records it.

Init files use the same syntax as *command files* (see [\(undefined\) \[Command Files\]](#), page [\(undefined\)](#)) and are processed by GDB in the same way. The init file in your home directory can set options (such as ‘set complaints’) that affect subsequent processing of command line options and operands. Init files are not executed if you use the ‘-nx’ option (see [\(undefined\) \[Choosing Modes\]](#), page [\(undefined\)](#)).

To display the list of init files loaded by gdb at startup, you can use `gdb --help`.

The GDB init files are normally called ‘.gdbinit’. The DJGPP port of GDB uses the name ‘gdb.ini’, due to the limitations of file names imposed by DOS filesystems. The Windows ports of GDB use the standard name, but if they find a ‘gdb.ini’ file, they warn you about that and suggest to rename the file to the standard name.

2.2 Quitting GDB

`quit` [*expression*]

q To exit GDB, use the `quit` command (abbreviated **q**), or type an end-of-file character (usually *Ctrl-d*). If you do not supply *expression*, GDB will terminate normally; otherwise it will terminate using the result of *expression* as the error code.

An interrupt (often *Ctrl-c*) does not exit from GDB, but rather terminates the action of any GDB command that is in progress and returns to GDB command level. It is safe to type the interrupt character at any time because GDB does not allow it to take effect until a time when it is safe.

If you have been using GDB to control an attached process or device, you can release it with the `detach` command (see [\(undefined\) \[Debugging an Already-running Process\]](#), page [\(undefined\)](#)).

2.3 Shell Commands

If you need to execute occasional shell commands during your debugging session, there is no need to leave or suspend GDB; you can just use the `shell` command.

`shell` *command string*

Invoke a standard shell to execute *command string*. If it exists, the environment variable SHELL determines which shell to run. Otherwise GDB uses the default shell (‘/bin/sh’ on Unix systems, ‘COMMAND.COM’ on MS-DOS, etc.).

The utility `make` is often needed in development environments. You do not have to use the `shell` command for this purpose in GDB:

`make` *make-args*

Execute the `make` program with the specified arguments. This is equivalent to ‘shell make *make-args*’.

2.4 Logging Output

You may want to save the output of GDB commands to a file. There are several commands to control GDB's logging.

`set logging on`

Enable logging.

`set logging off`

Disable logging.

`set logging file file`

Change the name of the current logfile. The default logfile is 'gdb.txt'.

`set logging overwrite [on|off]`

By default, GDB will append to the logfile. Set `overwrite` if you want `set logging on` to overwrite the logfile instead.

`set logging redirect [on|off]`

By default, GDB output will go to both the terminal and the logfile. Set `redirect` if you want output to go only to the log file.

`show logging`

Show the current values of the logging settings.

3 GDB Commands

You can abbreviate a GDB command to the first few letters of the command name, if that abbreviation is unambiguous; and you can repeat certain GDB commands by typing just RET. You can also use the TAB key to get GDB to fill out the rest of a word in a command (or to show you the alternatives available, if there is more than one possibility).

3.1 Command Syntax

A GDB command is a single line of input. There is no limit on how long it can be. It starts with a command name, which is followed by arguments whose meaning depends on the command name. For example, the command `step` accepts an argument which is the number of times to step, as in `step 5`. You can also use the `step` command with no arguments. Some commands do not allow any arguments.

GDB command names may always be truncated if that abbreviation is unambiguous. Other possible command abbreviations are listed in the documentation for individual commands. In some cases, even ambiguous abbreviations are allowed; for example, `s` is specially defined as equivalent to `step` even though there are other commands whose names start with `s`. You can test abbreviations by using them as arguments to the `help` command.

A blank line as input to GDB (typing just RET) means to repeat the previous command. Certain commands (for example, `run`) will not repeat this way; these are commands whose unintentional repetition might cause trouble and which you are unlikely to want to repeat. User-defined commands can disable this feature; see [\(undefined\) \[Define\], page \(undefined\)](#).

The `list` and `x` commands, when you repeat them with RET, construct new arguments rather than repeating exactly as typed. This permits easy scanning of source or memory.

GDB can also use RET in another way: to partition lengthy output, in a way similar to the common utility `more` (see [\(undefined\) \[Screen Size\], page \(undefined\)](#)). Since it is easy to press one RET too many in this situation, GDB disables command repetition after any command that generates this sort of display.

Any text from a `#` to the end of the line is a comment; it does nothing. This is useful mainly in command files (see [\(undefined\) \[Command Files\], page \(undefined\)](#)).

The `Ctrl-o` binding is useful for repeating a complex sequence of commands. This command accepts the current line, like RET, and then fetches the next line relative to the current line from the history for editing.

3.2 Command Completion

GDB can fill in the rest of a word in a command for you, if there is only one possibility; it can also show you what the valid possibilities are for the next word in a command, at any time. This works for GDB commands, GDB subcommands, and the names of symbols in your program.

Press the TAB key whenever you want GDB to fill out the rest of a word. If there is only one possibility, GDB fills in the word, and waits for you to finish the command (or press RET to enter it). For example, if you type

```
(gdb) info bre TAB
```

GDB fills in the rest of the word `'breakpoints'`, since that is the only `info` subcommand beginning with `'bre'`:


```
(gdb) info breakpoints
```

You can either press RET at this point, to run the `info breakpoints` command, or backspace and enter something else, if `'breakpoints'` does not look like the command you expected. (If you were sure you wanted `info breakpoints` in the first place, you might as well just type RET immediately after `'info bre'`, to exploit command abbreviations rather than command completion).

If there is more than one possibility for the next word when you press TAB, GDB sounds a bell. You can either supply more characters and try again, or just press TAB a second time; GDB displays all the possible completions for that word. For example, you might want to set a breakpoint on a subroutine whose name begins with `'make_'`, but when you type `b make_TAB` GDB just sounds the bell. Typing TAB again displays all the function names in your program that begin with those characters, for example:

```
(gdb) b make_ TAB
GDB sounds bell; press TAB again, to see:
make_a_section_from_file      make_enviro
make_abs_section              make_functi
make_blockvector              make_point
make_cleanup                   make_refer
make_command                   make_symbol
(gdb) b make_
```

After displaying the available possibilities, GDB copies your partial input (`'b make_'` in the example) so you can finish the command.

If you just want to see the list of alternatives in the first place, you can press `M-?` rather than pressing TAB twice. `M-?` means *META ?*. You can type this either by holding down a key designated as the META shift on your keyboard (if there is one) while typing `?`, or as ESC followed by `?`.

Sometimes the string you need, while logically a “word”, may contain parentheses or other characters that GDB normally excludes from its notion of a word. To permit word completion to work in this situation, you may enclose words in `'` (single quote marks) in GDB commands.

The most likely situation where you might need this is in typing the name of a C++ function. This is because C++ allows function overloading (multiple definitions of the same function, distinguished by argument type). For example, when you want to set a breakpoint you may need to distinguish whether you mean the version of `name` that takes an `int` parameter, `name(int)`, or the version that takes a `float` parameter, `name(float)`. To use the word-completion facilities in this situation, type a single quote `'` at the beginning of the function name. This alerts GDB that it may need to consider more information than usual when you press TAB or `M-?` to request word completion:

```
(gdb) b 'bubble( M-?
bubble(double,double)      bubble(int,int)
(gdb) b 'bubble(
```

In some cases, GDB can tell that completing a name requires using quotes. When this happens, GDB inserts the quote for you (while completing as much as it can) if you do not type the quote in the first place:

```
(gdb) b bub TAB
GDB alters your input line to the following, and rings a bell:
(gdb) b 'bubble(
```

In general, GDB can tell that a quote is needed (and inserts it) if you have not yet started typing the argument list when you ask for completion on an overloaded symbol.

For more information about overloaded functions, see [\[C++ Expressions\]](#), page [\[undefined\]](#). You can use the command `set overload-resolution off` to disable overload resolution; see [\[GDB Features for C++\]](#), page [\[undefined\]](#).

When completing in an expression which looks up a field in a structure, GDB also tries¹ to limit completions to the field names available in the type of the left-hand-side:

```
(gdb) p gdb_stdout.M-?
magic      to_delete to_fputs  to_put     to_rewind
to_data    to_flush  to_isatty to_read    to_write
```

This is because the `gdb_stdout` is a variable of the type `struct ui_file` that is defined in GDB sources as follows:

```
struct ui_file
{
    int *magic;
    ui_file_flush_ftype *to_flush;
    ui_file_write_ftype *to_write;
    ui_file_fputs_ftype *to_fputs;
    ui_file_read_ftype *to_read;
    ui_file_delete_ftype *to_delete;
    ui_file_isatty_ftype *to_isatty;
    ui_file_rewind_ftype *to_rewind;
    ui_file_put_ftype *to_put;
    void *to_data;
}
```

3.3 Getting Help

You can always ask GDB itself for information on its commands, using the command `help`.

`help`

`h` You can use `help` (abbreviated `h`) with no arguments to display a short list of named classes of commands:

```
(gdb) help
List of classes of commands:

aliases -- Aliases of other commands
breakpoints -- Making program stop at certain points
data -- Examining data
files -- Specifying and examining files
internals -- Maintenance commands
obscure -- Obscure features
running -- Running the program
stack -- Examining the stack
status -- Status inquiries
support -- Support facilities
tracepoints -- Tracing of program execution without
                stopping the program
user-defined -- User-defined commands
```

Type "help" followed by a class name for a list of

¹ The completer can be confused by certain kinds of invalid expressions. Also, it only examines the static type of the expression, not the dynamic type.

```

commands in that class.
Type "help" followed by command name for full
documentation.
Command name abbreviations are allowed if unambiguous.
(gdb)

```

help class

Using one of the general help classes as an argument, you can get a list of the individual commands in that class. For example, here is the help display for the class `status`:

```

(gdb) help status
Status inquiries.

List of commands:

info -- Generic command for showing things
      about the program being debugged
show -- Generic command for showing things
      about the debugger

Type "help" followed by command name for full
documentation.
Command name abbreviations are allowed if unambiguous.
(gdb)

```

help command

With a command name as `help` argument, GDB displays a short paragraph on how to use that command.

apropos args

The `apropos` command searches through all of the GDB commands, and their documentation, for the regular expression specified in `args`. It prints out all matches found. For example:

```

apropos reload
results in:
set symbol-reloading -- Set dynamic symbol table reloading
                      multiple times in one run
show symbol-reloading -- Show dynamic symbol table reloading
                      multiple times in one run

```

complete args

The `complete args` command lists all the possible completions for the beginning of a command. Use `args` to specify the beginning of the command you want completed. For example:

```

complete i
results in:
if
ignore
info
inspect

```

This is intended for use by GNU Emacs.

In addition to `help`, you can use the GDB commands `info` and `show` to inquire about the state of your program, or the state of GDB itself. Each command supports many topics

of inquiry; this manual introduces each of them in the appropriate context. The listings under `info` and under `show` in the Index point to all the sub-commands. See [\(undefined\) \[Index\], page \(undefined\)](#).

- `info` This command (abbreviated `i`) is for describing the state of your program. For example, you can show the arguments passed to a function with `info args`, list the registers currently in use with `info registers`, or list the breakpoints you have set with `info breakpoints`. You can get a complete list of the `info` sub-commands with `help info`.
- `set` You can assign the result of an expression to an environment variable with `set`. For example, you can set the GDB prompt to a `$`-sign with `set prompt $`.
- `show` In contrast to `info`, `show` is for describing the state of GDB itself. You can change most of the things you can `show`, by using the related command `set`; for example, you can control what number system is used for displays with `set radix`, or simply inquire which is currently in use with `show radix`.
- To display all the settable parameters and their current values, you can use `show` with no arguments; you may also use `info set`. Both commands produce the same display.

Here are three miscellaneous `show` subcommands, all of which are exceptional in lacking corresponding `set` commands:

`show version`

Show what version of GDB is running. You should include this information in GDB bug-reports. If multiple versions of GDB are in use at your site, you may need to determine which version of GDB you are running; as GDB evolves, new commands are introduced, and old ones may wither away. Also, many system vendors ship variant versions of GDB, and there are variant versions of GDB in GNU/Linux distributions as well. The version number is the same as the one announced when you start GDB.

`show copying`

`info copying`

Display information about permission for copying GDB.

`show warranty`

`info warranty`

Display the GNU “NO WARRANTY” statement, or a warranty, if your version of GDB comes with one.

4 Running Programs Under GDB

When you run a program under GDB, you must first generate debugging information when you compile it.

You may start GDB with its arguments, if any, in an environment of your choice. If you are doing native debugging, you may redirect your program's input and output, debug an already running process, or kill a child process.

4.1 Compiling for Debugging

In order to debug a program effectively, you need to generate debugging information when you compile it. This debugging information is stored in the object file; it describes the data type of each variable or function and the correspondence between source line numbers and addresses in the executable code.

To request debugging information, specify the `'-g'` option when you run the compiler.

Programs that are to be shipped to your customers are compiled with optimizations, using the `'-O'` compiler option. However, some compilers are unable to handle the `'-g'` and `'-O'` options together. Using those compilers, you cannot generate optimized executables containing debugging information.

GCC, the GNU C/C++ compiler, supports `'-g'` with or without `'-O'`, making it possible to debug optimized code. We recommend that you *always* use `'-g'` whenever you compile a program. You may think your program is correct, but there is no sense in pushing your luck. For more information, see [\(undefined\) \[Optimized Code\], page \(undefined\)](#).

Older versions of the GNU C compiler permitted a variant option `'-gg'` for debugging information. GDB no longer supports this format; if your GNU C compiler has this option, do not use it.

GDB knows about preprocessor macros and can show you their expansion (see [\(undefined\) \[Macros\], page \(undefined\)](#)). Most compilers do not include information about preprocessor macros in the debugging information if you specify the `'-g'` flag alone, because this information is rather large. Version 3.1 and later of GCC, the GNU C compiler, provides macro information if you specify the options `'-gdwarf-2'` and `'-g3'`; the former option requests debugging information in the Dwarf 2 format, and the latter requests "extra information". In the future, we hope to find more compact ways to represent macro information, so that it can be included with `'-g'` alone.

4.2 Starting your Program

`run`

`r` Use the `run` command to start your program under GDB. You must first specify the program name (except on VxWorks) with an argument to GDB (see [\(undefined\) \[Getting In and Out of GDB\], page \(undefined\)](#)), or by using the `file` or `exec-file` command (see [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#)).

If you are running your program in an execution environment that supports processes, `run` creates an inferior process and makes that process run your program. In some environments without processes, `run` jumps to the start of your program. Other targets, like `'remote'`, are always running. If you get an error message like this one:

The "remote" target does not support "run".
Try "help target" or "continue".

then use `continue` to run your program. You may need `load` first (see [\[load\]](#), page [\[undefined\]](#)).

The execution of a program is affected by certain information it receives from its superior. GDB provides ways to specify this information, which you must do *before* starting your program. (You can change it after starting your program, but such changes only affect your program the next time you start it.) This information may be divided into four categories:

The *arguments*.

Specify the arguments to give your program as the arguments of the `run` command. If a shell is available on your target, the shell is used to pass the arguments, so that you may use normal conventions (such as wildcard expansion or variable substitution) in describing the arguments. In Unix systems, you can control which shell is used with the `SHELL` environment variable. See [\[Your Program's Arguments\]](#), page [\[undefined\]](#).

The *environment*.

Your program normally inherits its environment from GDB, but you can use the GDB commands `set environment` and `unset environment` to change parts of the environment that affect your program. See [\[Your Program's Environment\]](#), page [\[undefined\]](#).

The *working directory*.

Your program inherits its working directory from GDB. You can set the GDB working directory with the `cd` command in GDB. See [\[Your Program's Working Directory\]](#), page [\[undefined\]](#).

The *standard input and output*.

Your program normally uses the same device for standard input and standard output as GDB is using. You can redirect input and output in the `run` command line, or you can use the `tty` command to set a different device for your program. See [\[Your Program's Input and Output\]](#), page [\[undefined\]](#).

Warning: While input and output redirection work, you cannot use pipes to pass the output of the program you are debugging to another program; if you attempt this, GDB is likely to wind up debugging the wrong program.

When you issue the `run` command, your program begins to execute immediately. See [\[Stopping and Continuing\]](#), page [\[undefined\]](#), for discussion of how to arrange for your program to stop. Once your program has stopped, you may call functions in your program, using the `print` or `call` commands. See [\[Examining Data\]](#), page [\[undefined\]](#).

If the modification time of your symbol file has changed since the last time GDB read its symbols, GDB discards its symbol table, and reads it again. When it does this, GDB tries to retain your current breakpoints.

start The name of the main procedure can vary from language to language. With C or C++, the main procedure name is always `main`, but other languages such as Ada do not require a specific name for their main procedure. The debugger

provides a convenient way to start the execution of the program and to stop at the beginning of the main procedure, depending on the language used.

The `start` command does the equivalent of setting a temporary breakpoint at the beginning of the main procedure and then invoking the `run` command.

Some programs contain an *elaboration* phase where some startup code is executed before the main procedure is called. This depends on the languages used to write your program. In C++, for instance, constructors for static and global objects are executed before `main` is called. It is therefore possible that the debugger stops before reaching the main procedure. However, the temporary breakpoint will remain to halt execution.

Specify the arguments to give to your program as arguments to the `start` command. These arguments will be given verbatim to the underlying `run` command. Note that the same arguments will be reused if no argument is provided during subsequent calls to `start` or `run`.

It is sometimes necessary to debug the program during elaboration. In these cases, using the `start` command would stop the execution of your program too late, as the program would have already completed the elaboration phase. Under these circumstances, insert breakpoints in your elaboration code before running your program.

```
set exec-wrapper wrapper
show exec-wrapper
unset exec-wrapper
```

When `exec-wrapper` is set, the specified wrapper is used to launch programs for debugging. GDB starts your program with a shell command of the form `exec wrapper program`. Quoting is added to `program` and its arguments, but not to `wrapper`, so you should add quotes if appropriate for your shell. The wrapper runs until it executes your program, and then GDB takes control.

You can use any program that eventually calls `execve` with its arguments as a wrapper. Several standard Unix utilities do this, e.g. `env` and `nohup`. Any Unix shell script ending with `exec "$@"` will also work.

For example, you can use `env` to pass an environment variable to the debugged program, without setting the variable in your shell's environment:

```
(gdb) set exec-wrapper env 'LD_PRELOAD=libtest.so'
(gdb) run
```

This command is available when debugging locally on most targets, excluding DJGPP, Cygwin, MS Windows, and QNX Neutrino.

```
set disable-randomization
set disable-randomization on
```

This option (enabled by default in GDB) will turn off the native randomization of the virtual address space of the started program. This option is useful for multiple debugging sessions to make the execution better reproducible and memory addresses reusable across debugging sessions.

This feature is implemented only on GNU/Linux. You can get the same behavior using


```
(gdb) set exec-wrapper setarch 'uname -m' -R
```

`set disable-randomization off`

Leave the behavior of the started executable unchanged. Some bugs rear their ugly heads only when the program is loaded at certain addresses. If your bug disappears when you run the program under GDB, that might be because GDB by default disables the address randomization on platforms, such as GNU/Linux, which do that for stand-alone programs. Use *set disable-randomization off* to try to reproduce such elusive bugs.

The virtual address space randomization is implemented only on GNU/Linux. It protects the programs against some kinds of security attacks. In these cases the attacker needs to know the exact location of a concrete executable code. Randomizing its location makes it impossible to inject jumps misusing a code at its expected addresses.

Prelinking shared libraries provides a startup performance advantage but it makes addresses in these libraries predictable for privileged processes by having just unprivileged access at the target system. Reading the shared library binary gives enough information for assembling the malicious code misusing it. Still even a prelinked shared library can get loaded at a new random address just requiring the regular relocation process during the startup. Shared libraries not already prelinked are always loaded at a randomly chosen address.

Position independent executables (PIE) contain position independent code similar to the shared libraries and therefore such executables get loaded at a randomly chosen address upon startup. PIE executables always load even already prelinked shared libraries at a random address. You can build such executable using `gcc -fPIE -pie`.

Heap (malloc storage), stack and custom mmap areas are always placed randomly (as long as the randomization is enabled).

`show disable-randomization`

Show the current setting of the explicit disable of the native randomization of the virtual address space of the started program.

4.3 Your Program's Arguments

The arguments to your program can be specified by the arguments of the `run` command. They are passed to a shell, which expands wildcard characters and performs redirection of I/O, and thence to your program. Your `SHELL` environment variable (if it exists) specifies what shell GDB uses. If you do not define `SHELL`, GDB uses the default shell (`/bin/sh` on Unix).

On non-Unix systems, the program is usually invoked directly by GDB, which emulates I/O redirection via the appropriate system calls, and the wildcard characters are expanded by the startup code of the program, not by the shell.

`run` with no arguments uses the same arguments used by the previous `run`, or those set by the `set args` command.

`set args` Specify the arguments to be used the next time your program is run. If `set args` has no arguments, `run` executes your program with no arguments. Once

you have run your program with arguments, using `set args` before the next `run` is the only way to run it again without arguments.

`show args` Show the arguments to give your program when it is started.

4.4 Your Program's Environment

The *environment* consists of a set of environment variables and their values. Environment variables conventionally record such things as your user name, your home directory, your terminal type, and your search path for programs to run. Usually you set up environment variables with the shell and they are inherited by all the other programs you run. When debugging, it can be useful to try running your program with a modified environment without having to start GDB over again.

`path directory`

Add *directory* to the front of the `PATH` environment variable (the search path for executables) that will be passed to your program. The value of `PATH` used by GDB does not change. You may specify several directory names, separated by whitespace or by a system-dependent separator character (':' on Unix, ';' on MS-DOS and MS-Windows). If *directory* is already in the path, it is moved to the front, so it is searched sooner.

You can use the string '\$`cwd`' to refer to whatever is the current working directory at the time GDB searches the path. If you use '.' instead, it refers to the directory where you executed the `path` command. GDB replaces '.' in the *directory* argument (with the current path) before adding *directory* to the search path.

`show paths`

Display the list of search paths for executables (the `PATH` environment variable).

`show environment [varname]`

Print the value of environment variable *varname* to be given to your program when it starts. If you do not supply *varname*, print the names and values of all environment variables to be given to your program. You can abbreviate `environment` as `env`.

`set environment varname [=value]`

Set environment variable *varname* to *value*. The value changes for your program only, not for GDB itself. *value* may be any string; the values of environment variables are just strings, and any interpretation is supplied by your program itself. The *value* parameter is optional; if it is eliminated, the variable is set to a null value.

For example, this command:

```
set env USER = foo
```

tells the debugged program, when subsequently run, that its user is named 'foo'. (The spaces around '=' are used for clarity here; they are not actually required.)

unset environment varname

Remove variable *varname* from the environment to be passed to your program. This is different from `'set env varname ='`; `unset environment` removes the variable from the environment, rather than assigning it an empty value.

Warning: On Unix systems, GDB runs your program using the shell indicated by your `SHELL` environment variable if it exists (or `/bin/sh` if not). If your `SHELL` variable names a shell that runs an initialization file—such as `‘.cshrc’` for C-shell, or `‘.bashrc’` for BASH—any variables you set in that file affect your program. You may wish to move setting of environment variables to files that are only run when you sign on, such as `‘.login’` or `‘.profile’`.

4.5 Your Program’s Working Directory

Each time you start your program with `run`, it inherits its working directory from the current working directory of GDB. The GDB working directory is initially whatever it inherited from its parent process (typically the shell), but you can specify a new working directory in GDB with the `cd` command.

The GDB working directory also serves as a default for the commands that specify files for GDB to operate on. See [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#).

cd directory

Set the GDB working directory to *directory*.

pwd Print the GDB working directory.

It is generally impossible to find the current working directory of the process being debugged (since a program can change its directory during its run). If you work on a system where GDB is configured with the `‘/proc’` support, you can use the `info proc` command (see [\(undefined\) \[SVR4 Process Information\], page \(undefined\)](#)) to find out the current working directory of the debuggee.

4.6 Your Program’s Input and Output

By default, the program you run under GDB does input and output to the same terminal that GDB uses. GDB switches the terminal to its own terminal modes to interact with you, but it records the terminal modes your program was using and switches back to them when you continue running your program.

info terminal

Displays information recorded by GDB about the terminal modes your program is using.

You can redirect your program’s input and/or output using shell redirection with the `run` command. For example,

```
run > outfile
```

starts your program, diverting its output to the file `‘outfile’`.

Another way to specify where your program should do input and output is with the `tty` command. This command accepts a file name as argument, and causes this file to be the default for future `run` commands. It also resets the controlling terminal for the child process, for future `run` commands. For example,

```
tty /dev/ttyb
```

directs that processes started with subsequent `run` commands default to do input and output on the terminal `/dev/ttyb` and have that as their controlling terminal.

An explicit redirection in `run` overrides the `tty` command's effect on the input/output device, but not its effect on the controlling terminal.

When you use the `tty` command or redirect input in the `run` command, only the input *for your program* is affected. The input for GDB still comes from your terminal. `tty` is an alias for `set inferior-tty`.

You can use the `show inferior-tty` command to tell GDB to display the name of the terminal that will be used for future runs of your program.

```
set inferior-tty /dev/ttyb
```

Set the tty for the program being debugged to `/dev/ttyb`.

```
show inferior-tty
```

Show the current tty for the program being debugged.

4.7 Debugging an Already-running Process

```
attach process-id
```

This command attaches to a running process—one that was started outside GDB. (`info files` shows your active targets.) The command takes as argument a process ID. The usual way to find out the *process-id* of a Unix process is with the `ps` utility, or with the `'jobs -l'` shell command.

`attach` does not repeat if you press RET a second time after executing the command.

To use `attach`, your program must be running in an environment which supports processes; for example, `attach` does not work for programs on bare-board targets that lack an operating system. You must also have permission to send the process a signal.

When you use `attach`, the debugger finds the program running in the process first by looking in the current working directory, then (if the program is not found) by using the source file search path (see [\(undefined\) \[Specifying Source Directories\], page \(undefined\)](#)). You can also use the `file` command to load the program. See [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#).

The first thing GDB does after arranging to debug the specified process is to stop it. You can examine and modify an attached process with all the GDB commands that are ordinarily available when you start processes with `run`. You can insert breakpoints; you can step and continue; you can modify storage. If you would rather the process continue running, you may use the `continue` command after attaching GDB to the process.

detach When you have finished debugging the attached process, you can use the `detach` command to release it from GDB control. Detaching the process continues its execution. After the `detach` command, that process and GDB become completely independent once more, and you are ready to `attach` another process or start one with `run`. `detach` does not repeat if you press RET again after executing the command.

If you exit GDB while you have an attached process, you detach that process. If you use the `run` command, you kill that process. By default, GDB asks for confirmation if you try to do either of these things; you can control whether or not you need to confirm by using the `set confirm` command (see [\(undefined\) \[Optional Warnings and Messages\]](#), page [\(undefined\)](#)).

4.8 Killing the Child Process

`kill` Kill the child process in which your program is running under GDB.

This command is useful if you wish to debug a core dump instead of a running process. GDB ignores any core dump file while your program is running.

On some operating systems, a program cannot be executed outside GDB while you have breakpoints set on it inside GDB. You can use the `kill` command in this situation to permit running your program outside the debugger.

The `kill` command is also useful if you wish to recompile and relink your program, since on many systems it is impossible to modify an executable file while it is running in a process. In this case, when you next type `run`, GDB notices that the file has changed, and reads the symbol table again (while trying to preserve your current breakpoint settings).

4.9 Debugging Multiple Inferiors and Programs

GDB lets you run and debug multiple programs in a single session. In addition, GDB on some systems may let you run several programs simultaneously (otherwise you have to exit from one before starting another). In the most general case, you can have multiple threads of execution in each of multiple processes, launched from multiple executables.

GDB represents the state of each program execution with an object called an *inferior*. An inferior typically corresponds to a process, but is more general and applies also to targets that do not have processes. Inferiors may be created before a process runs, and may be retained after a process exits. Inferiors have unique identifiers that are different from process ids. Usually each inferior will also have its own distinct address space, although some embedded targets may have several inferiors running in different parts of a single address space. Each inferior may in turn have multiple threads running in it.

To find out what inferiors exist at any moment, use `info inferiors`:

`info inferiors`

Print a list of all inferiors currently being managed by GDB.

GDB displays for each inferior (in this order):

1. the inferior number assigned by GDB
2. the target system's inferior identifier
3. the name of the executable the inferior is running.

An asterisk `*` preceding the GDB inferior number indicates the current inferior.

For example,

```
(gdb) info inferiors
  Num  Description      Executable
  ---  ---
   2   process 2307      hello
  * 1   process 3401      goodbye
```

To switch focus between inferiors, use the `inferior` command:

`inferior infno`

Make inferior number *infno* the current inferior. The argument *infno* is the inferior number assigned by GDB, as shown in the first field of the ‘`info inferiors`’ display.

You can get multiple executables into a debugging session via the `add-inferior` and `clone-inferior` commands. On some systems GDB can add inferiors to the debug session automatically by following calls to `fork` and `exec`. To remove inferiors from the debugging session use the `remove-inferior` command.

`add-inferior [-copies n] [-exec executable]`

Adds *n* inferiors to be run using *executable* as the executable. *n* defaults to 1. If no executable is specified, the inferiors begins empty, with no program. You can still assign or change the program assigned to the inferior at any time by using the `file` command with the executable name as its argument.

`clone-inferior [-copies n] [infno]`

Adds *n* inferiors ready to execute the same program as inferior *infno*. *n* defaults to 1. *infno* defaults to the number of the current inferior. This is a convenient command when you want to run another instance of the inferior you are debugging.

```
(gdb) info inferiors
  Num  Description      Executable
* 1    process 29964      helloworld
(gdb) clone-inferior
Added inferior 2.
1 inferiors added.
(gdb) info inferiors
  Num  Description      Executable
  2    <null>            helloworld
* 1    process 29964      helloworld
```

You can now simply switch focus to inferior 2 and run it.

`remove-inferior infno`

Removes the inferior *infno*. It is not possible to remove an inferior that is running with this command. For those, use the `kill` or `detach` command first.

To quit debugging one of the running inferiors that is not the current inferior, you can either detach from it by using the `detach inferior` command (allowing it to run independently), or kill it using the `kill inferior` command:

`detach inferior infno`

Detach from the inferior identified by GDB inferior number *infno*. Note that the inferior’s entry still stays on the list of inferiors shown by `info inferiors`, but its Description will show ‘<null>’.

`kill inferior infno`

Kill the inferior identified by GDB inferior number *infno*. Note that the inferior’s entry still stays on the list of inferiors shown by `info inferiors`, but its Description will show ‘<null>’.

After the successful completion of a command such as `detach`, `detach inferior`, `kill` or `kill inferior`, or after a normal process exit, the inferior is still valid and listed with `info inferiors`, ready to be restarted.

To be notified when inferiors are started or exit under GDB's control use `set print inferior-events`:

```
set print inferior-events
set print inferior-events on
set print inferior-events off
```

The `set print inferior-events` command allows you to enable or disable printing of messages when GDB notices that new inferiors have started or that inferiors have exited or have been detached. By default, these messages will not be printed.

```
show print inferior-events
```

Show whether messages will be printed when GDB detects that inferiors have started, exited or have been detached.

Many commands will work the same with multiple programs as with a single program: e.g., `print myglobal` will simply display the value of `myglobal` in the current inferior.

Occasionally, when debugging GDB itself, it may be useful to get more info about the relationship of inferiors, programs, address spaces in a debug session. You can do that with the `maint info program-spaces` command.

```
maint info program-spaces
```

Print a list of all program spaces currently being managed by GDB.

GDB displays for each program space (in this order):

1. the program space number assigned by GDB
2. the name of the executable loaded into the program space, with e.g., the `file` command.

An asterisk `*` preceding the GDB program space number indicates the current program space.

In addition, below each program space line, GDB prints extra information that isn't suitable to display in tabular form. For example, the list of inferiors bound to the program space.

```
(gdb) maint info program-spaces
  Id  Executable
  2   goodbye
      Bound inferiors: ID 1 (process 21561)
* 1   hello
```

Here we can see that no inferior is running the program `hello`, while `process 21561` is running the program `goodbye`. On some targets, it is possible that multiple inferiors are bound to the same program space. The most common example is that of debugging both the parent and child processes of a `vfork` call. For example,

```
(gdb) maint info program-spaces
  Id  Executable
* 1   vfork-test
```

```
Bound inferiors: ID 2 (process 18050), ID 1 (process 18045)
```

Here, both inferior 2 and inferior 1 are running in the same program space as a result of inferior 1 having executed a `vfork` call.

4.10 Debugging Programs with Multiple Threads

In some operating systems, such as HP-UX and Solaris, a single program may have more than one *thread* of execution. The precise semantics of threads differ from one operating system to another, but in general the threads of a single program are akin to multiple processes—except that they share one address space (that is, they can all examine and modify the same variables). On the other hand, each thread has its own registers and execution stack, and perhaps private memory.

GDB provides these facilities for debugging multi-thread programs:

- automatic notification of new threads
- ‘`thread threadno`’, a command to switch among threads
- ‘`info threads`’, a command to inquire about existing threads
- ‘`thread apply [threadno] [all] args`’, a command to apply a command to a list of threads
- thread-specific breakpoints
- ‘`set print thread-events`’, which controls printing of messages on thread start and exit.
- ‘`set libthread-db-search-path path`’, which lets the user specify which `libthread_db` to use if the default choice isn’t compatible with the program.

Warning: These facilities are not yet available on every GDB configuration where the operating system supports threads. If your GDB does not support threads, these commands have no effect. For example, a system without thread support shows no output from ‘`info threads`’, and always rejects the `thread` command, like this:

```
(gdb) info threads
(gdb) thread 1
Thread ID 1 not known. Use the "info threads" command to
see the IDs of currently known threads.
```

The GDB thread debugging facility allows you to observe all threads while your program runs—but whenever GDB takes control, one thread in particular is always the focus of debugging. This thread is called the *current thread*. Debugging commands show program information from the perspective of the current thread.

Whenever GDB detects a new thread in your program, it displays the target system’s identification for the thread with a message in the form ‘`[New systag]`’. *systag* is a thread identifier whose form varies depending on the particular system. For example, on GNU/Linux, you might see

```
[New Thread 46912507313328 (LWP 25582)]
```

when GDB notices a new thread. In contrast, on an SGI system, the *systag* is simply something like ‘`process 368`’, with no further qualifier.

For debugging purposes, GDB associates its own thread number—always a single integer—with each thread in your program.

info threads

Display a summary of all threads currently in your program. GDB displays for each thread (in this order):

1. the thread number assigned by GDB
2. the target system's thread identifier (*systag*)
3. the current stack frame summary for that thread

An asterisk '*' to the left of the GDB thread number indicates the current thread.

For example,

```
(gdb) info threads
 3 process 35 thread 27 0x34e5 in sigpause ()
 2 process 35 thread 23 0x34e5 in sigpause ()
* 1 process 35 thread 13 main (argc=1, argv=0x7ffffff8)
   at threadtest.c:68
```

On HP-UX systems:

For debugging purposes, GDB associates its own thread number—a small integer assigned in thread-creation order—with each thread in your program.

Whenever GDB detects a new thread in your program, it displays both GDB's thread number and the target system's identification for the thread with a message in the form '[New *systag*]'. *systag* is a thread identifier whose form varies depending on the particular system. For example, on HP-UX, you see

```
[New thread 2 (system thread 26594)]
```

when GDB notices a new thread.

info threads

Display a summary of all threads currently in your program. GDB displays for each thread (in this order):

1. the thread number assigned by GDB
2. the target system's thread identifier (*systag*)
3. the current stack frame summary for that thread

An asterisk '*' to the left of the GDB thread number indicates the current thread.

For example,

```
(gdb) info threads
* 3 system thread 26607 worker (wptr=0x7b09c318 "@") \
                                     at quicksort.c:137
 2 system thread 26606 0x7b0030d8 in __ksleep () \
                                     from /usr/lib/libc.2
 1 system thread 27905 0x7b003498 in _brk () \
                                     from /usr/lib/libc.2
```

On Solaris, you can display more information about user threads with a Solaris-specific command:

maint info sol-threads

Display info on Solaris user threads.

thread *threadno*

Make thread number *threadno* the current thread. The command argument *threadno* is the internal GDB thread number, as shown in the first field of the ‘`info threads`’ display. GDB responds by displaying the system identifier of the thread you selected, and its current stack frame summary:

```
(gdb) thread 2
[Switching to process 35 thread 23]
0x34e5 in sigpause ()
```

As with the ‘[New ...]’ message, the form of the text after ‘Switching to’ depends on your system’s conventions for identifying threads.

The debugger convenience variable ‘`$_thread`’ contains the number of the current thread. You may find this useful in writing breakpoint conditional expressions, command scripts, and so forth. See [\(undefined\) \[Convenience Variables\], page \(undefined\)](#), for general information on convenience variables.

thread apply [*threadno*] [*all*] *command*

The `thread apply` command allows you to apply the named *command* to one or more threads. Specify the numbers of the threads that you want affected with the command argument *threadno*. It can be a single thread number, one of the numbers shown in the first field of the ‘`info threads`’ display; or it could be a range of thread numbers, as in 2-4. To apply a command to all threads, type `thread apply all command`.

set print thread-events

```
set print thread-events on
```

```
set print thread-events off
```

The `set print thread-events` command allows you to enable or disable printing of messages when GDB notices that new threads have started or that threads have exited. By default, these messages will be printed if detection of these events is supported by the target. Note that these messages cannot be disabled on all targets.

show print thread-events

Show whether messages will be printed when GDB detects that threads have started and exited.

See [\(undefined\) \[Stopping and Starting Multi-thread Programs\], page \(undefined\)](#), for more information about how GDB behaves when you stop and start programs with multiple threads.

See [\(undefined\) \[Setting Watchpoints\], page \(undefined\)](#), for information about watchpoints in programs with multiple threads.

set libthread-db-search-path [*path*]

If this variable is set, *path* is a colon-separated list of directories GDB will use to search for `libthread_db`. If you omit *path*, ‘`libthread-db-search-path`’ will be reset to an empty list.

On GNU/Linux and Solaris systems, GDB uses a “helper” `libthread_db` library to obtain information about threads in the inferior process. GDB will use ‘`libthread-db-search-path`’ to find `libthread_db`. If that fails, GDB will

continue with default system shared library directories, and finally the directory from which `libpthread` was loaded in the inferior process.

For any `libthread_db` library GDB finds in above directories, GDB attempts to initialize it with the current inferior process. If this initialization fails (which could happen because of a version mismatch between `libthread_db` and `libpthread`), GDB will unload `libthread_db`, and continue with the next directory. If none of `libthread_db` libraries initialize successfully, GDB will issue a warning and thread debugging will be disabled.

Setting `libthread-db-search-path` is currently implemented only on some platforms.

```
show libthread-db-search-path
```

Display current `libthread_db` search path.

4.11 Debugging Forks

On most systems, GDB has no special support for debugging programs which create additional processes using the `fork` function. When a program forks, GDB will continue to debug the parent process and the child process will run unimpeded. If you have set a breakpoint in any code which the child then executes, the child will get a `SIGTRAP` signal which (unless it catches the signal) will cause it to terminate.

However, if you want to debug the child process there is a workaround which isn't too painful. Put a call to `sleep` in the code which the child process executes after the fork. It may be useful to sleep only if a certain environment variable is set, or a certain file exists, so that the delay need not occur when you don't want to run GDB on the child. While the child is sleeping, use the `ps` program to get its process ID. Then tell GDB (a new invocation of GDB if you are also debugging the parent process) to attach to the child process (see [\(undefined\) \[Attach\], page \(undefined\)](#)). From that point on you can debug the child process just like any other process which you attached to.

On some systems, GDB provides support for debugging programs that create additional processes using the `fork` or `vfork` functions. Currently, the only platforms with this feature are HP-UX (11.x and later only?) and GNU/Linux (kernel version 2.5.60 and later).

By default, when a program forks, GDB will continue to debug the parent process and the child process will run unimpeded.

If you want to follow the child process instead of the parent process, use the command `set follow-fork-mode`.

```
set follow-fork-mode mode
```

Set the debugger response to a program call of `fork` or `vfork`. A call to `fork` or `vfork` creates a new process. The *mode* argument can be:

- `parent` The original process is debugged after a fork. The child process runs unimpeded. This is the default.
- `child` The new process is debugged after a fork. The parent process runs unimpeded.

```
show follow-fork-mode
```

Display the current debugger response to a `fork` or `vfork` call.

On Linux, if you want to debug both the parent and child processes, use the command `set detach-on-fork`.

`set detach-on-fork mode`

Tells gdb whether to detach one of the processes after a fork, or retain debugger control over them both.

on The child process (or parent process, depending on the value of `follow-fork-mode`) will be detached and allowed to run independently. This is the default.

off Both processes will be held under the control of GDB. One process (child or parent, depending on the value of `follow-fork-mode`) is debugged as usual, while the other is held suspended.

`show detach-on-fork`

Show whether `detach-on-fork` mode is on/off.

If you choose to set ‘`detach-on-fork`’ mode off, then GDB will retain control of all forked processes (including nested forks). You can list the forked processes under the control of GDB by using the `info inferiors` command, and switch from one fork to another by using the `inferior` command (see [\(undefined\) \[Debugging Multiple Inferiors and Programs\]](#), page [\(undefined\)](#)).

To quit debugging one of the forked processes, you can either detach from it by using the `detach inferior` command (allowing it to run independently), or kill it using the `kill inferior` command. See [\(undefined\) \[Debugging Multiple Inferiors and Programs\]](#), page [\(undefined\)](#).

If you ask to debug a child process and a `vfork` is followed by an `exec`, GDB executes the new target up to the first breakpoint in the new target. If you have a breakpoint set on `main` in your original program, the breakpoint will also be set on the child process’s `main`.

On some systems, when a child process is spawned by `vfork`, you cannot debug the child or parent until an `exec` call completes.

If you issue a `run` command to GDB after an `exec` call executes, the new target restarts. To restart the parent process, use the `file` command with the parent executable name as its argument. By default, after an `exec` call executes, GDB discards the symbols of the previous executable image. You can change this behaviour with the `set follow-exec-mode` command.

`set follow-exec-mode mode`

Set debugger response to a program call of `exec`. An `exec` call replaces the program image of a process.

`follow-exec-mode` can be:

new GDB creates a new inferior and rebinds the process to this new inferior. The program the process was running before the `exec` call can be restarted afterwards by restarting the original inferior.

For example:

```
(gdb) info inferiors
(gdb) info inferior
  Id  Description  Executable
```

```

* 1  <null>      prog1
(gdb) run
process 12020 is executing new program: prog2
Program exited normally.
(gdb) info inferiors
  Id  Description  Executable
* 2  <null>      prog2
  1  <null>      prog1

```

same GDB keeps the process bound to the same inferior. The new executable image replaces the previous executable loaded in the inferior. Restarting the inferior after the `exec` call, with e.g., the `run` command, restarts the executable the process was running after the `exec` call. This is the default mode.

For example:

```

(gdb) info inferiors
  Id  Description  Executable
* 1  <null>      prog1
(gdb) run
process 12020 is executing new program: prog2
Program exited normally.
(gdb) info inferiors
  Id  Description  Executable
* 1  <null>      prog2

```

You can use the `catch` command to make GDB stop whenever a `fork`, `vfork`, or `exec` call is made. See [\(undefined\) \[Setting Catchpoints\], page \(undefined\)](#).

4.12 Setting a *Bookmark* to Return to Later

On certain operating systems¹, GDB is able to save a *snapshot* of a program's state, called a *checkpoint*, and come back to it later.

Returning to a checkpoint effectively undoes everything that has happened in the program since the `checkpoint` was saved. This includes changes in memory, registers, and even (within some limits) system state. Effectively, it is like going back in time to the moment when the checkpoint was saved.

Thus, if you're stepping thru a program and you think you're getting close to the point where things go wrong, you can save a checkpoint. Then, if you accidentally go too far and miss the critical statement, instead of having to restart your program from the beginning, you can just go back to the checkpoint and start again from there.

This can be especially useful if it takes a lot of time or steps to reach the point where you think the bug occurs.

To use the `checkpoint/restart` method of debugging:

checkpoint

Save a snapshot of the debugged program's current execution state. The `checkpoint` command takes no arguments, but each checkpoint is assigned a small integer id, similar to a breakpoint id.

¹ Currently, only GNU/Linux.

info checkpoints

List the checkpoints that have been saved in the current debugging session. For each checkpoint, the following information will be listed:

```
Checkpoint ID
Process ID
Code Address
Source line, or label
```

restart *checkpoint-id*

Restore the program state that was saved as checkpoint number *checkpoint-id*. All program variables, registers, stack frames etc. will be returned to the values that they had when the checkpoint was saved. In essence, gdb will “wind back the clock” to the point in time when the checkpoint was saved.

Note that breakpoints, GDB variables, command history etc. are not affected by restoring a checkpoint. In general, a checkpoint only restores things that reside in the program being debugged, not in the debugger.

delete checkpoint *checkpoint-id*

Delete the previously-saved checkpoint identified by *checkpoint-id*.

Returning to a previously saved checkpoint will restore the user state of the program being debugged, plus a significant subset of the system (OS) state, including file pointers. It won’t “un-write” data from a file, but it will rewind the file pointer to the previous location, so that the previously written data can be overwritten. For files opened in read mode, the pointer will also be restored so that the previously read data can be read again.

Of course, characters that have been sent to a printer (or other external device) cannot be “snatched back”, and characters received from eg. a serial device can be removed from internal program buffers, but they cannot be “pushed back” into the serial pipeline, ready to be received again. Similarly, the actual contents of files that have been changed cannot be restored (at this time).

However, within those constraints, you actually can “rewind” your program to a previously saved point in time, and begin debugging it again — and you can change the course of events so as to debug a different execution path this time.

Finally, there is one bit of internal program state that will be different when you return to a checkpoint — the program’s process id. Each checkpoint will have a unique process id (or *pid*), and each will be different from the program’s original *pid*. If your program has saved a local copy of its process id, this could potentially pose a problem.

4.12.1 A Non-obvious Benefit of Using Checkpoints

On some systems such as GNU/Linux, address space randomization is performed on new processes for security reasons. This makes it difficult or impossible to set a breakpoint, or watchpoint, on an absolute address if you have to restart the program, since the absolute location of a symbol will change from one execution to the next.

A checkpoint, however, is an *identical* copy of a process. Therefore if you create a checkpoint at (eg.) the start of main, and simply return to that checkpoint instead of restarting the process, you can avoid the effects of address randomization and your symbols will all stay in the same place.

5 Stopping and Continuing

The principal purposes of using a debugger are so that you can stop your program before it terminates; or so that, if your program runs into trouble, you can investigate and find out why.

Inside GDB, your program may stop for any of several reasons, such as a signal, a breakpoint, or reaching a new line after a GDB command such as `step`. You may then examine and change variables, set new breakpoints or remove old ones, and then continue execution. Usually, the messages shown by GDB provide ample explanation of the status of your program—but you can also explicitly request this information at any time.

`info program`

Display information about the status of your program: whether it is running or not, what process it is, and why it stopped.

5.1 Breakpoints, Watchpoints, and Catchpoints

A *breakpoint* makes your program stop whenever a certain point in the program is reached. For each breakpoint, you can add conditions to control in finer detail whether your program stops. You can set breakpoints with the `break` command and its variants (see [\(undefined\) \[Setting Breakpoints\], page \(undefined\)](#)), to specify the place where your program should stop by line number, function name or exact address in the program.

On some systems, you can set breakpoints in shared libraries before the executable is run. There is a minor limitation on HP-UX systems: you must wait until the executable is run in order to set breakpoints in shared library routines that are not called directly by the program (for example, routines that are arguments in a `pthread_create` call).

A *watchpoint* is a special breakpoint that stops your program when the value of an expression changes. The expression may be a value of a variable, or it could involve values of one or more variables combined by operators, such as `'a + b'`. This is sometimes called *data breakpoints*. You must use a different command to set watchpoints (see [\(undefined\) \[Setting Watchpoints\], page \(undefined\)](#)), but aside from that, you can manage a watchpoint like any other breakpoint: you enable, disable, and delete both breakpoints and watchpoints using the same commands.

You can arrange to have values from your program displayed automatically whenever GDB stops at a breakpoint. See [\(undefined\) \[Automatic Display\], page \(undefined\)](#).

A *catchpoint* is another special breakpoint that stops your program when a certain kind of event occurs, such as the throwing of a C++ exception or the loading of a library. As with watchpoints, you use a different command to set a catchpoint (see [\(undefined\) \[Setting Catchpoints\], page \(undefined\)](#)), but aside from that, you can manage a catchpoint like any other breakpoint. (To stop when your program receives a signal, use the `handle` command; see [\(undefined\) \[Signals\], page \(undefined\)](#).)

GDB assigns a number to each breakpoint, watchpoint, or catchpoint when you create it; these numbers are successive integers starting with one. In many of the commands for controlling various features of breakpoints you use the breakpoint number to say which breakpoint you want to change. Each breakpoint may be *enabled* or *disabled*; if disabled, it has no effect on your program until you enable it again.

Some GDB commands accept a range of breakpoints on which to operate. A breakpoint range is either a single breakpoint number, like ‘5’, or two such numbers, in increasing order, separated by a hyphen, like ‘5-7’. When a breakpoint range is given to a command, all breakpoints in that range are operated on.

5.1.1 Setting Breakpoints

Breakpoints are set with the `break` command (abbreviated `b`). The debugger convenience variable ‘`$bpnum`’ records the number of the breakpoint you’ve set most recently; see [\(undefined\) \[Convenience Variables\]](#), page [\(undefined\)](#), for a discussion of what you can do with convenience variables.

`break location`

Set a breakpoint at the given *location*, which can specify a function name, a line number, or an address of an instruction. (See [\(undefined\) \[Specify Location\]](#), page [\(undefined\)](#), for a list of all the possible ways to specify a *location*.) The breakpoint will stop your program just before it executes any of the code in the specified *location*.

When using source languages that permit overloading of symbols, such as C++, a function name may refer to more than one possible place to break. See [\(undefined\) \[Ambiguous Expressions\]](#), page [\(undefined\)](#), for a discussion of that situation.

It is also possible to insert a breakpoint that will stop the program only if a specific thread (see [\(undefined\) \[Thread-Specific Breakpoints\]](#), page [\(undefined\)](#)) or a specific task (see [\(undefined\) \[Ada Tasks\]](#), page [\(undefined\)](#)) hits that breakpoint.

`break` When called without any arguments, `break` sets a breakpoint at the next instruction to be executed in the selected stack frame (see [\(undefined\) \[Examining the Stack\]](#), page [\(undefined\)](#)). In any selected frame but the innermost, this makes your program stop as soon as control returns to that frame. This is similar to the effect of a `finish` command in the frame inside the selected frame—except that `finish` does not leave an active breakpoint. If you use `break` without an argument in the innermost frame, GDB stops the next time it reaches the current location; this may be useful inside loops.

GDB normally ignores breakpoints when it resumes execution, until at least one instruction has been executed. If it did not do this, you would be unable to proceed past a breakpoint without first disabling the breakpoint. This rule applies whether or not the breakpoint already existed when your program stopped.

`break ... if cond`

Set a breakpoint with condition *cond*; evaluate the expression *cond* each time the breakpoint is reached, and stop only if the value is nonzero—that is, if *cond* evaluates as true. ‘...’ stands for one of the possible arguments described above (or no argument) specifying where to break. See [\(undefined\) \[Break Conditions\]](#), page [\(undefined\)](#), for more information on breakpoint conditions.

`tbreak args`

Set a breakpoint enabled only for one stop. *args* are the same as for the `break` command, and the breakpoint is set in the same way, but the breakpoint is

automatically deleted after the first time your program stops there. See [\(undefined\) \[Disabling Breakpoints\]](#), page [\(undefined\)](#).

`hbreak args`

Set a hardware-assisted breakpoint. `args` are the same as for the `break` command and the breakpoint is set in the same way, but the breakpoint requires hardware support and some target hardware may not have this support. The main purpose of this is EPROM/ROM code debugging, so you can set a breakpoint at an instruction without changing the instruction. This can be used with the new trap-generation provided by SPARClite DSU and most x86-based targets. These targets will generate traps when a program accesses some data or instruction address that is assigned to the debug registers. However the hardware breakpoint registers can take a limited number of breakpoints. For example, on the DSU, only two data breakpoints can be set at a time, and GDB will reject this command if more than two are used. Delete or disable unused hardware breakpoints before setting new ones (see [\(undefined\) \[Disabling Breakpoints\]](#), page [\(undefined\)](#)). See [\(undefined\) \[Break Conditions\]](#), page [\(undefined\)](#). For remote targets, you can restrict the number of hardware breakpoints GDB will use, see [\(undefined\) \[set remote hardware-breakpoint-limit\]](#), page [\(undefined\)](#).

`thbreak args`

Set a hardware-assisted breakpoint enabled only for one stop. `args` are the same as for the `hbreak` command and the breakpoint is set in the same way. However, like the `tbreak` command, the breakpoint is automatically deleted after the first time your program stops there. Also, like the `hbreak` command, the breakpoint requires hardware support and some target hardware may not have this support. See [\(undefined\) \[Disabling Breakpoints\]](#), page [\(undefined\)](#). See also [\(undefined\) \[Break Conditions\]](#), page [\(undefined\)](#).

`rbreak regex`

Set breakpoints on all functions matching the regular expression `regex`. This command sets an unconditional breakpoint on all matches, printing a list of all breakpoints it set. Once these breakpoints are set, they are treated just like the breakpoints set with the `break` command. You can delete them, disable them, or make them conditional the same way as any other breakpoint.

The syntax of the regular expression is the standard one used with tools like ‘`grep`’. Note that this is different from the syntax used by shells, so for instance `foo*` matches all functions that include an `fo` followed by zero or more `os`. There is an implicit `.*` leading and trailing the regular expression you supply, so to match only functions that begin with `foo`, use `^foo`.

When debugging C++ programs, `rbreak` is useful for setting breakpoints on overloaded functions that are not members of any special classes.

The `rbreak` command can be used to set breakpoints in **all** the functions in a program, like this:

```
(gdb) rbreak .
```

rbreak *file:regex*

If **rbreak** is called with a filename qualification, it limits the search for functions matching the given regular expression to the specified *file*. This can be used, for example, to set breakpoints on every function in a given file:

```
(gdb) rbreak file.c:.
```

The colon separating the filename qualifier from the regex may optionally be surrounded by spaces.

info breakpoints [*n*]**info break** [*n*]

Print a table of all breakpoints, watchpoints, and catchpoints set and not deleted. Optional argument *n* means print information only about the specified breakpoint (or watchpoint or catchpoint). For each breakpoint, following columns are printed:

Breakpoint Numbers

Type Breakpoint, watchpoint, or catchpoint.

Disposition

Whether the breakpoint is marked to be disabled or deleted when hit.

Enabled or Disabled

Enabled breakpoints are marked with ‘y’. ‘n’ marks breakpoints that are not enabled.

Address

Where the breakpoint is in your program, as a memory address. For a pending breakpoint whose address is not yet known, this field will contain ‘<PENDING>’. Such breakpoint won’t fire until a shared library that has the symbol or line referred by breakpoint is loaded. See below for details. A breakpoint with several locations will have ‘<MULTIPLE>’ in this field—see below for details.

What

Where the breakpoint is in the source for your program, as a file and line number. For a pending breakpoint, the original string passed to the breakpoint command will be listed as it cannot be resolved until the appropriate shared library is loaded in the future.

If a breakpoint is conditional, **info break** shows the condition on the line following the affected breakpoint; breakpoint commands, if any, are listed after that. A pending breakpoint is allowed to have a condition specified for it. The condition is not parsed for validity until a shared library is loaded that allows the pending breakpoint to resolve to a valid location.

info break with a breakpoint number *n* as argument lists only that breakpoint. The convenience variable `$_` and the default examining-address for the **x** command are set to the address of the last breakpoint listed (see [\[Examining Memory\]](#), page [\(undefined\)](#)).

info break displays a count of the number of times the breakpoint has been hit. This is especially useful in conjunction with the **ignore** command. You can ignore a large number of breakpoint hits, look at the breakpoint info to see

how many times the breakpoint was hit, and then run again, ignoring one less than that number. This will get you quickly to the last hit of that breakpoint.

GDB allows you to set any number of breakpoints at the same place in your program. There is nothing silly or meaningless about this. When the breakpoints are conditional, this is even useful (see [\[Break Conditions\]](#), page [\(undefined\)](#)).

It is possible that a breakpoint corresponds to several locations in your program. Examples of this situation are:

- For a C++ constructor, the GCC compiler generates several instances of the function body, used in different cases.
- For a C++ template function, a given line in the function can correspond to any number of instantiations.
- For an inlined function, a given source line can correspond to several places where that function is inlined.

In all those cases, GDB will insert a breakpoint at all the relevant locations¹.

A breakpoint with multiple locations is displayed in the breakpoint table using several rows—one header row, followed by one row for each breakpoint location. The header row has ‘<MULTIPLE>’ in the address column. The rows for individual locations contain the actual addresses for locations, and show the functions to which those locations belong. The number column for a location is of the form *breakpoint-number.location-number*.

For example:

Num	Type	Disp	Enb	Address	What
1	breakpoint	keep	y	<MULTIPLE>	
	stop only if i==1				
	breakpoint already hit 1 time				
1.1			y	0x080486a2	in void foo<int>() at t.cc:8
1.2			y	0x080486ca	in void foo<double>() at t.cc:8

Each location can be individually enabled or disabled by passing *breakpoint-number.location-number* as argument to the `enable` and `disable` commands. Note that you cannot delete the individual locations from the list, you can only delete the entire list of locations that belong to their parent breakpoint (with the `delete num` command, where *num* is the number of the parent breakpoint, 1 in the above example). Disabling or enabling the parent breakpoint (see [\[Disabling\]](#), page [\(undefined\)](#)) affects all of the locations that belong to that breakpoint.

It’s quite common to have a breakpoint inside a shared library. Shared libraries can be loaded and unloaded explicitly, and possibly repeatedly, as the program is executed. To support this use case, GDB updates breakpoint locations whenever any shared library is loaded or unloaded. Typically, you would set a breakpoint in a shared library at the beginning of your debugging session, when the library is not loaded, and when the symbols from the library are not available. When you try to set breakpoint, GDB will ask you if you want to set a so called *pending breakpoint*—breakpoint whose address is not yet resolved.

After the program is run, whenever a new shared library is loaded, GDB reevaluates all the breakpoints. When a newly loaded shared library contains the symbol or line referred to by

¹ As of this writing, multiple-location breakpoints work only if there’s line number information for all the locations. This means that they will generally not work in system libraries, unless you have debug info with line numbers for them.

some pending breakpoint, that breakpoint is resolved and becomes an ordinary breakpoint. When a library is unloaded, all breakpoints that refer to its symbols or source lines become pending again.

This logic works for breakpoints with multiple locations, too. For example, if you have a breakpoint in a C++ template function, and a newly loaded shared library has an instantiation of that template, a new location is added to the list of locations for the breakpoint.

Except for having unresolved address, pending breakpoints do not differ from regular breakpoints. You can set conditions or commands, enable and disable them and perform other breakpoint operations.

GDB provides some additional commands for controlling what happens when the ‘**break**’ command cannot resolve breakpoint address specification to an address:

set breakpoint pending auto

This is the default behavior. When GDB cannot find the breakpoint location, it queries you whether a pending breakpoint should be created.

set breakpoint pending on

This indicates that an unrecognized breakpoint location should automatically result in a pending breakpoint being created.

set breakpoint pending off

This indicates that pending breakpoints are not to be created. Any unrecognized breakpoint location results in an error. This setting does not affect any pending breakpoints previously created.

show breakpoint pending

Show the current behavior setting for creating pending breakpoints.

The settings above only affect the **break** command and its variants. Once breakpoint is set, it will be automatically updated as shared libraries are loaded and unloaded.

For some targets, GDB can automatically decide if hardware or software breakpoints should be used, depending on whether the breakpoint address is read-only or read-write. This applies to breakpoints set with the **break** command as well as to internal breakpoints set by commands like **next** and **finish**. For breakpoints set with **hbreak**, GDB will always use hardware breakpoints.

You can control this automatic behaviour with the following commands::

set breakpoint auto-hw on

This is the default behavior. When GDB sets a breakpoint, it will try to use the target memory map to decide if software or hardware breakpoint must be used.

set breakpoint auto-hw off

This indicates GDB should not automatically select breakpoint type. If the target provides a memory map, GDB will warn when trying to set software breakpoint at a read-only address.

GDB normally implements breakpoints by replacing the program code at the breakpoint address with a special instruction, which, when executed, given control to the debugger. By default, the program code is so modified only when the program is resumed. As soon as the program stops, GDB restores the original instructions. This behaviour guards against

leaving breakpoints inserted in the target should gdb abruptly disconnect. However, with slow remote targets, inserting and removing breakpoint can reduce the performance. This behavior can be controlled with the following commands::

set breakpoint always-inserted off

All breakpoints, including newly added by the user, are inserted in the target only when the target is resumed. All breakpoints are removed from the target when it stops.

set breakpoint always-inserted on

Causes all breakpoints to be inserted in the target at all times. If the user adds a new breakpoint, or changes an existing breakpoint, the breakpoints in the target are updated immediately. A breakpoint is removed from the target only when breakpoint itself is removed.

set breakpoint always-inserted auto

This is the default mode. If GDB is controlling the inferior in non-stop mode (see [\(undefined\) \[Non-Stop Mode\], page \(undefined\)](#)), gdb behaves as if `breakpoint always-inserted` mode is on. If GDB is controlling the inferior in all-stop mode, GDB behaves as if `breakpoint always-inserted` mode is off.

GDB itself sometimes sets breakpoints in your program for special purposes, such as proper handling of `longjmp` (in C programs). These internal breakpoints are assigned negative numbers, starting with `-1`; `'info breakpoints'` does not display them. You can see these breakpoints with the GDB maintenance command `'maint info breakpoints'` (see [\(undefined\) \[maint info breakpoints\], page \(undefined\)](#)).

5.1.2 Setting Watchpoints

You can use a watchpoint to stop execution whenever the value of an expression changes, without having to predict a particular place where this may happen. (This is sometimes called a *data breakpoint*.) The expression may be as simple as the value of a single variable, or as complex as many variables combined by operators. Examples include:

- A reference to the value of a single variable.
- An address cast to an appropriate data type. For example, `'*(int *)0x12345678'` will watch a 4-byte region at the specified address (assuming an `int` occupies 4 bytes).
- An arbitrarily complex expression, such as `'a*b + c/d'`. The expression can use any operators valid in the program's native language (see [\(undefined\) \[Languages\], page \(undefined\)](#)).

You can set a watchpoint on an expression even if the expression can not be evaluated yet. For instance, you can set a watchpoint on `'*global_ptr'` before `'global_ptr'` is initialized. GDB will stop when your program sets `'global_ptr'` and the expression produces a valid value. If the expression becomes valid in some other way than changing a variable (e.g. if the memory pointed to by `'*global_ptr'` becomes readable as the result of a `malloc` call), GDB may not stop until the next time the expression changes.

Depending on your system, watchpoints may be implemented in software or hardware. GDB does software watchpointing by single-stepping your program and testing the variable's value each time, which is hundreds of times slower than normal execution. (But this may

still be worth it, to catch errors where you have no clue what part of your program is the culprit.)

On some systems, such as HP-UX, PowerPC, GNU/Linux and most other x86-based targets, GDB includes support for hardware watchpoints, which do not slow down the running of your program.

watch *expr* [*thread threadnum*]

Set a watchpoint for an expression. GDB will break when the expression *expr* is written into by the program and its value changes. The simplest (and the most popular) use of this command is to watch the value of a single variable:

```
(gdb) watch foo
```

If the command includes a [*thread threadnum*] clause, GDB breaks only when the thread identified by *threadnum* changes the value of *expr*. If any other threads change the value of *expr*, GDB will not break. Note that watchpoints restricted to a single thread in this way only work with Hardware Watchpoints.

rwatch *expr* [*thread threadnum*]

Set a watchpoint that will break when the value of *expr* is read by the program.

awatch *expr* [*thread threadnum*]

Set a watchpoint that will break when *expr* is either read from or written into by the program.

info watchpoints

This command prints a list of watchpoints, using the same format as **info break** (see [\(undefined\) \[Set Breaks\]](#), page [\(undefined\)](#)).

If you watch for a change in a numerically entered address you need to dereference it, as the address itself is just a constant number which will never change. GDB refuses to create a watchpoint that watches a never-changing value:

```
(gdb) watch 0x600850
Cannot watch constant value 0x600850.
(gdb) watch *(int *) 0x600850
Watchpoint 1: *(int *) 6293584
```

GDB sets a *hardware watchpoint* if possible. Hardware watchpoints execute very quickly, and the debugger reports a change in value at the exact instruction where the change occurs. If GDB cannot set a hardware watchpoint, it sets a software watchpoint, which executes more slowly and reports the change in value at the next *statement*, not the instruction, after the change occurs.

You can force GDB to use only software watchpoints with the **set can-use-hw-watchpoints 0** command. With this variable set to zero, GDB will never try to use hardware watchpoints, even if the underlying system supports them. (Note that hardware-assisted watchpoints that were set *before* setting **can-use-hw-watchpoints** to zero will still use the hardware mechanism of watching expression values.)

set can-use-hw-watchpoints

Set whether or not to use hardware watchpoints.

show can-use-hw-watchpoints

Show the current mode of using hardware watchpoints.

For remote targets, you can restrict the number of hardware watchpoints GDB will use, see [\[set remote hardware-breakpoint-limit\]](#), page [\[undefined\]](#).

When you issue the `watch` command, GDB reports

```
Hardware watchpoint num: expr
```

if it was able to set a hardware watchpoint.

Currently, the `awatch` and `rwatch` commands can only set hardware watchpoints, because accesses to data that don't change the value of the watched expression cannot be detected without examining every instruction as it is being executed, and GDB does not do that currently. If GDB finds that it is unable to set a hardware breakpoint with the `awatch` or `rwatch` command, it will print a message like this:

```
Expression cannot be implemented with read/access watchpoint.
```

Sometimes, GDB cannot set a hardware watchpoint because the data type of the watched expression is wider than what a hardware watchpoint on the target machine can handle. For example, some systems can only watch regions that are up to 4 bytes wide; on such systems you cannot set hardware watchpoints for an expression that yields a double-precision floating-point number (which is typically 8 bytes wide). As a work-around, it might be possible to break the large region into a series of smaller ones and watch them with separate watchpoints.

If you set too many hardware watchpoints, GDB might be unable to insert all of them when you resume the execution of your program. Since the precise number of active watchpoints is unknown until such time as the program is about to be resumed, GDB might not be able to warn you about this when you set the watchpoints, and the warning will be printed only when the program is resumed:

```
Hardware watchpoint num: Could not insert watchpoint
```

If this happens, delete or disable some of the watchpoints.

Watching complex expressions that reference many variables can also exhaust the resources available for hardware-assisted watchpoints. That's because GDB needs to watch every variable in the expression with separately allocated resources.

If you call a function interactively using `print` or `call`, any watchpoints you have set will be inactive until GDB reaches another kind of breakpoint or the call completes.

GDB automatically deletes watchpoints that watch local (automatic) variables, or expressions that involve such variables, when they go out of scope, that is, when the execution leaves the block in which these variables were defined. In particular, when the program being debugged terminates, *all* local variables go out of scope, and so only watchpoints that watch global variables remain set. If you rerun the program, you will need to set all such watchpoints again. One way of doing that would be to set a code breakpoint at the entry to the `main` function and when it breaks, set all the watchpoints.

In multi-threaded programs, watchpoints will detect changes to the watched expression from every thread.

Warning: In multi-threaded programs, software watchpoints have only limited usefulness. If GDB creates a software watchpoint, it can only watch the value of an expression *in a single thread*. If you are confident that the expression can only change due to the current thread's activity (and if you are also confident that no other thread can become current), then you can use software watchpoints as usual. However, GDB may not notice when a non-current thread's

activity changes the expression. (Hardware watchpoints, in contrast, watch an expression in all threads.)

See [\(undefined\) \[set remote hardware-watchpoint-limit\]](#), page [\(undefined\)](#).

5.1.3 Setting Catchpoints

You can use *catchpoints* to cause the debugger to stop for certain kinds of program events, such as C++ exceptions or the loading of a shared library. Use the `catch` command to set a catchpoint.

`catch event`

Stop when *event* occurs. *event* can be any of the following:

`throw` The throwing of a C++ exception.

`catch` The catching of a C++ exception.

`exception`

An Ada exception being raised. If an exception name is specified at the end of the command (eg `catch exception Program_Error`), the debugger will stop only when this specific exception is raised. Otherwise, the debugger stops execution when any Ada exception is raised.

When inserting an exception catchpoint on a user-defined exception whose name is identical to one of the exceptions defined by the language, the fully qualified name must be used as the exception name. Otherwise, GDB will assume that it should stop on the pre-defined exception rather than the user-defined one. For instance, assuming an exception called `Constraint_Error` is defined in package `Pck`, then the command to use to catch such exceptions is `catch exception Pck.Constraint_Error`.

`exception unhandled`

An exception that was raised but is not handled by the program.

`assert` A failed Ada assertion.

`exec` A call to `exec`. This is currently only available for HP-UX and GNU/Linux.

`syscall`

`syscall [name | number] ...`

A call to or return from a system call, a.k.a. *syscall*. A *syscall* is a mechanism for application programs to request a service from the operating system (OS) or one of the OS system services. GDB can catch some or all of the *syscalls* issued by the debuggee, and show the related information for each *syscall*. If no argument is specified, calls to and returns from all system calls will be caught.

name can be any system call name that is valid for the underlying OS. Just what *syscalls* are valid depends on the OS. On GNU and Unix systems, you can find the full list of valid *syscall* names on `'/usr/include/asm/unistd.h'`.

Normally, GDB knows in advance which syscalls are valid for each OS, so you can use the GDB command-line completion facilities (see [\(undefined\) \[command completion\], page \(undefined\)](#)) to list the available choices.

You may also specify the system call numerically. A syscall's number is the value passed to the OS's syscall dispatcher to identify the requested service. When you specify the syscall by its name, GDB uses its database of syscalls to convert the name into the corresponding numeric code, but using the number directly may be useful if GDB's database does not have the complete list of syscalls on your system (e.g., because GDB lags behind the OS upgrades). The example below illustrates how this command works if you don't provide arguments to it:

```
(gdb) catch syscall
Catchpoint 1 (syscall)
(gdb) r
Starting program: /tmp/catch-syscall

Catchpoint 1 (call to syscall 'close'), \
0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.

Catchpoint 1 (returned from syscall 'close'), \
0xffffe424 in __kernel_vsyscall ()
(gdb)
```

Here is an example of catching a system call by name:

```
(gdb) catch syscall chroot
Catchpoint 1 (syscall 'chroot' [61])
(gdb) r
Starting program: /tmp/catch-syscall

Catchpoint 1 (call to syscall 'chroot'), \
0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.

Catchpoint 1 (returned from syscall 'chroot'), \
0xffffe424 in __kernel_vsyscall ()
(gdb)
```

An example of specifying a system call numerically. In the case below, the syscall number has a corresponding entry in the XML file, so GDB finds its name and prints it:

```
(gdb) catch syscall 252
Catchpoint 1 (syscall(s) 'exit_group')
(gdb) r
Starting program: /tmp/catch-syscall

Catchpoint 1 (call to syscall 'exit_group'), \
0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.
```

```
Program exited normally.
(gdb)
```

However, there can be situations when there is no corresponding name in XML file for that syscall number. In this case, GDB prints a warning message saying that it was not able to find the syscall name, but the catchpoint will be set anyway. See the example below:

```
(gdb) catch syscall 764
warning: The number '764' does not represent a known syscall.
Catchpoint 2 (syscall 764)
(gdb)
```

If you configure GDB using the `--without-expat` option, it will not be able to display syscall names. Also, if your architecture does not have an XML file describing its system calls, you will not be able to see the syscall names. It is important to notice that these two features are used for accessing the syscall name database. In either case, you will see a warning like this:

```
(gdb) catch syscall
warning: Could not open "syscalls/i386-linux.xml"
warning: Could not load the syscall XML file 'syscalls/i386-linux.xml'.
GDB will not be able to display syscall names.
Catchpoint 1 (syscall)
(gdb)
```

Of course, the file name will change depending on your architecture and system.

Still using the example above, you can also try to catch a syscall by its number. In this case, you would see something like:

```
(gdb) catch syscall 252
Catchpoint 1 (syscall(s) 252)
```

Again, in this case GDB would not be able to display syscall's names.

<code>fork</code>	A call to <code>fork</code> . This is currently only available for HP-UX and GNU/Linux.
<code>vfork</code>	A call to <code>vfork</code> . This is currently only available for HP-UX and GNU/Linux.

`tcatch event`

Set a catchpoint that is enabled only for one stop. The catchpoint is automatically deleted after the first time the event is caught.

Use the `info break` command to list the current catchpoints.

There are currently some limitations to C++ exception handling (`catch throw` and `catch catch`) in GDB:

- If you call a function interactively, GDB normally returns control to you when the function has finished executing. If the call raises an exception, however, the call may bypass the mechanism that returns control to you and cause your program either to abort or to simply continue running until it hits a breakpoint, catches a signal that GDB is listening for, or exits. This is the case even if you set a catchpoint for the exception; catchpoints on exceptions are disabled within interactive calls.

- You cannot raise an exception interactively.
- You cannot install an exception handler interactively.

Sometimes `catch` is not the best way to debug exception handling: if you need to know exactly where an exception is raised, it is better to stop *before* the exception handler is called, since that way you can see the stack before any unwinding takes place. If you set a breakpoint in an exception handler instead, it may not be easy to find out where the exception was raised.

To stop just before an exception handler is called, you need some knowledge of the implementation. In the case of GNU C++, exceptions are raised by calling a library function named `__raise_exception` which has the following ANSI C interface:

```
/* addr is where the exception identifier is stored.
   id is the exception identifier. */
void __raise_exception (void **addr, void *id);
```

To make the debugger catch all exceptions before any stack unwinding takes place, set a breakpoint on `__raise_exception` (see [\(undefined\) \[Breakpoints; Watchpoints; and Exceptions\]](#), page [\(undefined\)](#)).

With a conditional breakpoint (see [\(undefined\) \[Break Conditions\]](#), page [\(undefined\)](#)) that depends on the value of `id`, you can stop your program when a specific exception is raised. You can use multiple conditional breakpoints to stop your program when any of a number of exceptions are raised.

5.1.4 Deleting Breakpoints

It is often necessary to eliminate a breakpoint, watchpoint, or catchpoint once it has done its job and you no longer want your program to stop there. This is called *deleting* the breakpoint. A breakpoint that has been deleted no longer exists; it is forgotten.

With the `clear` command you can delete breakpoints according to where they are in your program. With the `delete` command you can delete individual breakpoints, watchpoints, or catchpoints by specifying their breakpoint numbers.

It is not necessary to delete a breakpoint to proceed past it. GDB automatically ignores breakpoints on the first instruction to be executed when you continue execution without changing the execution address.

clear Delete any breakpoints at the next instruction to be executed in the selected stack frame (see [\(undefined\) \[Selecting a Frame\]](#), page [\(undefined\)](#)). When the innermost frame is selected, this is a good way to delete a breakpoint where your program just stopped.

clear location

Delete any breakpoints set at the specified *location*. See [\(undefined\) \[Specify Location\]](#), page [\(undefined\)](#), for the various forms of *location*; the most useful ones are listed below:

clear function

clear filename:function

Delete any breakpoints set at entry to the named *function*.

```
clear linenum
```

```
clear filename:linenum
```

Delete any breakpoints set at or within the code of the specified *linenum* of the specified *filename*.

```
delete [breakpoints] [range...]
```

Delete the breakpoints, watchpoints, or catchpoints of the breakpoint ranges specified as arguments. If no argument is specified, delete all breakpoints (GDB asks confirmation, unless you have `set confirm off`). You can abbreviate this command as `d`.

5.1.5 Disabling Breakpoints

Rather than deleting a breakpoint, watchpoint, or catchpoint, you might prefer to *disable* it. This makes the breakpoint inoperative as if it had been deleted, but remembers the information on the breakpoint so that you can *enable* it again later.

You disable and enable breakpoints, watchpoints, and catchpoints with the `enable` and `disable` commands, optionally specifying one or more breakpoint numbers as arguments. Use `info break` to print a list of all breakpoints, watchpoints, and catchpoints if you do not know which numbers to use.

Disabling and enabling a breakpoint that has multiple locations affects all of its locations.

A breakpoint, watchpoint, or catchpoint can have any of four different states of enablement:

- Enabled. The breakpoint stops your program. A breakpoint set with the `break` command starts out in this state.
- Disabled. The breakpoint has no effect on your program.
- Enabled once. The breakpoint stops your program, but then becomes disabled.
- Enabled for deletion. The breakpoint stops your program, but immediately after it does so it is deleted permanently. A breakpoint set with the `tbreak` command starts out in this state.

You can use the following commands to enable or disable breakpoints, watchpoints, and catchpoints:

```
disable [breakpoints] [range...]
```

Disable the specified breakpoints—or all breakpoints, if none are listed. A disabled breakpoint has no effect but is not forgotten. All options such as `ignore-counts`, `conditions` and `commands` are remembered in case the breakpoint is enabled again later. You may abbreviate `disable` as `dis`.

```
enable [breakpoints] [range...]
```

Enable the specified breakpoints (or all defined breakpoints). They become effective once again in stopping your program.

```
enable [breakpoints] once range...
```

Enable the specified breakpoints temporarily. GDB disables any of these breakpoints immediately after stopping your program.

`enable [breakpoints] delete range...`

Enable the specified breakpoints to work once, then die. GDB deletes any of these breakpoints as soon as your program stops there. Breakpoints set by the `tbreak` command start out in this state.

Except for a breakpoint set with `tbreak` (see [\(undefined\)](#) [Setting Breakpoints], page [\(undefined\)](#)), breakpoints that you set are initially enabled; subsequently, they become disabled or enabled only when you use one of the commands above. (The command `until` can set and delete a breakpoint of its own, but it does not change the state of your other breakpoints; see [\(undefined\)](#) [Continuing and Stepping], page [\(undefined\)](#).)

5.1.6 Break Conditions

The simplest sort of breakpoint breaks every time your program reaches a specified place. You can also specify a *condition* for a breakpoint. A condition is just a Boolean expression in your programming language (see [\(undefined\)](#) [Expressions], page [\(undefined\)](#)). A breakpoint with a condition evaluates the expression each time your program reaches it, and your program stops only if the condition is *true*.

This is the converse of using assertions for program validation; in that situation, you want to stop when the assertion is violated—that is, when the condition is false. In C, if you want to test an assertion expressed by the condition `assert`, you should set the condition `‘! assert’` on the appropriate breakpoint.

Conditions are also accepted for watchpoints; you may not need them, since a watchpoint is inspecting the value of an expression anyhow—but it might be simpler, say, to just set a watchpoint on a variable name, and specify a condition that tests whether the new value is an interesting one.

Break conditions can have side effects, and may even call functions in your program. This can be useful, for example, to activate functions that log program progress, or to use your own print functions to format special data structures. The effects are completely predictable unless there is another enabled breakpoint at the same address. (In that case, GDB might see the other breakpoint first and stop your program without checking the condition of this one.) Note that breakpoint commands are usually more convenient and flexible than break conditions for the purpose of performing side effects when a breakpoint is reached (see [\(undefined\)](#) [Breakpoint Command Lists], page [\(undefined\)](#)).

Break conditions can be specified when a breakpoint is set, by using `‘if’` in the arguments to the `break` command. See [\(undefined\)](#) [Setting Breakpoints], page [\(undefined\)](#). They can also be changed at any time with the `condition` command.

You can also use the `if` keyword with the `watch` command. The `catch` command does not recognize the `if` keyword; `condition` is the only way to impose a further condition on a catchpoint.

`condition bnum expression`

Specify *expression* as the break condition for breakpoint, watchpoint, or catchpoint number *bnum*. After you set a condition, breakpoint *bnum* stops your program only if the value of *expression* is true (nonzero, in C). When you use `condition`, GDB checks *expression* immediately for syntactic correctness, and to determine whether symbols in it have referents in the context of your

breakpoint. If *expression* uses symbols not referenced in the context of the breakpoint, GDB prints an error message:

```
No symbol "foo" in current context.
```

GDB does not actually evaluate *expression* at the time the `condition` command (or a command that sets a breakpoint with a condition, like `break if ...`) is given, however. See [\(undefined\)](#) [Expressions], page [\(undefined\)](#).

`condition` *bnum*

Remove the condition from breakpoint number *bnum*. It becomes an ordinary unconditional breakpoint.

A special case of a breakpoint condition is to stop only when the breakpoint has been reached a certain number of times. This is so useful that there is a special way to do it, using the *ignore count* of the breakpoint. Every breakpoint has an ignore count, which is an integer. Most of the time, the ignore count is zero, and therefore has no effect. But if your program reaches a breakpoint whose ignore count is positive, then instead of stopping, it just decrements the ignore count by one and continues. As a result, if the ignore count value is *n*, the breakpoint does not stop the next *n* times your program reaches it.

`ignore` *bnum count*

Set the ignore count of breakpoint number *bnum* to *count*. The next *count* times the breakpoint is reached, your program's execution does not stop; other than to decrement the ignore count, GDB takes no action.

To make the breakpoint stop the next time it is reached, specify a count of zero. When you use `continue` to resume execution of your program from a breakpoint, you can specify an ignore count directly as an argument to `continue`, rather than using `ignore`. See [\(undefined\)](#) [Continuing and Stepping], page [\(undefined\)](#).

If a breakpoint has a positive ignore count and a condition, the condition is not checked. Once the ignore count reaches zero, GDB resumes checking the condition.

You could achieve the effect of the ignore count with a condition such as `'$foo-- <= 0'` using a debugger convenience variable that is decremented each time. See [\(undefined\)](#) [Convenience Variables], page [\(undefined\)](#).

Ignore counts apply to breakpoints, watchpoints, and catchpoints.

5.1.7 Breakpoint Command Lists

You can give any breakpoint (or watchpoint or catchpoint) a series of commands to execute when your program stops due to that breakpoint. For example, you might want to print the values of certain expressions, or enable other breakpoints.

```
commands [range...]
```

```
... command-list ...
```

`end` Specify a list of commands for the given breakpoints. The commands themselves appear on the following lines. Type a line containing just `end` to terminate the commands.

To remove all commands from a breakpoint, type `commands` and follow it immediately with `end`; that is, give no commands.

With no argument, `commands` refers to the last breakpoint, watchpoint, or catchpoint set (not to the breakpoint most recently encountered). If the most recent breakpoints were set with a single command, then the `commands` will apply to all the breakpoints set by that command. This applies to breakpoints set by `rbreak`, and also applies when a single `break` command creates multiple breakpoints (see [\(undefined\)](#) [Ambiguous Expressions], page [\(undefined\)](#)).

Pressing RET as a means of repeating the last GDB command is disabled within a *command-list*.

You can use breakpoint commands to start your program up again. Simply use the `continue` command, or `step`, or any other command that resumes execution.

Any other commands in the command list, after a command that resumes execution, are ignored. This is because any time you resume execution (even with a simple `next` or `step`), you may encounter another breakpoint—which could have its own command list, leading to ambiguities about which list to execute.

If the first command you specify in a command list is `silent`, the usual message about stopping at a breakpoint is not printed. This may be desirable for breakpoints that are to print a specific message and then continue. If none of the remaining commands print anything, you see no sign that the breakpoint was reached. `silent` is meaningful only at the beginning of a breakpoint command list.

The commands `echo`, `output`, and `printf` allow you to print precisely controlled output, and are often useful in silent breakpoints. See [\(undefined\)](#) [Commands for Controlled Output], page [\(undefined\)](#).

For example, here is how you could use breakpoint commands to print the value of `x` at entry to `foo` whenever `x` is positive.

```
break foo if x>0
commands
silent
printf "x is %d\n",x
cont
end
```

One application for breakpoint commands is to compensate for one bug so you can test for another. Put a breakpoint just after the erroneous line of code, give it a condition to detect the case in which something erroneous has been done, and give it commands to assign correct values to any variables that need them. End with the `continue` command so that your program does not stop, and start with the `silent` command so that no output is produced. Here is an example:

```
break 403
commands
silent
set x = y + 4
cont
end
```

5.1.8 How to save breakpoints to a file

To save breakpoint definitions to a file use the `save breakpoints` command.

`save breakpoints [filename]`

This command saves all current breakpoint definitions together with their commands and ignore counts, into a file ‘*filename*’ suitable for use in a later debugging session. This includes all types of breakpoints (breakpoints, watchpoints, catchpoints, tracepoints). To read the saved breakpoint definitions, use the `source` command (see [\(undefined\) \[Command Files\], page \(undefined\)](#)). Note that watchpoints with expressions involving local variables may fail to be recreated because it may not be possible to access the context where the watchpoint is valid anymore. Because the saved breakpoint definitions are simply a sequence of GDB commands that recreate the breakpoints, you can edit the file in your favorite editing program, and remove the breakpoint definitions you’re not interested in, or that can no longer be recreated.

5.1.9 “Cannot insert breakpoints”

If you request too many active hardware-assisted breakpoints and watchpoints, you will see this error message:

```
Stopped; cannot insert breakpoints.
You may have requested too many hardware breakpoints and watchpoints.
```

This message is printed when you attempt to resume the program, since only then GDB knows exactly how many hardware breakpoints and watchpoints it needs to insert.

When this message is printed, you need to disable or remove some of the hardware-assisted breakpoints and watchpoints, and then continue.

5.1.10 “Breakpoint address adjusted...”

Some processor architectures place constraints on the addresses at which breakpoints may be placed. For architectures thus constrained, GDB will attempt to adjust the breakpoint’s address to comply with the constraints dictated by the architecture.

One example of such an architecture is the Fujitsu FR-V. The FR-V is a VLIW architecture in which a number of RISC-like instructions may be bundled together for parallel execution. The FR-V architecture constrains the location of a breakpoint instruction within such a bundle to the instruction with the lowest address. GDB honors this constraint by adjusting a breakpoint’s address to the first in the bundle.

It is not uncommon for optimized code to have bundles which contain instructions from different source statements, thus it may happen that a breakpoint’s address will be adjusted from one source statement to another. Since this adjustment may significantly alter GDB’s breakpoint related behavior from what the user expects, a warning is printed when the breakpoint is first set and also when the breakpoint is hit.

A warning like the one below is printed when setting a breakpoint that’s been subject to address adjustment:

```
warning: Breakpoint address adjusted from 0x00010414 to 0x00010410.
```

Such warnings are printed both for user settable and GDB’s internal breakpoints. If you see one of these warnings, you should verify that a breakpoint set at the adjusted address will have the desired affect. If not, the breakpoint in question may be removed and other breakpoints may be set which will have the desired behavior. E.g., it may be sufficient to place the breakpoint at a later instruction. A conditional breakpoint may also be useful in some cases to prevent the breakpoint from triggering too often.

GDB will also issue a warning when stopping at one of these adjusted breakpoints:

```
warning: Breakpoint 1 address previously adjusted from 0x00010414
to 0x00010410.
```

When this warning is encountered, it may be too late to take remedial action except in cases where the breakpoint is hit earlier or more frequently than expected.

5.2 Continuing and Stepping

Continuing means resuming program execution until your program completes normally. In contrast, *stepping* means executing just one more “step” of your program, where “step” may mean either one line of source code, or one machine instruction (depending on what particular command you use). Either when continuing or when stepping, your program may stop even sooner, due to a breakpoint or a signal. (If it stops due to a signal, you may want to use `handle`, or use `‘signal 0’` to resume execution. See [\(undefined\) \[Signals\]](#), page [\(undefined\)](#).)

```
continue [ignore-count]
c [ignore-count]
fg [ignore-count]
```

Resume program execution, at the address where your program last stopped; any breakpoints set at that address are bypassed. The optional argument *ignore-count* allows you to specify a further number of times to ignore a breakpoint at this location; its effect is like that of `ignore` (see [\(undefined\) \[Break Conditions\]](#), page [\(undefined\)](#)).

The argument *ignore-count* is meaningful only when your program stopped due to a breakpoint. At other times, the argument to `continue` is ignored.

The synonyms `c` and `fg` (for *foreground*, as the debugged program is deemed to be the foreground program) are provided purely for convenience, and have exactly the same behavior as `continue`.

To resume execution at a different place, you can use `return` (see [\(undefined\) \[Returning from a Function\]](#), page [\(undefined\)](#)) to go back to the calling function; or `jump` (see [\(undefined\) \[Continuing at a Different Address\]](#), page [\(undefined\)](#)) to go to an arbitrary location in your program.

A typical technique for using stepping is to set a breakpoint (see [\(undefined\) \[Breakpoints; Watchpoints; and Catchpoints\]](#), page [\(undefined\)](#)) at the beginning of the function or the section of your program where a problem is believed to lie, run your program until it stops at that breakpoint, and then step through the suspect area, examining the variables that are interesting, until you see the problem happen.

```
step          Continue running your program until control reaches a different source line,
              then stop it and return control to GDB. This command is abbreviated s.
```

Warning: If you use the `step` command while control is within a function that was compiled without debugging information, execution proceeds until control reaches a function that does have debugging information. Likewise, it will not step into a function which is compiled without debugging information. To step through

functions without debugging information, use the `stepi` command, described below.

The `step` command only stops at the first instruction of a source line. This prevents the multiple stops that could otherwise occur in `switch` statements, `for` loops, etc. `step` continues to stop if a function that has debugging information is called within the line. In other words, `step` *steps inside* any functions called within the line.

Also, the `step` command only enters a function if there is line number information for the function. Otherwise it acts like the `next` command. This avoids problems when using `cc -g1` on MIPS machines. Previously, `step` entered sub-routines if there was any debugging information about the routine.

`step count`

Continue running as in `step`, but do so *count* times. If a breakpoint is reached, or a signal not related to stepping occurs before *count* steps, stepping stops right away.

`next [count]`

Continue to the next source line in the current (innermost) stack frame. This is similar to `step`, but function calls that appear within the line of code are executed without stopping. Execution stops when control reaches a different line of code at the original stack level that was executing when you gave the `next` command. This command is abbreviated `n`.

An argument *count* is a repeat count, as for `step`.

The `next` command only stops at the first instruction of a source line. This prevents multiple stops that could otherwise occur in `switch` statements, `for` loops, etc.

`set step-mode`

`set step-mode on`

The `set step-mode on` command causes the `step` command to stop at the first instruction of a function which contains no debug line information rather than stepping over it.

This is useful in cases where you may be interested in inspecting the machine instructions of a function which has no symbolic info and do not want GDB to automatically skip over this function.

`set step-mode off`

Causes the `step` command to step over any functions which contains no debug information. This is the default.

`show step-mode`

Show whether GDB will stop in or step over functions without source line debug information.

`finish`

Continue running until just after function in the selected stack frame returns. Print the returned value (if any). This command can be abbreviated as `fin`.

Contrast this with the `return` command (see [\(undefined\)](#) [Returning from a Function], page [\(undefined\)](#)).

until

u Continue running until a source line past the current line, in the current stack frame, is reached. This command is used to avoid single stepping through a loop more than once. It is like the **next** command, except that when **until** encounters a jump, it automatically continues execution until the program counter is greater than the address of the jump.

This means that when you reach the end of a loop after single stepping through it, **until** makes your program continue execution until it exits the loop. In contrast, a **next** command at the end of a loop simply steps back to the beginning of the loop, which forces you to step through the next iteration.

until always stops your program if it attempts to exit the current stack frame.

until may produce somewhat counterintuitive results if the order of machine code does not match the order of the source lines. For example, in the following excerpt from a debugging session, the **f (frame)** command shows that execution is stopped at line 206; yet when we use **until**, we get to line 195:

```
(gdb) f
#0 main (argc=4, argv=0xf7fffae8) at m4.c:206
   206     expand_input();
(gdb) until
   195     for ( ; argc > 0; NEXTARG) {
```

This happened because, for execution efficiency, the compiler had generated code for the loop closure test at the end, rather than the start, of the loop—even though the test in a C **for**-loop is written before the body of the loop. The **until** command appeared to step back to the beginning of the loop when it advanced to this expression; however, it has not really gone to an earlier statement—not in terms of the actual machine code.

until with no argument works by means of single instruction stepping, and hence is slower than **until** with an argument.

until location**u location**

Continue running your program until either the specified location is reached, or the current stack frame returns. *location* is any of the forms described in [\(undefined\) \[Specify Location\], page \(undefined\)](#). This form of the command uses temporary breakpoints, and hence is quicker than **until** without an argument. The specified location is actually reached only if it is in the current frame. This implies that **until** can be used to skip over recursive function invocations. For instance in the code below, if the current location is line 96, issuing **until 99** will execute the program up to line 99 in the same invocation of **factorial**, i.e., after the inner invocations have returned.

```
94 int factorial (int value)
95 {
96     if (value > 1) {
97         value *= factorial (value - 1);
98     }
99     return (value);
```

100 } }

`advance location`

Continue running the program up to the given *location*. An argument is required, which should be of one of the forms described in [\[Specify Location\], page \[\\(undefined\\)\]\(#\)](#). Execution will also stop upon exit from the current stack frame. This command is similar to `until`, but `advance` will not skip over recursive function calls, and the target location doesn't have to be in the same frame as the current one.

`stepi`

`stepi arg`

`si` Execute one machine instruction, then stop and return to the debugger.

It is often useful to do `'display/i $pc'` when stepping by machine instructions. This makes GDB automatically display the next instruction to be executed, each time your program stops. See [\(undefined\) \[Automatic Display\], page \[\\(undefined\\)\]\(#\)](#).

An argument is a repeat count, as in `step`.

`nexti`

`nexti arg`

`ni` Execute one machine instruction, but if it is a function call, proceed until the function returns.

An argument is a repeat count, as in `next`.

5.3 Signals

A signal is an asynchronous event that can happen in a program. The operating system defines the possible kinds of signals, and gives each kind a name and a number. For example, in Unix `SIGINT` is the signal a program gets when you type an interrupt character (often *Ctrl-c*); `SIGSEGV` is the signal a program gets from referencing a place in memory far away from all the areas in use; `SIGALRM` occurs when the alarm clock timer goes off (which happens only if your program has requested an alarm).

Some signals, including `SIGALRM`, are a normal part of the functioning of your program. Others, such as `SIGSEGV`, indicate errors; these signals are *fatal* (they kill your program immediately) if the program has not specified in advance some other way to handle the signal. `SIGINT` does not indicate an error in your program, but it is normally fatal so it can carry out the purpose of the interrupt: to kill the program.

GDB has the ability to detect any occurrence of a signal in your program. You can tell GDB in advance what to do for each kind of signal.

Normally, GDB is set up to let the non-erroneous signals like `SIGALRM` be silently passed to your program (so as not to interfere with their role in the program's functioning) but to stop your program immediately whenever an error signal happens. You can change these settings with the `handle` command.

`info signals`

`info handle`

Print a table of all the kinds of signals and how GDB has been told to handle each one. You can use this to see the signal numbers of all the defined types of signals.

`info signals sig`

Similar, but print information only about the specified signal number.

`info handle` is an alias for `info signals`.

`handle signal [keywords...]`

Change the way GDB handles signal *signal*. *signal* can be the number of a signal or its name (with or without the ‘SIG’ at the beginning); a list of signal numbers of the form ‘*low-high*’; or the word ‘all’, meaning all the known signals. Optional arguments *keywords*, described below, say what change to make.

The keywords allowed by the `handle` command can be abbreviated. Their full names are:

`nostop` GDB should not stop your program when this signal happens. It may still print a message telling you that the signal has come in.

`stop` GDB should stop your program when this signal happens. This implies the `print` keyword as well.

`print` GDB should print a message when this signal happens.

`noprint` GDB should not mention the occurrence of the signal at all. This implies the `nostop` keyword as well.

`pass`

`noignore` GDB should allow your program to see this signal; your program can handle the signal, or else it may terminate if the signal is fatal and not handled. `pass` and `noignore` are synonyms.

`nopass`

`ignore` GDB should not allow your program to see this signal. `nopass` and `ignore` are synonyms.

When a signal stops your program, the signal is not visible to the program until you continue. Your program sees the signal then, if `pass` is in effect for the signal in question *at that time*. In other words, after GDB reports a signal, you can use the `handle` command with `pass` or `nopass` to control whether your program sees that signal when you continue.

The default is set to `nostop`, `noprint`, `pass` for non-erroneous signals such as `SIGALRM`, `SIGWINCH` and `SIGCHLD`, and to `stop`, `print`, `pass` for the erroneous signals.

You can also use the `signal` command to prevent your program from seeing a signal, or cause it to see a signal it normally would not see, or to give it any signal at any time. For example, if your program stopped due to some sort of memory reference error, you might store correct values into the erroneous variables and continue, hoping to see more execution; but your program would probably terminate immediately as a result of the fatal signal once

it saw the signal. To prevent this, you can continue with ‘signal 0’. See [\(undefined\) \[Giving your Program a Signal\]](#), page [\(undefined\)](#).

On some targets, GDB can inspect extra signal information associated with the intercepted signal, before it is actually delivered to the program being debugged. This information is exported by the convenience variable `$_siginfo`, and consists of data that is passed by the kernel to the signal handler at the time of the receipt of a signal. The data type of the information itself is target dependent. You can see the data type using the `ptype $_siginfo` command. On Unix systems, it typically corresponds to the standard `siginfo_t` type, as defined in the ‘`signal.h`’ system header.

Here’s an example, on a GNU/Linux system, printing the stray referenced address that raised a segmentation fault.

```
(gdb) continue
Program received signal SIGSEGV, Segmentation fault.
0x000000000400766 in main ()
69      *(int *)p = 0;
(gdb) ptype $_siginfo
type = struct {
    int si_signo;
    int si_errno;
    int si_code;
    union {
        int _pad[28];
        struct {...} _kill;
        struct {...} _timer;
        struct {...} _rt;
        struct {...} _sigchld;
        struct {...} _sigfault;
        struct {...} _sigpoll;
    } _sifields;
}
(gdb) ptype $_siginfo._sifields._sigfault
type = struct {
    void *si_addr;
}
(gdb) p $_siginfo._sifields._sigfault.si_addr
$1 = (void *) 0x7ffff7ff7000
```

Depending on target support, `$_siginfo` may also be writable.

5.4 Stopping and Starting Multi-thread Programs

GDB supports debugging programs with multiple threads (see [\(undefined\) \[Debugging Programs with Multiple Threads\]](#), page [\(undefined\)](#)). There are two modes of controlling execution of your program within the debugger. In the default mode, referred to as *all-stop mode*, when any thread in your program stops (for example, at a breakpoint or while being stepped), all other threads in the program are also stopped by GDB. On some targets, GDB also supports *non-stop mode*, in which other threads can continue to run freely while you examine the stopped thread in the debugger.

5.4.1 All-Stop Mode

In all-stop mode, whenever your program stops under GDB for any reason, *all* threads of execution stop, not just the current thread. This allows you to examine the overall state

of the program, including switching between threads, without worrying that things may change underfoot.

Conversely, whenever you restart the program, *all* threads start executing. *This is true even when single-stepping* with commands like `step` or `next`.

In particular, GDB cannot single-step all threads in lockstep. Since thread scheduling is up to your debugging target's operating system (not controlled by GDB), other threads may execute more than one statement while the current thread completes a single step. Moreover, in general other threads stop in the middle of a statement, rather than at a clean statement boundary, when the program stops.

You might even find your program stopped in another thread after continuing or even single-stepping. This happens whenever some other thread runs into a breakpoint, a signal, or an exception before the first thread completes whatever you requested.

Whenever GDB stops your program, due to a breakpoint or a signal, it automatically selects the thread where that breakpoint or signal happened. GDB alerts you to the context switch with a message such as `'[Switching to Thread n]'` to identify the thread.

On some OSes, you can modify GDB's default behavior by locking the OS scheduler to allow only a single thread to run.

`set scheduler-locking mode`

Set the scheduler locking mode. If it is `off`, then there is no locking and any thread may run at any time. If `on`, then only the current thread may run when the inferior is resumed. The `step` mode optimizes for single-stepping; it prevents other threads from preempting the current thread while you are stepping, so that the focus of debugging does not change unexpectedly. Other threads only rarely (or never) get a chance to run when you step. They are more likely to run when you `'next'` over a function call, and they are completely free to run when you use commands like `'continue'`, `'until'`, or `'finish'`. However, unless another thread hits a breakpoint during its timeslice, GDB does not change the current thread away from the thread that you are debugging.

`show scheduler-locking`

Display the current scheduler locking mode.

By default, when you issue one of the execution commands such as `continue`, `next` or `step`, GDB allows only threads of the current inferior to run. For example, if GDB is attached to two inferiors, each with two threads, the `continue` command resumes only the two threads of the current inferior. This is useful, for example, when you debug a program that forks and you want to hold the parent stopped (so that, for instance, it doesn't run to exit), while you debug the child. In other situations, you may not be interested in inspecting the current state of any of the processes GDB is attached to, and you may want to resume them all until some breakpoint is hit. In the latter case, you can instruct GDB to allow all threads of all the inferiors to run with the `set schedule-multiple` command.

`set schedule-multiple`

Set the mode for allowing threads of multiple processes to be resumed when an execution command is issued. When `on`, all threads of all processes are allowed to run. When `off`, only the threads of the current process are resumed. The

default is `off`. The `scheduler-locking` mode takes precedence when set to `on`, or while you are stepping and set to `step`.

`show schedule-multiple`

Display the current mode for resuming the execution of threads of multiple processes.

5.4.2 Non-Stop Mode

For some multi-threaded targets, GDB supports an optional mode of operation in which you can examine stopped program threads in the debugger while other threads continue to execute freely. This minimizes intrusion when debugging live systems, such as programs where some threads have real-time constraints or must continue to respond to external events. This is referred to as *non-stop* mode.

In non-stop mode, when a thread stops to report a debugging event, *only* that thread is stopped; GDB does not stop other threads as well, in contrast to the all-stop mode behavior. Additionally, execution commands such as `continue` and `step` apply by default only to the current thread in non-stop mode, rather than all threads as in all-stop mode. This allows you to control threads explicitly in ways that are not possible in all-stop mode — for example, stepping one thread while allowing others to run freely, stepping one thread while holding all others stopped, or stepping several threads independently and simultaneously.

To enter non-stop mode, use this sequence of commands before you run or attach to your program:

```
# Enable the async interface.
set target-async 1

# If using the CLI, pagination breaks non-stop.
set pagination off

# Finally, turn it on!
set non-stop on
```

You can use these commands to manipulate the non-stop mode setting:

`set non-stop on`

Enable selection of non-stop mode.

`set non-stop off`

Disable selection of non-stop mode.

`show non-stop`

Show the current non-stop enablement setting.

Note these commands only reflect whether non-stop mode is enabled, not whether the currently-executing program is being run in non-stop mode. In particular, the `set non-stop` preference is only consulted when GDB starts or connects to the target program, and it is generally not possible to switch modes once debugging has started. Furthermore, since not all targets support non-stop mode, even when you have enabled non-stop mode, GDB may still fall back to all-stop operation by default.

In non-stop mode, all execution commands apply only to the current thread by default. That is, `continue` only continues one thread. To continue all threads, issue `continue -a` or `c -a`.

You can use GDB’s background execution commands (see [\[Background Execution\]](#), page [\[undefined\]](#)) to run some threads in the background while you continue to examine or step others from GDB. The MI execution commands (see [\[GDB/MI Program Execution\]](#), page [\[undefined\]](#)) are always executed asynchronously in non-stop mode.

Suspending execution is done with the `interrupt` command when running in the background, or `Ctrl-c` during foreground execution. In all-stop mode, this stops the whole process; but in non-stop mode the interrupt applies only to the current thread. To stop the whole program, use `interrupt -a`.

Other execution commands do not currently support the `-a` option.

In non-stop mode, when a thread stops, GDB doesn’t automatically make that thread current, as it does in all-stop mode. This is because the thread stop notifications are asynchronous with respect to GDB’s command interpreter, and it would be confusing if GDB unexpectedly changed to a different thread just as you entered a command to operate on the previously current thread.

5.4.3 Background Execution

GDB’s execution commands have two variants: the normal foreground (synchronous) behavior, and a background (asynchronous) behavior. In foreground execution, GDB waits for the program to report that some thread has stopped before prompting for another command. In background execution, GDB immediately gives a command prompt so that you can issue other commands while your program runs.

You need to explicitly enable asynchronous mode before you can use background execution commands. You can use these commands to manipulate the asynchronous mode setting:

```
set target-async on
    Enable asynchronous mode.

set target-async off
    Disable asynchronous mode.

show target-async
    Show the current target-async setting.
```

If the target doesn’t support async mode, GDB issues an error message if you attempt to use the background execution commands.

To specify background execution, add a `&` to the command. For example, the background form of the `continue` command is `continue&`, or just `c&`. The execution commands that accept background execution are:

<code>run</code>	See [Starting your Program] , page [undefined] .
<code>attach</code>	See [Debugging an Already-running Process] , page [undefined] .
<code>step</code>	See [Continuing and Stepping] , page [undefined] .
<code>stepi</code>	See [Continuing and Stepping] , page [undefined] .
<code>next</code>	See [Continuing and Stepping] , page [undefined] .

`nexti` See [\(undefined\) \[Continuing and Stepping\]](#), page [\(undefined\)](#).
`continue` See [\(undefined\) \[Continuing and Stepping\]](#), page [\(undefined\)](#).
`finish` See [\(undefined\) \[Continuing and Stepping\]](#), page [\(undefined\)](#).
`until` See [\(undefined\) \[Continuing and Stepping\]](#), page [\(undefined\)](#).

Background execution is especially useful in conjunction with non-stop mode for debugging programs with multiple threads; see [\(undefined\) \[Non-Stop Mode\]](#), page [\(undefined\)](#). However, you can also use these commands in the normal all-stop mode with the restriction that you cannot issue another execution command until the previous one finishes. Examples of commands that are valid in all-stop mode while the program is running include `help` and `info break`.

You can interrupt your program while it is running in the background by using the `interrupt` command.

`interrupt`

`interrupt -a`

Suspend execution of the running program. In all-stop mode, `interrupt` stops the whole process, but in non-stop mode, it stops only the current thread. To stop the whole program in non-stop mode, use `interrupt -a`.

5.4.4 Thread-Specific Breakpoints

When your program has multiple threads (see [\(undefined\) \[Debugging Programs with Multiple Threads\]](#), page [\(undefined\)](#)), you can choose whether to set breakpoints on all threads, or on a particular thread.

`break linespec thread threadno`

`break linespec thread threadno if ...`

linespec specifies source lines; there are several ways of writing them (see [\(undefined\) \[Specify Location\]](#), page [\(undefined\)](#)), but the effect is always to specify some source line.

Use the qualifier ‘`thread threadno`’ with a breakpoint command to specify that you only want GDB to stop the program when a particular thread reaches this breakpoint. *threadno* is one of the numeric thread identifiers assigned by GDB, shown in the first column of the ‘`info threads`’ display.

If you do not specify ‘`thread threadno`’ when you set a breakpoint, the breakpoint applies to *all* threads of your program.

You can use the `thread` qualifier on conditional breakpoints as well; in this case, place ‘`thread threadno`’ before or after the breakpoint condition, like this:

```
(gdb) break frik.c:13 thread 28 if bartab > lim
```

5.4.5 Interrupted System Calls

There is an unfortunate side effect when using GDB to debug multi-threaded programs. If one thread stops for a breakpoint, or for some other reason, and another thread is blocked in a system call, then the system call may return prematurely. This is a consequence of the interaction between multiple threads and the signals that GDB uses to implement breakpoints and other events that stop execution.

To handle this problem, your program should check the return value of each system call and react appropriately. This is good programming style anyways.

For example, do not write code like this:

```
sleep (10);
```

The call to `sleep` will return early if a different thread stops at a breakpoint or for some other reason.

Instead, write this:

```
int unslept = 10;
while (unslept > 0)
    unslept = sleep (unslept);
```

A system call is allowed to return early, so the system is still conforming to its specification. But GDB does cause your multi-threaded program to behave differently than it would without GDB.

Also, GDB uses internal breakpoints in the thread library to monitor certain events such as thread creation and thread destruction. When such an event happens, a system call in another thread may return prematurely, even though your program does not appear to stop.

5.4.6 Observer Mode

If you want to build on non-stop mode and observe program behavior without any chance of disruption by GDB, you can set variables to disable all of the debugger's attempts to modify state, whether by writing memory, inserting breakpoints, etc. These operate at a low level, intercepting operations from all commands.

When all of these are set to `off`, then GDB is said to be *observer mode*. As a convenience, the variable `observer` can be set to disable these, plus enable non-stop mode.

Note that GDB will not prevent you from making nonsensical combinations of these settings. For instance, if you have enabled `may-insert-breakpoints` but disabled `may-write-memory`, then breakpoints that work by writing trap instructions into the code stream will still not be able to be placed.

```
set observer on
set observer off
```

When set to `on`, this disables all the permission variables below (except for `insert-fast-tracepoints`), plus enables non-stop debugging. Setting this to `off` switches back to normal debugging, though remaining in non-stop mode.

```
show observer
```

Show whether observer mode is on or off.

```
set may-write-registers on
set may-write-registers off
```

This controls whether GDB will attempt to alter the values of registers, such as with assignment expressions in `print`, or the `jump` command. It defaults to `on`.

```
show may-write-registers
```

Show the current permission to write registers.

```
set may-write-memory on
set may-write-memory off
```

This controls whether GDB will attempt to alter the contents of memory, such as with assignment expressions in `print`. It defaults to `on`.

```
show may-write-memory
```

Show the current permission to write memory.

```
set may-insert-breakpoints on
set may-insert-breakpoints off
```

This controls whether GDB will attempt to insert breakpoints. This affects all breakpoints, including internal breakpoints defined by GDB. It defaults to `on`.

```
show may-insert-breakpoints
```

Show the current permission to insert breakpoints.

```
set may-insert-tracepoints on
set may-insert-tracepoints off
```

This controls whether GDB will attempt to insert (regular) tracepoints at the beginning of a tracing experiment. It affects only non-fast tracepoints, fast tracepoints being under the control of `may-insert-fast-tracepoints`. It defaults to `on`.

```
show may-insert-tracepoints
```

Show the current permission to insert tracepoints.

```
set may-insert-fast-tracepoints on
set may-insert-fast-tracepoints off
```

This controls whether GDB will attempt to insert fast tracepoints at the beginning of a tracing experiment. It affects only fast tracepoints, regular (non-fast) tracepoints being under the control of `may-insert-tracepoints`. It defaults to `on`.

```
show may-insert-fast-tracepoints
```

Show the current permission to insert fast tracepoints.

```
set may-interrupt on
set may-interrupt off
```

This controls whether GDB will attempt to interrupt or stop program execution. When this variable is `off`, the `interrupt` command will have no effect, nor will `Ctrl-c`. It defaults to `on`.

```
show may-interrupt
```

Show the current permission to interrupt or stop the program.

6 Running programs backward

When you are debugging a program, it is not unusual to realize that you have gone too far, and some event of interest has already happened. If the target environment supports it, GDB can allow you to “rewind” the program by running it backward.

A target environment that supports reverse execution should be able to “undo” the changes in machine state that have taken place as the program was executing normally. Variables, registers etc. should revert to their previous values. Obviously this requires a great deal of sophistication on the part of the target environment; not all target environments can support reverse execution.

When a program is executed in reverse, the instructions that have most recently been executed are “un-executed”, in reverse order. The program counter runs backward, following the previous thread of execution in reverse. As each instruction is “un-executed”, the values of memory and/or registers that were changed by that instruction are reverted to their previous states. After executing a piece of source code in reverse, all side effects of that code should be “undone”, and all variables should be returned to their prior values¹.

If you are debugging in a target environment that supports reverse execution, GDB provides the following commands.

`reverse-continue` [*ignore-count*]
`rc` [*ignore-count*]

Beginning at the point where your program last stopped, start executing in reverse. Reverse execution will stop for breakpoints and synchronous exceptions (signals), just like normal execution. Behavior of asynchronous signals depends on the target environment.

`reverse-step` [*count*]

Run the program backward until control reaches the start of a different source line; then stop it, and return control to GDB.

Like the `step` command, `reverse-step` will only stop at the beginning of a source line. It “un-executes” the previously executed source line. If the previous source line included calls to debuggable functions, `reverse-step` will step (backward) into the called function, stopping at the beginning of the *last* statement in the called function (typically a return statement).

Also, as with the `step` command, if non-debuggable functions are called, `reverse-step` will run thru them backward without stopping.

`reverse-stepi` [*count*]

Reverse-execute one machine instruction. Note that the instruction to be reverse-executed is *not* the one pointed to by the program counter, but the

¹ Note that some side effects are easier to undo than others. For instance, memory and registers are relatively easy, but device I/O is hard. Some targets may be able undo things like device I/O, and some may not.

The contract between GDB and the reverse executing target requires only that the target do something reasonable when GDB tells it to execute backwards, and then report the results back to GDB. Whatever the target reports back to GDB, GDB will report back to the user. GDB assumes that the memory and registers that the target reports are in a consistent state, but GDB accepts whatever it is given.

instruction executed prior to that one. For instance, if the last instruction was a jump, `reverse-stepi` will take you back from the destination of the jump to the jump instruction itself.

`reverse-next [count]`

Run backward to the beginning of the previous line executed in the current (innermost) stack frame. If the line contains function calls, they will be “un-executed” without stopping. Starting from the first line of a function, `reverse-next` will take you back to the caller of that function, *before* the function was called, just as the normal `next` command would take you from the last line of a function back to its return to its caller².

`reverse-nexti [count]`

Like `nexti`, `reverse-nexti` executes a single instruction in reverse, except that called functions are “un-executed” atomically. That is, if the previously executed instruction was a return from another function, `reverse-nexti` will continue to execute in reverse until the call to that function (from the current stack frame) is reached.

`reverse-finish`

Just as the `finish` command takes you to the point where the current function returns, `reverse-finish` takes you to the point where it was called. Instead of ending up at the end of the current function invocation, you end up at the beginning.

`set exec-direction`

Set the direction of target execution.

`set exec-direction reverse`

GDB will perform all execution commands in reverse, until the `exec-direction` mode is changed to “forward”. Affected commands include `step`, `stepi`, `next`, `nexti`, `continue`, and `finish`. The `return` command cannot be used in reverse mode.

`set exec-direction forward`

GDB will perform all execution commands in the normal fashion. This is the default.

² Unless the code is too heavily optimized.

7 Recording Inferior's Execution and Replaying It

On some platforms, GDB provides a special *process record and replay* target that can record a log of the process execution, and replay it later with both forward and reverse execution commands.

When this target is in use, if the execution log includes the record for the next instruction, GDB will debug in *replay mode*. In the replay mode, the inferior does not really execute code instructions. Instead, all the events that normally happen during code execution are taken from the execution log. While code is not really executed in replay mode, the values of registers (including the program counter register) and the memory of the inferior are still changed as they normally would. Their contents are taken from the execution log.

If the record for the next instruction is not in the execution log, GDB will debug in *record mode*. In this mode, the inferior executes normally, and GDB records the execution log for future replay.

The process record and replay target supports reverse execution (see [\(undefined\) \[Reverse Execution\], page \(undefined\)](#)), even if the platform on which the inferior runs does not. However, the reverse execution is limited in this case by the range of the instructions recorded in the execution log. In other words, reverse execution on platforms that don't support it directly can only be done in the replay mode.

When debugging in the reverse direction, GDB will work in replay mode as long as the execution log includes the record for the previous instruction; otherwise, it will work in record mode, if the platform supports reverse execution, or stop if not.

For architecture environments that support process record and replay, GDB provides the following commands:

`target record`

This command starts the process record and replay target. The process record and replay target can only debug a process that is already running. Therefore, you need first to start the process with the *run* or *start* commands, and then start the recording with the *target record* command.

Both *record* and *rec* are aliases of *target record*.

Displaced stepping (see [\(undefined\) \[displaced stepping\], page \(undefined\)](#)) will be automatically disabled when process record and replay target is started. That's because the process record and replay target doesn't support displaced stepping.

If the inferior is in the non-stop mode (see [\(undefined\) \[Non-Stop Mode\], page \(undefined\)](#)) or in the asynchronous execution mode (see [\(undefined\) \[Background Execution\], page \(undefined\)](#)), the process record and replay target cannot be started because it doesn't support these two modes.

`record stop`

Stop the process record and replay target. When process record and replay target stops, the entire execution log will be deleted and the inferior will either be terminated, or will remain in its final state.

When you stop the process record and replay target in record mode (at the end of the execution log), the inferior will be stopped at the next instruction

that would have been recorded. In other words, if you record for a while and then stop recording, the inferior process will be left in the same state as if the recording never happened.

On the other hand, if the process record and replay target is stopped while in replay mode (that is, not at the end of the execution log, but at some earlier point), the inferior process will become “live” at that earlier state, and it will then be possible to continue the usual “live” debugging of the process from that state.

When the inferior process exits, or GDB detaches from it, process record and replay target will automatically stop itself.

`record save filename`

Save the execution log to a file ‘*filename*’. Default filename is ‘`gdb_record.process_id`’, where *process_id* is the process ID of the inferior.

`record restore filename`

Restore the execution log from a file ‘*filename*’. File must have been created with `record save`.

`set record insn-number-max limit`

Set the limit of instructions to be recorded. Default value is 200000.

If *limit* is a positive number, then GDB will start deleting instructions from the log once the number of the record instructions becomes greater than *limit*. For every new recorded instruction, GDB will delete the earliest recorded instruction to keep the number of recorded instructions at the limit. (Since deleting recorded instructions loses information, GDB lets you control what happens when the limit is reached, by means of the `stop-at-limit` option, described below.)

If *limit* is zero, GDB will never delete recorded instructions from the execution log. The number of recorded instructions is unlimited in this case.

`show record insn-number-max`

Show the limit of instructions to be recorded.

`set record stop-at-limit`

Control the behavior when the number of recorded instructions reaches the limit. If ON (the default), GDB will stop when the limit is reached for the first time and ask you whether you want to stop the inferior or continue running it and recording the execution log. If you decide to continue recording, each new recorded instruction will cause the oldest one to be deleted.

If this option is OFF, GDB will automatically delete the oldest record to make room for each new one, without asking.

`show record stop-at-limit`

Show the current setting of `stop-at-limit`.

`set record memory-query`

Control the behavior when GDB is unable to record memory changes caused by an instruction. If ON, GDB will query whether to stop the inferior in that case.

If this option is OFF (the default), GDB will automatically ignore the effect of such instructions on memory. Later, when GDB replays this execution log, it will mark the log of this instruction as not accessible, and it will not affect the replay results.

show record memory-query

Show the current setting of `memory-query`.

info record

Show various statistics about the state of process record and its in-memory execution log buffer, including:

- Whether in record mode or replay mode.
- Lowest recorded instruction number (counting from when the current execution log started recording instructions).
- Highest recorded instruction number.
- Current instruction about to be replayed (if in replay mode).
- Number of instructions contained in the execution log.
- Maximum number of instructions that may be contained in the execution log.

record delete

When record target runs in replay mode (“in the past”), delete the subsequent execution log and begin to record a new execution log starting from the current address. This means you will abandon the previously recorded “future” and begin recording a new “future”.

8 Examining the Stack

When your program has stopped, the first thing you need to know is where it stopped and how it got there.

Each time your program performs a function call, information about the call is generated. That information includes the location of the call in your program, the arguments of the call, and the local variables of the function being called. The information is saved in a block of data called a *stack frame*. The stack frames are allocated in a region of memory called the *call stack*.

When your program stops, the GDB commands for examining the stack allow you to see all of this information.

One of the stack frames is *selected* by GDB and many GDB commands refer implicitly to the selected frame. In particular, whenever you ask GDB for the value of a variable in your program, the value is found in the selected frame. There are special GDB commands to select whichever frame you are interested in. See [\[Selecting a Frame\]](#), page [\[undefined\]](#).

When your program stops, GDB automatically selects the currently executing frame and describes it briefly, similar to the `frame` command (see [\[Information about a Frame\]](#), page [\[undefined\]](#)).

8.1 Stack Frames

The call stack is divided up into contiguous pieces called *stack frames*, or *frames* for short; each frame is the data associated with one call to one function. The frame contains the arguments given to the function, the function's local variables, and the address at which the function is executing.

When your program is started, the stack has only one frame, that of the function `main`. This is called the *initial* frame or the *outermost* frame. Each time a function is called, a new frame is made. Each time a function returns, the frame for that function invocation is eliminated. If a function is recursive, there can be many frames for the same function. The frame for the function in which execution is actually occurring is called the *innermost* frame. This is the most recently created of all the stack frames that still exist.

Inside your program, stack frames are identified by their addresses. A stack frame consists of many bytes, each of which has its own address; each kind of computer has a convention for choosing one byte whose address serves as the address of the frame. Usually this address is kept in a register called the *frame pointer register* (see [\[Registers\]](#), page [\[undefined\]](#)) while execution is going on in that frame.

GDB assigns numbers to all existing stack frames, starting with zero for the innermost frame, one for the frame that called it, and so on upward. These numbers do not really exist in your program; they are assigned by GDB to give you a way of designating stack frames in GDB commands.

Some compilers provide a way to compile functions so that they operate without stack frames. (For example, the GCC option

```
'-fomit-frame-pointer'
```

generates functions without a frame.) This is occasionally done with heavily used library functions to save the frame setup time. GDB has limited facilities for dealing with

these function invocations. If the innermost function invocation has no stack frame, GDB nevertheless regards it as though it had a separate frame, which is numbered zero as usual, allowing correct tracing of the function call chain. However, GDB has no provision for frameless functions elsewhere in the stack.

`frame args`

The `frame` command allows you to move from one stack frame to another, and to print the stack frame you select. `args` may be either the address of the frame or the stack frame number. Without an argument, `frame` prints the current stack frame.

`select-frame`

The `select-frame` command allows you to move from one stack frame to another without printing the frame. This is the silent version of `frame`.

8.2 Backtraces

A backtrace is a summary of how your program got where it is. It shows one line per frame, for many frames, starting with the currently executing frame (frame zero), followed by its caller (frame one), and on up the stack.

`backtrace`

`bt` Print a backtrace of the entire stack: one line per frame for all frames in the stack.

You can stop the backtrace at any time by typing the system interrupt character, normally `Ctrl-c`.

`backtrace n`

`bt n` Similar, but print only the innermost `n` frames.

`backtrace -n`

`bt -n` Similar, but print only the outermost `n` frames.

`backtrace full`

`bt full`

`bt full n`

`bt full -n`

Print the values of the local variables also. `n` specifies the number of frames to print, as described above.

The names `where` and `info stack` (abbreviated `info s`) are additional aliases for `backtrace`.

In a multi-threaded program, GDB by default shows the backtrace only for the current thread. To display the backtrace for several or all of the threads, use the command `thread apply` (see [\(undefined\) \[Threads\], page \(undefined\)](#)). For example, if you type `thread apply all backtrace`, GDB will display the backtrace for all the threads; this is handy when you debug a core dump of a multi-threaded program.

Each line in the backtrace shows the frame number and the function name. The program counter value is also shown—unless you use `set print address off`. The backtrace also shows the source file name and line number, as well as the arguments to the function. The program counter value is omitted if it is at the beginning of the code for that line number.

Here is an example of a backtrace. It was made with the command ‘`bt 3`’, so it shows the innermost three frames.

```
#0  m4_traceon (obs=0x24eb0, argc=1, argv=0x2b8c8)
    at builtin.c:993
#1  0x6e38 in expand_macro (sym=0x2b600, data=...) at macro.c:242
#2  0x6840 in expand_token (obs=0x0, t=177664, td=0xf7ffb08)
    at macro.c:71
(More stack frames follow...)
```

The display for frame zero does not begin with a program counter value, indicating that your program has stopped at the beginning of the code for line 993 of `builtin.c`.

The value of parameter `data` in frame 1 has been replaced by `...`. By default, GDB prints the value of a parameter only if it is a scalar (integer, pointer, enumeration, etc). See command `set print frame-arguments` in [\(undefined\) \[Print Settings\], page \(undefined\)](#) for more details on how to configure the way function parameter values are printed.

If your program was compiled with optimizations, some compilers will optimize away arguments passed to functions if those arguments are never used after the call. Such optimizations generate code that passes arguments through registers, but doesn’t store those arguments in the stack frame. GDB has no way of displaying such arguments in stack frames other than the innermost one. Here’s what such a backtrace might look like:

```
#0  m4_traceon (obs=0x24eb0, argc=1, argv=0x2b8c8)
    at builtin.c:993
#1  0x6e38 in expand_macro (sym=<value optimized out>) at macro.c:242
#2  0x6840 in expand_token (obs=0x0, t=<value optimized out>, td=0xf7ffb08)
    at macro.c:71
(More stack frames follow...)
```

The values of arguments that were not saved in their stack frames are shown as ‘`<value optimized out>`’.

If you need to display the values of such optimized-out arguments, either deduce that from other variables whose values depend on the one you are interested in, or recompile without optimizations.

Most programs have a standard user entry point—a place where system libraries and startup code transition into user code. For C this is `main`¹. When GDB finds the entry function in a backtrace it will terminate the backtrace, to avoid tracing into highly system-specific (and generally uninteresting) code.

If you need to examine the startup code, or limit the number of levels in a backtrace, you can change this behavior:

```
set backtrace past-main
```

```
set backtrace past-main on
```

Backtraces will continue past the user entry point.

```
set backtrace past-main off
```

Backtraces will stop when they encounter the user entry point. This is the default.

```
show backtrace past-main
```

Display the current user entry point backtrace policy.

¹ Note that embedded programs (the so-called “free-standing” environment) are not required to have a `main` function as the entry point. They could even have multiple entry points.

`set backtrace past-entry`

`set backtrace past-entry on`

Backtraces will continue past the internal entry point of an application. This entry point is encoded by the linker when the application is built, and is likely before the user entry point `main` (or equivalent) is called.

`set backtrace past-entry off`

Backtraces will stop when they encounter the internal entry point of an application. This is the default.

`show backtrace past-entry`

Display the current internal entry point backtrace policy.

`set backtrace limit n`

`set backtrace limit 0`

Limit the backtrace to n levels. A value of zero means unlimited.

`show backtrace limit`

Display the current limit on backtrace levels.

8.3 Selecting a Frame

Most commands for examining the stack and other data in your program work on whichever stack frame is selected at the moment. Here are the commands for selecting a stack frame; all of them finish by printing a brief description of the stack frame just selected.

`frame n`

`f n` Select frame number n . Recall that frame zero is the innermost (currently executing) frame, frame one is the frame that called the innermost one, and so on. The highest-numbered frame is the one for `main`.

`frame addr`

`f addr` Select the frame at address `addr`. This is useful mainly if the chaining of stack frames has been damaged by a bug, making it impossible for GDB to assign numbers properly to all frames. In addition, this can be useful when your program has multiple stacks and switches between them.

On the SPARC architecture, `frame` needs two addresses to select an arbitrary frame: a frame pointer and a stack pointer.

On the MIPS and Alpha architecture, it needs two addresses: a stack pointer and a program counter.

On the 29k architecture, it needs three addresses: a register stack pointer, a program counter, and a memory stack pointer.

`up n`

Move n frames up the stack. For positive numbers n , this advances toward the outermost frame, to higher frame numbers, to frames that have existed longer. n defaults to one.

`down n`

Move n frames down the stack. For positive numbers n , this advances toward the innermost frame, to lower frame numbers, to frames that were created more recently. n defaults to one. You may abbreviate `down` as `do`.

All of these commands end by printing two lines of output describing the frame. The first line shows the frame number, the function name, the arguments, and the source file and line number of execution in that frame. The second line shows the text of that source line.

For example:

```
(gdb) up
#1 0x22f0 in main (argc=1, argv=0xf7ffbf4, env=0xf7ffbf4)
    at env.c:10
10      read_input_file (argv[i]);
```

After such a printout, the `list` command with no arguments prints ten lines centered on the point of execution in the frame. You can also edit the program at the point of execution with your favorite editing program by typing `edit`. See [\(undefined\) \[Printing Source Lines\]](#), page [\(undefined\)](#), for details.

`up-silently n`
`down-silently n`

These two commands are variants of `up` and `down`, respectively; they differ in that they do their work silently, without causing display of the new frame. They are intended primarily for use in GDB command scripts, where the output might be unnecessary and distracting.

8.4 Information About a Frame

There are several other commands to print information about the selected stack frame.

`frame`

`f` When used without any argument, this command does not change which frame is selected, but prints a brief description of the currently selected stack frame. It can be abbreviated `f`. With an argument, this command is used to select a stack frame. See [\(undefined\) \[Selecting a Frame\]](#), page [\(undefined\)](#).

`info frame`

`info f` This command prints a verbose description of the selected stack frame, including:

- the address of the frame
- the address of the next frame down (called by this frame)
- the address of the next frame up (caller of this frame)
- the language in which the source code corresponding to this frame is written
- the address of the frame's arguments
- the address of the frame's local variables
- the program counter saved in it (the address of execution in the caller frame)
- which registers were saved in the frame

The verbose description is useful when something has gone wrong that has made the stack format fail to fit the usual conventions.

`info frame addr`

`info f addr`

Print a verbose description of the frame at address *addr*, without selecting that frame. The selected frame remains unchanged by this command. This requires the same kind of address (more than one for some architectures) that you specify in the `frame` command. See [\[Selecting a Frame\]](#), page [\[undefined\]](#).

`info args` Print the arguments of the selected frame, each on a separate line.

`info locals`

Print the local variables of the selected frame, each on a separate line. These are all variables (declared either static or automatic) accessible at the point of execution of the selected frame.

`info catch`

Print a list of all the exception handlers that are active in the current stack frame at the current point of execution. To see other exception handlers, visit the associated frame (using the `up`, `down`, or `frame` commands); then type `info catch`. See [\[Setting Catchpoints\]](#), page [\[undefined\]](#).

9 Examining Source Files

GDB can print parts of your program's source, since the debugging information recorded in the program tells GDB what source files were used to build it. When your program stops, GDB spontaneously prints the line where it stopped. Likewise, when you select a stack frame (see [\(undefined\) \[Selecting a Frame\], page \(undefined\)](#)), GDB prints the line where execution in that frame has stopped. You can print other portions of source files by explicit command.

If you use GDB through its GNU Emacs interface, you may prefer to use Emacs facilities to view source; see [\(undefined\) \[Using GDB under GNU Emacs\], page \(undefined\)](#).

9.1 Printing Source Lines

To print lines from a source file, use the `list` command (abbreviated `l`). By default, ten lines are printed. There are several ways to specify what part of the file you want to print; see [\(undefined\) \[Specify Location\], page \(undefined\)](#), for the full list.

Here are the forms of the `list` command most commonly used:

`list linenum`

Print lines centered around line number *linenum* in the current source file.

`list function`

Print lines centered around the beginning of function *function*.

`list` Print more lines. If the last lines printed were printed with a `list` command, this prints lines following the last lines printed; however, if the last line printed was a solitary line printed as part of displaying a stack frame (see [\(undefined\) \[Examining the Stack\], page \(undefined\)](#)), this prints lines centered around that line.

`list -` Print lines just before the lines last printed.

By default, GDB prints ten source lines with any of these forms of the `list` command. You can change this using `set listsize`:

`set listsize count`

Make the `list` command display *count* source lines (unless the `list` argument explicitly specifies some other number).

`show listsize`

Display the number of lines that `list` prints.

Repeating a `list` command with RET discards the argument, so it is equivalent to typing just `list`. This is more useful than listing the same lines again. An exception is made for an argument of '-'; that argument is preserved in repetition so that each repetition moves up in the source file.

In general, the `list` command expects you to supply zero, one or two *linespecs*. Linespecs specify source lines; there are several ways of writing them (see [\(undefined\) \[Specify Location\], page \(undefined\)](#)), but the effect is always to specify some source line.

Here is a complete description of the possible arguments for `list`:

- list *linespec***
Print lines centered around the line specified by *linespec*.
- list *first*,*last***
Print lines from *first* to *last*. Both arguments are linespecs. When a **list** command has two linespecs, and the source file of the second linespec is omitted, this refers to the same source file as the first linespec.
- list ,*last***
Print lines ending with *last*.
- list *first*,**
Print lines starting with *first*.
- list +** Print lines just after the lines last printed.
- list -** Print lines just before the lines last printed.
- list** As described in the preceding table.

9.2 Specifying a Location

Several GDB commands accept arguments that specify a location of your program's code. Since GDB is a source-level debugger, a location usually specifies some line in the source code; for that reason, locations are also known as *linespecs*.

Here are all the different ways of specifying a code location that GDB understands:

- linenum*** Specifies the line number *linenum* of the current source file.
- offset***
+*offset* Specifies the line *offset* lines before or after the *current line*. For the **list** command, the current line is the last one printed; for the breakpoint commands, this is the line at which execution stopped in the currently selected *stack frame* (see [\(undefined\) \[Frames\]](#), page [\(undefined\)](#), for a description of stack frames.) When used as the second of the two linespecs in a **list** command, this specifies the line *offset* lines up or down from the first linespec.
- filename:linenum***
Specifies the line *linenum* in the source file *filename*.
- function*** Specifies the line that begins the body of the function *function*. For example, in C, this is the line with the open brace.
- filename:function***
Specifies the line that begins the body of the function *function* in the file *filename*. You only need the file name with a function name to avoid ambiguity when there are identically named functions in different source files.
- **address*** Specifies the program address *address*. For line-oriented commands, such as **list** and **edit**, this specifies a source line that contains *address*. For **break** and other breakpoint oriented commands, this can be used to set breakpoints in parts of your program which do not have debugging information or source files.

Here *address* may be any expression valid in the current working language (see [\(undefined\) \[Languages\], page \(undefined\)](#)) that specifies a code address. In addition, as a convenience, GDB extends the semantics of expressions used in locations to cover the situations that frequently happen during debugging. Here are the various forms of *address*:

expression

Any expression valid in the current working language.

funcaddr An address of a function or procedure derived from its name. In C, C++, Java, Objective-C, Fortran, minimal, and assembly, this is simply the function's name *function* (and actually a special case of a valid expression). In Pascal and Modula-2, this is *&function*. In Ada, this is *function'Address* (although the Pascal form also works).

This form specifies the address of the function's first instruction, before the stack frame and arguments have been set up.

'filename'::funcaddr

Like *funcaddr* above, but also specifies the name of the source file explicitly. This is useful if the name of the function does not specify the function unambiguously, e.g., if there are several functions with identical names in different source files.

9.3 Editing Source Files

To edit the lines in a source file, use the `edit` command. The editing program of your choice is invoked with the current line set to the active line in the program. Alternatively, there are several ways to specify what part of the file you want to print if you want to see other parts of the program:

edit location

Edit the source file specified by *location*. Editing starts at that *location*, e.g., at the specified source line of the specified file. See [\(undefined\) \[Specify Location\], page \(undefined\)](#), for all the possible forms of the *location* argument; here are the forms of the `edit` command most commonly used:

edit number

Edit the current source file with *number* as the active line number.

edit function

Edit the file containing *function* at the beginning of its definition.

9.3.1 Choosing your Editor

You can customize GDB to use any editor you want¹. By default, it is `"/bin/ex"`, but you can change this by setting the environment variable `EDITOR` before using GDB. For example, to configure GDB to use the `vi` editor, you could use these commands with the `sh` shell:

¹ The only restriction is that your editor (say `ex`), recognizes the following command-line syntax:

```
ex +number file
```

The optional numeric value `+number` specifies the number of the line in the file where to start editing.

```
EDITOR=/usr/bin/vi
export EDITOR
gdb ...
```

or in the `cs` shell,

```
setenv EDITOR /usr/bin/vi
gdb ...
```

9.4 Searching Source Files

There are two commands for searching through the current source file for a regular expression.

`forward-search regex`
`search regex`

The command ‘`forward-search regex`’ checks each line, starting with the one following the last line listed, for a match for *regex*. It lists the line that is found. You can use the synonym ‘`search regex`’ or abbreviate the command name as `fo`.

`reverse-search regex`

The command ‘`reverse-search regex`’ checks each line, starting with the one before the last line listed and going backward, for a match for *regex*. It lists the line that is found. You can abbreviate this command as `rev`.

9.5 Specifying Source Directories

Executable programs sometimes do not record the directories of the source files from which they were compiled, just the names. Even when they do, the directories could be moved between the compilation and your debugging session. GDB has a list of directories to search for source files; this is called the *source path*. Each time GDB wants a source file, it tries all the directories in the list, in the order they are present in the list, until it finds a file with the desired name.

For example, suppose an executable references the file ‘`/usr/src/foo-1.0/lib/foo.c`’, and our source path is ‘`/mnt/cross`’. The file is first looked up literally; if this fails, ‘`/mnt/cross/usr/src/foo-1.0/lib/foo.c`’ is tried; if this fails, ‘`/mnt/cross/foo.c`’ is opened; if this fails, an error message is printed. GDB does not look up the parts of the source file name, such as ‘`/mnt/cross/src/foo-1.0/lib/foo.c`’. Likewise, the subdirectories of the source path are not searched: if the source path is ‘`/mnt/cross`’, and the binary refers to ‘`foo.c`’, GDB would not find it under ‘`/mnt/cross/usr/src/foo-1.0/lib`’.

Plain file names, relative file names with leading directories, file names containing dots, etc. are all treated as described above; for instance, if the source path is ‘`/mnt/cross`’, and the source file is recorded as ‘`../lib/foo.c`’, GDB would first try ‘`../lib/foo.c`’, then ‘`/mnt/cross/../lib/foo.c`’, and after that—‘`/mnt/cross/foo.c`’.

Note that the executable search path is *not* used to locate the source files.

Whenever you reset or rearrange the source path, GDB clears out any information it has cached about where source files are found and where each line is in the file.

When you start GDB, its source path includes only ‘`cd`’ and ‘`cwd`’, in that order. To add other directories, use the `directory` command.

The search path is used to find both program source files and GDB script files (read using the ‘-command’ option and ‘source’ command).

In addition to the source path, GDB provides a set of commands that manage a list of source path substitution rules. A *substitution rule* specifies how to rewrite source directories stored in the program’s debug information in case the sources were moved to a different directory between compilation and debugging. A rule is made of two strings, the first specifying what needs to be rewritten in the path, and the second specifying how it should be rewritten. In [\(undefined\) \[set substitute-path\], page \(undefined\)](#), we name these two parts *from* and *to* respectively. GDB does a simple string replacement of *from* with *to* at the start of the directory part of the source file name, and uses that result instead of the original file name to look up the sources.

Using the previous example, suppose the ‘foo-1.0’ tree has been moved from ‘/usr/src’ to ‘/mnt/cross’, then you can tell GDB to replace ‘/usr/src’ in all source path names with ‘/mnt/cross’. The first lookup will then be ‘/mnt/cross/foo-1.0/lib/foo.c’ in place of the original location of ‘/usr/src/foo-1.0/lib/foo.c’. To define a source path substitution rule, use the `set substitute-path` command (see [\(undefined\) \[set substitute-path\], page \(undefined\)](#)).

To avoid unexpected substitution results, a rule is applied only if the *from* part of the directory name ends at a directory separator. For instance, a rule substituting ‘/usr/source’ into ‘/mnt/cross’ will be applied to ‘/usr/source/foo-1.0’ but not to ‘/usr/sourceware/foo-2.0’. And because the substitution is applied only at the beginning of the directory name, this rule will not be applied to ‘/root/usr/source/baz.c’ either.

In many cases, you can achieve the same result using the `directory` command. However, `set substitute-path` can be more efficient in the case where the sources are organized in a complex tree with multiple subdirectories. With the `directory` command, you need to add each subdirectory of your project. If you moved the entire tree while preserving its internal organization, then `set substitute-path` allows you to direct the debugger to all the sources with one single command.

`set substitute-path` is also more than just a shortcut command. The source path is only used if the file at the original location no longer exists. On the other hand, `set substitute-path` modifies the debugger behavior to look at the rewritten location instead. So, if for any reason a source file that is not relevant to your executable is located at the original location, a substitution rule is the only method available to point GDB at the new location.

You can configure a default source path substitution rule by configuring GDB with the ‘--with-relocated-sources=*dir*’ option. The *dir* should be the name of a directory under GDB’s configured prefix (set with ‘--prefix’ or ‘--exec-prefix’), and directory names in debug information under *dir* will be adjusted automatically if the installed GDB is moved to a new location. This is useful if GDB, libraries or executables with debug information and corresponding source code are being moved together.

```
directory dirname ...
```

```
dir dirname ...
```

Add directory *dirname* to the front of the source path. Several directory names may be given to this command, separated by ‘:’ (‘;’ on MS-DOS and MS-

Windows, where ‘.’ usually appears as part of absolute file names) or white-space. You may specify a directory that is already in the source path; this moves it forward, so GDB searches it sooner.

You can use the string ‘\$cdir’ to refer to the compilation directory (if one is recorded), and ‘\$cwd’ to refer to the current working directory. ‘\$cwd’ is not the same as ‘.’—the former tracks the current working directory as it changes during your GDB session, while the latter is immediately expanded to the current directory at the time you add an entry to the source path.

directory

Reset the source path to its default value (‘\$cdir:\$cwd’ on Unix systems). This requires confirmation.

show directories

Print the source path: show which directories it contains.

set substitute-path *from to*

Define a source path substitution rule, and add it at the end of the current list of existing substitution rules. If a rule with the same *from* was already defined, then the old rule is also deleted.

For example, if the file ‘/foo/bar/baz.c’ was moved to ‘/mnt/cross/baz.c’, then the command

```
(gdb) set substitute-path /usr/src /mnt/cross
```

will tell GDB to replace ‘/usr/src’ with ‘/mnt/cross’, which will allow GDB to find the file ‘baz.c’ even though it was moved.

In the case when more than one substitution rule have been defined, the rules are evaluated one by one in the order where they have been defined. The first one matching, if any, is selected to perform the substitution.

For instance, if we had entered the following commands:

```
(gdb) set substitute-path /usr/src/include /mnt/include
(gdb) set substitute-path /usr/src /mnt/src
```

GDB would then rewrite ‘/usr/src/include/defs.h’ into ‘/mnt/include/defs.h’ by using the first rule. However, it would use the second rule to rewrite ‘/usr/src/lib/foo.c’ into ‘/mnt/src/lib/foo.c’.

unset substitute-path [path]

If a path is specified, search the current list of substitution rules for a rule that would rewrite that path. Delete that rule if found. A warning is emitted by the debugger if no rule could be found.

If no path is specified, then all substitution rules are deleted.

show substitute-path [path]

If a path is specified, then print the source path substitution rule which would rewrite that path, if any.

If no path is specified, then print all existing source path substitution rules.

If your source path is cluttered with directories that are no longer of interest, GDB may sometimes cause confusion by finding the wrong versions of source. You can correct the situation as follows:

1. Use `directory` with no argument to reset the source path to its default value.
2. Use `directory` with suitable arguments to reinstall the directories you want in the source path. You can add all the directories in one command.

9.6 Source and Machine Code

You can use the command `info line` to map source lines to program addresses (and vice versa), and the command `disassemble` to display a range of addresses as machine instructions. You can use the command `set disassemble-next-line` to set whether to disassemble next source line when execution stops. When run under GNU Emacs mode, the `info line` command causes the arrow to point to the line specified. Also, `info line` prints addresses in symbolic form as well as hex.

`info line linespec`

Print the starting and ending addresses of the compiled code for source line *linespec*. You can specify source lines in any of the ways documented in [\(undefined\) \[Specify Location\], page \(undefined\)](#).

For example, we can use `info line` to discover the location of the object code for the first line of function `m4_changequote`:

```
(gdb) info line m4_changequote
Line 895 of "builtin.c" starts at pc 0x634c and ends at 0x6350.
```

We can also inquire (using `*addr` as the form for *linespec*) what source line covers a particular address:

```
(gdb) info line *0x63ff
Line 926 of "builtin.c" starts at pc 0x63e4 and ends at 0x6404.
```

After `info line`, the default address for the `x` command is changed to the starting address of the line, so that `'x/i'` is sufficient to begin examining the machine code (see [\(undefined\) \[Examining Memory\], page \(undefined\)](#)). Also, this address is saved as the value of the convenience variable `$_` (see [\(undefined\) \[Convenience Variables\], page \(undefined\)](#)).

`disassemble`

`disassemble /m`

`disassemble /r`

This specialized command dumps a range of memory as machine instructions. It can also print mixed source+disassembly by specifying the `/m` modifier and print the raw instructions in hex as well as in symbolic form by specifying the `/r`. The default memory range is the function surrounding the program counter of the selected frame. A single argument to this command is a program counter value; GDB dumps the function surrounding this value. When two arguments are given, they should be separated by a comma, possibly surrounded by whitespace. The arguments specify a range of addresses to dump, in one of two forms:

start, end

the addresses from *start* (inclusive) to *end* (exclusive)

start, +length

the addresses from *start* (inclusive) to *start+length* (exclusive).

When 2 arguments are specified, the name of the function is also printed (since there could be several functions in the given range).

The argument(s) can be any expression yielding a numeric value, such as ‘0x32c4’, ‘&main+10’ or ‘\$pc - 8’.

If the range of memory being disassembled contains current program counter, the instruction at that location is shown with a => marker.

The following example shows the disassembly of a range of addresses of HP PA-RISC 2.0 code:

```
(gdb) disas 0x32c4, 0x32e4
Dump of assembler code from 0x32c4 to 0x32e4:
0x32c4 <main+204>:      addil 0,dp
0x32c8 <main+208>:      ldw 0x22c(sr0,r1),r26
0x32cc <main+212>:      ldil 0x3000,r31
0x32d0 <main+216>:      ble 0x3f8(sr4,r31)
0x32d4 <main+220>:      ldo 0(r31),rp
0x32d8 <main+224>:      addil -0x800,dp
0x32dc <main+228>:      ldo 0x588(r1),r26
0x32e0 <main+232>:      ldil 0x3000,r31
End of assembler dump.
```

Here is an example showing mixed source+assembly for Intel x86, when the program is stopped just after function prologue:

```
(gdb) disas /m main
Dump of assembler code for function main:
5      {
    0x08048330 <+0>:      push  %ebp
    0x08048331 <+1>:      mov   %esp,%ebp
    0x08048333 <+3>:      sub  $0x8,%esp
    0x08048336 <+6>:      and  $0xffffffff0,%esp
    0x08048339 <+9>:      sub  $0x10,%esp

6      printf ("Hello.\n");
=> 0x0804833c <+12>:     movl  $0x8048440,(%esp)
    0x08048343 <+19>:     call  0x8048284 <puts@plt>

7      return 0;
8      }
    0x08048348 <+24>:     mov  $0x0,%eax
    0x0804834d <+29>:     leave
    0x0804834e <+30>:     ret
```

End of assembler dump.

Here is another example showing raw instructions in hex for AMD x86-64,

```
(gdb) disas /r 0x400281,+10
Dump of assembler code from 0x400281 to 0x40028b:
0x0000000000400281: 38 36  cmp    %dh,(%rsi)
0x0000000000400283: 2d 36 34 2e 73  sub    $0x732e3436,%eax
0x0000000000400288: 6f      outs1  %ds:(%rsi),(%dx)
0x0000000000400289: 2e 32 00      xor    %cs:(%rax),%al
End of assembler dump.
```

Some architectures have more than one commonly-used set of instruction mnemonics or other syntax.

For programs that were dynamically linked and use shared libraries, instructions that call functions or branch to locations in the shared libraries might show a seemingly bogus location—it’s actually a location of the relocation table. On some architectures, GDB might be able to resolve these to actual function names.

set disassembly-flavor *instruction-set*

Select the instruction set to use when disassembling the program via the `disassemble` or `x/i` commands.

Currently this command is only defined for the Intel x86 family. You can set *instruction-set* to either `intel` or `att`. The default is `att`, the AT&T flavor used by default by Unix assemblers for x86-based targets.

show disassembly-flavor

Show the current setting of the disassembly flavor.

set disassemble-next-line

show disassemble-next-line

Control whether or not GDB will disassemble the next source line or instruction when execution stops. If `ON`, GDB will display disassembly of the next source line when execution of the program being debugged stops. This is *in addition* to displaying the source line itself, which GDB always does if possible. If the next source line cannot be displayed for some reason (e.g., if GDB cannot find the source file, or there's no line info in the debug info), GDB will display disassembly of the next *instruction* instead of showing the next source line. If `AUTO`, GDB will display disassembly of next instruction only if the source line cannot be displayed. This setting causes GDB to display some feedback when you step through a function with no line info or whose source file is unavailable. The default is `OFF`, which means never display the disassembly of the next line or instruction.

10 Examining Data

The usual way to examine data in your program is with the `print` command (abbreviated `p`), or its synonym `inspect`. It evaluates and prints the value of an expression of the language your program is written in (see [Using GDB with Different Languages](#), page). It may also print the expression using a Python-based pretty-printer (see [Pretty Printing](#), page).

```
print expr
print /f expr
```

`expr` is an expression (in the source language). By default the value of `expr` is printed in a format appropriate to its data type; you can choose a different format by specifying `/f`, where `f` is a letter specifying the format; see [Output Formats](#), page .

```
print
```

```
print /f
```

If you omit `expr`, GDB displays the last value again (from the *value history*; see [Value History](#), page). This allows you to conveniently inspect the same value in an alternative format.

A more low-level way of examining data is with the `x` command. It examines data in memory at a specified address and prints it in a specified format. See [Examining Memory](#), page .

If you are interested in information about types, or about how the fields of a struct or a class are declared, use the `ptype exp` command rather than `print`. See [Examining the Symbol Table](#), page .

10.1 Expressions

`print` and many other GDB commands accept an expression and compute its value. Any kind of constant, variable or operator defined by the programming language you are using is valid in an expression in GDB. This includes conditional expressions, function calls, casts, and string constants. It also includes preprocessor macros, if you compiled your program to include this information; see [Compilation](#), page .

GDB supports array constants in expressions input by the user. The syntax is `{element, element...}`. For example, you can use the command `print {1, 2, 3}` to create an array of three integers. If you pass an array to a function or assign it to a program variable, GDB copies the array to memory that is `malloced` in the target program.

Because C is so widespread, most of the expressions shown in examples in this manual are in C. See [Using GDB with Different Languages](#), page , for information on how to use expressions in other languages.

In this section, we discuss operators that you can use in GDB expressions regardless of your programming language.

Casts are supported in all languages, not just in C, because it is so useful to cast a number into a pointer in order to examine a structure at that address in memory.

GDB supports these operators, in addition to those common to programming languages:

@ '@' is a binary operator for treating parts of memory as arrays. See [Artificial Arrays](#), page , for more information.

:: ‘::<’ allows you to specify a variable in terms of the file or function where it is defined. See [\(undefined\) \[Program Variables\], page \(undefined\)](#).

`{type} addr`

Refers to an object of type *type* stored at address *addr* in memory. *addr* may be any expression whose value is an integer or pointer (but parentheses are required around binary operators, just as in a cast). This construct is allowed regardless of what kind of data is normally supposed to reside at *addr*.

10.2 Ambiguous Expressions

Expressions can sometimes contain some ambiguous elements. For instance, some programming languages (notably Ada, C++ and Objective-C) permit a single function name to be defined several times, for application in different contexts. This is called *overloading*. Another example involving Ada is generics. A *generic package* is similar to C++ templates and is typically instantiated several times, resulting in the same function name being defined in different contexts.

In some cases and depending on the language, it is possible to adjust the expression to remove the ambiguity. For instance in C++, you can specify the signature of the function you want to break on, as in `break function(types)`. In Ada, using the fully qualified name of your function often makes the expression unambiguous as well.

When an ambiguity that needs to be resolved is detected, the debugger has the capability to display a menu of numbered choices for each possibility, and then waits for the selection with the prompt ‘>’. The first option is always ‘[0] cancel’, and typing `0 RET` aborts the current command. If the command in which the expression was used allows more than one choice to be selected, the next option in the menu is ‘[1] all’, and typing `1 RET` selects all possible choices.

For example, the following session excerpt shows an attempt to set a breakpoint at the overloaded symbol `String::after`. We choose three particular definitions of that function name:

```
(gdb) b String::after
[0] cancel
[1] all
[2] file:String.cc; line number:867
[3] file:String.cc; line number:860
[4] file:String.cc; line number:875
[5] file:String.cc; line number:853
[6] file:String.cc; line number:846
[7] file:String.cc; line number:735
> 2 4 6
Breakpoint 1 at 0xb26c: file String.cc, line 867.
Breakpoint 2 at 0xb344: file String.cc, line 875.
Breakpoint 3 at 0xafcc: file String.cc, line 846.
Multiple breakpoints were set.
Use the "delete" command to delete unwanted
breakpoints.
(gdb)
```

`set multiple-symbols mode`

This option allows you to adjust the debugger behavior when an expression is ambiguous.

By default, *mode* is set to `all`. If the command with which the expression is used allows more than one choice, then GDB automatically selects all possible choices. For instance, inserting a breakpoint on a function using an ambiguous name results in a breakpoint inserted on each possible match. However, if a unique choice must be made, then GDB uses the menu to help you disambiguate the expression. For instance, printing the address of an overloaded function will result in the use of the menu.

When *mode* is set to `ask`, the debugger always uses the menu when an ambiguity is detected.

Finally, when *mode* is set to `cancel`, the debugger reports an error due to the ambiguity and the command is aborted.

```
show multiple-symbols
```

Show the current value of the `multiple-symbols` setting.

10.3 Program Variables

The most common kind of expression to use is the name of a variable in your program.

Variables in expressions are understood in the selected stack frame (see [\(undefined\) \[Selecting a Frame\]](#), page [\(undefined\)](#)); they must be either:

- global (or file-static)

or

- visible according to the scope rules of the programming language from the point of execution in that frame

This means that in the function

```
foo (a)
    int a;
{
    bar (a);
    {
        int b = test ();
        bar (b);
    }
}
```

you can examine and use the variable `a` whenever your program is executing within the function `foo`, but you can only use or examine the variable `b` while your program is executing inside the block where `b` is declared.

There is an exception: you can refer to a variable or function whose scope is a single source file even if the current execution point is not in this file. But it is possible to have more than one such variable or function with the same name (in different source files). If that happens, referring to that name has unpredictable effects. If you wish, you can specify a static variable in a particular function or file, using the colon-colon (`::`) notation:

```
file::variable
function::variable
```

Here *file* or *function* is the name of the context for the static *variable*. In the case of file names, you can use quotes to make sure GDB parses the file name as a single word—for example, to print a global value of `x` defined in `'f2.c'`:

```
(gdb) p 'f2.c'::x
```

This use of `::` is very rarely in conflict with the very similar use of the same notation in C++. GDB also supports use of the C++ scope resolution operator in GDB expressions.

Warning: Occasionally, a local variable may appear to have the wrong value at certain points in a function—just after entry to a new scope, and just before exit.

You may see this problem when you are stepping by machine instructions. This is because, on most machines, it takes more than one instruction to set up a stack frame (including local variable definitions); if you are stepping by machine instructions, variables may appear to have the wrong values until the stack frame is completely built. On exit, it usually also takes more than one machine instruction to destroy a stack frame; after you begin stepping through that group of instructions, local variable definitions may be gone.

This may also happen when the compiler does significant optimizations. To be sure of always seeing accurate values, turn off all optimization when compiling.

Another possible effect of compiler optimizations is to optimize unused variables out of existence, or assign variables to registers (as opposed to memory addresses). Depending on the support for such cases offered by the debug info format used by the compiler, GDB might not be able to display values for such local variables. If that happens, GDB will print a message like this:

```
No symbol "foo" in current context.
```

To solve such problems, either recompile without optimizations, or use a different debug info format, if the compiler supports several such formats. For example, GCC, the GNU C/C++ compiler, usually supports the `-gstabs+` option. `-gstabs+` produces debug info in a format that is superior to formats such as COFF. You may be able to use DWARF 2 (`-gdwarf-2`), which is also an effective form for debug info. See [section “Options for Debugging Your Program or GCC” in *Using the GNU Compiler Collection \(GCC\)*](#). See [\(undefined\) \[C and C++\]](#), [page \(undefined\)](#), for more information about debug info formats that are best suited to C++ programs.

If you ask to print an object whose contents are unknown to GDB, e.g., because its data type is not completely specified by the debug information, GDB will say `<incomplete type>`. See [\(undefined\) \[Symbols\]](#), [page \(undefined\)](#), for more about this.

Strings are identified as arrays of `char` values without specified signedness. Arrays of either `signed char` or `unsigned char` get printed as arrays of 1 byte sized integers. `-fsigned-char` or `-funsigned-char` GCC options have no effect as GDB defines literal string type `"char"` as `char` without a sign. For program code

```
char var0[] = "A";
signed char var1[] = "A";
```

You get during debugging

```
(gdb) print var0
$1 = "A"
(gdb) print var1
$2 = {65 'A', 0 '\0'}
```

10.4 Artificial Arrays

It is often useful to print out several successive objects of the same type in memory; a section of an array, or an array of dynamically determined size for which only a pointer exists in the program.

You can do this by referring to a contiguous span of memory as an *artificial array*, using the binary operator '@'. The left operand of '@' should be the first element of the desired array and be an individual object. The right operand should be the desired length of the array. The result is an array value whose elements are all of the type of the left argument. The first element is actually the left argument; the second element comes from bytes of memory immediately following those that hold the first element, and so on. Here is an example. If a program says

```
int *array = (int *) malloc (len * sizeof (int));
```

you can print the contents of `array` with

```
p *array@len
```

The left operand of '@' must reside in memory. Array values made with '@' in this way behave just like other arrays in terms of subscripting, and are coerced to pointers when used in expressions. Artificial arrays most often appear in expressions via the value history (see [\(undefined\) \[Value History\]](#), page [\(undefined\)](#)), after printing one out.

Another way to create an artificial array is to use a cast. This re-interprets a value as if it were an array. The value need not be in memory:

```
(gdb) p/x (short[2])0x12345678
$1 = {0x1234, 0x5678}
```

As a convenience, if you leave the array length out (as in '(type[])value') GDB calculates the size to fill the value (as 'sizeof(value)/sizeof(type)'):

```
(gdb) p/x (short[])0x12345678
$2 = {0x1234, 0x5678}
```

Sometimes the artificial array mechanism is not quite enough; in moderately complex data structures, the elements of interest may not actually be adjacent—for example, if you are interested in the values of pointers in an array. One useful work-around in this situation is to use a convenience variable (see [\(undefined\) \[Convenience Variables\]](#), page [\(undefined\)](#)) as a counter in an expression that prints the first interesting value, and then repeat that expression via RET. For instance, suppose you have an array `dtab` of pointers to structures, and you are interested in the values of a field `fv` in each structure. Here is an example of what you might type:

```
set $i = 0
p dtab[$i++]->fv
RET
RET
...
```

10.5 Output Formats

By default, GDB prints a value according to its data type. Sometimes this is not what you want. For example, you might want to print a number in hex, or a pointer in decimal. Or you might want to view data in memory at a certain address as a character string or as an instruction. To do these things, specify an *output format* when you print a value.

The simplest use of output formats is to say how to print a value already computed. This is done by starting the arguments of the `print` command with a slash and a format letter. The format letters supported are:

- `x` Regard the bits of the value as an integer, and print the integer in hexadecimal.
- `d` Print as integer in signed decimal.
- `u` Print as integer in unsigned decimal.
- `o` Print as integer in octal.
- `t` Print as integer in binary. The letter ‘`t`’ stands for “two”.¹
- `a` Print as an address, both absolute in hexadecimal and as an offset from the nearest preceding symbol. You can use this format used to discover where (in what function) an unknown address is located:


```
(gdb) p/a 0x54320
$3 = 0x54320 <_initialize_vx+396>
```

 The command `info symbol 0x54320` yields similar results. See [\(undefined\) \[Symbols\], page \(undefined\)](#).
- `c` Regard as an integer and print it as a character constant. This prints both the numerical value and its character representation. The character representation is replaced with the octal escape ‘`\nnn`’ for characters outside the 7-bit ASCII range.

Without this format, GDB displays `char`, `unsigned char`, and `signed char` data as character constants. Single-byte members of vectors are displayed as integer data.
- `f` Regard the bits of the value as a floating point number and print using typical floating point syntax.
- `s` Regard as a string, if possible. With this format, pointers to single-byte data are displayed as null-terminated strings and arrays of single-byte data are displayed as fixed-length strings. Other values are displayed in their natural types.

Without this format, GDB displays pointers to and arrays of `char`, `unsigned char`, and `signed char` as strings. Single-byte members of a vector are displayed as an integer array.
- `r` Print using the ‘`raw`’ formatting. By default, GDB will use a Python-based pretty-printer, if one is available (see [\(undefined\) \[Pretty Printing\], page \(undefined\)](#)). This typically results in a higher-level display of the value’s contents. The ‘`r`’ format bypasses any Python pretty-printer which might exist.

For example, to print the program counter in hex (see [\(undefined\) \[Registers\], page \(undefined\)](#)), type

```
p/x $pc
```

Note that no space is required before the slash; this is because command names in GDB cannot contain a slash.

¹ ‘`b`’ cannot be used because these format letters are also used with the `x` command, where ‘`b`’ stands for “byte”; see [\(undefined\) \[Examining Memory\], page \(undefined\)](#).

To reprint the last value in the value history with a different format, you can use the `print` command with just a format and no expression. For example, `p/x` reprints the last value in hex.

10.6 Examining Memory

You can use the command `x` (for “examine”) to examine memory in any of several formats, independently of your program’s data types.

`x/nfu addr`

`x addr`

`x` Use the `x` command to examine memory.

`n`, `f`, and `u` are all optional parameters that specify how much memory to display and how to format it; `addr` is an expression giving the address where you want to start displaying memory. If you use defaults for `nfu`, you need not type the slash `/`. Several commands set convenient defaults for `addr`.

`n`, the repeat count

The repeat count is a decimal integer; the default is 1. It specifies how much memory (counting by units `u`) to display.

`f`, the display format

The display format is one of the formats used by `print` (`'x'`, `'d'`, `'u'`, `'o'`, `'t'`, `'a'`, `'c'`, `'f'`, `'s'`), and in addition `'i'` (for machine instructions). The default is `'x'` (hexadecimal) initially. The default changes each time you use either `x` or `print`.

`u`, the unit size

The unit size is any of

`b` Bytes.

`h` Halfwords (two bytes).

`w` Words (four bytes). This is the initial default.

`g` Giant words (eight bytes).

Each time you specify a unit size with `x`, that size becomes the default unit the next time you use `x`. For the `'i'` format, the unit size is ignored and is normally not written. For the `'s'` format, the unit size defaults to `'b'`, unless it is explicitly given. Use `x /hs` to display 16-bit char strings and `x /ws` to display 32-bit strings. The next use of `x /s` will again display 8-bit strings. Note that the results depend on the programming language of the current compilation unit. If the language is C, the `'s'` modifier will use the UTF-16 encoding while `'w'` will use UTF-32. The encoding is set by the programming language and cannot be altered.

`addr`, starting display address

`addr` is the address where you want GDB to begin displaying memory. The expression need not have a pointer value (though it may); it is always interpreted as an integer address of a byte of memory. See [\(undefined\) \[Expressions\]](#),

page [\(undefined\)](#), for more information on expressions. The default for *addr* is usually just after the last address examined—but several other commands also set the default address: `info breakpoints` (to the address of the last breakpoint listed), `info line` (to the starting address of a line), and `print` (if you use it to display a value from memory).

For example, `'x/3uh 0x54320'` is a request to display three halfwords (h) of memory, formatted as unsigned decimal integers ('u'), starting at address 0x54320. `'x/4xw $sp'` prints the four words ('w') of memory above the stack pointer (here, '\$sp'; see [\(undefined\)](#) [Registers], page [\(undefined\)](#)) in hexadecimal ('x').

Since the letters indicating unit sizes are all distinct from the letters specifying output formats, you do not have to remember whether unit size or format comes first; either order works. The output specifications `'4xw'` and `'4wx'` mean exactly the same thing. (However, the count *n* must come first; `'wx4'` does not work.)

Even though the unit size *u* is ignored for the formats 's' and 'i', you might still want to use a count *n*; for example, `'3i'` specifies that you want to see three machine instructions, including any operands. For convenience, especially when used with the `display` command, the 'i' format also prints branch delay slot instructions, if any, beyond the count specified, which immediately follow the last instruction that is within the count. The command `disassemble` gives an alternative way of inspecting machine instructions; see [\(undefined\)](#) [Source and Machine Code], page [\(undefined\)](#).

All the defaults for the arguments to `x` are designed to make it easy to continue scanning memory with minimal specifications each time you use `x`. For example, after you have inspected three machine instructions with `'x/3i addr'`, you can inspect the next seven with just `'x/7'`. If you use RET to repeat the `x` command, the repeat count *n* is used again; the other arguments default as for successive uses of `x`.

When examining machine instructions, the instruction at current program counter is shown with a => marker. For example:

```
(gdb) x/5i $pc-6
0x804837f <main+11>: mov    %esp,%ebp
0x8048381 <main+13>: push  %ecx
0x8048382 <main+14>: sub    $0x4,%esp
=> 0x8048385 <main+17>: movl   $0x8048460,(%esp)
0x804838c <main+24>: call  0x80482d4 <puts@plt>
```

The addresses and contents printed by the `x` command are not saved in the value history because there is often too much of them and they would get in the way. Instead, GDB makes these values available for subsequent use in expressions as values of the convenience variables `$_` and `$__`. After an `x` command, the last address examined is available for use in expressions in the convenience variable `$_`. The contents of that address, as examined, are available in the convenience variable `$__`.

If the `x` command has a repeat count, the address and contents saved are from the last memory unit printed; this is not the same as the last address printed if several units were printed on the last line of output.

When you are debugging a program running on a remote target machine (see [\(undefined\)](#) [Remote Debugging], page [\(undefined\)](#)), you may wish to verify the program's image in the remote machine's memory against the executable file you downloaded to the target. The `compare-sections` command is provided for such situations.

`compare-sections` [*section-name*]

Compare the data of a loadable section *section-name* in the executable file of the program being debugged with the same section in the remote machine's memory, and report any mismatches. With no arguments, compares all loadable sections. This command's availability depends on the target's support for the "qCRC" remote request.

10.7 Automatic Display

If you find that you want to print the value of an expression frequently (to see how it changes), you might want to add it to the *automatic display list* so that GDB prints its value each time your program stops. Each expression added to the list is given a number to identify it; to remove an expression from the list, you specify that number. The automatic display looks like this:

```
2: foo = 38
3: bar[5] = (struct hack *) 0x3804
```

This display shows item numbers, expressions and their current values. As with displays you request manually using `x` or `print`, you can specify the output format you prefer; in fact, `display` decides whether to use `print` or `x` depending your format specification—it uses `x` if you specify either the 'i' or 's' format, or a unit size; otherwise it uses `print`.

`display` *expr*

Add the expression *expr* to the list of expressions to display each time your program stops. See [\(undefined\) \[Expressions\], page \(undefined\)](#).

`display` does not repeat if you press RET again after using it.

`display/fmt` *expr*

For *fmt* specifying only a display format and not a size or count, add the expression *expr* to the auto-display list but arrange to display it each time in the specified format *fmt*. See [\(undefined\) \[Output Formats\], page \(undefined\)](#).

`display/fmt` *addr*

For *fmt* 'i' or 's', or including a unit-size or a number of units, add the expression *addr* as a memory address to be examined each time your program stops. Examining means in effect doing '`x/fmt addr`'. See [\(undefined\) \[Examining Memory\], page \(undefined\)](#).

For example, '`display/i $pc`' can be helpful, to see the machine instruction about to be executed each time execution stops ('`$pc`' is a common name for the program counter; see [\(undefined\) \[Registers\], page \(undefined\)](#)).

`undisplay` *dnums*...

`delete display` *dnums*...

Remove item numbers *dnums* from the list of expressions to display.

`undisplay` does not repeat if you press RET after using it. (Otherwise you would just get the error 'No display number ...'.)

`disable display` *dnums*...

Disable the display of item numbers *dnums*. A disabled display item is not printed automatically, but is not forgotten. It may be enabled again later.

enable display *dnums* . . .

Enable display of item numbers *dnums*. It becomes effective once again in auto display of its expression, until you specify otherwise.

display Display the current values of the expressions on the list, just as is done when your program stops.

info display

Print the list of expressions previously set up to display automatically, each one with its item number, but without showing the values. This includes disabled expressions, which are marked as such. It also includes expressions which would not be displayed right now because they refer to automatic variables not currently available.

If a display expression refers to local variables, then it does not make sense outside the lexical context for which it was set up. Such an expression is disabled when execution enters a context where one of its variables is not defined. For example, if you give the command `display last_char` while inside a function with an argument `last_char`, GDB displays this argument while your program continues to stop inside that function. When it stops elsewhere—where there is no variable `last_char`—the display is disabled automatically. The next time your program stops where `last_char` is meaningful, you can enable the display expression once again.

10.8 Print Settings

GDB provides the following ways to control how arrays, structures, and symbols are printed. These settings are useful for debugging programs in any language:

set print address

set print address on

GDB prints memory addresses showing the location of stack traces, structure values, pointer values, breakpoints, and so forth, even when it also displays the contents of those addresses. The default is `on`. For example, this is what a stack frame display looks like with `set print address on`:

```
(gdb) f
#0 set_quotes (lq=0x34c78 "<<", rq=0x34c88 ">>")
   at input.c:530
530         if (lquote != def_lquote)
```

set print address off

Do not print addresses when displaying their contents. For example, this is the same stack frame displayed with `set print address off`:

```
(gdb) set print addr off
(gdb) f
#0 set_quotes (lq="<<", rq=">>") at input.c:530
530         if (lquote != def_lquote)
```

You can use `'set print address off'` to eliminate all machine dependent displays from the GDB interface. For example, with `print address off`, you should get the same text for backtraces on all machines—whether or not they involve pointer arguments.

show print address

Show whether or not addresses are to be printed.

When GDB prints a symbolic address, it normally prints the closest earlier symbol plus an offset. If that symbol does not uniquely identify the address (for example, it is a name whose scope is a single source file), you may need to clarify. One way to do this is with `info line`, for example `'info line *0x4537'`. Alternately, you can set GDB to print the source file and line number when it prints a symbolic address:

set print symbol-filename on

Tell GDB to print the source file name and line number of a symbol in the symbolic form of an address.

set print symbol-filename off

Do not print source file name and line number of a symbol. This is the default.

show print symbol-filename

Show whether or not GDB will print the source file name and line number of a symbol in the symbolic form of an address.

Another situation where it is helpful to show symbol filenames and line numbers is when disassembling code; GDB shows you the line number and source file that corresponds to each instruction.

Also, you may wish to see the symbolic form only if the address being printed is reasonably close to the closest earlier symbol:

set print max-symbolic-offset *max-offset*

Tell GDB to only display the symbolic form of an address if the offset between the closest earlier symbol and the address is less than *max-offset*. The default is 0, which tells GDB to always print the symbolic form of an address if any symbol precedes it.

show print max-symbolic-offset

Ask how large the maximum offset is that GDB prints in a symbolic address.

If you have a pointer and you are not sure where it points, try `'set print symbol-filename on'`. Then you can determine the name and source file location of the variable where it points, using `'p/a pointer'`. This interprets the address in symbolic form. For example, here GDB shows that a variable `ptt` points at another variable `t`, defined in `'hi2.c'`:

```
(gdb) set print symbol-filename on
(gdb) p/a ptt
$4 = 0xe008 <t in hi2.c>
```

Warning: For pointers that point to a local variable, `'p/a'` does not show the symbol name and filename of the referent, even with the appropriate `set print` options turned on.

Other settings control how different kinds of objects are printed:

set print array**set print array on**

Pretty print arrays. This format is more convenient to read, but uses more space. The default is off.

set print array off

Return to compressed format for arrays.

show print array

Show whether compressed or pretty format is selected for displaying arrays.

set print array-indexes

set print array-indexes on

Print the index of each element when displaying arrays. May be more convenient to locate a given element in the array or quickly find the index of a given element in that printed array. The default is off.

set print array-indexes off

Stop printing element indexes when displaying arrays.

show print array-indexes

Show whether the index of each element is printed when displaying arrays.

set print elements *number-of-elements*

Set a limit on how many elements of an array GDB will print. If GDB is printing a large array, it stops printing after it has printed the number of elements set by the **set print elements** command. This limit also applies to the display of strings. When GDB starts, this limit is set to 200. Setting *number-of-elements* to zero means that the printing is unlimited.

show print elements

Display the number of elements of a large array that GDB will print. If the number is 0, then the printing is unlimited.

set print frame-arguments value

This command allows to control how the values of arguments are printed when the debugger prints a frame (see [\(undefined\) \[Frames\], page \(undefined\)](#)). The possible values are:

all The values of all arguments are printed.

scalars Print the value of an argument only if it is a scalar. The value of more complex arguments such as arrays, structures, unions, etc, is replaced by `....`. This is the default. Here is an example where only scalar arguments are shown:

```
#1 0x08048361 in call_me (i=3, s=..., ss=0xbf8d508c, u=..., e=green)
   at frame-args.c:23
```

none None of the argument values are printed. Instead, the value of each argument is replaced by `....`. In this case, the example above now becomes:

```
#1 0x08048361 in call_me (i=..., s=..., ss=..., u=..., e=...)
   at frame-args.c:23
```

By default, only scalar arguments are printed. This command can be used to configure the debugger to print the value of all arguments, regardless of their type. However, it is often advantageous to not print the value of more complex parameters. For instance, it reduces the amount of information printed in each

frame, making the backtrace more readable. Also, it improves performance when displaying Ada frames, because the computation of large arguments can sometimes be CPU-intensive, especially in large applications. Setting `print frame-arguments` to `scalars` (the default) or `none` avoids this computation, thus speeding up the display of each Ada frame.

show print frame-arguments

Show how the value of arguments should be displayed when printing a frame.

set print repeats

Set the threshold for suppressing display of repeated array elements. When the number of consecutive identical elements of an array exceeds the threshold, GDB prints the string "`<repeats n times>`", where *n* is the number of identical repetitions, instead of displaying the identical elements themselves. Setting the threshold to zero will cause all elements to be individually printed. The default threshold is 10.

show print repeats

Display the current threshold for printing repeated identical elements.

set print null-stop

Cause GDB to stop printing the characters of an array when the first `NULL` is encountered. This is useful when large arrays actually contain only short strings. The default is off.

show print null-stop

Show whether GDB stops printing an array on the first `NULL` character.

set print pretty on

Cause GDB to print structures in an indented format with one member per line, like this:

```
$1 = {
  next = 0x0,
  flags = {
    sweet = 1,
    sour = 1
  },
  meat = 0x54 "Pork"
}
```

set print pretty off

Cause GDB to print structures in a compact format, like this:

```
$1 = {next = 0x0, flags = {sweet = 1, sour = 1}, \
meat = 0x54 "Pork"}
```

This is the default format.

show print pretty

Show which format GDB is using to print structures.

set print sevenbit-strings on

Print using only seven-bit characters; if this option is set, GDB displays any eight-bit characters (in strings or character values) using the notation `\nnn`. This setting is best if you are working in English (ASCII) and you use the high-order bit of characters as a marker or “meta” bit.

set print sevenbit-strings off
 Print full eight-bit characters. This allows the use of more international character sets, and is the default.

show print sevenbit-strings
 Show whether or not GDB is printing only seven-bit characters.

set print union on
 Tell GDB to print unions which are contained in structures and other unions. This is the default setting.

set print union off
 Tell GDB not to print unions which are contained in structures and other unions. GDB will print "{...}" instead.

show print union
 Ask GDB whether or not it will print unions which are contained in structures and other unions.

For example, given the declarations

```
typedef enum {Tree, Bug} Species;
typedef enum {Big_tree, Acorn, Seedling} Tree_forms;
typedef enum {Caterpillar, Cocoon, Butterfly}
    Bug_forms;
```

```
struct thing {
    Species it;
    union {
        Tree_forms tree;
        Bug_forms bug;
    } form;
};
```

```
struct thing foo = {Tree, {Acorn}};
```

with **set print union on** in effect 'p foo' would print

```
$1 = {it = Tree, form = {tree = Acorn, bug = Cocoon}}
```

and with **set print union off** in effect it would print

```
$1 = {it = Tree, form = {...}}
```

set print union affects programs written in C-like languages and in Pascal.

These settings are of interest when debugging C++ programs:

set print demangle
set print demangle on
 Print C++ names in their source form rather than in the encoded ("mangled") form passed to the assembler and linker for type-safe linkage. The default is on.

show print demangle
 Show whether C++ names are printed in mangled or demangled form.

set print asm-demangle
set print asm-demangle on
 Print C++ names in their source form rather than their mangled form, even in assembler code printouts such as instruction disassemblies. The default is off.

`show print asm-demangle`

Show whether C++ names in assembly listings are printed in mangled or demangled form.

`set demangle-style style`

Choose among several encoding schemes used by different compilers to represent C++ names. The choices for *style* are currently:

- `auto` Allow GDB to choose a decoding style by inspecting your program.
- `gnu` Decode based on the GNU C++ compiler (`g++`) encoding algorithm. This is the default.
- `hp` Decode based on the HP ANSI C++ (`aCC`) encoding algorithm.
- `lucid` Decode based on the Lucid C++ compiler (`lcc`) encoding algorithm.
- `arm` Decode using the algorithm in the *C++ Annotated Reference Manual*. **Warning:** this setting alone is not sufficient to allow debugging `cfront`-generated executables. GDB would require further enhancement to permit that.

If you omit *style*, you will see a list of possible formats.

`show demangle-style`

Display the encoding style currently in use for decoding C++ symbols.

`set print object`

`set print object on`

When displaying a pointer to an object, identify the *actual* (derived) type of the object rather than the *declared* type, using the virtual function table.

`set print object off`

Display only the declared type of objects, without reference to the virtual function table. This is the default setting.

`show print object`

Show whether actual, or declared, object types are displayed.

`set print static-members`

`set print static-members on`

Print static members when displaying a C++ object. The default is on.

`set print static-members off`

Do not print static members when displaying a C++ object.

`show print static-members`

Show whether C++ static members are printed or not.

`set print pascal_static-members`

`set print pascal_static-members on`

Print static members when displaying a Pascal object. The default is on.

`set print pascal_static-members off`

Do not print static members when displaying a Pascal object.

```
show print pascal_static-members
    Show whether Pascal static members are printed or not.

set print vtbl
set print vtbl on
    Pretty print C++ virtual function tables. The default is off. (The vtbl com-
    mands do not work on programs compiled with the HP ANSI C++ compiler
    (aCC).)

set print vtbl off
    Do not pretty print C++ virtual function tables.

show print vtbl
    Show whether C++ virtual function tables are pretty printed, or not.
```

10.9 Pretty Printing

GDB provides a mechanism to allow pretty-printing of values using Python code. It greatly simplifies the display of complex objects. This mechanism works for both MI and the CLI.

For example, here is how a C++ `std::string` looks without a pretty-printer:

```
(gdb) print s
$1 = {
  static npos = 4294967295,
  _M_dataplus = {
    <std::allocator<char>> = {
      <_gnu_cxx::new_allocator<char>> = {
        <No data fields>}, <No data fields>
      },
    members of std::basic_string<char, std::char_traits<char>,
      std::allocator<char> >::_Alloc_hider:
      _M_p = 0x804a014 "abcd"
  }
}
```

With a pretty-printer for `std::string` only the contents are printed:

```
(gdb) print s
$2 = "abcd"
```

For implementing pretty printers for new types you should read the Python API details (see [\(undefined\) \[Pretty Printing API\], page \(undefined\)](#)).

10.10 Value History

Values printed by the `print` command are saved in the GDB *value history*. This allows you to refer to them in other expressions. Values are kept until the symbol table is re-read or discarded (for example with the `file` or `symbol-file` commands). When the symbol table changes, the value history is discarded, since the values may contain pointers back to the types defined in the symbol table.

The values printed are given *history numbers* by which you can refer to them. These are successive integers starting with one. `print` shows you the history number assigned to a value by printing ‘`$num =`’ before the value; here *num* is the history number.

To refer to any previous value, use ‘`$`’ followed by the value’s history number. The way `print` labels its output is designed to remind you of this. Just `$` refers to the most recent

value in the history, and `$$` refers to the value before that. `$$n` refers to the *n*th value from the end; `$$2` is the value just prior to `$$`, `$$1` is equivalent to `$$`, and `$$0` is equivalent to `$`.

For example, suppose you have just printed a pointer to a structure and want to see the contents of the structure. It suffices to type

```
p *$
```

If you have a chain of structures where the component `next` points to the next one, you can print the contents of the next one with this:

```
p *$.next
```

You can print successive links in the chain by repeating this command—which you can do by just typing RET.

Note that the history records values, not expressions. If the value of `x` is 4 and you type these commands:

```
print x
set x=5
```

then the value recorded in the value history by the `print` command remains 4 even though the value of `x` has changed.

show values

Print the last ten values in the value history, with their item numbers. This is like `'p $$9'` repeated ten times, except that `show values` does not change the history.

show values n

Print ten history values centered on history item number *n*.

show values +

Print ten history values just after the values last printed. If no more values are available, `show values +` produces no display.

Pressing RET to repeat `show values n` has exactly the same effect as `'show values +'`.

10.11 Convenience Variables

GDB provides *convenience variables* that you can use within GDB to hold on to a value and refer to it later. These variables exist entirely within GDB; they are not part of your program, and setting a convenience variable has no direct effect on further execution of your program. That is why you can use them freely.

Convenience variables are prefixed with `'$'`. Any name preceded by `'$'` can be used for a convenience variable, unless it is one of the predefined machine-specific register names (see [\(undefined\) \[Registers\], page \(undefined\)](#)). (Value history references, in contrast, are *numbers* preceded by `'$'`. See [\(undefined\) \[Value History\], page \(undefined\)](#).)

You can save a value in a convenience variable with an assignment expression, just as you would set a variable in your program. For example:

```
set $foo = *object_ptr
```

would save in `$foo` the value contained in the object pointed to by `object_ptr`.

Using a convenience variable for the first time creates it, but its value is `void` until you assign a new value. You can alter the value with another assignment at any time.

Convenience variables have no fixed types. You can assign a convenience variable any type of value, including structures and arrays, even if that variable already has a value of a different type. The convenience variable, when used as an expression, has the type of its current value.

`show convenience`

Print a list of convenience variables used so far, and their values. Abbreviated `show conv`.

`init-if-undefined $variable = expression`

Set a convenience variable if it has not already been set. This is useful for user-defined commands that keep some state. It is similar, in concept, to using local static variables with initializers in C (except that convenience variables are global). It can also be used to allow users to override default values used in a command script.

If the variable is already defined then the expression is not evaluated so any side-effects do not occur.

One of the ways to use a convenience variable is as a counter to be incremented or a pointer to be advanced. For example, to print a field from successive elements of an array of structures:

```
set $i = 0
print bar[$i++]>contents
```

Repeat that command by typing RET.

Some convenience variables are created automatically by GDB and given values likely to be useful.

`$_` The variable `$_` is automatically set by the `x` command to the last address examined (see [\(undefined\) \[Examining Memory\], page \(undefined\)](#)). Other commands which provide a default address for `x` to examine also set `$_` to that address; these commands include `info line` and `info breakpoint`. The type of `$_` is `void *` except when set by the `x` command, in which case it is a pointer to the type of `$__`.

`$__` The variable `$__` is automatically set by the `x` command to the value found in the last address examined. Its type is chosen to match the format in which the data was printed.

`$_exitcode`

The variable `$_exitcode` is automatically set to the exit code when the program being debugged terminates.

`$_sdata` The variable `$_sdata` contains extra collected static tracepoint data. See [\(undefined\) \[Tracepoint Action Lists\], page \(undefined\)](#). Note that `$_sdata` could be empty, if not inspecting a trace buffer, or if extra static tracepoint data has not been collected.

`$_siginfo`

The variable `$_siginfo` contains extra signal information (see [\(undefined\) \[extra signal information\], page \(undefined\)](#)). Note that `$_siginfo` could be empty, if the application has not yet received any signals. For example, it will be empty before you execute the `run` command.

`$_tlb` The variable `$_tlb` is automatically set when debugging applications running on MS-Windows in native mode or connected to gdbserver that supports the `qGetTIBAddr` request. See [\(undefined\) \[General Query Packets\]](#), page [\(undefined\)](#). This variable contains the address of the thread information block.

On HP-UX systems, if you refer to a function or variable name that begins with a dollar sign, GDB searches for a user or system name first, before it searches for a convenience variable.

GDB also supplies some *convenience functions*. These have a syntax similar to convenience variables. A convenience function can be used in an expression just like an ordinary function; however, a convenience function is implemented internally to GDB.

`help function`

Print a list of all convenience functions.

10.12 Registers

You can refer to machine register contents, in expressions, as variables with names starting with ‘\$’. The names of registers are different for each machine; use `info registers` to see the names used on your machine.

`info registers`

Print the names and values of all registers except floating-point and vector registers (in the selected stack frame).

`info all-registers`

Print the names and values of all registers, including floating-point and vector registers (in the selected stack frame).

`info registers regname ...`

Print the *relativized* value of each specified register *regname*. As discussed in detail below, register values are normally relative to the selected stack frame. *regname* may be any register name valid on the machine you are using, with or without the initial ‘\$’.

GDB has four “standard” register names that are available (in expressions) on most machines—whenever they do not conflict with an architecture’s canonical mnemonics for registers. The register names `$pc` and `$sp` are used for the program counter register and the stack pointer. `$fp` is used for a register that contains a pointer to the current stack frame, and `$ps` is used for a register that contains the processor status. For example, you could print the program counter in hex with

```
p/x $pc
```

or print the instruction to be executed next with

```
x/i $pc
```

or add four to the stack pointer² with

² This is a way of removing one word from the stack, on machines where stacks grow downward in memory (most machines, nowadays). This assumes that the innermost stack frame is selected; setting `$sp` is not allowed when other stack frames are selected. To pop entire frames off the stack, regardless of machine architecture, use `return`; see [\(undefined\) \[Returning from a Function\]](#), page [\(undefined\)](#).

```
set $sp += 4
```

Whenever possible, these four standard register names are available on your machine even though the machine has different canonical mnemonics, so long as there is no conflict. The `info registers` command shows the canonical names. For example, on the SPARC, `info registers` displays the processor status register as `$psr` but you can also refer to it as `$ps`; and on x86-based machines `$ps` is an alias for the `EFLAGS` register.

GDB always considers the contents of an ordinary register as an integer when the register is examined in this way. Some machines have special registers which can hold nothing but floating point; these registers are considered to have floating point values. There is no way to refer to the contents of an ordinary register as floating point value (although you can *print* it as a floating point value with `'print/f $regname'`).

Some registers have distinct “raw” and “virtual” data formats. This means that the data format in which the register contents are saved by the operating system is not the same one that your program normally sees. For example, the registers of the 68881 floating point coprocessor are always saved in “extended” (raw) format, but all C programs expect to work with “double” (virtual) format. In such cases, GDB normally works with the virtual format only (the format that makes sense for your program), but the `info registers` command prints the data in both formats.

Some machines have special registers whose contents can be interpreted in several different ways. For example, modern x86-based machines have SSE and MMX registers that can hold several values packed together in several different formats. GDB refers to such registers in `struct` notation:

```
(gdb) print $xmm1
$1 = {
  v4_float = {0, 3.43859137e-038, 1.54142831e-044, 1.821688e-044},
  v2_double = {9.92129282474342e-303, 2.7585945287983262e-313},
  v16_int8 = "\000\000\000\000\03706;\001\v\000\000\000\r\000\000",
  v8_int16 = {0, 0, 14072, 315, 11, 0, 13, 0},
  v4_int32 = {0, 20657912, 11, 13},
  v2_int64 = {88725056443645952, 55834574859},
  uint128 = 0x00000000d0000000b013b36f800000000
}
```

To set values of such registers, you need to tell GDB which view of the register you wish to change, as if you were assigning value to a `struct` member:

```
(gdb) set $xmm1.uint128 = 0x00000000000000000000000000000000FFFFFFFF
```

Normally, register values are relative to the selected stack frame (see [\(undefined\)](#) [Selecting a Frame], page [\(undefined\)](#)). This means that you get the value that the register would contain if all stack frames farther in were exited and their saved registers restored. In order to see the true contents of hardware registers, you must select the innermost frame (with `'frame 0'`).

However, GDB must deduce where registers are saved, from the machine code generated by your compiler. If some registers are not saved, or if GDB is unable to locate the saved registers, the selected stack frame makes no difference.

10.13 Floating Point Hardware

Depending on the configuration, GDB may be able to give you more information about the status of the floating point hardware.

info float

Display hardware-dependent information about the floating point unit. The exact contents and layout vary depending on the floating point chip. Currently, ‘`info float`’ is supported on the ARM and x86 machines.

10.14 Vector Unit

Depending on the configuration, GDB may be able to give you more information about the status of the vector unit.

info vector

Display information about the vector unit. The exact contents and layout vary depending on the hardware.

10.15 Operating System Auxiliary Information

GDB provides interfaces to useful OS facilities that can help you debug your program.

When GDB runs on a *Posix system* (such as GNU or Unix machines), it interfaces with the inferior via the `ptrace` system call. The operating system creates a special data structure, called `struct user`, for this interface. You can use the command `info udot` to display the contents of this data structure.

info udot Display the contents of the `struct user` maintained by the OS kernel for the program being debugged. GDB displays the contents of `struct user` as a list of hex numbers, similar to the `examine` command.

Some operating systems supply an *auxiliary vector* to programs at startup. This is akin to the arguments and environment that you specify for a program, but contains a system-dependent variety of binary values that tell system libraries important details about the hardware, operating system, and process. Each value’s purpose is identified by an integer tag; the meanings are well-known but system-specific. Depending on the configuration and operating system facilities, GDB may be able to show you this information. For remote targets, this functionality may further depend on the remote stub’s support of the ‘`qXfer:auxv:read`’ packet, see [\(undefined\) \[qXfer auxiliary vector read\], page \(undefined\)](#).

info auxv Display the auxiliary vector of the inferior, which can be either a live process or a core dump file. GDB prints each tag value numerically, and also shows names and text descriptions for recognized tags. Some values in the vector are numbers, some bit masks, and some pointers to strings or other data. GDB displays each value in the most appropriate form for a recognized tag, and in hexadecimal for an unrecognized tag.

On some targets, GDB can access operating-system-specific information and display it to user, without interpretation. For remote targets, this functionality depends on the remote stub’s support of the ‘`qXfer:osdata:read`’ packet, see [\(undefined\) \[qXfer osdata read\], page \(undefined\)](#).

info os List the types of OS information available for the target. If the target does not return a list of possible types, this command will report an error.

info os processes

Display the list of processes on the target. For each process, GDB prints the process identifier, the name of the user, and the command corresponding to the process.

10.16 Memory Region Attributes

Memory region attributes allow you to describe special handling required by regions of your target's memory. GDB uses attributes to determine whether to allow certain types of memory accesses; whether to use specific width accesses; and whether to cache target memory. By default the description of memory regions is fetched from the target (if the current target supports this), but the user can override the fetched regions.

Defined memory regions can be individually enabled and disabled. When a memory region is disabled, GDB uses the default attributes when accessing memory in that region. Similarly, if no memory regions have been defined, GDB uses the default attributes when accessing all memory.

When a memory region is defined, it is given a number to identify it; to enable, disable, or remove a memory region, you specify that number.

mem lower upper attributes...

Define a memory region bounded by *lower* and *upper* with attributes *attributes...*, and add it to the list of regions monitored by GDB. Note that *upper == 0* is a special case: it is treated as the target's maximum memory address. (0xffff on 16 bit targets, 0xffffffff on 32 bit targets, etc.)

mem auto Discard any user changes to the memory regions and use target-supplied regions, if available, or no regions if the target does not support.

delete mem nums...

Remove memory regions *nums...* from the list of regions monitored by GDB.

disable mem nums...

Disable monitoring of memory regions *nums...*. A disabled memory region is not forgotten. It may be enabled again later.

enable mem nums...

Enable monitoring of memory regions *nums...*

info mem Print a table of all defined memory regions, with the following columns for each region:

Memory Region Number

Enabled or Disabled.

Enabled memory regions are marked with 'y'. Disabled memory regions are marked with 'n'.

Lo Address

The address defining the inclusive lower bound of the memory region.

Hi Address

The address defining the exclusive upper bound of the memory region.

Attributes The list of attributes set for this memory region.

10.16.1 Attributes

10.16.1.1 Memory Access Mode

The access mode attributes set whether GDB may make read or write accesses to a memory region.

While these attributes prevent GDB from performing invalid memory accesses, they do nothing to prevent the target system, I/O DMA, etc. from accessing memory.

`ro` Memory is read only.
`wo` Memory is write only.
`rw` Memory is read/write. This is the default.

10.16.1.2 Memory Access Size

The access size attribute tells GDB to use specific sized accesses in the memory region. Often memory mapped device registers require specific sized accesses. If no access size attribute is specified, GDB may use accesses of any size.

`8` Use 8 bit memory accesses.
`16` Use 16 bit memory accesses.
`32` Use 32 bit memory accesses.
`64` Use 64 bit memory accesses.

10.16.1.3 Data Cache

The data cache attributes set whether GDB will cache target memory. While this generally improves performance by reducing debug protocol overhead, it can lead to incorrect results because GDB does not know about volatile variables or memory mapped device registers.

`cache` Enable GDB to cache target memory.
`nocache` Disable GDB from caching target memory. This is the default.

10.16.2 Memory Access Checking

GDB can be instructed to refuse accesses to memory that is not explicitly described. This can be useful if accessing such regions has undesired effects for a specific target, or to provide better error checking. The following commands control this behaviour.

`set mem inaccessible-by-default [on|off]`

If `on` is specified, make GDB treat memory not explicitly described by the memory ranges as non-existent and refuse accesses to such memory. The checks are only performed if there's at least one memory range defined. If `off` is specified, make GDB treat the memory not explicitly described by the memory ranges as RAM. The default value is `on`.

`show mem inaccessible-by-default`

Show the current handling of accesses to unknown memory.

10.17 Copy Between Memory and a File

You can use the commands `dump`, `append`, and `restore` to copy data between target memory and a file. The `dump` and `append` commands write data to a file, and the `restore` command reads data from a file back into the inferior's memory. Files may be in binary, Motorola S-record, Intel hex, or Tektronix Hex format; however, GDB can only append to binary files.

```
dump [format] memory filename start_addr end_addr
dump [format] value filename expr
```

Dump the contents of memory from *start_addr* to *end_addr*, or the value of *expr*, to *filename* in the given format.

The *format* parameter may be any one of:

<code>binary</code>	Raw binary form.
<code>ihex</code>	Intel hex format.
<code>srec</code>	Motorola S-record format.
<code>tekhex</code>	Tektronix Hex format.

GDB uses the same definitions of these formats as the GNU binary utilities, like `objdump` and `objcopy`. If *format* is omitted, GDB dumps the data in raw binary form.

```
append [binary] memory filename start_addr end_addr
append [binary] value filename expr
```

Append the contents of memory from *start_addr* to *end_addr*, or the value of *expr*, to the file *filename*, in raw binary form. (GDB can only append data to files in raw binary form.)

```
restore filename [binary] bias start end
```

Restore the contents of file *filename* into memory. The `restore` command can automatically recognize any known BFD file format, except for raw binary. To restore a raw binary file you must specify the optional keyword `binary` after the filename.

If *bias* is non-zero, its value will be added to the addresses contained in the file. Binary files always start at address zero, so they will be restored at address *bias*. Other bfd files have a built-in location; they will be restored at offset *bias* from that location.

If *start* and/or *end* are non-zero, then only data between file offset *start* and file offset *end* will be restored. These offsets are relative to the addresses in the file, before the *bias* argument is applied.

10.18 How to Produce a Core File from Your Program

A *core file* or *core dump* is a file that records the memory image of a running process and its process status (register values etc.). Its primary use is post-mortem debugging of a program that crashed while it ran outside a debugger. A program that crashes automatically produces a core file, unless this feature is disabled by the user. See [\(undefined\) \[Files\]](#), page [\(undefined\)](#), for information on invoking GDB in the post-mortem debugging mode.

Occasionally, you may wish to produce a core file of the program you are debugging in order to preserve a snapshot of its state. GDB has a special command for that.

`generate-core-file [file]`

`gcore [file]`

Produce a core dump of the inferior process. The optional argument *file* specifies the file name where to put the core dump. If not specified, the file name defaults to `core.pid`, where *pid* is the inferior process ID.

Note that this command is implemented only for some systems (as of this writing, GNU/Linux, FreeBSD, Solaris, Unixware, and S390).

10.19 Character Sets

If the program you are debugging uses a different character set to represent characters and strings than the one GDB uses itself, GDB can automatically translate between the character sets for you. The character set GDB uses we call the *host character set*; the one the inferior program uses we call the *target character set*.

For example, if you are running GDB on a GNU/Linux system, which uses the ISO Latin 1 character set, but you are using GDB's remote protocol (see [\[Remote Debugging\]](#), page [\(undefined\)](#)) to debug a program running on an IBM mainframe, which uses the EBCDIC character set, then the host character set is Latin-1, and the target character set is EBCDIC. If you give GDB the command `set target-charset EBCDIC-US`, then GDB translates between EBCDIC and Latin 1 as you print character or string values, or use character and string literals in expressions.

GDB has no way to automatically recognize which character set the inferior program uses; you must tell it, using the `set target-charset` command, described below.

Here are the commands for controlling GDB's character set support:

`set target-charset charset`

Set the current target character set to *charset*. To display the list of supported target character sets, type `set target-charset TABTAB`.

`set host-charset charset`

Set the current host character set to *charset*.

By default, GDB uses a host character set appropriate to the system it is running on; you can override that default using the `set host-charset` command. On some systems, GDB cannot automatically determine the appropriate host character set. In this case, GDB uses `'UTF-8'`.

GDB can only use certain character sets as its host character set. If you type `set target-charset TABTAB`, GDB will list the host character sets it supports.

`set charset charset`

Set the current host and target character sets to *charset*. As above, if you type `set charset TABTAB`, GDB will list the names of the character sets that can be used for both host and target.

`show charset`

Show the names of the current host and target character sets.

`show host-charset`

Show the name of the current host character set.

`show target-charset`

Show the name of the current target character set.

`set target-wide-charset charset`

Set the current target's wide character set to *charset*. This is the character set used by the target's `wchar_t` type. To display the list of supported wide character sets, type `set target-wide-charset TABTAB`.

`show target-wide-charset`

Show the name of the current target's wide character set.

Here is an example of GDB's character set support in action. Assume that the following source code has been placed in the file `'charset-test.c'`:

```
#include <stdio.h>

char ascii_hello[]
= {72, 101, 108, 108, 111, 44, 32, 119,
  111, 114, 108, 100, 33, 10, 0};
char ibm1047_hello[]
= {200, 133, 147, 147, 150, 107, 64, 166,
  150, 153, 147, 132, 90, 37, 0};

main ()
{
  printf ("Hello, world!\n");
}
```

In this program, `ascii_hello` and `ibm1047_hello` are arrays containing the string `'Hello, world!'` followed by a newline, encoded in the ASCII and IBM1047 character sets.

We compile the program, and invoke the debugger on it:

```
$ gcc -g charset-test.c -o charset-test
$ gdb -nw charset-test
GNU gdb 2001-12-19-cvs
Copyright 2001 Free Software Foundation, Inc.
...
(gdb)
```

We can use the `show charset` command to see what character sets GDB is currently using to interpret and display characters and strings:

```
(gdb) show charset
The current host and target character set is 'ISO-8859-1'.
(gdb)
```

For the sake of printing this manual, let's use ASCII as our initial character set:

```
(gdb) set charset ASCII
(gdb) show charset
The current host and target character set is 'ASCII'.
(gdb)
```

Let's assume that ASCII is indeed the correct character set for our host system — in other words, let's assume that if GDB prints characters using the ASCII character set, our terminal will display them properly. Since our current target character set is also ASCII, the contents of `ascii_hello` print legibly:

```
(gdb) print ascii_hello
$1 = 0x401698 "Hello, world!\n"
(gdb) print ascii_hello[0]
$2 = 72 'H'
(gdb)
```

GDB uses the target character set for character and string literals you use in expressions:

```
(gdb) print '+'
$3 = 43 '+'
(gdb)
```

The ASCII character set uses the number 43 to encode the '+' character.

GDB relies on the user to tell it which character set the target program uses. If we print `ibm1047_hello` while our target character set is still ASCII, we get jibberish:

```
(gdb) print ibm1047_hello
$4 = 0x4016a8 "\310\205\223\223\226k@\246\226\231\223\204Z%"
(gdb) print ibm1047_hello[0]
$5 = 200 '\310'
(gdb)
```

If we invoke the `set target-charset` followed by `TABTAB`, GDB tells us the character sets it supports:

```
(gdb) set target-charset
ASCII      EBCDIC-US  IBM1047    ISO-8859-1
(gdb) set target-charset
```

We can select `IBM1047` as our target character set, and examine the program's strings again. Now the ASCII string is wrong, but GDB translates the contents of `ibm1047_hello` from the target character set, `IBM1047`, to the host character set, `ASCII`, and they display correctly:

```
(gdb) set target-charset IBM1047
(gdb) show charset
The current host character set is 'ASCII'.
The current target character set is 'IBM1047'.
(gdb) print ascii_hello
$6 = 0x401698 "\110\145%?\054\040\167?\162%\144\041\012"
(gdb) print ascii_hello[0]
$7 = 72 '\110'
(gdb) print ibm1047_hello
$8 = 0x4016a8 "Hello, world!\n"
(gdb) print ibm1047_hello[0]
$9 = 200 'H'
(gdb)
```

As above, GDB uses the target character set for character and string literals you use in expressions:

```
(gdb) print '+'
$10 = 78 '+'
(gdb)
```

The `IBM1047` character set uses the number 78 to encode the '+' character.

10.20 Caching Data of Remote Targets

GDB caches data exchanged between the debugger and a remote target (see [\[Remote Debugging\]](#), page [\[Remote Debugging\]](#)). Such caching generally improves performance, because it reduces the overhead of the remote protocol by bundling memory reads and writes

into large chunks. Unfortunately, simply caching everything would lead to incorrect results, since GDB does not necessarily know anything about volatile values, memory-mapped I/O addresses, etc. Furthermore, in non-stop mode (see [\(undefined\) \[Non-Stop Mode\], page \(undefined\)](#)) memory can be changed *while* a gdb command is executing. Therefore, by default, GDB only caches data known to be on the stack³. Other regions of memory can be explicitly marked as cacheable; see see [\(undefined\) \[Memory Region Attributes\], page \(undefined\)](#).

`set remotecache on`

`set remotecache off`

This option no longer does anything; it exists for compatibility with old scripts.

`show remotecache`

Show the current state of the obsolete remotecache flag.

`set stack-cache on`

`set stack-cache off`

Enable or disable caching of stack accesses. When ON, use caching. By default, this option is ON.

`show stack-cache`

Show the current state of data caching for memory accesses.

`info dcache [line]`

Print the information about the data cache performance. The information displayed includes the dcache width and depth, and for each cache line, its number, address, and how many times it was referenced. This command is useful for debugging the data cache operation.

If a line number is specified, the contents of that line will be printed in hex.

10.21 Search Memory

Memory can be searched for a particular sequence of bytes with the `find` command.

`find [/sn] start_addr, +len, val1 [, val2, ...]`

`find [/sn] start_addr, end_addr, val1 [, val2, ...]`

Search memory for the sequence of bytes specified by `val1`, `val2`, etc. The search begins at address `start_addr` and continues for either `len` bytes or through to `end_addr` inclusive.

`s` and `n` are optional parameters. They may be specified in either order, apart or together.

`s`, search query size

The size of each search query value.

`b` bytes

`h` halfwords (two bytes)

`w` words (four bytes)

`g` giant words (eight bytes)

³ In non-stop mode, it is moderately rare for a running thread to modify the stack of a stopped thread in a way that would interfere with a backtrace, and caching of stack reads provides a significant speed up of remote backtraces.

All values are interpreted in the current language. This means, for example, that if the current source language is C/C++ then searching for the string “hello” includes the trailing ‘\0’.

If the value size is not specified, it is taken from the value’s type in the current language. This is useful when one wants to specify the search pattern as a mixture of types. Note that this means, for example, that in the case of C-like languages a search for an untyped 0x42 will search for ‘(int) 0x42’ which is typically four bytes.

n, maximum number of finds

The maximum number of matches to print. The default is to print all finds.

You can use strings as search values. Quote them with double-quotes (“). The string value is copied into the search pattern byte by byte, regardless of the endianness of the target and the size specification.

The address of each match found is printed as well as a count of the number of matches found.

The address of the last value found is stored in convenience variable ‘\$’. A count of the number of matches is stored in ‘\$numfound’.

For example, if stopped at the `printf` in this function:

```
void
hello ()
{
    static char hello[] = "hello-hello";
    static struct { char c; short s; int i; }
    __attribute__((packed)) mixed
    = { 'c', 0x1234, 0x87654321 };
    printf ("%s\n", hello);
}
```

you get during debugging:

```
(gdb) find &hello[0], +sizeof(hello), "hello"
0x804956d <hello.1620+6>
1 pattern found
(gdb) find &hello[0], +sizeof(hello), 'h', 'e', 'l', 'l', 'o'
0x8049567 <hello.1620>
0x804956d <hello.1620+6>
2 patterns found
(gdb) find /b1 &hello[0], +sizeof(hello), 'h', 0x65, 'l'
0x8049567 <hello.1620>
1 pattern found
(gdb) find &mixed, +sizeof(mixed), (char) 'c', (short) 0x1234, (int) 0x87654321
0x8049560 <mixed.1625>
1 pattern found
(gdb) print $numfound
$1 = 1
(gdb) print $_
$2 = (void *) 0x8049560
```


11 Debugging Optimized Code

Almost all compilers support optimization. With optimization disabled, the compiler generates assembly code that corresponds directly to your source code, in a simplistic way. As the compiler applies more powerful optimizations, the generated assembly code diverges from your original source code. With help from debugging information generated by the compiler, GDB can map from the running program back to constructs from your original source.

GDB is more accurate with optimization disabled. If you can recompile without optimization, it is easier to follow the progress of your program during debugging. But, there are many cases where you may need to debug an optimized version.

When you debug a program compiled with ‘`-g -O`’, remember that the optimizer has rearranged your code; the debugger shows you what is really there. Do not be too surprised when the execution path does not exactly match your source file! An extreme example: if you define a variable, but never use it, GDB never sees that variable—because the compiler optimizes it out of existence.

Some things do not work as well with ‘`-g -O`’ as with just ‘`-g`’, particularly on machines with instruction scheduling. If in doubt, recompile with ‘`-g`’ alone, and if this fixes the problem, please report it to us as a bug (including a test case!). See [\(undefined\) \[Variables\], page \(undefined\)](#), for more information about debugging optimized code.

11.1 Inline Functions

Inlining is an optimization that inserts a copy of the function body directly at each call site, instead of jumping to a shared routine. GDB displays inlined functions just like non-inlined functions. They appear in backtraces. You can view their arguments and local variables, step into them with `step`, skip them with `next`, and escape from them with `finish`. You can check whether a function was inlined by using the `info frame` command.

For GDB to support inlined functions, the compiler must record information about inlining in the debug information — GCC using the DWARF 2 format does this, and several other compilers do also. GDB only supports inlined functions when using DWARF 2. Versions of GCC before 4.1 do not emit two required attributes (‘`DW_AT_call_file`’ and ‘`DW_AT_call_line`’); GDB does not display inlined function calls with earlier versions of GCC. It instead displays the arguments and local variables of inlined functions as local variables in the caller.

The body of an inlined function is directly included at its call site; unlike a non-inlined function, there are no instructions devoted to the call. GDB still pretends that the call site and the start of the inlined function are different instructions. Stepping to the call site shows the call site, and then stepping again shows the first line of the inlined function, even though no additional instructions are executed.

This makes source-level debugging much clearer; you can see both the context of the call and then the effect of the call. Only stepping by a single instruction using `stepi` or `nexti` does not do this; single instruction steps always show the inlined body.

There are some ways that GDB does not pretend that inlined function calls are the same as normal calls:

- You cannot set breakpoints on inlined functions. GDB either reports that there is no symbol with that name, or else sets the breakpoint only on non-inlined copies of the function. This limitation will be removed in a future version of GDB; until then, set a breakpoint by line number on the first line of the inlined function instead.
- Setting breakpoints at the call site of an inlined function may not work, because the call site does not contain any code. GDB may incorrectly move the breakpoint to the next line of the enclosing function, after the call. This limitation will be removed in a future version of GDB; until then, set a breakpoint on an earlier line or inside the inlined function instead.
- GDB cannot locate the return value of inlined calls after using the `finish` command. This is a limitation of compiler-generated debugging information; after `finish`, you can step to the next line and print a variable where your program stored the return value.

12 C Preprocessor Macros

Some languages, such as C and C++, provide a way to define and invoke “preprocessor macros” which expand into strings of tokens. GDB can evaluate expressions containing macro invocations, show the result of macro expansion, and show a macro’s definition, including where it was defined.

You may need to compile your program specially to provide GDB with information about preprocessor macros. Most compilers do not include macros in their debugging information, even when you compile with the ‘-g’ flag. See [\(undefined\) \[Compilation\], page \(undefined\)](#).

A program may define a macro at one point, remove that definition later, and then provide a different definition after that. Thus, at different points in the program, a macro may have different definitions, or have no definition at all. If there is a current stack frame, GDB uses the macros in scope at that frame’s source code line. Otherwise, GDB uses the macros in scope at the current listing location; see [\(undefined\) \[List\], page \(undefined\)](#).

Whenever GDB evaluates an expression, it always expands any macro invocations present in the expression. GDB also provides the following commands for working with macros explicitly.

macro expand *expression*

macro exp *expression*

Show the results of expanding all preprocessor macro invocations in *expression*. Since GDB simply expands macros, but does not parse the result, *expression* need not be a valid expression; it can be any string of tokens.

macro expand-once *expression*

macro exp1 *expression*

(This command is not yet implemented.) Show the results of expanding those preprocessor macro invocations that appear explicitly in *expression*. Macro invocations appearing in that expansion are left unchanged. This command allows you to see the effect of a particular macro more clearly, without being confused by further expansions. Since GDB simply expands macros, but does not parse the result, *expression* need not be a valid expression; it can be any string of tokens.

info macro *macro*

Show the definition of the macro named *macro*, and describe the source location or compiler command-line where that definition was established.

macro define *macro replacement-list*

macro define *macro(arglist) replacement-list*

Introduce a definition for a preprocessor macro named *macro*, invocations of which are replaced by the tokens given in *replacement-list*. The first form of this command defines an “object-like” macro, which takes no arguments; the second form defines a “function-like” macro, which takes the arguments given in *arglist*.

A definition introduced by this command is in scope in every expression evaluated in GDB, until it is removed with the **macro undef** command, described below. The definition overrides all definitions for *macro* present in the program being debugged, as well as any previous user-supplied definition.

macro undef *macro*

Remove any user-supplied definition for the macro named *macro*. This command only affects definitions provided with the **macro define** command, described above; it cannot remove definitions present in the program being debugged.

macro list

List all the macros defined using the **macro define** command.

Here is a transcript showing the above commands in action. First, we show our source files:

```
$ cat sample.c
#include <stdio.h>
#include "sample.h"

#define M 42
#define ADD(x) (M + x)

main ()
{
#define N 28
    printf ("Hello, world!\n");
#undef N
    printf ("We're so creative.\n");
#define N 1729
    printf ("Goodbye, world!\n");
}
$ cat sample.h
#define Q <
$
```

Now, we compile the program using the GNU C compiler, GCC. We pass the ‘-gdwarf-2’ and ‘-g3’ flags to ensure the compiler includes information about preprocessor macros in the debugging information.

```
$ gcc -gdwarf-2 -g3 sample.c -o sample
$
```

Now, we start GDB on our sample program:

```
$ gdb -nw sample
GNU gdb 2002-05-06-cvs
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, ...
(gdb)
```

We can expand macros and examine their definitions, even when the program is not running. GDB uses the current listing position to decide which macro definitions are in scope:

```
(gdb) list main
3
4     #define M 42
5     #define ADD(x) (M + x)
6
7     main ()
8     {
9     #define N 28
10    printf ("Hello, world!\n");
11    #undef N
```

```

12      printf ("We're so creative.\n");
(gdb) info macro ADD
Defined at /home/jimb/gdb/macros/play/sample.c:5
#define ADD(x) (M + x)
(gdb) info macro Q
Defined at /home/jimb/gdb/macros/play/sample.h:1
  included at /home/jimb/gdb/macros/play/sample.c:2
#define Q <
(gdb) macro expand ADD(1)
expands to: (42 + 1)
(gdb) macro expand-once ADD(1)
expands to: once (M + 1)
(gdb)

```

In the example above, note that macro `expand-once` expands only the macro invocation explicit in the original text — the invocation of `ADD` — but does not expand the invocation of the macro `M`, which was introduced by `ADD`.

Once the program is running, GDB uses the macro definitions in force at the source line of the current stack frame:

```

(gdb) break main
Breakpoint 1 at 0x8048370: file sample.c, line 10.
(gdb) run
Starting program: /home/jimb/gdb/macros/play/sample

Breakpoint 1, main () at sample.c:10
10      printf ("Hello, world!\n");
(gdb)

```

At line 10, the definition of the macro `N` at line 9 is in force:

```

(gdb) info macro N
Defined at /home/jimb/gdb/macros/play/sample.c:9
#define N 28
(gdb) macro expand N Q M
expands to: 28 < 42
(gdb) print N Q M
$1 = 1
(gdb)

```

As we step over directives that remove `N`'s definition, and then give it a new definition, GDB finds the definition (or lack thereof) in force at each point:

```

(gdb) next
Hello, world!
12      printf ("We're so creative.\n");
(gdb) info macro N
The symbol 'N' has no definition as a C/C++ preprocessor macro
at /home/jimb/gdb/macros/play/sample.c:12
(gdb) next
We're so creative.
14      printf ("Goodbye, world!\n");
(gdb) info macro N
Defined at /home/jimb/gdb/macros/play/sample.c:13
#define N 1729
(gdb) macro expand N Q M
expands to: 1729 < 42
(gdb) print N Q M
$2 = 0
(gdb)

```

In addition to source files, macros can be defined on the compilation command line using the `'-Dname=value'` syntax. For macros defined in such a way, GDB displays the location of their definition as line zero of the source file submitted to the compiler.

```
(gdb) info macro __STDC__  
Defined at /home/jimb/gdb/macros/play/sample.c:0  
-D__STDC__=1  
(gdb)
```

13 Tracepoints

In some applications, it is not feasible for the debugger to interrupt the program's execution long enough for the developer to learn anything helpful about its behavior. If the program's correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to change its behavior drastically, or perhaps fail, even when the code itself is correct. It is useful to be able to observe the program's behavior without interrupting it.

Using GDB's `trace` and `collect` commands, you can specify locations in the program, called *tracepoints*, and arbitrary expressions to evaluate when those tracepoints are reached. Later, using the `tfind` command, you can examine the values those expressions had when the program hit the tracepoints. The expressions may also denote objects in memory—structures or arrays, for example—whose values GDB should record; while visiting a particular tracepoint, you may inspect those objects as if they were in memory at that moment. However, because GDB records these values without interacting with you, it can do so quickly and unobtrusively, hopefully not disturbing the program's behavior.

The tracepoint facility is currently available only for remote targets. See [\(undefined\) \[Targets\], page \(undefined\)](#). In addition, your remote target must know how to collect trace data. This functionality is implemented in the remote stub; however, none of the stubs distributed with GDB support tracepoints as of this writing. The format of the remote packets used to implement tracepoints are described in [\(undefined\) \[Tracepoint Packets\], page \(undefined\)](#).

It is also possible to get trace data from a file, in a manner reminiscent of corefiles; you specify the filename, and use `tfind` to search through the file. See [\(undefined\) \[Trace Files\], page \(undefined\)](#), for more details.

This chapter describes the tracepoint commands and features.

13.1 Commands to Set Tracepoints

Before running such a *trace experiment*, an arbitrary number of tracepoints can be set. A tracepoint is actually a special type of breakpoint (see [\(undefined\) \[Set Breaks\], page \(undefined\)](#)), so you can manipulate it using standard breakpoint commands. For instance, as with breakpoints, tracepoint numbers are successive integers starting from one, and many of the commands associated with tracepoints take the tracepoint number as their argument, to identify which tracepoint to work on.

For each tracepoint, you can specify, in advance, some arbitrary set of data that you want the target to collect in the trace buffer when it hits that tracepoint. The collected data can include registers, local variables, or global data. Later, you can use GDB commands to examine the values these data had at the time the tracepoint was hit.

Tracepoints do not support every breakpoint feature. Ignore counts on tracepoints have no effect, and tracepoints cannot run GDB commands when they are hit. Tracepoints may not be thread-specific either.

Some targets may support *fast tracepoints*, which are inserted in a different way (such as with a jump instead of a trap), that is faster but possibly restricted in where they may be installed.

Regular and fast tracepoints are dynamic tracing facilities, meaning that they can be used to insert tracepoints at (almost) any location in the target. Some targets may also support controlling *static tracepoints* from GDB. With static tracing, a set of instrumentation points, also known as *markers*, are embedded in the target program, and can be activated or deactivated by name or address. These are usually placed at locations which facilitate investigating what the target is actually doing. GDB's support for static tracing includes being able to list instrumentation points, and attach them with GDB defined high level tracepoints that expose the whole range of convenience of GDB's tracepoints support. Namely, support for collecting registers values and values of global or local (to the instrumentation point) variables; tracepoint conditions and trace state variables. The act of installing a GDB static tracepoint on an instrumentation point, or marker, is referred to as *probing* a static tracepoint marker.

`gdbserver` supports tracepoints on some target systems. See [\(undefined\) \[Tracepoints support in gdbserver\], page \(undefined\)](#).

This section describes commands to set tracepoints and associated conditions and actions.

13.1.1 Create and Delete Tracepoints

`trace location`

The `trace` command is very similar to the `break` command. Its argument *location* can be a source line, a function name, or an address in the target program. See [\(undefined\) \[Specify Location\], page \(undefined\)](#). The `trace` command defines a tracepoint, which is a point in the target program where the debugger will briefly stop, collect some data, and then allow the program to continue. Setting a tracepoint or changing its actions doesn't take effect until the next `tstart` command, and once a trace experiment is running, further changes will not have any effect until the next trace experiment starts.

Here are some examples of using the `trace` command:

```
(gdb) trace foo.c:121    // a source file and line number

(gdb) trace +2          // 2 lines forward

(gdb) trace my_function // first source line of function

(gdb) trace *my_function // EXACT start address of function

(gdb) trace *0x2117c4   // an address
```

You can abbreviate `trace` as `tr`.

`trace location if cond`

Set a tracepoint with condition *cond*; evaluate the expression *cond* each time the tracepoint is reached, and collect data only if the value is nonzero—that is, if *cond* evaluates as true. See [\(undefined\) \[Tracepoint Conditions\], page \(undefined\)](#), for more information on tracepoint conditions.

`ftrace location [if cond]`

The `ftrace` command sets a fast tracepoint. For targets that support them, fast tracepoints will use a more efficient but possibly less general technique to

trigger data collection, such as a jump instruction instead of a trap, or some sort of hardware support. It may not be possible to create a fast tracepoint at the desired location, in which case the command will exit with an explanatory message.

GDB handles arguments to `ftrace` exactly as for `trace`.

`strace location [if cond]`

The `strace` command sets a static tracepoint. For targets that support it, setting a static tracepoint probes a static instrumentation point, or marker, found at *location*. It may not be possible to set a static tracepoint at the desired location, in which case the command will exit with an explanatory message.

GDB handles arguments to `strace` exactly as for `trace`, with the addition that the user can also specify `-m marker` as *location*. This probes the marker identified by the *marker* string identifier. This identifier depends on the static tracepoint backend library your program is using. You can find all the marker identifiers in the ‘ID’ field of the `info static-tracepoint-markers` command output. See [\[Listing Static Tracepoint Markers\]](#), page [\[undefined\]](#). For example, in the following small program using the UST tracing engine:

```
main ()
{
    trace_mark(ust, bar33, "str %s", "FOOBAZ");
}
```

the marker id is composed of joining the first two arguments to the `trace_mark` call with a slash, which translates to:

```
(gdb) info static-tracepoint-markers
Cnt Enb ID          Address          What
1   n   ust/bar33 0x000000000400ddc in main at stexample.c:22
      Data: "str %s"
[etc...]
```

so you may probe the marker above with:

```
(gdb) strace -m ust/bar33
```

Static tracepoints accept an extra collect action — `collect $_sdata`. This collects arbitrary user data passed in the probe point call to the tracing library. In the UST example above, you’ll see that the third argument to `trace_mark` is a printf-like format string. The user data is then the result of running that formatting string against the following arguments. Note that `info static-tracepoint-markers` command output lists that format string in the ‘Data:’ field.

You can inspect this data when analyzing the trace buffer, by printing the `$_sdata` variable like any other variable available to GDB. See [\[Tracepoint Action Lists\]](#), page [\[undefined\]](#).

The convenience variable `$tptime` records the tracepoint number of the most recently set tracepoint.

delete tracepoint [*num*]

Permanently delete one or more tracepoints. With no argument, the default is to delete all tracepoints. Note that the regular `delete` command can remove tracepoints also.

Examples:

```
(gdb) delete trace 1 2 3 // remove three tracepoints
```

```
(gdb) delete trace      // remove all tracepoints
```

You can abbreviate this command as `del tr`.

13.1.2 Enable and Disable Tracepoints

These commands are deprecated; they are equivalent to plain `disable` and `enable`.

disable tracepoint [*num*]

Disable tracepoint *num*, or all tracepoints if no argument *num* is given. A disabled tracepoint will have no effect during the next trace experiment, but it is not forgotten. You can re-enable a disabled tracepoint using the `enable tracepoint` command.

enable tracepoint [*num*]

Enable tracepoint *num*, or all tracepoints. The enabled tracepoints will become effective the next time a trace experiment is run.

13.1.3 Tracepoint Passcounts

passcount [*n* [*num*]]

Set the *passcount* of a tracepoint. The passcount is a way to automatically stop a trace experiment. If a tracepoint's passcount is *n*, then the trace experiment will be automatically stopped on the *n*'th time that tracepoint is hit. If the tracepoint number *num* is not specified, the `passcount` command sets the passcount of the most recently defined tracepoint. If no passcount is given, the trace experiment will run until stopped explicitly by the user.

Examples:

```
(gdb) passcount 5 2 // Stop on the 5th execution of
                  // tracepoint 2
```

```
(gdb) passcount 12 // Stop on the 12th execution of the
                  // most recently defined tracepoint.
```

```
(gdb) trace foo
```

```
(gdb) pass 3
```

```
(gdb) trace bar
```

```
(gdb) pass 2
```

```
(gdb) trace baz
```

```
(gdb) pass 1 // Stop tracing when foo has been
             // executed 3 times OR when bar has
             // been executed 2 times
             // OR when baz has been executed 1 time.
```

13.1.4 Tracepoint Conditions

The simplest sort of tracepoint collects data every time your program reaches a specified place. You can also specify a *condition* for a tracepoint. A condition is just a Boolean

expression in your programming language (see [\(undefined\) \[Expressions\]](#), page [\(undefined\)](#)). A tracepoint with a condition evaluates the expression each time your program reaches it, and data collection happens only if the condition is true.

Tracepoint conditions can be specified when a tracepoint is set, by using ‘if’ in the arguments to the `trace` command. See [\(undefined\) \[Setting Tracepoints\]](#), page [\(undefined\)](#). They can also be set or changed at any time with the `condition` command, just as with breakpoints.

Unlike breakpoint conditions, GDB does not actually evaluate the conditional expression itself. Instead, GDB encodes the expression into an agent expression (see [\(undefined\) \[Agent Expressions\]](#), page [\(undefined\)](#) suitable for execution on the target, independently of GDB. Global variables become raw memory locations, locals become stack accesses, and so forth.

For instance, suppose you have a function that is usually called frequently, but should not be called after an error has occurred. You could use the following tracepoint command to collect data about calls of that function that happen while the error code is propagating through the program; an unconditional tracepoint could end up collecting thousands of useless trace frames that you would have to search through.

```
(gdb) trace normal_operation if errcode > 0
```

13.1.5 Trace State Variables

A *trace state variable* is a special type of variable that is created and managed by target-side code. The syntax is the same as that for GDB’s convenience variables (a string prefixed with “\$”), but they are stored on the target. They must be created explicitly, using a `tvariable` command. They are always 64-bit signed integers.

Trace state variables are remembered by GDB, and downloaded to the target along with tracepoint information when the trace experiment starts. There are no intrinsic limits on the number of trace state variables, beyond memory limitations of the target.

Although trace state variables are managed by the target, you can use them in print commands and expressions as if they were convenience variables; GDB will get the current value from the target while the trace experiment is running. Trace state variables share the same namespace as other “\$” variables, which means that you cannot have trace state variables with names like \$23 or \$pc, nor can you have a trace state variable and a convenience variable with the same name.

```
tvariable $name [ = expression ]
```

The `tvariable` command creates a new trace state variable named `$name`, and optionally gives it an initial value of `expression`. `expression` is evaluated when this command is entered; the result will be converted to an integer if possible, otherwise GDB will report an error. A subsequent `tvariable` command specifying the same name does not create a variable, but instead assigns the supplied initial value to the existing variable of that name, overwriting any previous initial value. The default initial value is 0.

```
info tvariables
```

List all the trace state variables along with their initial values. Their current values may also be displayed, if the trace experiment is currently running.

```
delete tvariable [ $name ... ]
```

Delete the given trace state variables, or all of them if no arguments are specified.

13.1.6 Tracepoint Action Lists

```
actions [num]
```

This command will prompt for a list of actions to be taken when the tracepoint is hit. If the tracepoint number *num* is not specified, this command sets the actions for the one that was most recently defined (so that you can define a tracepoint and then say `actions` without bothering about its number). You specify the actions themselves on the following lines, one action at a time, and terminate the actions list with a line containing just `end`. So far, the only defined actions are `collect`, `teval`, and `while-stepping`.

`actions` is actually equivalent to `commands` (see [\(undefined\) \[Breakpoint Command Lists\]](#), page [\(undefined\)](#)), except that only the defined actions are allowed; any other GDB command is rejected.

To remove all actions from a tracepoint, type `'actions num'` and follow it immediately with `'end'`.

```
(gdb) collect data // collect some data

(gdb) while-stepping 5 // single-step 5 times, collect data

(gdb) end // signals the end of actions.
```

In the following example, the action list begins with `collect` commands indicating the things to be collected when the tracepoint is hit. Then, in order to single-step and collect additional data following the tracepoint, a `while-stepping` command is used, followed by the list of things to be collected after each step in a sequence of single steps. The `while-stepping` command is terminated by its own separate `end` command. Lastly, the action list is terminated by an `end` command.

```
(gdb) trace foo
(gdb) actions
Enter actions for tracepoint 1, one per line:
> collect bar,baz
> collect $regs
> while-stepping 12
  > collect $pc, arr[i]
  > end
end
```

```
collect expr1, expr2, ...
```

Collect values of the given expressions when the tracepoint is hit. This command accepts a comma-separated list of any valid expressions. In addition to global, static, or local variables, the following special arguments are supported:

```
$regs    Collect all registers.
$args    Collect all function arguments.
$locals  Collect all local variables.
```

`$_sdata` Collect static tracepoint marker specific data. Only available for static tracepoints. See [\(undefined\) \[Tracepoint Action Lists\], page \(undefined\)](#). On the UST static tracepoints library backend, an instrumentation point resembles a `printf` function call. The tracing library is able to collect user specified data formatted to a character string using the format provided by the programmer that instrumented the program. Other backends have similar mechanisms. Here's an example of a UST marker call:

```
const char master_name[] = "$your_name";
trace_mark(channel1, marker1, "hello %s", master_name)
```

In this case, collecting `$_sdata` collects the string `'hello $yourname'`. When analyzing the trace buffer, you can inspect `'$_sdata'` like any other variable available to GDB.

You can give several consecutive `collect` commands, each one with a single argument, or one `collect` command with several arguments separated by commas; the effect is the same.

The command `info scope` (see [\(undefined\) \[Symbols\], page \(undefined\)](#)) is particularly useful for figuring out what data to collect.

`teval expr1, expr2, ...`

Evaluate the given expressions when the tracepoint is hit. This command accepts a comma-separated list of expressions. The results are discarded, so this is mainly useful for assigning values to trace state variables (see [\(undefined\) \[Trace State Variables\], page \(undefined\)](#)) without adding those values to the trace buffer, as would be the case if the `collect` action were used.

`while-stepping n`

Perform *n* single-step instruction traces after the tracepoint, collecting new data after each step. The `while-stepping` command is followed by the list of what to collect while stepping (followed by its own `end` command):

```
> while-stepping 12
> collect $regs, myglobal
> end
>
```

Note that `$pc` is not automatically collected by `while-stepping`; you need to explicitly collect that register if you need it. You may abbreviate `while-stepping` as `ws` or `stepping`.

`set default-collect expr1, expr2, ...`

This variable is a list of expressions to collect at each tracepoint hit. It is effectively an additional `collect` action prepended to every tracepoint action list. The expressions are parsed individually for each tracepoint, so for instance a variable named `xyz` may be interpreted as a global for one tracepoint, and a local for another, as appropriate to the tracepoint's location.

`show default-collect`

Show the list of expressions that are collected by default at each tracepoint hit.

13.1.7 Listing Tracepoints

`info tracepoints [num]`

Display information about the tracepoint *num*. If you don't specify a tracepoint number, displays information about all the tracepoints defined so far. The format is similar to that used for `info breakpoints`; in fact, `info tracepoints` is the same command, simply restricting itself to tracepoints.

A tracepoint's listing may include additional information specific to tracing:

- its passcount as given by the `passcount n` command

```
(gdb) info trace
Num      Type          Disp Enb Address      What
1       tracepoint    keep y  0x0804ab57  in foo() at main.cxx:7
      while-stepping 20
      collect globfoo, $regs
      end
      collect globfoo2
      end
      pass count 1200
(gdb)
```

This command can be abbreviated `info tp`.

13.1.8 Listing Static Tracepoint Markers

`info static-tracepoint-markers`

Display information about all static tracepoint markers defined in the program.

For each marker, the following columns are printed:

Count An incrementing counter, output to help readability. This is not a stable identifier.

ID The marker ID, as reported by the target.

Enabled or Disabled
Probed markers are tagged with 'y'. 'n' identifies marks that are not enabled.

Address Where the marker is in your program, as a memory address.

What Where the marker is in the source for your program, as a file and line number. If the debug information included in the program does not allow GDB to locate the source of the marker, this column will be left blank.

In addition, the following information may be printed for each marker:

Data User data passed to the tracing library by the marker call. In the UST backend, this is the format string passed as argument to the marker call.

Static tracepoints probing the marker

The list of static tracepoints attached to the marker.

```
(gdb) info static-tracepoint-markers
Cnt ID      Enb Address      What
1   ust/bar2  y   0x000000000400e1a  in main at stexample.c:25
```

```

      Data: number1 %d number2 %d
      Probed by static tracepoints: #2
2  ust/bar33 n 0x000000000400c87 in main at stexample.c:24
      Data: str %s
(gdb)

```

13.1.9 Starting and Stopping Trace Experiments

tstart This command takes no arguments. It starts the trace experiment, and begins collecting data. This has the side effect of discarding all the data collected in the trace buffer during the previous trace experiment.

tstop This command takes no arguments. It ends the trace experiment, and stops collecting data.

Note: a trace experiment and data collection may stop automatically if any tracepoint's passcount is reached (see [\(undefined\) \[Tracepoint Passcounts\]](#), page [\(undefined\)](#)), or if the trace buffer becomes full.

tstatus This command displays the status of the current trace data collection.

Here is an example of the commands we described so far:

```

(gdb) trace gdb.c_test
(gdb) actions
Enter actions for tracepoint #1, one per line.
> collect $regs,$locals,$args
> while-stepping 11
> collect $regs
> end
> end
(gdb) tstart
[time passes ...]
(gdb) tstop

```

You can choose to continue running the trace experiment even if GDB disconnects from the target, voluntarily or involuntarily. For commands such as `detach`, the debugger will ask what you want to do with the trace. But for unexpected terminations (GDB crash, network outage), it would be unfortunate to lose hard-won trace data, so the variable `disconnected-tracing` lets you decide whether the trace should continue running without GDB.

`set disconnected-tracing on`

`set disconnected-tracing off`

Choose whether a tracing run should continue to run if GDB has disconnected from the target. Note that `detach` or `quit` will ask you directly what to do about a running trace no matter what this variable's setting, so the variable is mainly useful for handling unexpected situations, such as loss of the network.

`show disconnected-tracing`

Show the current choice for disconnected tracing.

When you reconnect to the target, the trace experiment may or may not still be running; it might have filled the trace buffer in the meantime, or stopped for one of the other reasons. If it is running, it will continue after reconnection.

Upon reconnection, the target will upload information about the tracepoints in effect. GDB will then compare that information to the set of tracepoints currently defined, and

attempt to match them up, allowing for the possibility that the numbers may have changed due to creation and deletion in the meantime. If one of the target's tracepoints does not match any in GDB, the debugger will create a new tracepoint, so that you have a number with which to specify that tracepoint. This matching-up process is necessarily heuristic, and it may result in useless tracepoints being created; you may simply delete them if they are of no use.

If your target agent supports a *circular trace buffer*, then you can run a trace experiment indefinitely without filling the trace buffer; when space runs out, the agent deletes already-collected trace frames, oldest first, until there is enough room to continue collecting. This is especially useful if your tracepoints are being hit too often, and your trace gets terminated prematurely because the buffer is full. To ask for a circular trace buffer, simply set `'circular_trace_buffer'` to on. You can set this at any time, including during tracing; if the agent can do it, it will change buffer handling on the fly, otherwise it will not take effect until the next run.

```
set circular-trace-buffer on
set circular-trace-buffer off
```

Choose whether a tracing run should use a linear or circular buffer for trace data. A linear buffer will not lose any trace data, but may fill up prematurely, while a circular buffer will discard old trace data, but it will have always room for the latest tracepoint hits.

```
show circular-trace-buffer
```

Show the current choice for the trace buffer. Note that this may not match the agent's current buffer handling, nor is it guaranteed to match the setting that might have been in effect during a past run, for instance if you are looking at frames from a trace file.

13.1.10 Tracepoint Restrictions

There are a number of restrictions on the use of tracepoints. As described above, tracepoint data gathering occurs on the target without interaction from GDB. Thus the full capabilities of the debugger are not available during data gathering, and then at data examination time, you will be limited by only having what was collected. The following items describe some common problems, but it is not exhaustive, and you may run into additional difficulties not mentioned here.

- Tracepoint expressions are intended to gather objects (lvalues). Thus the full flexibility of GDB's expression evaluator is not available. You cannot call functions, cast objects to aggregate types, access convenience variables or modify values (except by assignment to trace state variables). Some language features may implicitly call functions (for instance Objective-C fields with accessors), and therefore cannot be collected either.
- Collection of local variables, either individually or in bulk with `$locals` or `$args`, during `while-stepping` may behave erratically. The stepping action may enter a new scope (for instance by stepping into a function), or the location of the variable may change (for instance it is loaded into a register). The tracepoint data recorded uses the location information for the variables that is correct for the tracepoint location. When the tracepoint is created, it is not possible, in general, to determine where the steps

of a `while-stepping` sequence will advance the program—particularly if a conditional branch is stepped.

- Collection of an incompletely-initialized or partially-destroyed object may result in something that GDB cannot display, or displays in a misleading way.
- When GDB displays a pointer to character it automatically dereferences the pointer to also display characters of the string being pointed to. However, collecting the pointer during tracing does not automatically collect the string. You need to explicitly dereference the pointer and provide size information if you want to collect not only the pointer, but the memory pointed to. For example, `*ptr@50` can be used to collect the 50 element array pointed to by `ptr`.
- It is not possible to collect a complete stack backtrace at a tracepoint. Instead, you may collect the registers and a few hundred bytes from the stack pointer with something like `*$esp@300` (adjust to use the name of the actual stack pointer register on your target architecture, and the amount of stack you wish to capture). Then the `backtrace` command will show a partial backtrace when using a trace frame. The number of stack frames that can be examined depends on the sizes of the frames in the collected stack. Note that if you ask for a block so large that it goes past the bottom of the stack, the target agent may report an error trying to read from an invalid address.
- If you do not collect registers at a tracepoint, GDB can infer that the value of `$pc` must be the same as the address of the tracepoint and use that when you are looking at a trace frame for that tracepoint. However, this cannot work if the tracepoint has multiple locations (for instance if it was set in a function that was inlined), or if it has a `while-stepping` loop. In those cases GDB will warn you that it can't infer `$pc`, and default it to zero.

13.2 Using the Collected Data

After the tracepoint experiment ends, you use GDB commands for examining the trace data. The basic idea is that each tracepoint collects a trace *snapshot* every time it is hit and another snapshot every time it single-steps. All these snapshots are consecutively numbered from zero and go into a buffer, and you can examine them later. The way you examine them is to *focus* on a specific trace snapshot. When the remote stub is focused on a trace snapshot, it will respond to all GDB requests for memory and registers by reading from the buffer which belongs to that snapshot, rather than from *real* memory or registers of the program being debugged. This means that **all** GDB commands (`print`, `info registers`, `backtrace`, etc.) will behave as if we were currently debugging the program state as it was when the tracepoint occurred. Any requests for data that are not in the buffer will fail.

13.2.1 `tfind n`

The basic command for selecting a trace snapshot from the buffer is `tfind n`, which finds trace snapshot number `n`, counting from zero. If no argument `n` is given, the next snapshot is selected.

Here are the various forms of using the `tfind` command.

`tfind start`

Find the first snapshot in the buffer. This is a synonym for `tfind 0` (since 0 is the number of the first snapshot).

tfind none
Stop debugging trace snapshots, resume *live* debugging.

tfind end Same as ‘**tfind none**’.

tfind No argument means find the next trace snapshot.

tfind - Find the previous trace snapshot before the current one. This permits retracing earlier steps.

tfind tracepoint *num*
Find the next snapshot associated with tracepoint *num*. Search proceeds forward from the last examined trace snapshot. If no argument *num* is given, it means find the next snapshot collected for the same tracepoint as the current snapshot.

tfind pc *addr*
Find the next snapshot associated with the value *addr* of the program counter. Search proceeds forward from the last examined trace snapshot. If no argument *addr* is given, it means find the next snapshot with the same value of PC as the current snapshot.

tfind outside *addr1*, *addr2*
Find the next snapshot whose PC is outside the given range of addresses (exclusive).

tfind range *addr1*, *addr2*
Find the next snapshot whose PC is between *addr1* and *addr2* (inclusive).

tfind line [*file*]:*n*
Find the next snapshot associated with the source line *n*. If the optional argument *file* is given, refer to line *n* in that source file. Search proceeds forward from the last examined trace snapshot. If no argument *n* is given, it means find the next line other than the one currently being examined; thus saying **tfind line** repeatedly can appear to have the same effect as stepping from line to line in a *live* debugging session.

The default arguments for the **tfind** commands are specifically designed to make it easy to scan through the trace buffer. For instance, **tfind** with no argument selects the next trace snapshot, and **tfind -** with no argument selects the previous trace snapshot. So, by giving one **tfind** command, and then simply hitting RET repeatedly you can examine all the trace snapshots in order. Or, by saying **tfind -** and then hitting RET repeatedly you can examine the snapshots in reverse order. The **tfind line** command with no argument selects the snapshot for the next source line executed. The **tfind pc** command with no argument selects the next snapshot with the same program counter (PC) as the current frame. The **tfind tracepoint** command with no argument selects the next trace snapshot collected by the same tracepoint as the current one.

In addition to letting you scan through the trace buffer manually, these commands make it easy to construct GDB scripts that scan through the trace buffer and print out whatever collected data you are interested in. Thus, if we want to examine the PC, FP, and SP registers from each trace frame in the buffer, we can say this:

```
(gdb) tfind start
(gdb) while ($trace_frame != -1)
> printf "Frame %d, PC = %08X, SP = %08X, FP = %08X\n", \
    $trace_frame, $pc, $sp, $fp
> tfind
> end

Frame 0, PC = 0020DC64, SP = 0030BF3C, FP = 0030BF44
Frame 1, PC = 0020DC6C, SP = 0030BF38, FP = 0030BF44
Frame 2, PC = 0020DC70, SP = 0030BF34, FP = 0030BF44
Frame 3, PC = 0020DC74, SP = 0030BF30, FP = 0030BF44
Frame 4, PC = 0020DC78, SP = 0030BF2C, FP = 0030BF44
Frame 5, PC = 0020DC7C, SP = 0030BF28, FP = 0030BF44
Frame 6, PC = 0020DC80, SP = 0030BF24, FP = 0030BF44
Frame 7, PC = 0020DC84, SP = 0030BF20, FP = 0030BF44
Frame 8, PC = 0020DC88, SP = 0030BF1C, FP = 0030BF44
Frame 9, PC = 0020DC8E, SP = 0030BF18, FP = 0030BF44
Frame 10, PC = 00203F6C, SP = 0030BE3C, FP = 0030BF14
```

Or, if we want to examine the variable X at each source line in the buffer:

```
(gdb) tfind start
(gdb) while ($trace_frame != -1)
> printf "Frame %d, X == %d\n", $trace_frame, X
> tfind line
> end

Frame 0, X = 1
Frame 7, X = 2
Frame 13, X = 255
```

13.2.2 tdump

This command takes no arguments. It prints all the data collected at the current trace snapshot.

```
(gdb) trace 444
(gdb) actions
Enter actions for tracepoint #2, one per line:
> collect $regs, $locals, $args, gdb_long_test
> end

(gdb) tstart

(gdb) tfind line 444
#0 gdb_test (p1=0x11, p2=0x22, p3=0x33, p4=0x44, p5=0x55, p6=0x66)
at gdb_test.c:444
444     printp( "%s: arguments = 0x%X 0x%X 0x%X 0x%X 0x%X 0x%X\n", )

(gdb) tdump
Data collected at tracepoint 2, trace frame 1:
d0          0xc4aa0085      -995491707
d1          0x18          24
d2          0x80          128
d3          0x33          51
d4          0x71aea3d       119204413
d5          0x22          34
d6          0xe0          224
d7          0x380035     3670069
a0          0x19e24a     1696330
```

```

a1          0x3000668      50333288
a2          0x100      256
a3          0x322000 3284992
a4          0x3000698      50333336
a5          0x1ad3cc 1758156
fp          0x30bf3c 0x30bf3c
sp          0x30bf34 0x30bf34
ps          0x0      0
pc          0x20b2c8 0x20b2c8
fpcontrol  0x0      0
fpstatus   0x0      0
fpiaddr    0x0      0
p = 0x20e5b4 "gdb-test"
p1 = (void *) 0x11
p2 = (void *) 0x22
p3 = (void *) 0x33
p4 = (void *) 0x44
p5 = (void *) 0x55
p6 = (void *) 0x66
gdb_long_test = 17 '\021'

```

(gdb)

`tdump` works by scanning the tracepoint's current collection actions and printing the value of each expression listed. So `tdump` can fail, if after a run, you change the tracepoint's actions to mention variables that were not collected during the run.

Also, for tracepoints with `while-stepping` loops, `tdump` uses the collected value of `$pc` to distinguish between trace frames that were collected at the tracepoint hit, and frames that were collected while stepping. This allows it to correctly choose whether to display the basic list of collections, or the collections from the body of the while-stepping loop. However, if `$pc` was not collected, then `tdump` will always attempt to dump using the basic collection list, and may fail if a while-stepping frame does not include all the same data that is collected at the tracepoint hit.

13.2.3 save tracepoints *filename*

This command saves all current tracepoint definitions together with their actions and passcounts, into a file '*filename*' suitable for use in a later debugging session. To read the saved tracepoint definitions, use the `source` command (see [\(undefined\) \[Command Files\], page \(undefined\)](#)). The `save-tracepoints` command is a deprecated alias for `save tracepoints`

13.3 Convenience Variables for Tracepoints

(int) `$trace_frame`

The current trace snapshot (a.k.a. *frame*) number, or -1 if no snapshot is selected.

(int) `$tracepoint`

The tracepoint for the current trace snapshot.

(int) `$trace_line`

The line number for the current trace snapshot.

```
(char []) $trace_file
```

The source file for the current trace snapshot.

```
(char []) $trace_func
```

The name of the function containing `$tracepoint`.

Note: `$trace_file` is not suitable for use in `printf`, use `output` instead.

Here's a simple example of using these convenience variables for stepping through all the trace snapshots and printing some of their data. Note that these are not the same as trace state variables, which are managed by the target.

```
(gdb) tfind start

(gdb) while $trace_frame != -1
> output $trace_file
> printf ", line %d (tracepoint #%d)\n", $trace_line, $tracepoint
> tfind
> end
```

13.4 Using Trace Files

In some situations, the target running a trace experiment may no longer be available; perhaps it crashed, or the hardware was needed for a different activity. To handle these cases, you can arrange to dump the trace data into a file, and later use that file as a source of trace data, via the `target tfile` command.

```
tsave [ -r ] filename
```

Save the trace data to *filename*. By default, this command assumes that *filename* refers to the host filesystem, so if necessary GDB will copy raw trace data up from the target and then save it. If the target supports it, you can also supply the optional argument `-r` (“remote”) to direct the target to save the data directly into *filename* in its own filesystem, which may be more efficient if the trace buffer is very large. (Note, however, that `target tfile` can only read from files accessible to the host.)

```
target tfile filename
```

Use the file named *filename* as a source of trace data. Commands that examine data work as they do with a live target, but it is not possible to run any new trace experiments. `tstatus` will report the state of the trace run at the moment the data was saved, as well as the current trace frame you are examining. *filename* must be on a filesystem accessible to the host.

14 Debugging Programs That Use Overlays

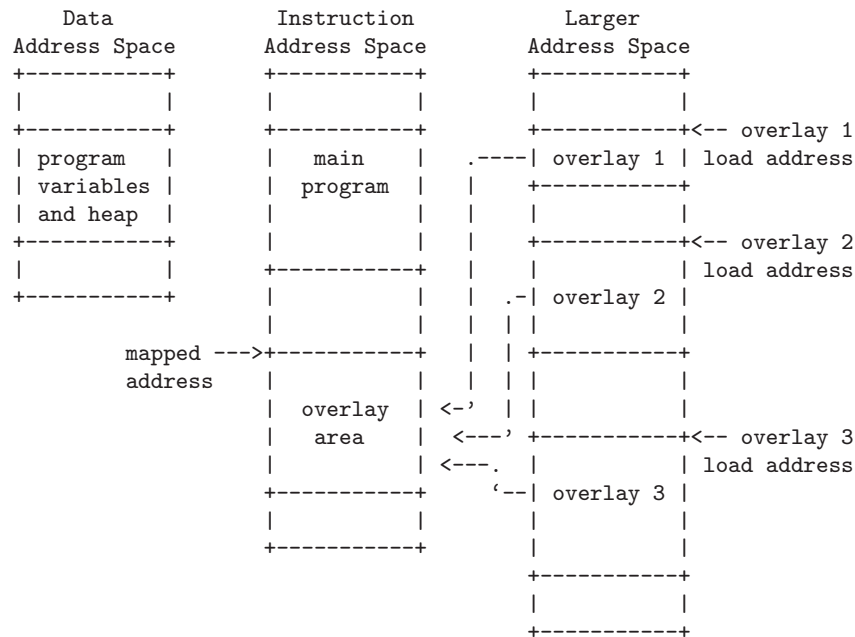
If your program is too large to fit completely in your target system's memory, you can sometimes use *overlays* to work around this problem. GDB provides some support for debugging programs that use overlays.

14.1 How Overlays Work

Suppose you have a computer whose instruction address space is only 64 kilobytes long, but which has much more memory which can be accessed by other means: special instructions, segment registers, or memory management hardware, for example. Suppose further that you want to adapt a program which is larger than 64 kilobytes to run on this system.

One solution is to identify modules of your program which are relatively independent, and need not call each other directly; call these modules *overlays*. Separate the overlays from the main program, and place their machine code in the larger memory. Place your main program in instruction memory, but leave at least enough space there to hold the largest overlay as well.

Now, to call a function located in an overlay, you must first copy that overlay's machine code from the large memory into the space set aside for it in the instruction memory, and then jump to its entry point there.



A code overlay

The diagram (see [\[A code overlay\]](#), page [\[undefined\]](#)) shows a system with separate data and instruction address spaces. To map an overlay, the program copies its code from the larger address space to the instruction address space. Since the overlays shown here all use the same mapped address, only one may be mapped at a time. For a system with a single address space for data and instructions, the diagram would be similar, except that the program variables and heap would share an address space with the main program and the overlay area.

An overlay loaded into instruction memory and ready for use is called a *mapped* overlay; its *mapped address* is its address in the instruction memory. An overlay not present (or only partially present) in instruction memory is called *unmapped*; its *load address* is its address in the larger memory. The mapped address is also called the *virtual memory address*, or *VMA*; the load address is also called the *load memory address*, or *LMA*.

Unfortunately, overlays are not a completely transparent way to adapt a program to limited instruction memory. They introduce a new set of global constraints you must keep in mind as you design your program:

- Before calling or returning to a function in an overlay, your program must make sure that overlay is actually mapped. Otherwise, the call or return will transfer control to the right address, but in the wrong overlay, and your program will probably crash.
- If the process of mapping an overlay is expensive on your system, you will need to choose your overlays carefully to minimize their effect on your program's performance.
- The executable file you load onto your system must contain each overlay's instructions, appearing at the overlay's load address, not its mapped address. However, each overlay's instructions must be relocated and its symbols defined as if the overlay were at its mapped address. You can use GNU linker scripts to specify different load and relocation addresses for pieces of your program; see [section "Overlay Description" in *Using ld: the GNU linker*](#).
- The procedure for loading executable files onto your system must be able to load their contents into the larger address space as well as the instruction and data spaces.

The overlay system described above is rather simple, and could be improved in many ways:

- If your system has suitable bank switch registers or memory management hardware, you could use those facilities to make an overlay's load area contents simply appear at their mapped address in instruction space. This would probably be faster than copying the overlay to its mapped area in the usual way.
- If your overlays are small enough, you could set aside more than one overlay area, and have more than one overlay mapped at a time.
- You can use overlays to manage data, as well as instructions. In general, data overlays are even less transparent to your design than code overlays: whereas code overlays only require care when you call or return to functions, data overlays require care every time you access the data. Also, if you change the contents of a data overlay, you must copy its contents back out to its load address before you can copy a different data overlay into the same mapped area.

14.2 Overlay Commands

To use GDB's overlay support, each overlay in your program must correspond to a separate section of the executable file. The section's virtual memory address and load memory address must be the overlay's mapped and load addresses. Identifying overlays with sections allows GDB to determine the appropriate address of a function or variable, depending on whether the overlay is mapped or not.

GDB's overlay commands all start with the word `overlay`; you can abbreviate this as `ov` or `ovly`. The commands are:

overlay off

Disable GDB's overlay support. When overlay support is disabled, GDB assumes that all functions and variables are always present at their mapped addresses. By default, GDB's overlay support is disabled.

overlay manual

Enable *manual* overlay debugging. In this mode, GDB relies on you to tell it which overlays are mapped, and which are not, using the `overlay map-overlay` and `overlay unmap-overlay` commands described below.

overlay map-overlay *overlay***overlay map *overlay***

Tell GDB that *overlay* is now mapped; *overlay* must be the name of the object file section containing the overlay. When an overlay is mapped, GDB assumes it can find the overlay's functions and variables at their mapped addresses. GDB assumes that any other overlays whose mapped ranges overlap that of *overlay* are now unmapped.

overlay unmap-overlay *overlay***overlay unmap *overlay***

Tell GDB that *overlay* is no longer mapped; *overlay* must be the name of the object file section containing the overlay. When an overlay is unmapped, GDB assumes it can find the overlay's functions and variables at their load addresses.

overlay auto

Enable *automatic* overlay debugging. In this mode, GDB consults a data structure the overlay manager maintains in the inferior to see which overlays are mapped. For details, see [\[Automatic Overlay Debugging\]](#), page [\(undefined\)](#).

overlay load-target**overlay load**

Re-read the overlay table from the inferior. Normally, GDB re-reads the table GDB automatically each time the inferior stops, so this command should only be necessary if you have changed the overlay mapping yourself using GDB. This command is only useful when using automatic overlay debugging.

overlay list-overlays**overlay list**

Display a list of the overlays currently mapped, along with their mapped addresses, load addresses, and sizes.

Normally, when GDB prints a code address, it includes the name of the function the address falls in:

```
(gdb) print main
$3 = {int ()} 0x11a0 <main>
```

When overlay debugging is enabled, GDB recognizes code in unmapped overlays, and prints the names of unmapped functions with asterisks around them. For example, if `foo` is a function in an unmapped overlay, GDB prints it this way:

```
(gdb) overlay list
No sections are mapped.
```

```
(gdb) print foo
$5 = {int (int)} 0x100000 <*foo*>
```

When `foo`'s overlay is mapped, GDB prints the function's name normally:

```
(gdb) overlay list
Section .ov.foo.text, loaded at 0x100000 - 0x100034,
    mapped at 0x1016 - 0x104a
(gdb) print foo
$6 = {int (int)} 0x1016 <foo>
```

When overlay debugging is enabled, GDB can find the correct address for functions and variables in an overlay, whether or not the overlay is mapped. This allows most GDB commands, like `break` and `disassemble`, to work normally, even on unmapped code. However, GDB's breakpoint support has some limitations:

- You can set breakpoints in functions in unmapped overlays, as long as GDB can write to the overlay at its load address.
- GDB can not set hardware or simulator-based breakpoints in unmapped overlays. However, if you set a breakpoint at the end of your overlay manager (and tell GDB which overlays are now mapped, if you are using manual overlay management), GDB will re-set its breakpoints properly.

14.3 Automatic Overlay Debugging

GDB can automatically track which overlays are mapped and which are not, given some simple co-operation from the overlay manager in the inferior. If you enable automatic overlay debugging with the `overlay auto` command (see [\(undefined\) \[Overlay Commands\], page \(undefined\)](#)), GDB looks in the inferior's memory for certain variables describing the current state of the overlays.

Here are the variables your overlay manager must define to support GDB's automatic overlay debugging:

`_ovly_table`:

This variable must be an array of the following structures:

```
struct
{
    /* The overlay's mapped address. */
    unsigned long vma;

    /* The size of the overlay, in bytes. */
    unsigned long size;

    /* The overlay's load address. */
    unsigned long lma;

    /* Non-zero if the overlay is currently mapped;
       zero otherwise. */
    unsigned long mapped;
}
```

`_novlys`: This variable must be a four-byte signed integer, holding the total number of elements in `_ovly_table`.

To decide whether a particular overlay is mapped or not, GDB looks for an entry in `_ovly_table` whose `vma` and `lma` members equal the VMA and LMA of the overlay's section

in the executable file. When GDB finds a matching entry, it consults the entry's `mapped` member to determine whether the overlay is currently mapped.

In addition, your overlay manager may define a function called `_ovly_debug_event`. If this function is defined, GDB will silently set a breakpoint there. If the overlay manager then calls this function whenever it has changed the overlay table, this will enable GDB to accurately keep track of which overlays are in program memory, and update any breakpoints that may be set in overlays. This will allow breakpoints to work even if the overlays are kept in ROM or other non-writable memory while they are not being executed.

14.4 Overlay Sample Program

When linking a program which uses overlays, you must place the overlays at their load addresses, while relocating them to run at their mapped addresses. To do this, you must write a linker script (see [section “Overlay Description” in *Using ld: the GNU linker*](#)). Unfortunately, since linker scripts are specific to a particular host system, target architecture, and target memory layout, this manual cannot provide portable sample code demonstrating GDB's overlay support.

However, the GDB source distribution does contain an overlaid program, with linker scripts for a few systems, as part of its test suite. The program consists of the following files from `'gdb/testsuite/gdb.base'`:

```
'overlays.c'
    The main program file.

'ovlymgr.c'
    A simple overlay manager, used by 'overlays.c'.

'foo.c'
'bar.c'
'baz.c'
'grbx.c'  Overlay modules, loaded and used by 'overlays.c'.

'd10v.ld'
'm32r.ld' Linker scripts for linking the test program on the d10v-elf and m32r-elf
          targets.
```

You can build the test program using the `d10v-elf` GCC cross-compiler like this:

```
$ d10v-elf-gcc -g -c overlays.c
$ d10v-elf-gcc -g -c ovlymgr.c
$ d10v-elf-gcc -g -c foo.c
$ d10v-elf-gcc -g -c bar.c
$ d10v-elf-gcc -g -c baz.c
$ d10v-elf-gcc -g -c grbx.c
$ d10v-elf-gcc -g overlays.o ovlymgr.o foo.o bar.o \
    baz.o grbx.o -Wl,-Td10v.ld -o overlays
```

The build process is identical for any other architecture, except that you must substitute the appropriate compiler and linker script for the target system for `d10v-elf-gcc` and `d10v.ld`.

15 Using GDB with Different Languages

Although programming languages generally have common aspects, they are rarely expressed in the same manner. For instance, in ANSI C, dereferencing a pointer `p` is accomplished by `*p`, but in Modula-2, it is accomplished by `p^`. Values can also be represented (and displayed) differently. Hex numbers in C appear as `'0x1ae'`, while in Modula-2 they appear as `'1AEH'`.

Language-specific information is built into GDB for some languages, allowing you to express operations like the above in your program's native language, and allowing GDB to output values in a manner consistent with the syntax of your program's native language. The language you use to build expressions is called the *working language*.

15.1 Switching Between Source Languages

There are two ways to control the working language—either have GDB set it automatically, or select it manually yourself. You can use the `set language` command for either purpose. On startup, GDB defaults to setting the language automatically. The working language is used to determine how expressions you type are interpreted, how values are printed, etc.

In addition to the working language, every source file that GDB knows about has its own working language. For some object file formats, the compiler might indicate which language a particular source file is in. However, most of the time GDB infers the language from the name of the file. The language of a source file controls whether C++ names are demangled—this way `backtrace` can show each frame appropriately for its own language. There is no way to set the language of a source file from within GDB, but you can set the language associated with a filename extension. See [\(undefined\) \[Displaying the Language\], page \(undefined\)](#).

This is most commonly a problem when you use a program, such as `cf` or `f2c`, that generates C but is written in another language. In that case, make the program use `#line` directives in its C output; that way GDB will know the correct language of the source code of the original program, and will display that source code, not the generated C code.

15.1.1 List of Filename Extensions and Languages

If a source file name ends in one of the following extensions, then GDB infers that its language is the one indicated.

```
' .ada'
' .ads'
' .adb'
' .a'      Ada source file.
' .c'      C source file
' .C'
' .cc'
' .cp'
' .cpp'
' .cxx'
' .c++'    C++ source file
```

<code>‘.d’</code>	D source file
<code>‘.m’</code>	Objective-C source file
<code>‘.f’</code>	
<code>‘.F’</code>	Fortran source file
<code>‘.mod’</code>	Modula-2 source file
<code>‘.s’</code>	
<code>‘.S’</code>	Assembler source file. This actually behaves almost like C, but GDB does not skip over function prologues when stepping.

In addition, you may set the language associated with a filename extension. See [\(undefined\)](#) [Displaying the Language], page [\(undefined\)](#).

15.1.2 Setting the Working Language

If you allow GDB to set the language automatically, expressions are interpreted the same way in your debugging session and your program.

If you wish, you may set the language manually. To do this, issue the command `‘set language lang’`, where *lang* is the name of a language, such as `c` or `modula-2`. For a list of the supported languages, type `‘set language’`.

Setting the language manually prevents GDB from updating the working language automatically. This can lead to confusion if you try to debug a program when the working language is not the same as the source language, when an expression is acceptable to both languages—but means different things. For instance, if the current source file were written in C, and GDB was parsing Modula-2, a command such as:

```
print a = b + c
```

might not have the effect you intended. In C, this means to add `b` and `c` and place the result in `a`. The result printed would be the value of `a`. In Modula-2, this means to compare `a` to the result of `b+c`, yielding a `BOOLEAN` value.

15.1.3 Having GDB Infer the Source Language

To have GDB set the working language automatically, use `‘set language local’` or `‘set language auto’`. GDB then infers the working language. That is, when your program stops in a frame (usually by encountering a breakpoint), GDB sets the working language to the language recorded for the function in that frame. If the language for a frame is unknown (that is, if the function or block corresponding to the frame was defined in a source file that does not have a recognized extension), the current working language is not changed, and GDB issues a warning.

This may not seem necessary for most programs, which are written entirely in one source language. However, program modules and libraries written in one source language can be used by a main program written in a different source language. Using `‘set language auto’` in this case frees you from having to set the working language manually.

15.2 Displaying the Language

The following commands help you find out which language is the working language, and also what language source files were written in.

show language

Display the current working language. This is the language you can use with commands such as **print** to build and compute expressions that may involve variables in your program.

info frame

Display the source language for this frame. This language becomes the working language if you use an identifier from this frame. See [⟨undefined⟩ \[Information about a Frame\]](#), page [⟨undefined⟩](#), to identify the other information listed here.

info source

Display the source language of this source file. See [⟨undefined⟩ \[Examining the Symbol Table\]](#), page [⟨undefined⟩](#), to identify the other information listed here.

In unusual circumstances, you may have source files with extensions not in the standard list. You can then set the extension associated with a language explicitly:

set extension-language *ext language*

Tell GDB that source files with extension *ext* are to be assumed as written in the source language *language*.

info extensions

List all the filename extensions and the associated languages.

15.3 Type and Range Checking

Warning: In this release, the GDB commands for type and range checking are included, but they do not yet have any effect. This section documents the intended facilities.

Some languages are designed to guard you against making seemingly common errors through a series of compile- and run-time checks. These include checking the type of arguments to functions and operators, and making sure mathematical overflows are caught at run time. Checks such as these help to ensure a program's correctness once it has been compiled by eliminating type mismatches, and providing active checks for range errors when your program is running.

GDB can check for conditions like the above if you wish. Although GDB does not check the statements in your program, it can check expressions entered directly into GDB for evaluation via the **print** command, for example. As with the working language, GDB can also decide whether or not to check automatically based on your program's source language. See [⟨undefined⟩ \[Supported Languages\]](#), page [⟨undefined⟩](#), for the default settings of supported languages.

15.3.1 An Overview of Type Checking

Some languages, such as Modula-2, are strongly typed, meaning that the arguments to operators and functions have to be of the correct type, otherwise an error occurs. These checks prevent type mismatch errors from ever causing any run-time problems. For example,

$1 + 2 \Rightarrow 3$

but

error $1 + 2.3$

The second example fails because the `CARDINAL 1` is not type-compatible with the `REAL 2.3`.

For the expressions you use in GDB commands, you can tell the GDB type checker to skip checking; to treat any mismatches as errors and abandon the expression; or to only issue warnings when type mismatches occur, but evaluate the expression anyway. When you choose the last of these, GDB evaluates expressions like the second example above, but also issues a warning.

Even if you turn type checking off, there may be other reasons related to type that prevent GDB from evaluating an expression. For instance, GDB does not know how to add an `int` and a `struct foo`. These particular type errors have nothing to do with the language in use, and usually arise from expressions, such as the one described above, which make little sense to evaluate anyway.

Each language defines to what degree it is strict about type. For instance, both Modula-2 and C require the arguments to arithmetical operators to be numbers. In C, enumerated types and pointers can be represented as numbers, so that they are valid arguments to mathematical operators. See [\(undefined\) \[Supported Languages\], page \(undefined\)](#), for further details on specific languages.

GDB provides some additional commands for controlling the type checker:

set check type auto

Set type checking on or off based on the current working language. See [\(undefined\) \[Supported Languages\], page \(undefined\)](#), for the default settings for each language.

set check type on

set check type off

Set type checking on or off, overriding the default setting for the current working language. Issue a warning if the setting does not match the language default. If any type mismatches occur in evaluating an expression while type checking is on, GDB prints a message and aborts evaluation of the expression.

set check type warn

Cause the type checker to issue warnings, but to always attempt to evaluate the expression. Evaluating the expression may still be impossible for other reasons. For example, GDB cannot add numbers and structures.

show type Show the current setting of the type checker, and whether or not GDB is setting it automatically.

15.3.2 An Overview of Range Checking

In some languages (such as Modula-2), it is an error to exceed the bounds of a type; this is enforced with run-time checks. Such range checking is meant to ensure program correctness by making sure computations do not overflow, or indices on an array element access do not exceed the bounds of the array.

For expressions you use in GDB commands, you can tell GDB to treat range errors in one of three ways: ignore them, always treat them as errors and abandon the expression, or issue warnings but evaluate the expression anyway.

A range error can result from numerical overflow, from exceeding an array index bound, or when you type a constant that is not a member of any type. Some languages, however, do not treat overflows as an error. In many implementations of C, mathematical overflow causes the result to “wrap around” to lower values—for example, if m is the largest integer value, and s is the smallest, then

$$m + 1 \Rightarrow s$$

This, too, is specific to individual languages, and in some cases specific to individual compilers or machines. See [\[Supported Languages\]](#), page [\[Supported Languages\]](#), for further details on specific languages.

GDB provides some additional commands for controlling the range checker:

set check range auto

Set range checking on or off based on the current working language. See [\[Supported Languages\]](#), page [\[Supported Languages\]](#), for the default settings for each language.

set check range on

set check range off

Set range checking on or off, overriding the default setting for the current working language. A warning is issued if the setting does not match the language default. If a range error occurs and range checking is on, then a message is printed and evaluation of the expression is aborted.

set check range warn

Output messages when the GDB range checker detects a range error, but attempt to evaluate the expression anyway. Evaluating the expression may still be impossible for other reasons, such as accessing memory that the process does not own (a typical example from many Unix systems).

show range

Show the current setting of the range checker, and whether or not it is being set automatically by GDB.

15.4 Supported Languages

GDB supports C, C++, D, Objective-C, Fortran, Java, Pascal, assembly, Modula-2, and Ada. Some GDB features may be used in expressions regardless of the language you use: the GDB `@` and `::` operators, and the `{type}addr` construct (see [\[Expressions\]](#), page [\[Expressions\]](#)) can be used with the constructs of any supported language.

The following sections detail to what degree each source language is supported by GDB. These sections are not meant to be language tutorials or references, but serve only as a reference guide to what the GDB expression parser accepts, and what input and output formats should look like for different languages. There are many good books written on each of these languages; please look to these for a language reference or tutorial.

15.4.1 C and C++

Since C and C++ are so closely related, many features of GDB apply to both languages. Whenever this is the case, we discuss those languages together.

The C++ debugging facilities are jointly implemented by the C++ compiler and GDB. Therefore, to debug your C++ code effectively, you must compile your C++ programs with a supported C++ compiler, such as GNU `g++`, or the HP ANSI C++ compiler (`aCC`).

For best results when using GNU C++, use the DWARF 2 debugging format; if it doesn't work on your system, try the stabs+ debugging format. You can select those formats explicitly with the `g++` command-line options `'-gdwarf-2'` and `'-gstabs+'`. See [section "Options for Debugging Your Program or GCC" in *Using the GNU Compiler Collection \(GCC\)*](#).

15.4.1.1 C and C++ Operators

Operators must be defined on values of specific types. For instance, `+` is defined on numbers, but not on structures. Operators are often defined on groups of types.

For the purposes of C and C++, the following definitions hold:

- *Integral types* include `int` with any of its storage-class specifiers; `char`; `enum`; and, for C++, `bool`.
- *Floating-point types* include `float`, `double`, and `long double` (if supported by the target platform).
- *Pointer types* include all types defined as `(type *)`.
- *Scalar types* include all of the above.

The following operators are supported. They are listed here in order of increasing precedence:

<code>,</code>	The comma or sequencing operator. Expressions in a comma-separated list are evaluated from left to right, with the result of the entire expression being the last expression evaluated.
<code>=</code>	Assignment. The value of an assignment expression is the value assigned. Defined on scalar types.
<code>op=</code>	Used in an expression of the form <code>a op= b</code> , and translated to <code>a = a op b</code> . <code>op=</code> and <code>=</code> have the same precedence. <code>op</code> is any one of the operators <code> </code> , <code>^</code> , <code>&</code> , <code><<</code> , <code>>></code> , <code>+</code> , <code>-</code> , <code>*</code> , <code>/</code> , <code>%</code> .
<code>?:</code>	The ternary operator. <code>a ? b : c</code> can be thought of as: if <code>a</code> then <code>b</code> else <code>c</code> . <code>a</code> should be of an integral type.
<code> </code>	Logical OR. Defined on integral types.
<code>&&</code>	Logical AND. Defined on integral types.
<code> </code>	Bitwise OR. Defined on integral types.
<code>^</code>	Bitwise exclusive-OR. Defined on integral types.
<code>&</code>	Bitwise AND. Defined on integral types.
<code>==, !=</code>	Equality and inequality. Defined on scalar types. The value of these expressions is 0 for false and non-zero for true.
<code><, >, <=, >=</code>	Less than, greater than, less than or equal, greater than or equal. Defined on scalar types. The value of these expressions is 0 for false and non-zero for true.

<<, >>	left shift, and right shift. Defined on integral types.
@	The GDB “artificial array” operator (see (undefined) [Expressions], page (undefined)).
+, -	Addition and subtraction. Defined on integral types, floating-point types and pointer types.
*, /, %	Multiplication, division, and modulus. Multiplication and division are defined on integral and floating-point types. Modulus is defined on integral types.
++, --	Increment and decrement. When appearing before a variable, the operation is performed before the variable is used in an expression; when appearing after it, the variable’s value is used before the operation takes place.
*	Pointer dereferencing. Defined on pointer types. Same precedence as ++.
&	Address operator. Defined on variables. Same precedence as ++. For debugging C++, GDB implements a use of ‘&’ beyond what is allowed in the C++ language itself: you can use ‘&(&ref)’ to examine the address where a C++ reference variable (declared with ‘&ref’) is stored.
-	Negative. Defined on integral and floating-point types. Same precedence as ++.
!	Logical negation. Defined on integral types. Same precedence as ++.
~	Bitwise complement operator. Defined on integral types. Same precedence as ++.
., ->	Structure member, and pointer-to-structure member. For convenience, GDB regards the two as equivalent, choosing whether to dereference a pointer based on the stored type information. Defined on <code>struct</code> and <code>union</code> data.
.*, ->*	Dereferences of pointers to members.
[]	Array indexing. <code>a[i]</code> is defined as <code>*(a+i)</code> . Same precedence as <code>-></code> .
()	Function parameter list. Same precedence as <code>-></code> .
::	C++ scope resolution operator. Defined on <code>struct</code> , <code>union</code> , and <code>class</code> types.
::	Doubled colons also represent the GDB scope operator (see (undefined) [Expressions], page (undefined)). Same precedence as <code>::</code> , above.

If an operator is redefined in the user code, GDB usually attempts to invoke the redefined version instead of using the operator’s predefined meaning.

15.4.1.2 C and C++ Constants

GDB allows you to express the constants of C and C++ in the following ways:

- Integer constants are a sequence of digits. Octal constants are specified by a leading ‘0’ (i.e. zero), and hexadecimal constants by a leading ‘0x’ or ‘0X’. Constants may also end with a letter ‘l’, specifying that the constant should be treated as a `long` value.
- Floating point constants are a sequence of digits, followed by a decimal point, followed by a sequence of digits, and optionally followed by an exponent. An exponent is of the form: ‘e[+|-]nnn’, where *nnn* is another sequence of digits. The ‘+’ is optional

for positive exponents. A floating-point constant may also end with a letter ‘f’ or ‘F’, specifying that the constant should be treated as being of the `float` (as opposed to the default `double`) type; or with a letter ‘l’ or ‘L’, which specifies a `long double` constant.

- Enumerated constants consist of enumerated identifiers, or their integral equivalents.
- Character constants are a single character surrounded by single quotes (’), or a number—the ordinal value of the corresponding character (usually its ASCII value). Within quotes, the single character may be represented by a letter or by *escape sequences*, which are of the form ‘\nnn’, where *nnn* is the octal representation of the character’s ordinal value; or of the form ‘\x’, where ‘x’ is a predefined special character—for example, ‘\n’ for newline.
- String constants are a sequence of character constants surrounded by double quotes ("). Any valid character constant (as described above) may appear. Double quotes within the string must be preceded by a backslash, so for instance “a\b’c” is a string of five characters.
- Pointer constants are an integral value. You can also write pointers to constants using the C operator ‘&’.
- Array constants are comma-separated lists surrounded by braces ‘{’ and ‘}’; for example, ‘{1,2,3}’ is a three-element array of integers, ‘{{1,2}, {3,4}, {5,6}}’ is a three-by-two array, and ‘{&"hi", &"there", &"fred"}’ is a three-element array of pointers.

15.4.1.3 C++ Expressions

GDB expression handling can interpret most C++ expressions.

Warning: GDB can only debug C++ code if you use the proper compiler and the proper debug format. Currently, GDB works best when debugging C++ code that is compiled with GCC 2.95.3 or with GCC 3.1 or newer, using the options ‘-gdwarf-2’ or ‘-gstabs+’. DWARF 2 is preferred over stabs+. Most configurations of GCC emit either DWARF 2 or stabs+ as their default debug format, so you usually don’t need to specify a debug format explicitly. Other compilers and/or debug formats are likely to work badly or not at all when using GDB to debug C++ code.

1. Member function calls are allowed; you can use expressions like


```
count = aml->GetOriginal(x, y)
```
2. While a member function is active (in the selected stack frame), your expressions have the same namespace available as the member function; that is, GDB allows implicit references to the class instance pointer `this` following the same rules as C++.
3. You can call overloaded functions; GDB resolves the function call to the right definition, with some restrictions. GDB does not perform overload resolution involving user-defined type conversions, calls to constructors, or instantiations of templates that do not exist in the program. It also cannot handle ellipsis argument lists or default arguments.

It does perform integral conversions and promotions, floating-point promotions, arithmetic conversions, pointer conversions, conversions of class objects to base classes, and standard conversions such as those of functions or arrays to pointers; it requires an exact match on the number of function arguments.

Overload resolution is always performed, unless you have specified `set overload-resolution off`. See [\[GDB Features for C++\]](#), page [\(undefined\)](#).

You must specify `set overload-resolution off` in order to use an explicit function signature to call an overloaded function, as in

```
p 'foo(char,int)'('x', 13)
```

The GDB command-completion facility can simplify this; see [\[Command Completion\]](#), page [\(undefined\)](#).

4. GDB understands variables declared as C++ references; you can use them in expressions just as you do in C++ source—they are automatically dereferenced.

In the parameter list shown when GDB displays a frame, the values of reference variables are not displayed (unlike other variables); this avoids clutter, since references are often used for large structures. The *address* of a reference variable is always shown, unless you have specified `'set print address off'`.

5. GDB supports the C++ name resolution operator `::`—your expressions can use it just as expressions in your program do. Since one scope may be defined in another, you can use `::` repeatedly if necessary, for example in an expression like `'scope1::scope2::name'`. GDB also allows resolving name scope by reference to source files, in both C and C++ debugging (see [\[Program Variables\]](#), page [\(undefined\)](#)).

In addition, when used with HP's C++ compiler, GDB supports calling virtual functions correctly, printing out virtual bases of objects, calling functions in a base subobject, casting objects, and invoking user-defined operators.

15.4.1.4 C and C++ Defaults

If you allow GDB to set type and range checking automatically, they both default to `off` whenever the working language changes to C or C++. This happens regardless of whether you or GDB selects the working language.

If you allow GDB to set the language automatically, it recognizes source files whose names end with `'.c'`, `'.C'`, or `'.cc'`, etc, and when GDB enters code compiled from one of these files, it sets the working language to C or C++. See [\[Having GDB Infer the Source Language\]](#), page [\(undefined\)](#), for further details.

15.4.1.5 C and C++ Type and Range Checks

By default, when GDB parses C or C++ expressions, type checking is not used. However, if you turn type checking on, GDB considers two variables type equivalent if:

- The two variables are structured and have the same structure, union, or enumerated tag.
- The two variables have the same type name, or types that have been declared equivalent through `typedef`.

Range checking, if turned on, is done on mathematical operations. Array indices are not checked, since they are often used to index a pointer that is not itself an array.

15.4.1.6 GDB and C

The `set print union` and `show print union` commands apply to the union type. When set to `'on'`, any union that is inside a `struct` or `class` is also printed. Otherwise, it appears as `'{...}'`.

The @ operator aids in the debugging of dynamic arrays, formed with pointers and a memory allocation function. See [Expressions](#), page [undefined](#).

15.4.1.7 GDB Features for C++

Some GDB commands are particularly useful with C++, and some are designed specifically for use with C++. Here is a summary:

`breakpoint menus`

When you want a breakpoint in a function whose name is overloaded, GDB has the capability to display a menu of possible breakpoint locations to help you specify which function definition you want. See [Ambiguous Expressions](#), page [undefined](#).

`rbreak regex`

Setting breakpoints using regular expressions is helpful for setting breakpoints on overloaded functions that are not members of any special classes. See [Setting Breakpoints](#), page [undefined](#).

`catch throw`

`catch catch`

Debug C++ exception handling using these commands. See [Setting Catchpoints](#), page [undefined](#).

`ptype typename`

Print inheritance relationships as well as other information for type *typename*. See [Examining the Symbol Table](#), page [undefined](#).

`set print demangle`

`show print demangle`

`set print asm-demangle`

`show print asm-demangle`

Control whether C++ symbols display in their source form, both when displaying code as C++ source and when displaying disassemblies. See [Print Settings](#), page [undefined](#).

`set print object`

`show print object`

Choose whether to print derived (actual) or declared types of objects. See [Print Settings](#), page [undefined](#).

`set print vtbl`

`show print vtbl`

Control the format for printing virtual function tables. See [Print Settings](#), page [undefined](#). (The `vtbl` commands do not work on programs compiled with the HP ANSI C++ compiler (`aCC`.)

`set overload-resolution on`

Enable overload resolution for C++ expression evaluation. The default is on. For overloaded functions, GDB evaluates the arguments and searches for a function whose signature matches the argument types, using the standard C++ conversion rules (see [C++ Expressions](#), page [undefined](#), for details). If it cannot find a match, it emits a message.

set overload-resolution off

Disable overload resolution for C++ expression evaluation. For overloaded functions that are not class member functions, GDB chooses the first function of the specified name that it finds in the symbol table, whether or not its arguments are of the correct type. For overloaded functions that are class member functions, GDB searches for a function whose signature *exactly* matches the argument types.

show overload-resolution

Show the current setting of overload resolution.

Overloaded symbol names

You can specify a particular definition of an overloaded symbol, using the same notation that is used to declare such symbols in C++: `type symbol (types)` rather than just `symbol`. You can also use the GDB command-line word completion facilities to list the available choices, or to finish the type list for you. See [\(undefined\) \[Command Completion\]](#), page [\(undefined\)](#), for details on how to do this.

15.4.1.8 Decimal Floating Point format

GDB can examine, set and perform computations with numbers in decimal floating point format, which in the C language correspond to the `_Decimal32`, `_Decimal64` and `_Decimal128` types as specified by the extension to support decimal floating-point arithmetic.

There are two encodings in use, depending on the architecture: BID (Binary Integer Decimal) for x86 and x86-64, and DPD (Densely Packed Decimal) for PowerPC. GDB will use the appropriate encoding for the configured target.

Because of a limitation in ‘`libdecnumber`’, the library used by GDB to manipulate decimal floating point numbers, it is not possible to convert (using a cast, for example) integers wider than 32-bit to decimal float.

In addition, in order to imitate GDB’s behaviour with binary floating point computations, error checking in decimal float operations ignores underflow, overflow and divide by zero exceptions.

In the PowerPC architecture, GDB provides a set of pseudo-registers to inspect `_Decimal128` values stored in floating point registers. See [\(undefined\) \[PowerPC\]](#), page [\(undefined\)](#) for more details.

15.4.2 D

GDB can be used to debug programs written in D and compiled with GDC, LDC or DMD compilers. Currently GDB supports only one D specific feature — dynamic arrays.

15.4.3 Objective-C

This section provides information about some commands and command options that are useful for debugging Objective-C code. See also [\(undefined\) \[Symbols\]](#), page [\(undefined\)](#), and [\(undefined\) \[Symbols\]](#), page [\(undefined\)](#), for a few more commands specific to Objective-C support.

15.4.3.1 Method Names in Commands

The following commands have been extended to accept Objective-C method names as line specifications:

- `clear`
- `break`
- `info line`
- `jump`
- `list`

A fully qualified Objective-C method name is specified as

```
-[Class methodName]
```

where the minus sign is used to indicate an instance method and a plus sign (not shown) is used to indicate a class method. The class name *Class* and method name *methodName* are enclosed in brackets, similar to the way messages are specified in Objective-C source code. For example, to set a breakpoint at the `create` instance method of class `Fruit` in the program currently being debugged, enter:

```
break -[Fruit create]
```

To list ten program lines around the `initialize` class method, enter:

```
list +[NSText initialize]
```

In the current version of GDB, the plus or minus sign is required. In future versions of GDB, the plus or minus sign will be optional, but you can use it to narrow the search. It is also possible to specify just a method name:

```
break create
```

You must specify the complete method name, including any colons. If your program's source files contain more than one `create` method, you'll be presented with a numbered list of classes that implement that method. Indicate your choice by number, or type '0' to exit if none apply.

As another example, to clear a breakpoint established at the `makeKeyAndOrderFront:` method of the `NSWindow` class, enter:

```
clear -[NSWindow makeKeyAndOrderFront:]
```

15.4.3.2 The Print Command With Objective-C

The print command has also been extended to accept methods. For example:

```
print -[object hash]
```

will tell GDB to send the `hash` message to *object* and print the result. Also, an additional command has been added, `print-object` or `po` for short, which is meant to print the description of an object. However, this command may only work with certain Objective-C libraries that have a particular hook function, `_NSPrintForDebugger`, defined.

15.4.4 Fortran

GDB can be used to debug programs written in Fortran, but it currently supports only the features of Fortran 77 language.

Some Fortran compilers (GNU Fortran 77 and Fortran 95 compilers among them) append an underscore to the names of variables and functions. When you debug programs compiled by those compilers, you will need to refer to variables and functions with a trailing underscore.

15.4.4.1 Fortran Operators and Expressions

Operators must be defined on values of specific types. For instance, `+` is defined on numbers, but not on characters or other non- arithmetic types. Operators are often defined on groups of types.

- **** The exponentiation operator. It raises the first operand to the power of the second one.
- :** The range operator. Normally used in the form of `array(low:high)` to represent a section of array.
- %** The access component operator. Normally used to access elements in derived types. Also suitable for unions. As unions aren't part of regular Fortran, this can only happen when accessing a register that uses a gdbarch-defined union type.

15.4.4.2 Fortran Defaults

Fortran symbols are usually case-insensitive, so GDB by default uses case-insensitive matches for Fortran symbols. You can change that with the `'set case-insensitive'` command, see [\(undefined\) \[Symbols\]](#), page [\(undefined\)](#), for the details.

15.4.4.3 Special Fortran Commands

GDB has some commands to support Fortran-specific features, such as displaying common blocks.

```
info common [common-name]
```

This command prints the values contained in the Fortran `COMMON` block whose name is *common-name*. With no argument, the names of all `COMMON` blocks visible at the current program location are printed.

15.4.5 Pascal

Debugging Pascal programs which use sets, subranges, file variables, or nested functions does not currently work. GDB does not support entering expressions, printing values, or similar features using Pascal syntax.

The Pascal-specific command `set print pascal_static-members` controls whether static members of Pascal objects are displayed. See [\(undefined\) \[Print Settings\]](#), page [\(undefined\)](#).

15.4.6 Modula-2

The extensions made to GDB to support Modula-2 only support output from the GNU Modula-2 compiler (which is currently being developed). Other Modula-2 compilers are not currently supported, and attempting to debug executables produced by them is most likely to give an error as GDB reads in the executable's symbol table.

15.4.6.1 Operators

Operators must be defined on values of specific types. For instance, `+` is defined on numbers, but not on structures. Operators are often defined on groups of types. For the purposes of Modula-2, the following definitions hold:

- *Integral types* consist of `INTEGER`, `CARDINAL`, and their subranges.
- *Character types* consist of `CHAR` and its subranges.
- *Floating-point types* consist of `REAL`.
- *Pointer types* consist of anything declared as `POINTER TO type`.
- *Scalar types* consist of all of the above.
- *Set types* consist of `SET` and `BITSET` types.
- *Boolean types* consist of `BOOLEAN`.

The following operators are supported, and appear in order of increasing precedence:

<code>,</code>	Function argument or array index separator.
<code>:=</code>	Assignment. The value of <code>var := value</code> is <code>value</code> .
<code><, ></code>	Less than, greater than on integral, floating-point, or enumerated types.
<code><=, >=</code>	Less than or equal to, greater than or equal to on integral, floating-point and enumerated types, or set inclusion on set types. Same precedence as <code><</code> .
<code>=, <>, #</code>	Equality and two ways of expressing inequality, valid on scalar types. Same precedence as <code><</code> . In GDB scripts, only <code><></code> is available for inequality, since <code>#</code> conflicts with the script comment character.
<code>IN</code>	Set membership. Defined on set types and the types of their members. Same precedence as <code><</code> .
<code>OR</code>	Boolean disjunction. Defined on boolean types.
<code>AND, &</code>	Boolean conjunction. Defined on boolean types.
<code>@</code>	The GDB “artificial array” operator (see (undefined) [Expressions], page (undefined)).
<code>+, -</code>	Addition and subtraction on integral and floating-point types, or union and difference on set types.
<code>*</code>	Multiplication on integral and floating-point types, or set intersection on set types.
<code>/</code>	Division on floating-point types, or symmetric set difference on set types. Same precedence as <code>*</code> .
<code>DIV, MOD</code>	Integer division and remainder. Defined on integral types. Same precedence as <code>*</code> .
<code>-</code>	Negative. Defined on <code>INTEGER</code> and <code>REAL</code> data.
<code>^</code>	Pointer dereferencing. Defined on pointer types.
<code>NOT</code>	Boolean negation. Defined on boolean types. Same precedence as <code>^</code> .

- . RECORD field selector. Defined on RECORD data. Same precedence as ^.
- [] Array indexing. Defined on ARRAY data. Same precedence as ^.
- () Procedure argument list. Defined on PROCEDURE objects. Same precedence as ^.
- ::, . GDB and Modula-2 scope operators.

Warning: Set expressions and their operations are not yet supported, so GDB treats the use of the operator IN, or the use of operators +, -, *, /, =, , <>, #, <=, and >= on sets as an error.

15.4.6.2 Built-in Functions and Procedures

Modula-2 also makes available several built-in procedures and functions. In describing these, the following metavariables are used:

- a* represents an ARRAY variable.
- c* represents a CHAR constant or variable.
- i* represents a variable or constant of integral type.
- m* represents an identifier that belongs to a set. Generally used in the same function with the metavariable *s*. The type of *s* should be SET OF *mtype* (where *mtype* is the type of *m*).
- n* represents a variable or constant of integral or floating-point type.
- r* represents a variable or constant of floating-point type.
- t* represents a type.
- v* represents a variable.
- x* represents a variable or constant of one of many types. See the explanation of the function for details.

All Modula-2 built-in procedures also return a result, described below.

- ABS(*n*) Returns the absolute value of *n*.
- CAP(*c*) If *c* is a lower case letter, it returns its upper case equivalent, otherwise it returns its argument.
- CHR(*i*) Returns the character whose ordinal value is *i*.
- DEC(*v*) Decrements the value in the variable *v* by one. Returns the new value.
- DEC(*v*, *i*) Decrements the value in the variable *v* by *i*. Returns the new value.
- EXCL(*m*, *s*) Removes the element *m* from the set *s*. Returns the new set.
- FLOAT(*i*) Returns the floating point equivalent of the integer *i*.
- HIGH(*a*) Returns the index of the last member of *a*.
- INC(*v*) Increments the value in the variable *v* by one. Returns the new value.

<code>INC(v, i)</code>	Increments the value in the variable <code>v</code> by <code>i</code> . Returns the new value.
<code>INCL(m, s)</code>	Adds the element <code>m</code> to the set <code>s</code> if it is not already there. Returns the new set.
<code>MAX(t)</code>	Returns the maximum value of the type <code>t</code> .
<code>MIN(t)</code>	Returns the minimum value of the type <code>t</code> .
<code>ODD(i)</code>	Returns boolean <code>TRUE</code> if <code>i</code> is an odd number.
<code>ORD(x)</code>	Returns the ordinal value of its argument. For example, the ordinal value of a character is its ASCII value (on machines supporting the ASCII character set). <code>x</code> must be of an ordered type, which include integral, character and enumerated types.
<code>SIZE(x)</code>	Returns the size of its argument. <code>x</code> can be a variable or a type.
<code>TRUNC(r)</code>	Returns the integral part of <code>r</code> .
<code>TSIZE(x)</code>	Returns the size of its argument. <code>x</code> can be a variable or a type.
<code>VAL(t, i)</code>	Returns the member of the type <code>t</code> whose ordinal value is <code>i</code> .

Warning: Sets and their operations are not yet supported, so GDB treats the use of procedures `INCL` and `EXCL` as an error.

15.4.6.3 Constants

GDB allows you to express the constants of Modula-2 in the following ways:

- Integer constants are simply a sequence of digits. When used in an expression, a constant is interpreted to be type-compatible with the rest of the expression. Hexadecimal integers are specified by a trailing ‘H’, and octal integers by a trailing ‘B’.
- Floating point constants appear as a sequence of digits, followed by a decimal point and another sequence of digits. An optional exponent can then be specified, in the form ‘E[+|-]nnn’, where ‘[+|-]nnn’ is the desired exponent. All of the digits of the floating point constant must be valid decimal (base 10) digits.
- Character constants consist of a single character enclosed by a pair of like quotes, either single (‘) or double ("). They may also be expressed by their ordinal value (their ASCII value, usually) followed by a ‘C’.
- String constants consist of a sequence of characters enclosed by a pair of like quotes, either single (‘) or double ("). Escape sequences in the style of C are also allowed. See [\[C and C++ Constants\]](#), page [\[C and C++ Constants\]](#), for a brief explanation of escape sequences.
- Enumerated constants consist of an enumerated identifier.
- Boolean constants consist of the identifiers `TRUE` and `FALSE`.
- Pointer constants consist of integral values only.
- Set constants are not yet supported.

15.4.6.4 Modula-2 Types

Currently GDB can print the following data types in Modula-2 syntax: array types, record types, set types, pointer types, procedure types, enumerated types, subrange types and base types. You can also print the contents of variables declared using these type. This section gives a number of simple source code examples together with sample GDB sessions.

The first example contains the following section of code:

```
VAR
  s: SET OF CHAR ;
  r: [20..40] ;
```

and you can request GDB to interrogate the type and value of `r` and `s`.

```
(gdb) print s
{'A'..'C', 'Z'}
(gdb) ptype s
SET OF CHAR
(gdb) print r
21
(gdb) ptype r
[20..40]
```

Likewise if your source code declares `s` as:

```
VAR
  s: SET ['A'..'Z'] ;
```

then you may query the type of `s` by:

```
(gdb) ptype s
type = SET ['A'..'Z']
```

Note that at present you cannot interactively manipulate set expressions using the debugger.

The following example shows how you might declare an array in Modula-2 and how you can interact with GDB to print its type and contents:

```
VAR
  s: ARRAY [-10..10] OF CHAR ;
(gdb) ptype s
ARRAY [-10..10] OF CHAR
```

Note that the array handling is not yet complete and although the type is printed correctly, expression handling still assumes that all arrays have a lower bound of zero and not `-10` as in the example above.

Here are some more type related Modula-2 examples:

```
TYPE
  colour = (blue, red, yellow, green) ;
  t = [blue..yellow] ;
VAR
  s: t ;
BEGIN
  s := blue ;
```

The GDB interaction shows how you can query the data type and value of a variable.

```
(gdb) print s
$1 = blue
(gdb) ptype t
type = [blue..yellow]
```

In this example a Modula-2 array is declared and its contents displayed. Observe that the contents are written in the same way as their C counterparts.

```

VAR
  s: ARRAY [1..5] OF CARDINAL ;
BEGIN
  s[1] := 1 ;

(gdb) print s
$1 = {1, 0, 0, 0, 0}
(gdb) ptype s
type = ARRAY [1..5] OF CARDINAL

```

The Modula-2 language interface to GDB also understands pointer types as shown in this example:

```

VAR
  s: POINTER TO ARRAY [1..5] OF CARDINAL ;
BEGIN
  NEW(s) ;
  s^ [1] := 1 ;

```

and you can request that GDB describes the type of `s`.

```

(gdb) ptype s
type = POINTER TO ARRAY [1..5] OF CARDINAL

```

GDB handles compound types as we can see in this example. Here we combine array types, record types, pointer types and subrange types:

```

TYPE
  foo = RECORD
    f1: CARDINAL ;
    f2: CHAR ;
    f3: myarray ;
  END ;

  myarray = ARRAY myrange OF CARDINAL ;
  myrange = [-2..2] ;
VAR
  s: POINTER TO ARRAY myrange OF foo ;

```

and you can ask GDB to describe the type of `s` as shown below.

```

(gdb) ptype s
type = POINTER TO ARRAY [-2..2] OF foo = RECORD
  f1 : CARDINAL;
  f2 : CHAR;
  f3 : ARRAY [-2..2] OF CARDINAL;
END

```

15.4.6.5 Modula-2 Defaults

If type and range checking are set automatically by GDB, they both default to `on` whenever the working language changes to Modula-2. This happens regardless of whether you or GDB selected the working language.

If you allow GDB to set the language automatically, then entering code compiled from a file whose name ends with `.mod` sets the working language to Modula-2. See [\[Having GDB Infer the Source Language\]](#), page [\[undefined\]](#), for further details.

15.4.6.6 Deviations from Standard Modula-2

A few changes have been made to make Modula-2 programs easier to debug. This is done primarily via loosening its type strictness:

- Unlike in standard Modula-2, pointer constants can be formed by integers. This allows you to modify pointer variables during debugging. (In standard Modula-2, the actual address contained in a pointer variable is hidden from you; it can only be modified through direct assignment to another pointer variable or expression that returned a pointer.)
- C escape sequences can be used in strings and characters to represent non-printable characters. GDB prints out strings with these escape sequences embedded. Single non-printable characters are printed using the ‘CHR(*nnn*)’ format.
- The assignment operator (`:=`) returns the value of its right-hand argument.
- All built-in procedures both modify *and* return their argument.

15.4.6.7 Modula-2 Type and Range Checks

Warning: in this release, GDB does not yet perform type or range checking.

GDB considers two Modula-2 variables type equivalent if:

- They are of types that have been declared equivalent via a `TYPE t1 = t2` statement
- They have been declared on the same line. (Note: This is true of the GNU Modula-2 compiler, but it may not be true of other compilers.)

As long as type checking is enabled, any attempt to combine variables whose types are not equivalent is an error.

Range checking is done on all mathematical operations, assignment, array index bounds, and all built-in functions and procedures.

15.4.6.8 The Scope Operators `::` and `.`

There are a few subtle differences between the Modula-2 scope operator (`.`) and the GDB scope operator (`::`). The two have similar syntax:

```
module . id
scope :: id
```

where *scope* is the name of a module or a procedure, *module* the name of a module, and *id* is any declared identifier within your program, except another module.

Using the `::` operator makes GDB search the scope specified by *scope* for the identifier *id*. If it is not found in the specified scope, then GDB searches all scopes enclosing the one specified by *scope*.

Using the `.` operator makes GDB search the current scope for the identifier specified by *id* that was imported from the definition module specified by *module*. With this operator, it is an error if the identifier *id* was not imported from definition module *module*, or if *id* is not an identifier in *module*.

15.4.6.9 GDB and Modula-2

Some GDB commands have little use when debugging Modula-2 programs. Five subcommands of `set print` and `show print` apply specifically to C and C++: ‘`vtbl`’, ‘`demangle`’, ‘`asm-demangle`’, ‘`object`’, and ‘`union`’. The first four apply to C++, and the last to the C `union` type, which has no direct analogue in Modula-2.

The @ operator (see [\[Expressions\]](#), page [\(undefined\)](#)), while available with any language, is not useful with Modula-2. Its intent is to aid the debugging of *dynamic arrays*, which cannot be created in Modula-2 as they can in C or C++. However, because an address can be specified by an integral constant, the construct ‘`{type}adrexpr`’ is still useful.

In GDB scripts, the Modula-2 inequality operator # is interpreted as the beginning of a comment. Use <> instead.

15.4.7 Ada

The extensions made to GDB for Ada only support output from the GNU Ada (GNAT) compiler. Other Ada compilers are not currently supported, and attempting to debug executables produced by them is most likely to be difficult.

15.4.7.1 Introduction

The Ada mode of GDB supports a fairly large subset of Ada expression syntax, with some extensions. The philosophy behind the design of this subset is

- That GDB should provide basic literals and access to operations for arithmetic, dereferencing, field selection, indexing, and subprogram calls, leaving more sophisticated computations to subprograms written into the program (which therefore may be called from GDB).
- That type safety and strict adherence to Ada language restrictions are not particularly important to the GDB user.
- That brevity is important to the GDB user.

Thus, for brevity, the debugger acts as if all names declared in user-written packages are directly visible, even if they are not visible according to Ada rules, thus making it unnecessary to fully qualify most names with their packages, regardless of context. Where this causes ambiguity, GDB asks the user’s intent.

The debugger will start in Ada mode if it detects an Ada main program. As for other languages, it will enter Ada mode when stopped in a program that was translated from an Ada source file.

While in Ada mode, you may use ‘--’ for comments. This is useful mostly for documenting command files. The standard GDB comment (‘#’) still works at the beginning of a line in Ada mode, but not in the middle (to allow based literals).

The debugger supports limited overloading. Given a subprogram call in which the function symbol has multiple definitions, it will use the number of actual parameters and some information about their types to attempt to narrow the set of definitions. It also makes very limited use of context, preferring procedures to functions in the context of the `call` command, and functions to procedures elsewhere.

15.4.7.2 Omissions from Ada

Here are the notable omissions from the subset:

- Only a subset of the attributes are supported:
 - ‘First’, ‘Last’, and ‘Length’ on array objects (not on types and subtypes).
 - ‘Min’ and ‘Max’.

- 'Pos and 'Val.
 - 'Tag.
 - 'Range on array objects (not subtypes), but only as the right operand of the membership (in) operator.
 - 'Access, 'Unchecked_Access, and 'Unrestricted_Access (a GNAT extension).
 - 'Address.
- The names in `Characters.Latin_1` are not available and concatenation is not implemented. Thus, escape characters in strings are not currently available.
 - Equality tests ('=' and '/=') on arrays test for bitwise equality of representations. They will generally work correctly for strings and arrays whose elements have integer or enumeration types. They may not work correctly for arrays whose element types have user-defined equality, for arrays of real values (in particular, IEEE-conformant floating point, because of negative zeroes and NaNs), and for arrays whose elements contain unused bits with indeterminate values.
 - The other component-by-component array operations (`and`, `or`, `xor`, `not`, and relational tests other than equality) are not implemented.
 - There is limited support for array and record aggregates. They are permitted only on the right sides of assignments, as in these examples:

```
(gdb) set An_Array := (1, 2, 3, 4, 5, 6)
(gdb) set An_Array := (1, others => 0)
(gdb) set An_Array := (0|4 => 1, 1..3 => 2, 5 => 6)
(gdb) set A_2D_Array := ((1, 2, 3), (4, 5, 6), (7, 8, 9))
(gdb) set A_Record := (1, "Peter", True);
(gdb) set A_Record := (Name => "Peter", Id => 1, Alive => True)
```

Changing a discriminant's value by assigning an aggregate has an undefined effect if that discriminant is used within the record. However, you can first modify discriminants by directly assigning to them (which normally would not be allowed in Ada), and then performing an aggregate assignment. For example, given a variable `A_Rec` declared to have a type such as:

```
type Rec (Len : Small_Integer := 0) is record
  Id : Integer;
  Vals : IntArray (1 .. Len);
end record;
```

you can assign a value with a different size of `Vals` with two assignments:

```
(gdb) set A_Rec.Len := 4
(gdb) set A_Rec := (Id => 42, Vals => (1, 2, 3, 4))
```

As this example also illustrates, GDB is very loose about the usual rules concerning aggregates. You may leave out some of the components of an array or record aggregate (such as the `Len` component in the assignment to `A_Rec` above); they will retain their original values upon assignment. You may freely use dynamic values as indices in component associations. You may even use overlapping or redundant component associations, although which component values are assigned in such cases is not defined.

- Calls to dispatching subprograms are not implemented.
- The overloading algorithm is much more limited (i.e., less selective) than that of real Ada. It makes only limited use of the context in which a subexpression appears to resolve its meaning, and it is much looser in its rules for allowing type matches. As a

result, some function calls will be ambiguous, and the user will be asked to choose the proper resolution.

- The `new` operator is not implemented.
- Entry calls are not implemented.
- Aside from printing, arithmetic operations on the native VAX floating-point formats are not supported.
- It is not possible to slice a packed array.
- The names `True` and `False`, when not part of a qualified name, are interpreted as if implicitly prefixed by `Standard`, regardless of context. Should your program redefine these names in a package or procedure (at best a dubious practice), you will have to use fully qualified names to access their new definitions.

15.4.7.3 Additions to Ada

As it does for other languages, GDB makes certain generic extensions to Ada (see [\(undefined\) \[Expressions\]](#), page [\(undefined\)](#)):

- If the expression E is a variable residing in memory (typically a local variable or array element) and N is a positive integer, then $E\&N$ displays the values of E and the $N-1$ adjacent variables following it in memory as an array. In Ada, this operator is generally not necessary, since its prime use is in displaying parts of an array, and slicing will usually do this in Ada. However, there are occasional uses when debugging programs in which certain debugging information has been optimized away.
- $B::\text{var}$ means “the variable named *var* that appears in function or file *B*.” When *B* is a file name, you must typically surround it in single quotes.
- The expression $\{\text{type}\} \text{addr}$ means “the variable of type *type* that appears at address *addr*.”
- A name starting with ‘\$’ is a convenience variable (see [\(undefined\) \[Convenience Vars\]](#), page [\(undefined\)](#)) or a machine register (see [\(undefined\) \[Registers\]](#), page [\(undefined\)](#)).

In addition, GDB provides a few other shortcuts and outright additions specific to Ada:

- The assignment statement is allowed as an expression, returning its right-hand operand as its value. Thus, you may enter

```
(gdb) set x := y + 3
(gdb) print A(tmp := y + 1)
```

- The semicolon is allowed as an “operator,” returning as its value the value of its right-hand operand. This allows, for example, complex conditional breaks:

```
(gdb) break f
(gdb) condition 1 (report(i); k += 1; A(k) > 100)
```

- Rather than use catenation and symbolic character names to introduce special characters into strings, one may instead use a special bracket notation, which is also used to print strings. A sequence of characters of the form ‘`["XX"]`’ within a string or character literal denotes the (single) character whose numeric encoding is *XX* in hexadecimal. The sequence of characters ‘`[""]`’ also denotes a single quotation mark in strings. For example,

```
"One line.["0a"]Next line.["0a"]"
```

contains an ASCII newline character (`Ada.Characters.Latin_1.LF`) after each period.

- The subtype used as a prefix for the attributes `'Pos`, `'Min`, and `'Max` is optional (and is ignored in any case). For example, it is valid to write

```
(gdb) print 'max(x, y)
```

- When printing arrays, GDB uses positional notation when the array has a lower bound of 1, and uses a modified named notation otherwise. For example, a one-dimensional array of three integers with a lower bound of 3 might print as

```
(3 => 10, 17, 1)
```

That is, in contrast to valid Ada, only the first component has a `=>` clause.

- You may abbreviate attributes in expressions with any unique, multi-character subsequence of their names (an exact match gets preference). For example, you may use `a'len`, `a'gth`, or `a'lh` in place of `a'length`.
- Since Ada is case-insensitive, the debugger normally maps identifiers you type to lower case. The GNAT compiler uses upper-case characters for some of its internal identifiers, which are normally of no interest to users. For the rare occasions when you actually have to look at them, enclose them in angle brackets to avoid the lower-case mapping. For example,

```
(gdb) print <JMPBUF_SAVE>[0]
```

- Printing an object of class-wide type or dereferencing an access-to-class-wide value will display all the components of the object's specific type (as indicated by its run-time tag). Likewise, component selection on such a value will operate on the specific type of the object.

15.4.7.4 Stopping at the Very Beginning

It is sometimes necessary to debug the program during elaboration, and before reaching the main procedure. As defined in the Ada Reference Manual, the elaboration code is invoked from a procedure called `adainit`. To run your program up to the beginning of elaboration, simply use the following two commands: `tbreak adainit` and `run`.

15.4.7.5 Extensions for Ada Tasks

Support for Ada tasks is analogous to that for threads (see [\[Threads\]](#), page [\(undefined\)](#)). GDB provides the following task-related commands:

`info tasks`

This command shows a list of current Ada tasks, as in the following example:

```
(gdb) info tasks
  ID      TID P-ID Pri State          Name
  1      8088000  0  15 Child Activation Wait main_task
  2      80a4000  1  15 Accept Statement      b
  3      809a800  1  15 Child Activation Wait a
* 4      80ae800  3  15 Runnable                c
```

In this listing, the asterisk before the last task indicates it to be the task currently being inspected.

ID Represents GDB's internal task number.

TID The Ada task ID.

P-ID	The parent's task ID (GDB's internal task number).
Pri	The base priority of the task.
State	Current state of the task.
	Unactivated
	The task has been created but has not been activated. It cannot be executing.
	Runnable
	The task is not blocked for any reason known to Ada. (It may be waiting for a mutex, though.) It is conceptually "executing" in normal mode.
	Terminated
	The task is terminated, in the sense of ARM 9.3 (5). Any dependents that were waiting on terminate alternatives have been awakened and have terminated themselves.
	Child Activation Wait
	The task is waiting for created tasks to complete activation.
	Accept Statement
	The task is waiting on an accept or selective wait statement.
	Waiting on entry call
	The task is waiting on an entry call.
	Async Select Wait
	The task is waiting to start the abortable part of an asynchronous select statement.
	Delay Sleep
	The task is waiting on a select statement with only a delay alternative open.
	Child Termination Wait
	The task is sleeping having completed a master within itself, and is waiting for the tasks dependent on that master to become terminated or waiting on a terminate Phase.
	Wait Child in Term Alt
	The task is sleeping waiting for tasks on terminate alternatives to finish terminating.
	Accepting RV with <i>taskno</i>
	The task is accepting a rendez-vous with the task <i>taskno</i> .
Name	Name of the task in the program.

info task taskno

This command shows detailed informations on the specified task, as in the following example:

```
(gdb) info tasks
  ID      TID P-ID Pri State           Name
   1    8077880   0 15 Child Activation Wait  main_task
*  2    807c468   1 15 Runnable              task_1
(gdb) info task 2
Ada Task: 0x807c468
Name: task_1
Thread: 0x807f378
Parent: 1 (main_task)
Base Priority: 15
State: Runnable
```

task This command prints the ID of the current task.

```
(gdb) info tasks
  ID      TID P-ID Pri State           Name
   1    8077870   0 15 Child Activation Wait  main_task
*  2    807c458   1 15 Runnable              t
(gdb) task
[Current task is 2]
```

task taskno

This command is like the `thread threadno` command (see [\(undefined\) \[Threads\], page \(undefined\)](#)). It switches the context of debugging from the current task to the given task.

```
(gdb) info tasks
  ID      TID P-ID Pri State           Name
   1    8077870   0 15 Child Activation Wait  main_task
*  2    807c458   1 15 Runnable              t
(gdb) task 1
[Switching to task 1]
#0 0x8067726 in pthread_cond_wait ()
(gdb) bt
#0 0x8067726 in pthread_cond_wait ()
#1 0x8056714 in system.os_interface.pthread_cond_wait ()
#2 0x805cb63 in system.task_primitives.operations.sleep ()
#3 0x806153e in system.tasking.stages.activate_tasks ()
#4 0x804aacc in un () at un.adb:5
```

break linespec task taskno**break linespec task taskno if ...**

These commands are like the `break ... thread ...` command (see [\(undefined\) \[Thread Stops\], page \(undefined\)](#)). `linespec` specifies source lines, as described in [\(undefined\) \[Specify Location\], page \(undefined\)](#).

Use the qualifier ‘`task taskno`’ with a breakpoint command to specify that you only want GDB to stop the program when a particular Ada task reaches

this breakpoint. *taskno* is one of the numeric task identifiers assigned by GDB, shown in the first column of the ‘`info tasks`’ display.

If you do not specify ‘`task taskno`’ when you set a breakpoint, the breakpoint applies to *all* tasks of your program.

You can use the `task` qualifier on conditional breakpoints as well; in this case, place ‘`task taskno`’ before the breakpoint condition (before the `if`).

For example,

```
(gdb) info tasks
  ID      TID P-ID Pri State          Name
  1 140022020 0 15 Child Activation Wait main_task
  2 140045060 1 15 Accept/Select Wait t2
  3 140044840 1 15 Runnable          t1
* 4 140056040 1 15 Runnable          t3
(gdb) b 15 task 2
Breakpoint 5 at 0x120044cb0: file test_task_debug.adb, line 15.
(gdb) cont
Continuing.
task # 1 running
task # 2 running

Breakpoint 5, test_task_debug () at test_task_debug.adb:15
15          flush;
(gdb) info tasks
  ID      TID P-ID Pri State          Name
  1 140022020 0 15 Child Activation Wait main_task
* 2 140045060 1 15 Runnable          t2
  3 140044840 1 15 Runnable          t1
  4 140056040 1 15 Delay Sleep          t3
```

15.4.7.6 Tasking Support when Debugging Core Files

When inspecting a core file, as opposed to debugging a live program, tasking support may be limited or even unavailable, depending on the platform being used. For instance, on `x86-linux`, the list of tasks is available, but task switching is not supported. On `Tru64`, however, task switching will work as usual.

On certain platforms, including `Tru64`, the debugger needs to perform some memory writes in order to provide Ada tasking support. When inspecting a core file, this means that the core file must be opened with read-write privileges, using the command “`set write on`” (see [\(undefined\) \[Patching\], page \(undefined\)](#)). Under these circumstances, you should make a backup copy of the core file before inspecting it with GDB.

15.4.7.7 Known Peculiarities of Ada Mode

Besides the omissions listed previously (see [\(undefined\) \[Omissions from Ada\], page \(undefined\)](#)), we know of several problems with and limitations of Ada mode in GDB, some of which will be fixed with planned future releases of the debugger and the GNU Ada compiler.

- Currently, the debugger has insufficient information to determine whether certain pointers represent pointers to objects or the objects themselves. Thus, the user may have to tack an extra `.all` after an expression to get it printed properly.

- Static constants that the compiler chooses not to materialize as objects in storage are invisible to the debugger.
- Named parameter associations in function argument lists are ignored (the argument lists are treated as positional).
- Many useful library packages are currently invisible to the debugger.
- Fixed-point arithmetic, conversions, input, and output is carried out using floating-point arithmetic, and may give results that only approximate those on the host machine.
- The GNAT compiler never generates the prefix `Standard` for any of the standard symbols defined by the Ada language. GDB knows about this: it will strip the prefix from names when you use it, and will never look for a name you have so qualified among local symbols, nor match against symbols in other packages or subprograms. If you have defined entities anywhere in your program other than parameters and local variables whose simple names match names in `Standard`, GNAT's lack of qualification here can cause confusion. When this happens, you can usually resolve the confusion by qualifying the problematic names with package `Standard` explicitly.

Older versions of the compiler sometimes generate erroneous debugging information, resulting in the debugger incorrectly printing the value of affected entities. In some cases, the debugger is able to work around an issue automatically. In other cases, the debugger is able to work around the issue, but the work-around has to be specifically enabled.

`set ada trust-PAD-over-XVS on`

Configure GDB to strictly follow the GNAT encoding when computing the value of Ada entities, particularly when `PAD` and `PAD__XVS` types are involved (see `ada/exp_dbug.ads` in the GCC sources for a complete description of the encoding used by the GNAT compiler). This is the default.

`set ada trust-PAD-over-XVS off`

This is related to the encoding using by the GNAT compiler. If GDB sometimes prints the wrong value for certain entities, changing `ada trust-PAD-over-XVS` to `off` activates a work-around which may fix the issue. It is always safe to set `ada trust-PAD-over-XVS` to `off`, but this incurs a slight performance penalty, so it is recommended to leave this setting to `on` unless necessary.

15.5 Unsupported Languages

In addition to the other fully-supported programming languages, GDB also provides a pseudo-language, called `minimal`. It does not represent a real programming language, but provides a set of capabilities close to what the C or assembly languages provide. This should allow most simple operations to be performed while debugging an application that uses a language currently not supported by GDB.

If the language is set to `auto`, GDB will automatically select this language if the current frame corresponds to an unsupported language.

16 Examining the Symbol Table

The commands described in this chapter allow you to inquire about the symbols (names of variables, functions and types) defined in your program. This information is inherent in the text of your program and does not change as your program executes. GDB finds it in your program's symbol table, in the file indicated when you started GDB (see [\(undefined\) \[Choosing Files\], page \(undefined\)](#)), or by one of the file-management commands (see [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#)).

Occasionally, you may need to refer to symbols that contain unusual characters, which GDB ordinarily treats as word delimiters. The most frequent case is in referring to static variables in other source files (see [\(undefined\) \[Program Variables\], page \(undefined\)](#)). File names are recorded in object files as debugging symbols, but GDB would ordinarily parse a typical file name, like `'foo.c'`, as the three words `'foo'` `'.'` `'c'`. To allow GDB to recognize `'foo.c'` as a single symbol, enclose it in single quotes; for example,

```
p 'foo.c':x
```

looks up the value of `x` in the scope of the file `'foo.c'`.

```
set case-sensitive on
set case-sensitive off
set case-sensitive auto
```

Normally, when GDB looks up symbols, it matches their names with case sensitivity determined by the current source language. Occasionally, you may wish to control that. The command `set case-sensitive` lets you do that by specifying `on` for case-sensitive matches or `off` for case-insensitive ones. If you specify `auto`, case sensitivity is reset to the default suitable for the source language. The default is case-sensitive matches for all languages except for Fortran, for which the default is case-insensitive matches.

```
show case-sensitive
```

This command shows the current setting of case sensitivity for symbols lookups.

```
info address symbol
```

Describe where the data for *symbol* is stored. For a register variable, this says which register it is kept in. For a non-register local variable, this prints the stack-frame offset at which the variable is always stored.

Note the contrast with `'print &symbol'`, which does not work at all for a register variable, and for a stack local variable prints the exact address of the current instantiation of the variable.

```
info symbol addr
```

Print the name of a symbol which is stored at the address *addr*. If no symbol is stored exactly at *addr*, GDB prints the nearest symbol and an offset from it:

```
(gdb) info symbol 0x54320
_initialize_vx + 396 in section .text
```

This is the opposite of the `info address` command. You can use it to find out the name of a variable or a function given its address.

For dynamically linked executables, the name of executable or shared library containing the symbol is also printed:

```
(gdb) info symbol 0x400225
_start + 5 in section .text of /tmp/a.out
(gdb) info symbol 0x2aaaac2811cf
__read_nocancel + 6 in section .text of /usr/lib64/libc.so.6
```

whatis [arg]

Print the data type of *arg*, which can be either an expression or a data type. With no argument, print the data type of \$, the last value in the value history. If *arg* is an expression, it is not actually evaluated, and any side-effecting operations (such as assignments or function calls) inside it do not take place. If *arg* is a type name, it may be the name of a type or typedef, or for C code it may have the form ‘class *class-name*’, ‘struct *struct-tag*’, ‘union *union-tag*’ or ‘enum *enum-tag*’. See [\(undefined\) \[Expressions\], page \(undefined\)](#).

ptype [arg]

`ptype` accepts the same arguments as `whatis`, but prints a detailed description of the type, instead of just the name of the type. See [\(undefined\) \[Expressions\], page \(undefined\)](#).

For example, for this variable declaration:

```
struct complex {double real; double imag;} v;
```

the two commands give this output:

```
(gdb) whatis v
type = struct complex
(gdb) ptype v
type = struct complex {
  double real;
  double imag;
}
```

As with `whatis`, using `ptype` without an argument refers to the type of \$, the last value in the value history.

Sometimes, programs use opaque data types or incomplete specifications of complex data structure. If the debug information included in the program does not allow GDB to display a full declaration of the data type, it will say ‘<incomplete type>’. For example, given these declarations:

```
struct foo;
struct foo *fooptr;
```

but no definition for `struct foo` itself, GDB will say:

```
(gdb) ptype foo
$1 = <incomplete type>
```

“Incomplete type” is C terminology for data types that are not completely specified.

info types *regexp*

info types

Print a brief description of all types whose names match the regular expression *regexp* (or all types in your program, if you supply no argument). Each complete typename is matched as though it were a complete line; thus, ‘i type *value*’ gives information on all types in your program whose names include the string *value*, but ‘i type ^*value*\$’ gives information only on types whose complete name is *value*.

This command differs from `ptype` in two ways: first, like `whatis`, it does not print a detailed description; second, it lists all source files where a type is defined.

`info scope location`

List all the variables local to a particular scope. This command accepts a *location* argument—a function name, a source line, or an address preceded by a ‘*’, and prints all the variables local to the scope defined by that location. (See [\(undefined\) \[Specify Location\], page \(undefined\)](#), for details about supported forms of *location*.) For example:

```
(gdb) info scope command_line_handler
Scope for command_line_handler:
Symbol rl is an argument at stack/frame offset 8, length 4.
Symbol linebuffer is in static storage at address 0x150a18, length 4.
Symbol linelength is in static storage at address 0x150a1c, length 4.
Symbol p is a local variable in register $esi, length 4.
Symbol p1 is a local variable in register $ebx, length 4.
Symbol nline is a local variable in register $edx, length 4.
Symbol repeat is a local variable at frame offset -8, length 4.
```

This command is especially useful for determining what data to collect during a *trace experiment*, see [\(undefined\) \[Tracepoint Actions\], page \(undefined\)](#).

`info source`

Show information about the current source file—that is, the source file for the function containing the current point of execution:

- the name of the source file, and the directory containing it,
- the directory it was compiled in,
- its length, in lines,
- which programming language it is written in,
- whether the executable includes debugging information for that file, and if so, what format the information is in (e.g., STABS, Dwarf 2, etc.), and
- whether the debugging information includes information about preprocessor macros.

`info sources`

Print the names of all source files in your program for which there is debugging information, organized into two lists: files whose symbols have already been read, and files whose symbols will be read when needed.

`info functions`

Print the names and data types of all defined functions.

`info functions regexp`

Print the names and data types of all defined functions whose names contain a match for regular expression *regexp*. Thus, ‘`info fun step`’ finds all functions whose names include `step`; ‘`info fun ^step`’ finds those whose names start with `step`. If a function name contains characters that conflict with the regular expression language (e.g. ‘`operator*()`’), they may be quoted with a backslash.

info variables

Print the names and data types of all variables that are defined outside of functions (i.e. excluding local variables).

info variables *regexp*

Print the names and data types of all variables (except for local variables) whose names contain a match for regular expression *regexp*.

info classes**info classes *regexp***

Display all Objective-C classes in your program, or (with the *regexp* argument) all those matching a particular regular expression.

info selectors**info selectors *regexp***

Display all Objective-C selectors in your program, or (with the *regexp* argument) all those matching a particular regular expression.

Some systems allow individual object files that make up your program to be replaced without stopping and restarting your program. For example, in Vx-Works you can simply recompile a defective object file and keep on running. If you are running on one of these systems, you can allow GDB to reload the symbols for automatically relinked modules:

set symbol-reloading on

Replace symbol definitions for the corresponding source file when an object file with a particular name is seen again.

set symbol-reloading off

Do not replace symbol definitions when encountering object files of the same name more than once. This is the default state; if you are not running on a system that permits automatic relinking of modules, you should leave **symbol-reloading** off, since otherwise GDB may discard symbols when linking large programs, that may contain several modules (from different directories or libraries) with the same name.

show symbol-reloading

Show the current **on** or **off** setting.

set opaque-type-resolution on

Tell GDB to resolve opaque types. An opaque type is a type declared as a pointer to a **struct**, **class**, or **union**—for example, **struct MyType ***—that is used in one source file although the full declaration of **struct MyType** is in another source file. The default is on.

A change in the setting of this subcommand will not take effect until the next time symbols for a file are loaded.

set opaque-type-resolution off

Tell GDB not to resolve opaque types. In this case, the type is printed as follows:

```
{<no data fields>}
```

```
show opaque-type-resolution
```

Show whether opaque types are resolved or not.

```
maint print symbols filename
```

```
maint print psymbols filename
```

```
maint print msymbols filename
```

Write a dump of debugging symbol data into the file *filename*. These commands are used to debug the GDB symbol-reading code. Only symbols with debugging data are included. If you use ‘`maint print symbols`’, GDB includes all the symbols for which it has already collected full details: that is, *filename* reflects symbols for only those files whose symbols GDB has read. You can use the command `info sources` to find out which files these are. If you use ‘`maint print psymbols`’ instead, the dump shows information about symbols that GDB only knows partially—that is, symbols defined in files that GDB has skimmed, but not yet read completely. Finally, ‘`maint print msymbols`’ dumps just the minimal symbol information required for each object file from which GDB has read some symbols. See [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#), for a discussion of how GDB reads symbols (in the description of `symbol-file`).

```
maint info symtabs [ regexp ]
```

```
maint info psymtabs [ regexp ]
```

List the `struct symtab` or `struct partial_symtab` structures whose names match *regexp*. If *regexp* is not given, list them all. The output includes expressions which you can copy into a GDB debugging this one to examine a particular structure in more detail. For example:

```
(gdb) maint info psymtabs dwarf2read
{ objfile /home/gnu/build/gdb/gdb
  ((struct objfile *) 0x82e69d0)
  { symtab /home/gnu/src/gdb/dwarf2read.c
    ((struct partial_symtab *) 0x8474b10)
    readin no
    fullname (null)
    text addresses 0x814d3c8 -- 0x8158074
    globals (* (struct partial_symbol **) 0x8507a08 @ 9)
    statics (* (struct partial_symbol **) 0x40e95b78 @ 2882)
    dependencies (none)
  }
}
(gdb) maint info symtabs
(gdb)
```

We see that there is one partial symbol table whose filename contains the string ‘`dwarf2read`’, belonging to the ‘`gdb`’ executable; and we see that GDB has not read in any symtabs yet at all. If we set a breakpoint on a function, that will cause GDB to read the symtab for the compilation unit containing that function:

```
(gdb) break dwarf2_psymtab_to_symtab
Breakpoint 1 at 0x814e5da: file /home/gnu/src/gdb/dwarf2read.c,
line 1574.
(gdb) maint info symtabs
{ objfile /home/gnu/build/gdb/gdb
  ((struct objfile *) 0x82e69d0)
  { symtab /home/gnu/src/gdb/dwarf2read.c
```

```
      ((struct symtab *) 0x86c1f38)
      dirname (null)
      fullname (null)
      blockvector ((struct blockvector *) 0x86c1bd0) (primary)
      linetable ((struct linetable *) 0x8370fa0)
      debugformat DWARF 2
    }
  }
(gdb)
```

17 Altering Execution

Once you think you have found an error in your program, you might want to find out for certain whether correcting the apparent error would lead to correct results in the rest of the run. You can find the answer by experiment, using the GDB features for altering execution of the program.

For example, you can store new values into variables or memory locations, give your program a signal, restart it at a different address, or even return prematurely from a function.

17.1 Assignment to Variables

To alter the value of a variable, evaluate an assignment expression. See [\(undefined\) \[Expressions\]](#), page [\(undefined\)](#). For example,

```
print x=4
```

stores the value 4 into the variable `x`, and then prints the value of the assignment expression (which is 4). See [\(undefined\) \[Using GDB with Different Languages\]](#), page [\(undefined\)](#), for more information on operators in supported languages.

If you are not interested in seeing the value of the assignment, use the `set` command instead of the `print` command. `set` is really the same as `print` except that the expression's value is not printed and is not put in the value history (see [\(undefined\) \[Value History\]](#), page [\(undefined\)](#)). The expression is evaluated only for its effects.

If the beginning of the argument string of the `set` command appears identical to a `set` subcommand, use the `set variable` command instead of just `set`. This command is identical to `set` except for its lack of subcommands. For example, if your program has a variable `width`, you get an error if you try to set a new value with just `'set width=13'`, because GDB has the command `set width`:

```
(gdb) whatis width
type = double
(gdb) p width
$4 = 13
(gdb) set width=47
Invalid syntax in expression.
```

The invalid expression, of course, is `'=47'`. In order to actually set the program's variable `width`, use

```
(gdb) set var width=47
```

Because the `set` command has many subcommands that can conflict with the names of program variables, it is a good idea to use the `set variable` command instead of just `set`. For example, if your program has a variable `g`, you run into problems if you try to set a new value with just `'set g=4'`, because GDB has the command `set gnutarget`, abbreviated `set g`:


```

(gdb) whatis g
type = double
(gdb) p g
$1 = 1
(gdb) set g=4
(gdb) p g
$2 = 1
(gdb) r
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/smith/cc_progs/a.out
"/home/smith/cc_progs/a.out": can't open to read symbols:
                               Invalid bfd target.

(gdb) show g
The current BFD target is "=4".

```

The program variable `g` did not change, and you silently set the `gnutarget` to an invalid value. In order to set the variable `g`, use

```
(gdb) set var g=4
```

GDB allows more implicit conversions in assignments than C; you can freely store an integer value into a pointer variable or vice versa, and you can convert any structure to any other structure that is the same length or shorter.

To store values into arbitrary places in memory, use the `{...}` construct to generate a value of specified type at a specified address (see [\(undefined\) \[Expressions\]](#), page [\(undefined\)](#)). For example, `{int}0x83040` refers to memory location `0x83040` as an integer (which implies a certain size and representation in memory), and

```
set {int}0x83040 = 4
```

stores the value 4 into that memory location.

17.2 Continuing at a Different Address

Ordinarily, when you continue your program, you do so at the place where it stopped, with the `continue` command. You can instead continue at an address of your own choosing, with the following commands:

```

jump linespec
jump location

```

Resume execution at line *linespec* or at address given by *location*. Execution stops again immediately if there is a breakpoint there. See [\(undefined\) \[Specify Location\]](#), page [\(undefined\)](#), for a description of the different forms of *linespec* and *location*. It is common practice to use the `tbreak` command in conjunction with `jump`. See [\(undefined\) \[Setting Breakpoints\]](#), page [\(undefined\)](#).

The `jump` command does not change the current stack frame, or the stack pointer, or the contents of any memory location or any register other than the program counter. If line *linespec* is in a different function from the one currently executing, the results may be bizarre if the two functions expect different patterns of arguments or of local variables. For this reason, the `jump` command requests confirmation if the specified line is not in the function currently executing. However, even bizarre results are predictable if you are well acquainted with the machine-language code of your program.

On many systems, you can get much the same effect as the `jump` command by storing a new value into the register `$pc`. The difference is that this does not start your program running; it only changes the address of where it *will* run when you continue. For example,

```
set $pc = 0x485
```

makes the next `continue` command or stepping command execute at address `0x485`, rather than at the address where your program stopped. See [\(undefined\) \[Continuing and Stepping\]](#), page [\(undefined\)](#).

The most common occasion to use the `jump` command is to back up—perhaps with more breakpoints set—over a portion of a program that has already executed, in order to examine its execution in more detail.

17.3 Giving your Program a Signal

`signal signal`

Resume execution where your program stopped, but immediately give it the signal *signal*. *signal* can be the name or the number of a signal. For example, on many systems `signal 2` and `signal SIGINT` are both ways of sending an interrupt signal.

Alternatively, if *signal* is zero, continue execution without giving a signal. This is useful when your program stopped on account of a signal and would ordinarily see the signal when resumed with the `continue` command; `'signal 0'` causes it to resume without a signal.

`signal` does not repeat when you press RET a second time after executing the command.

Invoking the `signal` command is not the same as invoking the `kill` utility from the shell. Sending a signal with `kill` causes GDB to decide what to do with the signal depending on the signal handling tables (see [\(undefined\) \[Signals\]](#), page [\(undefined\)](#)). The `signal` command passes the signal directly to your program.

17.4 Returning from a Function

`return`

`return expression`

You can cancel execution of a function call with the `return` command. If you give an *expression* argument, its value is used as the function's return value.

When you use `return`, GDB discards the selected stack frame (and all frames within it). You can think of this as making the discarded frame return prematurely. If you wish to specify a value to be returned, give that value as the argument to `return`.

This pops the selected stack frame (see [\(undefined\) \[Selecting a Frame\]](#), page [\(undefined\)](#)), and any other frames inside of it, leaving its caller as the innermost remaining frame. That frame becomes selected. The specified value is stored in the registers used for returning values of functions.

The `return` command does not resume execution; it leaves the program stopped in the state that would exist if the function had just returned. In contrast, the `finish` command

(see [\(undefined\)](#) [Continuing and Stepping], page [\(undefined\)](#)) resumes execution until the selected stack frame returns naturally.

GDB needs to know how the *expression* argument should be set for the inferior. The concrete registers assignment depends on the OS ABI and the type being returned by the selected stack frame. For example it is common for OS ABI to return floating point values in FPU registers while integer values in CPU registers. Still some ABIs return even floating point values in CPU registers. Larger integer widths (such as `long long int`) also have specific placement rules. GDB already knows the OS ABI from its current target so it needs to find out also the type being returned to make the assignment into the right register(s).

Normally, the selected stack frame has debug info. GDB will always use the debug info instead of the implicit type of *expression* when the debug info is available. For example, if you type `return -1`, and the function in the current stack frame is declared to return a `long long int`, GDB transparently converts the implicit `int` value of `-1` into a `long long int`:

```
Breakpoint 1, func () at gdb.base/return-nodbug.c:29
29      return 31;
(gdb) return -1
Make func return now? (y or n) y
#0 0x004004f6 in main () at gdb.base/return-nodbug.c:43
43      printf ("result=%lld\n", func ());
(gdb)
```

However, if the selected stack frame does not have a debug info, e.g., if the function was compiled without debug info, GDB has to find out the type to return from user. Specifying a different type by mistake may set the value in different inferior registers than the caller code expects. For example, typing `return -1` with its implicit type `int` would set only a part of a `long long int` result for a debug info less function (on 32-bit architectures). Therefore the user is required to specify the return type by an appropriate cast explicitly:

```
Breakpoint 2, 0x0040050b in func ()
(gdb) return -1
Return value type not available for selected stack frame.
Please use an explicit cast of the value to return.
(gdb) return (long long int) -1
Make selected stack frame return now? (y or n) y
#0 0x00400526 in main ()
(gdb)
```

17.5 Calling Program Functions

`print expr`

Evaluate the expression *expr* and display the resulting value. *expr* may include calls to functions in the program being debugged.

`call expr`

Evaluate the expression *expr* without displaying `void` returned values.

You can use this variant of the `print` command if you want to execute a function from your program that does not return anything (a.k.a. a *void function*), but without cluttering the output with `void` returned values that GDB will otherwise print. If the result is not `void`, it is printed and saved in the value history.

It is possible for the function you call via the `print` or `call` command to generate a signal (e.g., if there's a bug in the function, or if you passed it incorrect arguments). What happens in that case is controlled by the `set unwindonsignal` command.

Similarly, with a C++ program it is possible for the function you call via the `print` or `call` command to generate an exception that is not handled due to the constraints of the dummy frame. In this case, any exception that is raised in the frame, but has an out-of-frame exception handler will not be found. GDB builds a dummy-frame for the inferior function call, and the unwinder cannot seek for exception handlers outside of this dummy-frame. What happens in that case is controlled by the `set unwind-on-terminating-exception` command.

`set unwindonsignal`

Set unwinding of the stack if a signal is received while in a function that GDB called in the program being debugged. If set to on, GDB unwinds the stack it created for the call and restores the context to what it was before the call. If set to off (the default), GDB stops in the frame where the signal was received.

`show unwindonsignal`

Show the current setting of stack unwinding in the functions called by GDB.

`set unwind-on-terminating-exception`

Set unwinding of the stack if a C++ exception is raised, but left unhandled while in a function that GDB called in the program being debugged. If set to on (the default), GDB unwinds the stack it created for the call and restores the context to what it was before the call. If set to off, GDB the exception is delivered to the default C++ exception handler and the inferior terminated.

`show unwind-on-terminating-exception`

Show the current setting of stack unwinding in the functions called by GDB.

Sometimes, a function you wish to call is actually a *weak alias* for another function. In such case, GDB might not pick up the type information, including the types of the function arguments, which causes GDB to call the inferior function incorrectly. As a result, the called function will function erroneously and may even crash. A solution to that is to use the name of the aliased function instead.

17.6 Patching Programs

By default, GDB opens the file containing your program's executable code (or the corefile) read-only. This prevents accidental alterations to machine code; but it also prevents you from intentionally patching your program's binary.

If you'd like to be able to patch the binary, you can specify that explicitly with the `set write` command. For example, you might want to turn on internal debugging flags, or even to make emergency repairs.

`set write on`

`set write off`

If you specify '`set write on`', GDB opens executable and core files for both reading and writing; if you specify `set write off` (the default), GDB opens them read-only.

If you have already loaded a file, you must load it again (using the `exec-file` or `core-file` command) after changing `set write`, for your new setting to take effect.

`show write`

Display whether executable files and core files are opened for writing as well as reading.

18 GDB Files

GDB needs to know the file name of the program to be debugged, both in order to read its symbol table and in order to start your program. To debug a core dump of a previous run, you must also tell GDB the name of the core dump file.

18.1 Commands to Specify Files

You may want to specify executable and core dump file names. The usual way to do this is at start-up time, using the arguments to GDB's start-up commands (see [\(undefined\)](#) [Getting In and Out of GDB], page [\(undefined\)](#)).

Occasionally it is necessary to change to a different file during a GDB session. Or you may run GDB and forget to specify a file you want to use. Or you are debugging a remote target via `gdbserver` (see [\(undefined\)](#) [Using the `gdbserver` Program], page [\(undefined\)](#)). In these situations the GDB commands to specify new files are useful.

`file filename`

Use *filename* as the program to be debugged. It is read for its symbols and for the contents of pure memory. It is also the program executed when you use the `run` command. If you do not specify a directory and the file is not found in the GDB working directory, GDB uses the environment variable `PATH` as a list of directories to search, just as the shell does when looking for a program to run. You can change the value of this variable, for both GDB and your program, using the `path` command.

You can load unlinked object `.o` files into GDB using the `file` command. You will not be able to “run” an object file, but you can disassemble functions and inspect variables. Also, if the underlying BFD functionality supports it, you could use `gdb -write` to patch object files using this technique. Note that GDB can neither interpret nor modify relocations in this case, so branches and some initialized variables will appear to go to the wrong place. But this feature is still handy from time to time.

`file` *file* with no argument makes GDB discard any information it has on both executable file and the symbol table.

`exec-file [filename]`

Specify that the program to be run (but not the symbol table) is found in *filename*. GDB searches the environment variable `PATH` if necessary to locate your program. Omitting *filename* means to discard information on the executable file.

`symbol-file [filename]`

Read symbol table information from file *filename*. `PATH` is searched when necessary. Use the `file` command to get both symbol table and program to run from the same file.

`symbol-file` with no argument clears out GDB information on your program's symbol table.

The `symbol-file` command causes GDB to forget the contents of some break-points and auto-display expressions. This is because they may contain pointers

to the internal data recording symbols and data types, which are part of the old symbol table data being discarded inside GDB.

`symbol-file` does not repeat if you press RET again after executing it once.

When GDB is configured for a particular environment, it understands debugging information in whatever format is the standard generated for that environment; you may use either a GNU compiler, or other compilers that adhere to the local conventions. Best results are usually obtained from GNU compilers; for example, using GCC you can generate debugging information for optimized code.

For most kinds of object files, with the exception of old SVR3 systems using COFF, the `symbol-file` command does not normally read the symbol table in full right away. Instead, it scans the symbol table quickly to find which source files and which symbols are present. The details are read later, one source file at a time, as they are needed.

The purpose of this two-stage reading strategy is to make GDB start up faster. For the most part, it is invisible except for occasional pauses while the symbol table details for a particular source file are being read. (The `set verbose` command can turn these pauses into messages if desired. See [\(undefined\) \[Optional Warnings and Messages\]](#), page [\(undefined\)](#).)

We have not implemented the two-stage strategy for COFF yet. When the symbol table is stored in COFF format, `symbol-file` reads the symbol table data in full right away. Note that “stabs-in-COFF” still does the two-stage strategy, since the debug info is actually in stabs format.

```
symbol-file [ -readnow ] filename
```

```
file [ -readnow ] filename
```

You can override the GDB two-stage strategy for reading symbol tables by using the ‘`-readnow`’ option with any of the commands that load symbol table information, if you want to be sure GDB has the entire symbol table available.

```
core-file [filename]
```

```
core
```

Specify the whereabouts of a core dump file to be used as the “contents of memory”. Traditionally, core files contain only some parts of the address space of the process that generated them; GDB can access the executable file itself for other parts.

`core-file` with no argument specifies that no core file is to be used.

Note that the core file is ignored when your program is actually running under GDB. So, if you have been running your program and you wish to debug a core file instead, you must kill the subprocess in which the program is running. To do this, use the `kill` command (see [\(undefined\) \[Killing the Child Process\]](#), page [\(undefined\)](#)).

```
add-symbol-file filename address
```

```
add-symbol-file filename address [ -readnow ]
```

```
add-symbol-file filename -ssection address ...
```

The `add-symbol-file` command reads additional symbol table information from the file `filename`. You would use this command when `filename` has been dynamically loaded (by some other means) into the program that is running.

address should be the memory address at which the file has been loaded; GDB cannot figure this out for itself. You can additionally specify an arbitrary number of ‘*ssection address*’ pairs, to give an explicit section name and base address for that section. You can specify any *address* as an expression.

The symbol table of the file *filename* is added to the symbol table originally read with the `symbol-file` command. You can use the `add-symbol-file` command any number of times; the new symbol data thus read keeps adding to the old. To discard all old symbol data instead, use the `symbol-file` command without any arguments.

Although *filename* is typically a shared library file, an executable file, or some other object file which has been fully relocated for loading into a process, you can also load symbolic information from relocatable ‘.o’ files, as long as:

- the file’s symbolic information refers only to linker symbols defined in that file, not to symbols defined by other object files,
- every section the file’s symbolic information refers to has actually been loaded into the inferior, as it appears in the file, and
- you can determine the address at which every section was loaded, and provide these to the `add-symbol-file` command.

Some embedded operating systems, like Sun Chorus and VxWorks, can load relocatable files into an already running program; such systems typically make the requirements above easy to meet. However, it’s important to recognize that many native systems use complex link procedures (`.linkonce` section factoring and C++ constructor table assembly, for example) that make the requirements difficult to meet. In general, one cannot assume that using `add-symbol-file` to read a relocatable object file’s symbolic information will have the same effect as linking the relocatable object file into the program in the normal way.

`add-symbol-file` does not repeat if you press RET after using it.

`add-symbol-file-from-memory address`

Load symbols from the given *address* in a dynamically loaded object file whose image is mapped directly into the inferior’s memory. For example, the Linux kernel maps a `syscall` DSO into each process’s address space; this DSO provides kernel-specific code for some system calls. The argument can be any expression whose evaluation yields the address of the file’s shared object file header. For this command to work, you must have used `symbol-file` or `exec-file` commands in advance.

`add-shared-symbol-files library-file`

`assf library-file`

The `add-shared-symbol-files` command can currently be used only in the Cygwin build of GDB on MS-Windows OS, where it is an alias for the `dll-symbols` command (see [\(undefined\) \[Cygwin Native\], page \(undefined\)](#)). GDB automatically looks for shared libraries, however if GDB does not find yours, you can invoke `add-shared-symbol-files`. It takes one argument: the shared library’s file name. `assf` is a shorthand alias for `add-shared-symbol-files`.

section *section addr*

The **section** command changes the base address of the named *section* of the exec file to *addr*. This can be used if the exec file does not contain section addresses, (such as in the **a.out** format), or when the addresses specified in the file itself are wrong. Each section must be changed separately. The **info files** command, described below, lists all the sections and their addresses.

info files**info target**

info files and **info target** are synonymous; both print the current target (see [\(undefined\) \[Specifying a Debugging Target\], page \(undefined\)](#)), including the names of the executable and core dump files currently in use by GDB, and the files from which symbols were loaded. The command **help target** lists all possible targets rather than current ones.

maint info sections

Another command that can give you extra information about program sections is **maint info sections**. In addition to the section information displayed by **info files**, this command displays the flags and file offset of each section in the executable and core dump files. In addition, **maint info sections** provides the following command options (which may be arbitrarily combined):

ALLOBJ Display sections for all loaded object files, including shared libraries.

sections Display info only for named *sections*.

section-flags

Display info only for sections for which *section-flags* are true. The section flags that GDB currently knows about are:

ALLOC Section will have space allocated in the process when loaded. Set for all sections except those containing debug information.

LOAD Section will be loaded from the file into the child process memory. Set for pre-initialized code and data, clear for **.bss** sections.

RELOC Section needs to be relocated before loading.

READONLY Section cannot be modified by the child process.

CODE Section contains executable code only.

DATA Section contains data only (no executable code).

ROM Section will reside in ROM.

CONSTRUCTOR

Section contains data for constructor/destructor lists.

HAS_CONTENTS

Section is not empty.

NEVER_LOAD

An instruction to the linker to not output the section.

COFF_SHARED_LIBRARY

A notification to the linker that the section contains COFF shared library information.

IS_COMMON

Section contains common symbols.

set trust-readonly-sections on

Tell GDB that readonly sections in your object file really are read-only (i.e. that their contents will not change). In that case, GDB can fetch values from these sections out of the object file, rather than from the target program. For some targets (notably embedded ones), this can be a significant enhancement to debugging performance.

The default is off.

set trust-readonly-sections off

Tell GDB not to trust readonly sections. This means that the contents of the section might change while the program is running, and must therefore be fetched from the target when needed.

show trust-readonly-sections

Show the current setting of trusting readonly sections.

All file-specifying commands allow both absolute and relative file names as arguments. GDB always converts the file name to an absolute file name and remembers it that way.

GDB supports GNU/Linux, MS-Windows, HP-UX, SunOS, SVr4, Irix, and IBM RS/6000 AIX shared libraries.

On MS-Windows GDB must be linked with the Expat library to support shared libraries. See [\(undefined\) \[Expat\], page \(undefined\)](#).

GDB automatically loads symbol definitions from shared libraries when you use the **run** command, or when you examine a core file. (Before you issue the **run** command, GDB does not understand references to a function in a shared library, however—unless you are debugging a core file).

On HP-UX, if the program loads a library explicitly, GDB automatically loads the symbols at the time of the **shl_load** call.

There are times, however, when you may wish to not automatically load symbol definitions from shared libraries, such as when they are particularly large or there are many of them.

To control the automatic loading of shared library symbols, use the commands:

set auto-solib-add mode

If *mode* is **on**, symbols from all shared object libraries will be loaded automatically when the inferior begins execution, you attach to an independently started inferior, or when the dynamic linker informs GDB that a new library has been loaded. If *mode* is **off**, symbols must be loaded manually, using the **sharedlibrary** command. The default value is **on**.

If your program uses lots of shared libraries with debug info that takes large amounts of memory, you can decrease the GDB memory footprint by preventing it from automatically loading the symbols from shared libraries. To that end, type `set auto-solib-add off` before running the inferior, then load each library whose debug symbols you do need with `sharedlibrary regexp`, where `regexp` is a regular expression that matches the libraries whose symbols you want to be loaded.

`show auto-solib-add`

Display the current autoloading mode.

To explicitly load shared library symbols, use the `sharedlibrary` command:

`info share regex`

`info sharedlibrary regex`

Print the names of the shared libraries which are currently loaded that match `regex`. If `regex` is omitted then print all shared libraries that are loaded.

`sharedlibrary regex`

`share regex`

Load shared object library symbols for files matching a Unix regular expression. As with files loaded automatically, it only loads shared libraries required by your program for a core file or after typing `run`. If `regex` is omitted all shared libraries required by your program are loaded.

`nosharedlibrary`

Unload all shared object library symbols. This discards all symbols that have been loaded from all shared libraries. Symbols from shared libraries that were loaded by explicit user requests are not discarded.

Sometimes you may wish that GDB stops and gives you control when any of shared library events happen. Use the `set stop-on-solib-events` command for this:

`set stop-on-solib-events`

This command controls whether GDB should give you control when the dynamic linker notifies it about some shared library event. The most common event of interest is loading or unloading of a new shared library.

`show stop-on-solib-events`

Show whether GDB stops and gives you control when shared library events happen.

Shared libraries are also supported in many cross or remote debugging configurations. GDB needs to have access to the target's libraries; this can be accomplished either by providing copies of the libraries on the host system, or by asking GDB to automatically retrieve the libraries from the target. If copies of the target libraries are provided, they need to be the same as the target libraries, although the copies on the target can be stripped as long as the copies on the host are not.

For remote debugging, you need to tell GDB where the target libraries are, so that it can load the correct copies—otherwise, it may try to load the host's libraries. GDB has two variables to specify the search directories for target libraries.

set sysroot path

Use *path* as the system root for the program being debugged. Any absolute shared library paths will be prefixed with *path*; many runtime loaders store the absolute paths to the shared library in the target program's memory. If you use `set sysroot` to find shared libraries, they need to be laid out in the same way that they are on the target, with e.g. a `/lib` and `/usr/lib` hierarchy under *path*.

If *path* starts with the sequence `'remote:'`, GDB will retrieve the target libraries from the remote system. This is only supported when using a remote target that supports the `remote get` command (see [\(undefined\) \[Sending files to a remote system\], page \(undefined\)](#)). The part of *path* following the initial `'remote:'` (if present) is used as system root prefix on the remote file system.¹

For targets with an MS-DOS based filesystem, such as MS-Windows and SymbianOS, GDB tries prefixing a few variants of the target absolute file name with *path*. But first, on Unix hosts, GDB converts all backslash directory separators into forward slashes, because the backslash is not a directory separator on Unix:

```
c:\foo\bar.dll ⇒ c:/foo/bar.dll
```

Then, GDB attempts prefixing the target file name with *path*, and looks for the resulting file name in the host file system:

```
c:/foo/bar.dll ⇒ /path/to/sysroot/c:/foo/bar.dll
```

If that does not find the shared library, GDB tries removing the `':'` character from the drive spec, both for convenience, and, for the case of the host file system not supporting file names with colons:

```
c:/foo/bar.dll ⇒ /path/to/sysroot/c/foo/bar.dll
```

This makes it possible to have a system root that mirrors a target with more than one drive. E.g., you may want to setup your local copies of the target system shared libraries like so (note `'c'` vs `'z'`):

```
'/path/to/sysroot/c/sys/bin/foo.dll'  
'/path/to/sysroot/c/sys/bin/bar.dll'  
'/path/to/sysroot/z/sys/bin/bar.dll'
```

and point the system root at `'/path/to/sysroot'`, so that GDB can find the correct copies of both `'c:\sys\bin\foo.dll'`, and `'z:\sys\bin\bar.dll'`.

If that still does not find the shared library, GDB tries removing the whole drive spec from the target file name:

```
c:/foo/bar.dll ⇒ /path/to/sysroot/foo/bar.dll
```

This last lookup makes it possible to not care about the drive name, if you don't want or need to.

The `set solib-absolute-prefix` command is an alias for `set sysroot`.

You can set the default system root by using the configure-time `'--with-sysroot'` option. If the system root is inside GDB's configured binary prefix (set with `'--prefix'` or `'--exec-prefix'`), then the default system root will be updated automatically if the installed GDB is moved to a new location.

¹ If you want to specify a local system root using a directory that happens to be named `'remote:'`, you need to use some equivalent variant of the name like `'./remote:'`.

show sysroot

Display the current shared library prefix.

set solib-search-path *path*

If this variable is set, *path* is a colon-separated list of directories to search for shared libraries. ‘**solib-search-path**’ is used after ‘**sysroot**’ fails to locate the library, or if the path to the library is relative instead of absolute. If you want to use ‘**solib-search-path**’ instead of ‘**sysroot**’, be sure to set ‘**sysroot**’ to a nonexistent directory to prevent GDB from finding your host’s libraries. ‘**sysroot**’ is preferred; setting it to a nonexistent directory may interfere with automatic loading of shared library symbols.

show solib-search-path

Display the current shared library search path.

set target-file-system-kind *kind*

Set assumed file system kind for target reported file names.

Shared library file names as reported by the target system may not make sense as is on the system GDB is running on. For example, when remote debugging a target that has MS-DOS based file system semantics, from a Unix host, the target may be reporting to GDB a list of loaded shared libraries with file names such as ‘*c:\Windows\kernel32.dll*’. On Unix hosts, there’s no concept of drive letters, so the ‘*c:*’ prefix is not normally understood as indicating an absolute file name, and neither is the backslash normally considered a directory separator character. In that case, the native file system would interpret this whole absolute file name as a relative file name with no directory components. This would make it impossible to point GDB at a copy of the remote target’s shared libraries on the host using **set sysroot**, and impractical with **set solib-search-path**. Setting **target-file-system-kind** to **dos-based** tells GDB to interpret such file names similarly to how the target would, and to map them to file names valid on GDB’s native file system semantics. The value of *kind* can be “**auto**”, in addition to one of the supported file system kinds. In that case, GDB tries to determine the appropriate file system variant based on the current target’s operating system (see [\(undefined\) \[Configuring the Current ABI\], page \(undefined\)](#)). The supported file system settings are:

unix Instruct GDB to assume the target file system is of Unix kind. Only file names starting the forward slash (‘/’) character are considered absolute, and the directory separator character is also the forward slash.

dos-based

Instruct GDB to assume the target file system is DOS based. File names starting with either a forward slash, or a drive letter followed by a colon (e.g., ‘*c:*’), are considered absolute, and both the slash (‘/’) and the backslash (‘\’) characters are considered directory separators.

auto Instruct GDB to use the file system kind associated with the target operating system (see [\(undefined\) \[Configuring the Current ABI\], page \(undefined\)](#)). This is the default.

18.2 Debugging Information in Separate Files

GDB allows you to put a program’s debugging information in a file separate from the executable itself, in a way that allows GDB to find and load the debugging information automatically. Since debugging information can be very large—sometimes larger than the executable code itself—some systems distribute debugging information for their executables in separate files, which users can install only when they need to debug a problem.

GDB supports two ways of specifying the separate debug info file:

- The executable contains a *debug link* that specifies the name of the separate debug info file. The separate debug file’s name is usually ‘*executable.debug*’, where *executable* is the name of the corresponding executable file without leading directories (e.g., ‘*ls.debug*’ for ‘*/usr/bin/ls*’). In addition, the debug link specifies a 32-bit *Cyclic Redundancy Check* (CRC) checksum for the debug file, which GDB uses to validate that the executable and the debug file came from the same build.
- The executable contains a *build ID*, a unique bit string that is also present in the corresponding debug info file. (This is supported only on some operating systems, notably those which use the ELF format for binary files and the GNU Binutils.) For more details about this feature, see the description of the ‘*--build-id*’ command-line option in [section “Command Line Options” in *The GNU Linker*](#). The debug info file’s name is not specified explicitly by the build ID, but can be computed from the build ID, see below.

Depending on the way the debug info file is specified, GDB uses two different methods of looking for the debug file:

- For the “debug link” method, GDB looks up the named file in the directory of the executable file, then in a subdirectory of that directory named ‘*.debug*’, and finally under the global debug directory, in a subdirectory whose name is identical to the leading directories of the executable’s absolute file name.
- For the “build ID” method, GDB looks in the ‘*.build-id*’ subdirectory of the global debug directory for a file named ‘*nn/nnnnnnnn.debug*’, where *nn* are the first 2 hex characters of the build ID bit string, and *nnnnnnnn* are the rest of the bit string. (Real build ID strings are 32 or more hex characters, not 10.)

So, for example, suppose you ask GDB to debug ‘*/usr/bin/ls*’, which has a debug link that specifies the file ‘*ls.debug*’, and a build ID whose value in hex is *abcdef1234*. If the global debug directory is ‘*/usr/lib/debug*’, then GDB will look for the following debug information files, in the indicated order:

- ‘*/usr/lib/debug/.build-id/ab/cdef1234.debug*’
- ‘*/usr/bin/ls.debug*’
- ‘*/usr/bin/.debug/ls.debug*’
- ‘*/usr/lib/debug/usr/bin/ls.debug*’.

You can set the global debugging info directory’s name, and view the name GDB is currently using.

set debug-file-directory *directories*

Set the directories which GDB searches for separate debugging information files to *directory*. Multiple directory components can be set concatenating them by a directory separator.

show debug-file-directory

Show the directories GDB searches for separate debugging information files.

A debug link is a special section of the executable file named `.gnu_debuglink`. The section must contain:

- A filename, with any leading directory components removed, followed by a zero byte,
- zero to three bytes of padding, as needed to reach the next four-byte boundary within the section, and
- a four-byte CRC checksum, stored in the same endianness used for the executable file itself. The checksum is computed on the debugging information file's full contents by the function given below, passing zero as the *crc* argument.

Any executable file format can carry a debug link, as long as it can contain a section named `.gnu_debuglink` with the contents described above.

The build ID is a special section in the executable file (and in other ELF binary files that GDB may consider). This section is often named `.note.gnu.build-id`, but that name is not mandatory. It contains unique identification for the built files—the ID remains the same across multiple builds of the same build tree. The default algorithm SHA1 produces 160 bits (40 hexadecimal characters) of the content for the build ID string. The same section with an identical value is present in the original built binary with symbols, in its stripped variant, and in the separate debugging information file.

The debugging information file itself should be an ordinary executable, containing a full set of linker symbols, sections, and debugging information. The sections of the debugging information file should have the same names, addresses, and sizes as the original file, but they need not contain any data—much like a `.bss` section in an ordinary executable.

The GNU binary utilities (Binutils) package includes the ‘`objcopy`’ utility that can produce the separated executable / debugging information file pairs using the following commands:

```
objcopy --only-keep-debug foo foo.debug
strip -g foo
```

These commands remove the debugging information from the executable file ‘`foo`’ and place it in the file ‘`foo.debug`’. You can use the first, second or both methods to link the two files:

- The debug link method needs the following additional command to also leave behind a debug link in ‘`foo`’:

```
objcopy --add-gnu-debuglink=foo.debug foo
```

Ulrich Drepper’s ‘`elfutils`’ package, starting with version 0.53, contains a version of the `strip` command such that the command `strip foo -f foo.debug` has the same functionality as the two `objcopy` commands and the `ln -s` command above, together.

- Build ID gets embedded into the main executable using `ld --build-id` or the GCC counterpart `gcc -Wl,--build-id`. Build ID support plus compatibility fixes for debug files separation are present in GNU binary utilities (Binutils) package since version 2.18.

The CRC used in `.gnu_debuglink` is the CRC-32 defined in IEEE 802.3 using the polynomial:

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

The function is computed byte at a time, taking the least significant bit of each byte first. The initial pattern `0xffffffff` is used, to ensure leading zeros affect the CRC and the final result is inverted to ensure trailing zeros also affect the CRC.

Note: This is the same CRC polynomial as used in handling the *Remote Serial Protocol* qCRC packet (see [\(undefined\)](#) [GDB Remote Serial Protocol], page [\(undefined\)](#)). However in the case of the Remote Serial Protocol, the CRC is computed *most* significant bit first, and the result is not inverted, so trailing zeros have no effect on the CRC value.

To complete the description, we show below the code of the function which produces the CRC used in `.gnu_debuglink`. Inverting the initially supplied `crc` argument means that an initial call to this function passing in zero will start computing the CRC using `0xffffffff`.

```
unsigned long
gnu_debuglink_crc32 (unsigned long crc,
                    unsigned char *buf, size_t len)
{
    static const unsigned long crc32_table[256] =
    {
        0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419,
        0x706af48f, 0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4,
        0xe0d5e91e, 0x97d2d988, 0x09b64c2b, 0x7eb17cbd, 0xe7b82d07,
        0x90bf1d91, 0x1db71064, 0x6ab020f2, 0xf3b97148, 0x84be41de,
        0x1adad47d, 0x6ddde4eb, 0xf4d4b551, 0x83d385c7, 0x136c9856,
        0x646ba8c0, 0xfd62f97a, 0x8a65c9ec, 0x14015c4f, 0x63066cd9,
        0xfa0f3d63, 0x8d080df5, 0x3b6e20c8, 0x4c69105e, 0xd56041e4,
        0xa2677172, 0x3c03e4d1, 0x4b04d447, 0xd20d85fd, 0xa50ab56b,
        0x35b5a8fa, 0x42b2986c, 0xdbbbc9d6, 0xacbcf940, 0x32d86ce3,
        0x45df5c75, 0xdcd60dcf, 0xabd13d59, 0x26d930ac, 0x51de003a,
        0xc8d75180, 0xbfd06116, 0x21b4f4b5, 0x56b3c423, 0xcfba9599,
        0xb8bda50f, 0x2802b89e, 0x5f058808, 0xc60cd9b2, 0xb10be924,
        0x2f6f7c87, 0x58684c11, 0xc1611dab, 0xb6662d3d, 0x76dc4190,
        0x01db7106, 0x98d220bc, 0xefd5102a, 0x71b18589, 0x06b6b51f,
        0x9fbfe4a5, 0xe8b8d433, 0x7807c9a2, 0x0f00f934, 0x9609a88e,
        0xe10e9818, 0x7f6a0dbb, 0x086d3d2d, 0x91646c97, 0xe6635c01,
        0xb66b51f4, 0x1c6c6162, 0x856530d8, 0xf262004e, 0x6c0695ed,
        0x1b01a57b, 0x8208f4c1, 0xf50fc457, 0x65b0d9c6, 0x12b7e950,
        0x8bbeb8ea, 0xfcb9887c, 0x62dd1ddf, 0x15da2d49, 0x8cd37cf3,
        0xfbd44c65, 0x4db26158, 0x3ab551ce, 0xa3bc0074, 0xd4bb30e2,
        0x4adfa541, 0x3dd895d7, 0xa4d1c46d, 0xd3d6f4fb, 0x4369e96a,
        0x346ed9fc, 0xad678846, 0xda60b8d0, 0x44042d73, 0x33031de5,
        0xaa0a4c5f, 0xdd0d7cc9, 0x5005713c, 0x270241aa, 0xbe0b1010,
        0xc90c2086, 0x5e68b525, 0x206f85b3, 0xb966d409, 0xce61e49f,
        0x5edef90e, 0x29d9c998, 0xb0d09822, 0xc7d7a8b4, 0x59b33d17,
        0x2eb40d81, 0xb7bd5c3b, 0xc0ba6cad, 0xedb88320, 0x9abfb3b6,
        0x03b6e20c, 0x74b1d29a, 0xead54739, 0x9dd277af, 0x04db2615,
        0x73dc1683, 0xe3630b12, 0x94643b84, 0x0d6d6a3e, 0x7a6a5aa8,
        0xe40ecf0b, 0x9309ff9d, 0x0a00ae27, 0x7d079eb1, 0xf00f9344,
        0x8708a3d2, 0x1e01f268, 0x6906c2fe, 0xf762575d, 0x806567cb,
        0x196c3671, 0x6e6b06e7, 0xfed41b76, 0x89d32be0, 0x10da7a5a,
        0x67dd4acc, 0xf9b9df6f, 0x8ebeeff9, 0x17b7be43, 0x60b08ed5,
        0xd6d6a3e8, 0xa1d1937e, 0x38d8c2c4, 0x4fdff252, 0xd1bb67f1,
        0xa6bc5767, 0x3fb506dd, 0x48b2364b, 0xd80d2bda, 0xaf0a1b4c,
```



```

0x36034af6, 0x41047a60, 0xdf60efc3, 0xa867df55, 0x316e8eef,
0x4669be79, 0xcb61b38c, 0xbc66831a, 0x256fd2a0, 0x5268e236,
0xcc0c7795, 0xbb0b4703, 0x220216b9, 0x5505262f, 0xc5ba3bbe,
0xb2bd0b28, 0x2bb45a92, 0x5cb36a04, 0xc2d7ffa7, 0xb5d0cf31,
0x2cd99e8b, 0x5bdeae1d, 0x9b64c2b0, 0xec63f226, 0x756aa39c,
0x026d930a, 0x9c0906a9, 0xeb0e363f, 0x72076785, 0x05005713,
0x95bf4a82, 0xe2b87a14, 0x7bb12bae, 0x0cb61b38, 0x92d28e9b,
0xe5d5be0d, 0x7cdcefb7, 0x0bdbdf21, 0x86d3d2d4, 0xf1d4e242,
0x68ddb3f8, 0x1fda836e, 0x81be16cd, 0xf6b9265b, 0x6fb077e1,
0x18b74777, 0x88085ae6, 0xff0f6a70, 0x66063bca, 0x11010b5c,
0x8f659eff, 0xf862ae69, 0x616bffd3, 0x166ccf45, 0xa00ae278,
0xd70dd2ee, 0x4e048354, 0x3903b3c2, 0xa7672661, 0xd06016f7,
0x4969474d, 0x3e6e77db, 0xaed16a4a, 0xd9d65adc, 0x40df0b66,
0x37d83bf0, 0xa9bcae53, 0xdebb9ec5, 0x47b2cf7f, 0x30b5ffe9,
0xbdbdf21c, 0xcabac28a, 0x53b39330, 0x24b4a3a6, 0xbad03605,
0xcd70693, 0x54de5729, 0x23d967bf, 0xb3667a2e, 0xc4614ab8,
0x5d681b02, 0x2a6f2b94, 0xb40bbe37, 0xc30c8ea1, 0x5a05df1b,
0x2d02ef8d
};
unsigned char *end;

crc = ~crc & 0xffffffff;
for (end = buf + len; buf < end; ++buf)
    crc = crc32_table[(crc ^ *buf) & 0xff] ^ (crc >> 8);
return ~crc & 0xffffffff;
}

```

This computation does not apply to the “build ID” method.

18.3 Errors Reading Symbol Files

While reading a symbol file, GDB occasionally encounters problems, such as symbol types it does not recognize, or known bugs in compiler output. By default, GDB does not notify you of such problems, since they are relatively common and primarily of interest to people debugging compilers. If you are interested in seeing information about ill-constructed symbol tables, you can either ask GDB to print only one message about each such type of problem, no matter how many times the problem occurs; or you can ask GDB to print more messages, to see how many times the problems occur, with the `set complaints` command (see [\(undefined\)](#) [Optional Warnings and Messages], page [\(undefined\)](#)).

The messages currently printed, and their meanings, include:

`inner block not inside outer block in symbol`

The symbol information shows where symbol scopes begin and end (such as at the start of a function or a block of statements). This error indicates that an inner scope block is not fully contained in its outer scope blocks.

GDB circumvents the problem by treating the inner block as if it had the same scope as the outer block. In the error message, *symbol* may be shown as “(don’t know)” if the outer block is not a function.

`block at address out of order`

The symbol information for symbol scope blocks should occur in order of increasing addresses. This error indicates that it does not do so.

GDB does not circumvent this problem, and has trouble locating symbols in the source file whose symbols it is reading. (You can often determine what

source file is affected by specifying `set verbose on`. See [\(undefined\) \[Optional Warnings and Messages\]](#), page [\(undefined\)](#).)

bad block start address patched

The symbol information for a symbol scope block has a start address smaller than the address of the preceding source line. This is known to occur in the SunOS 4.1.1 (and earlier) C compiler.

GDB circumvents the problem by treating the symbol scope block as starting on the previous source line.

bad string table offset in symbol *n*

Symbol number *n* contains a pointer into the string table which is larger than the size of the string table.

GDB circumvents the problem by considering the symbol to have the name `foo`, which may cause other problems if many symbols end with this name.

unknown symbol type *0xnn*

The symbol information contains new data types that GDB does not yet know how to read. *0xnn* is the symbol type of the uncomprehended information, in hexadecimal.

GDB circumvents the error by ignoring this symbol information. This usually allows you to debug your program, though certain symbols are not accessible. If you encounter such a problem and feel like debugging it, you can debug `gdb` with itself, breakpoint on `complain`, then go up to the function `read_dbx_syntab` and examine `*bufp` to see the symbol.

stub type has NULL name

GDB could not find the full definition for a struct or class.

const/volatile indicator missing (ok if using `g++ v1.x`), got...

The symbol information for a C++ member function is missing some information that recent versions of the compiler should have output for it.

info mismatch between compiler and debugger

GDB could not parse a type specification output by the compiler.

18.4 GDB Data Files

GDB will sometimes read an auxiliary data file. These files are kept in a directory known as the *data directory*.

You can set the data directory's name, and view the name GDB is currently using.

set data-directory *directory*

Set the directory which GDB searches for auxiliary data files to *directory*.

show data-directory

Show the directory GDB searches for auxiliary data files.

You can set the default data directory by using the configure-time `'--with-gdb-datadir'` option. If the data directory is inside GDB's configured binary prefix (set with `'--prefix'` or `'--exec-prefix'`), then the default data directory will be updated automatically if the installed GDB is moved to a new location.

19 Specifying a Debugging Target

A *target* is the execution environment occupied by your program.

Often, GDB runs in the same host environment as your program; in that case, the debugging target is specified as a side effect when you use the `file` or `core` commands. When you need more flexibility—for example, running GDB on a physically separate host, or controlling a standalone system over a serial port or a realtime system over a TCP/IP connection—you can use the `target` command to specify one of the target types configured for GDB (see [\[Commands for Managing Targets\]](#), page [\(undefined\)](#)).

It is possible to build GDB for several different *target architectures*. When GDB is built like that, you can choose one of the available architectures with the `set architecture` command.

`set architecture arch`

This command sets the current target architecture to *arch*. The value of *arch* can be "auto", in addition to one of the supported architectures.

`show architecture`

Show the current target architecture.

`set processor`

`processor`

These are alias commands for, respectively, `set architecture` and `show architecture`.

19.1 Active Targets

There are three classes of targets: processes, core files, and executable files. GDB can work concurrently on up to three active targets, one in each class. This allows you to (for example) start a process and inspect its activity without abandoning your work on a core file.

For example, if you execute `'gdb a.out'`, then the executable file `a.out` is the only active target. If you designate a core file as well—presumably from a prior run that crashed and coredumped—then GDB has two active targets and uses them in tandem, looking first in the corefile target, then in the executable file, to satisfy requests for memory addresses. (Typically, these two classes of target are complementary, since core files contain only a program's read-write memory—variables and so on—plus machine status, while executable files contain only the program text and initialized data.)

When you type `run`, your executable file becomes an active process target as well. When a process target is active, all GDB commands requesting memory addresses refer to that target; addresses in an active core file or executable file target are obscured while the process target is active.

Use the `core-file` and `exec-file` commands to select a new core file or executable target (see [\[Commands to Specify Files\]](#), page [\(undefined\)](#)). To specify as a target a process that is already running, use the `attach` command (see [\[Debugging an Already-running Process\]](#), page [\(undefined\)](#)).

19.2 Commands for Managing Targets

`target type parameters`

Connects the GDB host environment to a target machine or process. A target is typically a protocol for talking to debugging facilities. You use the argument *type* to specify the type or protocol of the target machine.

Further *parameters* are interpreted by the target protocol, but typically include things like device names or host names to connect with, process numbers, and baud rates.

The `target` command does not repeat if you press RET again after executing the command.

`help target`

Displays the names of all targets available. To display targets currently selected, use either `info target` or `info files` (see [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#)).

`help target name`

Describe a particular target, including any parameters necessary to select it.

`set gnutarget args`

GDB uses its own library BFD to read your files. GDB knows whether it is reading an *executable*, a *core*, or a *.o* file; however, you can specify the file format with the `set gnutarget` command. Unlike most `target` commands, with `gnutarget` the `target` refers to a program, not a machine.

Warning: To specify a file format with `set gnutarget`, you must know the actual BFD name.

See [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#).

`show gnutarget`

Use the `show gnutarget` command to display what file format `gnutarget` is set to read. If you have not set `gnutarget`, GDB will determine the file format for each file automatically, and `show gnutarget` displays ‘The current BDF target is “auto”’.

Here are some common targets (available, or not, depending on the GDB configuration):

`target exec program`

An executable file. ‘`target exec program`’ is the same as ‘`exec-file program`’.

`target core filename`

A core dump file. ‘`target core filename`’ is the same as ‘`core-file filename`’.

`target remote medium`

A remote system connected to GDB via a serial line or network connection. This command tells GDB to use its own remote protocol over *medium* for debugging. See [\(undefined\) \[Remote Debugging\], page \(undefined\)](#).

For example, if you have a board connected to ‘`/dev/ttya`’ on the machine running GDB, you could say:

```
target remote /dev/ttya
```

`target remote` supports the `load` command. This is only useful if you have some other way of getting the stub to the target system, and you can put it somewhere in memory where it won't get clobbered by the download.

```
target sim [simargs] ...
```

Builtin CPU simulator. GDB includes simulators for most architectures. In general,

```
target sim
load
run
```

works; however, you cannot assume that a specific memory map, device drivers, or even basic I/O is available, although some simulators do provide these. For info about any processor-specific simulator details, see the appropriate section in [\(undefined\) \[Embedded Processors\], page \(undefined\)](#).

Some configurations may include these targets as well:

```
target nrom dev
```

NetROM ROM emulator. This target only supports downloading.

Different targets are available on different configurations of GDB; your configuration may have more or fewer targets.

Many remote targets require you to download the executable's code once you've successfully established a connection. You may wish to control various aspects of this process.

set hash This command controls whether a hash mark '#' is displayed while downloading a file to the remote monitor. If on, a hash mark is displayed after each S-record is successfully downloaded to the monitor.

show hash Show the current status of displaying the hash mark.

set debug monitor

Enable or disable display of communications messages between GDB and the remote monitor.

show debug monitor

Show the current status of displaying communications between GDB and the remote monitor.

load filename

Depending on what remote debugging facilities are configured into GDB, the `load` command may be available. Where it exists, it is meant to make *filename* (an executable) available for debugging on the remote system—by downloading, or dynamic linking, for example. `load` also records the *filename* symbol table in GDB, like the `add-symbol-file` command.

If your GDB does not have a `load` command, attempting to execute it gets the error message "You can't do that when your target is ..."

The file is loaded at whatever address is specified in the executable. For some object file formats, you can specify the load address when you link the program; for other formats, like `a.out`, the object file format specifies a fixed address.

Depending on the remote side capabilities, GDB may be able to load programs into flash memory.

`load` does not repeat if you press `RET` again after using it.

19.3 Choosing Target Byte Order

Some types of processors, such as the MIPS, PowerPC, and Renesas SH, offer the ability to run either big-endian or little-endian byte orders. Usually the executable or symbol will include a bit to designate the endian-ness, and you will not need to worry about which to use. However, you may still find it useful to adjust GDB's idea of processor endian-ness manually.

`set endian big`

Instruct GDB to assume the target is big-endian.

`set endian little`

Instruct GDB to assume the target is little-endian.

`set endian auto`

Instruct GDB to use the byte order associated with the executable.

`show endian`

Display GDB's current idea of the target byte order.

Note that these commands merely adjust interpretation of symbolic data on the host, and that they have absolutely no effect on the target system.

20 Debugging Remote Programs

If you are trying to debug a program running on a machine that cannot run GDB in the usual way, it is often useful to use remote debugging. For example, you might use remote debugging on an operating system kernel, or on a small system which does not have a general purpose operating system powerful enough to run a full-featured debugger.

Some configurations of GDB have special serial or TCP/IP interfaces to make this work with particular debugging targets. In addition, GDB comes with a generic serial protocol (specific to GDB, but not specific to any particular target system) which you can use if you write the remote stubs—the code that runs on the remote system to communicate with GDB.

Other remote targets may be available in your configuration of GDB; use `help target` to list them.

20.1 Connecting to a Remote Target

On the GDB host machine, you will need an unstripped copy of your program, since GDB needs symbol and debugging information. Start up GDB as usual, using the name of the local copy of your program as the first argument.

GDB can communicate with the target over a serial line, or over an IP network using TCP or UDP. In each case, GDB uses the same protocol for debugging your program; only the medium carrying the debugging packets varies. The `target remote` command establishes a connection to the target. Its arguments indicate which medium to use:

`target remote serial-device`

Use *serial-device* to communicate with the target. For example, to use a serial line connected to the device named `/dev/ttyb`:

```
target remote /dev/ttyb
```

If you're using a serial line, you may want to give GDB the `--baud` option, or use the `set remotebaud` command (see [\[Remote Configuration\]](#), page [\(undefined\)](#)) before the `target` command.

`target remote host:port`

`target remote tcp:host:port`

Debug using a TCP connection to *port* on *host*. The *host* may be either a host name or a numeric IP address; *port* must be a decimal number. The *host* could be the target machine itself, if it is directly connected to the net, or it might be a terminal server which in turn has a serial line to the target.

For example, to connect to port 2828 on a terminal server named `manyfarms`:

```
target remote manyfarms:2828
```

If your remote target is actually running on the same machine as your debugger session (e.g. a simulator for your target running on the same host), you can omit the hostname. For example, to connect to port 1234 on your local machine:

```
target remote :1234
```

Note that the colon is still required here.

target remote udp:host:port

Debug using UDP packets to *port* on *host*. For example, to connect to UDP port 2828 on a terminal server named **manyfarms**:

```
target remote udp:manyfarms:2828
```

When using a UDP connection for remote debugging, you should keep in mind that the ‘U’ stands for “Unreliable”. UDP can silently drop packets on busy or unreliable networks, which will cause havoc with your debugging session.

target remote | command

Run *command* in the background and communicate with it using a pipe. The *command* is a shell command, to be parsed and expanded by the system’s command shell, `/bin/sh`; it should expect remote protocol packets on its standard input, and send replies on its standard output. You could use this to run a stand-alone simulator that speaks the remote debugging protocol, to make net connections using programs like `ssh`, or for other similar tricks.

If *command* closes its standard output (perhaps by exiting), GDB will try to send it a `SIGTERM` signal. (If the program has already exited, this will have no effect.)

Once the connection has been established, you can use all the usual commands to examine and change data. The remote program is already running; you can use *step* and *continue*, and you do not need to use *run*.

Whenever GDB is waiting for the remote program, if you type the interrupt character (often `Ctrl-c`), GDB attempts to stop the program. This may or may not succeed, depending in part on the hardware and the serial drivers the remote system uses. If you type the interrupt character once again, GDB displays this prompt:

```
Interrupted while waiting for the program.
Give up (and stop debugging it)? (y or n)
```

If you type `y`, GDB abandons the remote debugging session. (If you decide you want to try again later, you can use ‘`target remote`’ again to connect once more.) If you type `n`, GDB goes back to waiting.

detach When you have finished debugging the remote program, you can use the **detach** command to release it from GDB control. Detaching from the target normally resumes its execution, but the results will depend on your particular remote stub. After the **detach** command, GDB is free to connect to another target.

disconnect

The **disconnect** command behaves like **detach**, except that the target is generally not resumed. It will wait for GDB (this instance or another one) to connect and continue debugging. After the **disconnect** command, GDB is again free to connect to another target.

monitor cmd

This command allows you to send arbitrary commands directly to the remote monitor. Since GDB doesn’t care about the commands it sends like this, this command is the way to extend GDB—you can add new commands that only the external monitor will understand and implement.

20.2 Sending files to a remote system

Some remote targets offer the ability to transfer files over the same connection used to communicate with GDB. This is convenient for targets accessible through other means, e.g. GNU/Linux systems running `gdbserver` over a network interface. For other targets, e.g. embedded devices with only a single serial port, this may be the only way to upload or download files.

Not all remote targets support these commands.

```
remote put hostfile targetfile
```

Copy file *hostfile* from the host system (the machine running GDB) to *targetfile* on the target system.

```
remote get targetfile hostfile
```

Copy file *targetfile* from the target system to *hostfile* on the host system.

```
remote delete targetfile
```

Delete *targetfile* from the target system.

20.3 Using the gdbserver Program

`gdbserver` is a control program for Unix-like systems, which allows you to connect your program with a remote GDB via `target remote`—but without linking in the usual debugging stub.

`gdbserver` is not a complete replacement for the debugging stubs, because it requires essentially the same operating-system facilities that GDB itself does. In fact, a system that can run `gdbserver` to connect to a remote GDB could also run GDB locally! `gdbserver` is sometimes useful nevertheless, because it is a much smaller program than GDB itself. It is also easier to port than all of GDB, so you may be able to get started more quickly on a new system by using `gdbserver`. Finally, if you develop code for real-time systems, you may find that the tradeoffs involved in real-time operation make it more convenient to do as much development work as possible on another system, for example by cross-compiling. You can use `gdbserver` to make a similar choice for debugging.

GDB and `gdbserver` communicate via either a serial line or a TCP connection, using the standard GDB remote serial protocol.

Warning: `gdbserver` does not have any built-in security. Do not run `gdbserver` connected to any public network; a GDB connection to `gdbserver` provides access to the target system with the same privileges as the user running `gdbserver`.

20.3.1 Running gdbserver

Run `gdbserver` on the target system. You need a copy of the program you want to debug, including any libraries it requires. `gdbserver` does not need your program's symbol table, so you can strip the program if necessary to save space. GDB on the host system does all the symbol handling.

To use the server, you must tell it how to communicate with GDB; the name of your program; and the arguments for your program. The usual syntax is:

```
target> gdbserver comm program [ args ... ]
```

comm is either a device name (to use a serial line) or a TCP hostname and portnumber. For example, to debug Emacs with the argument ‘foo.txt’ and communicate with GDB over the serial port ‘/dev/com1’:

```
target> gdbserver /dev/com1 emacs foo.txt
```

`gdbserver` waits passively for the host GDB to communicate with it.

To use a TCP connection instead of a serial line:

```
target> gdbserver host:2345 emacs foo.txt
```

The only difference from the previous example is the first argument, specifying that you are communicating with the host GDB via TCP. The ‘host:2345’ argument means that `gdbserver` is to expect a TCP connection from machine ‘host’ to local TCP port 2345. (Currently, the ‘host’ part is ignored.) You can choose any number you want for the port number as long as it does not conflict with any TCP ports already in use on the target system (for example, 23 is reserved for `telnet`).¹ You must use the same port number with the host GDB `target remote` command.

20.3.1.1 Attaching to a Running Program

On some targets, `gdbserver` can also attach to running programs. This is accomplished via the `--attach` argument. The syntax is:

```
target> gdbserver --attach comm pid
```

pid is the process ID of a currently running process. It isn’t necessary to point `gdbserver` at a binary for the running process.

You can debug processes by name instead of process ID if your target has the `pidof` utility:

```
target> gdbserver --attach comm ‘pidof program’
```

In case more than one copy of *program* is running, or *program* has multiple threads, most versions of `pidof` support the `-s` option to only return the first process ID.

20.3.1.2 Multi-Process Mode for gdbserver

When you connect to `gdbserver` using `target remote`, `gdbserver` debugs the specified program only once. When the program exits, or you detach from it, GDB closes the connection and `gdbserver` exits.

If you connect using `target extended-remote`, `gdbserver` enters multi-process mode. When the debugged program exits, or you detach from it, GDB stays connected to `gdbserver` even though no program is running. The `run` and `attach` commands instruct `gdbserver` to run or attach to a new program. The `run` command uses `set remote exec-file` (see [\(undefined\) \[set remote exec-file\], page \(undefined\)](#)) to select the program to run. Command line arguments are supported, except for wildcard expansion and I/O redirection (see [\(undefined\) \[Arguments\], page \(undefined\)](#)).

To start `gdbserver` without supplying an initial command to run or process ID to attach, use the ‘`--multi`’ command line option. Then you can connect using `target extended-remote` and start the program you want to debug.

¹ If you choose a port number that conflicts with another service, `gdbserver` prints an error message and exits.

`gdbserver` does not automatically exit in multi-process mode. You can terminate it by using `monitor exit` (see [\(undefined\) \[Monitor Commands for gdbserver\]](#), page [\(undefined\)](#)).

20.3.1.3 Other Command-Line Arguments for `gdbserver`

The ‘`--debug`’ option tells `gdbserver` to display extra status information about the debugging process. The ‘`--remote-debug`’ option tells `gdbserver` to display remote protocol debug output. These options are intended for `gdbserver` development and for bug reports to the developers.

The ‘`--wrapper`’ option specifies a wrapper to launch programs for debugging. The option should be followed by the name of the wrapper, then any command-line arguments to pass to the wrapper, then `--` indicating the end of the wrapper arguments.

`gdbserver` runs the specified wrapper program with a combined command line including the wrapper arguments, then the name of the program to debug, then any arguments to the program. The wrapper runs until it executes your program, and then GDB gains control.

You can use any program that eventually calls `execve` with its arguments as a wrapper. Several standard Unix utilities do this, e.g. `env` and `nohup`. Any Unix shell script ending with `exec "$@"` will also work.

For example, you can use `env` to pass an environment variable to the debugged program, without setting the variable in `gdbserver`’s environment:

```
$ gdbserver --wrapper env LD_PRELOAD=libtest.so -- :2222 ./testprog
```

20.3.2 Connecting to `gdbserver`

Run GDB on the host system.

First make sure you have the necessary symbol files. Load symbols for your application using the `file` command before you connect. Use `set sysroot` to locate target libraries (unless your GDB was compiled with the correct `sysroot` using `--with-sysroot`).

The symbol file and target libraries must exactly match the executable and libraries on the target, with one exception: the files on the host system should not be stripped, even if the files on the target system are. Mismatched or missing files will lead to confusing results during debugging. On GNU/Linux targets, mismatched or missing files may also prevent `gdbserver` from debugging multi-threaded programs.

Connect to your target (see [\(undefined\) \[Connecting to a Remote Target\]](#), page [\(undefined\)](#)). For TCP connections, you must start up `gdbserver` prior to using the `target remote` command. Otherwise you may get an error whose text depends on the host system, but which usually looks something like ‘`Connection refused`’. Don’t use the `load` command in GDB when using `gdbserver`, since the program is already on the target.

20.3.3 Monitor Commands for `gdbserver`

During a GDB session using `gdbserver`, you can use the `monitor` command to send special requests to `gdbserver`. Here are the available commands.

```
monitor help
```

List the available monitor commands.

```
monitor set debug 0
```

```
monitor set debug 1
```

Disable or enable general debugging messages.

```
monitor set remote-debug 0
```

```
monitor set remote-debug 1
```

Disable or enable specific debugging messages associated with the remote protocol (see [\(undefined\)](#) [Remote Protocol], page [\(undefined\)](#)).

```
monitor set libthread-db-search-path [PATH]
```

When this command is issued, *path* is a colon-separated list of directories to search for `libthread_db` (see [\(undefined\)](#) [set libthread-db-search-path], page [\(undefined\)](#)). If you omit *path*, ‘libthread-db-search-path’ will be reset to an empty list.

```
monitor exit
```

Tell `gdbserver` to exit immediately. This command should be followed by `disconnect` to close the debugging session. `gdbserver` will detach from any attached processes and kill any processes it created. Use `monitor exit` to terminate `gdbserver` at the end of a multi-process mode debug session.

20.3.4 Tracepoints support in gdbserver

On some targets, `gdbserver` supports tracepoints, fast tracepoints and static tracepoints.

For fast or static tracepoints to work, a special library called the *in-process agent* (IPA), must be loaded in the inferior process. This library is built and distributed as an integral part of `gdbserver`. In addition, support for static tracepoints requires building the in-process agent library with static tracepoints support. At present, the UST (LTTng Userspace Tracer, <http://lttng.org/ust>) tracing engine is supported. This support is automatically available if UST development headers are found in the standard include path when `gdbserver` is built, or if `gdbserver` was explicitly configured using ‘`--with-ust`’ to point at such headers. You can explicitly disable the support using ‘`--with-ust=no`’.

There are several ways to load the in-process agent in your program:

Specifying it as dependency at link time

You can link your program dynamically with the in-process agent library. On most systems, this is accomplished by adding `-linproctrace` to the link command.

Using the system’s preloading mechanisms

You can force loading the in-process agent at startup time by using your system’s support for preloading shared libraries. Many Unixes support the concept of preloading user defined libraries. In most cases, you do that by specifying `LD_PRELOAD=libinproctrace.so` in the environment. See also the description of `gdbserver`’s ‘`--wrapper`’ command line option.

Using GDB to force loading the agent at run time

On some systems, you can force the inferior to load a shared library, by calling a dynamic loader function in the inferior that takes care of dynamically looking up and loading a shared library. On most Unix systems, the function is `dlopen`. You’ll use the `call` command for that. For example:

```
(gdb) call dlopen ("libinproctrace.so", ...)
```

Note that on most Unix systems, for the `dlopen` function to be available, the program needs to be linked with `-ldl`.

On systems that have a userspace dynamic loader, like most Unix systems, when you connect to `gdbserver` using `target remote`, you'll find that the program is stopped at the dynamic loader's entry point, and no shared library has been loaded in the program's address space yet, including the in-process agent. In that case, before being able to use any of the fast or static tracepoints features, you need to let the loader run and load the shared libraries. The simplest way to do that is to run the program to the main procedure. E.g., if debugging a C or C++ program, start `gdbserver` like so:

```
$ gdbserver :9999 myprogram
```

Start GDB and connect to `gdbserver` like so, and run to main:

```
$ gdb myprogram
(gdb) target remote myhost:9999
0x00007f215893ba60 in ?? () from /lib64/ld-linux-x86-64.so.2
(gdb) b main
(gdb) continue
```

The in-process tracing agent library should now be loaded into the process; you can confirm it with the `info sharedlibrary` command, which will list `'libinproctrace.so'` as loaded in the process. You are now ready to install fast tracepoints, list static tracepoint markers, probe static tracepoints markers, and start tracing.

20.4 Remote Configuration

This section documents the configuration options available when debugging remote programs. For the options related to the File I/O extensions of the remote protocol, see [\(undefined\) \[system\], page \(undefined\)](#).

`set remoteaddresssize bits`

Set the maximum size of address in a memory packet to the specified number of bits. GDB will mask off the address bits above that number, when it passes addresses to the remote target. The default value is the number of bits in the target's address.

`show remoteaddresssize`

Show the current value of remote address size in bits.

`set remotebaud n`

Set the baud rate for the remote serial I/O to `n` baud. The value is used to set the speed of the serial port used for debugging remote targets.

`show remotebaud`

Show the current speed of the remote connection.

`set remotebreak`

If set to on, GDB sends a `BREAK` signal to the remote when you type `Ctrl-c` to interrupt the program running on the remote. If set to off, GDB sends the `'Ctrl-C'` character instead. The default is off, since most remote systems expect to see `'Ctrl-C'` as the interrupt signal.

`show remotebreak`

Show whether GDB sends `BREAK` or `'Ctrl-C'` to interrupt the remote program.

`set remoteflow on`
`set remoteflow off`
Enable or disable hardware flow control (RTS/CTS) on the serial port used to communicate to the remote target.

`show remoteflow`
Show the current setting of hardware flow control.

`set remotelogbase base`
Set the base (a.k.a. radix) of logging serial protocol communications to *base*. Supported values of *base* are: `ascii`, `octal`, and `hex`. The default is `ascii`.

`show remotelogbase`
Show the current setting of the radix for logging remote serial protocol.

`set remotelogfile file`
Record remote serial communications on the named *file*. The default is not to record at all.

`show remotelogfile.`
Show the current setting of the file name on which to record the serial communications.

`set remotetimeout num`
Set the timeout limit to wait for the remote target to respond to *num* seconds. The default is 2 seconds.

`show remotetimeout`
Show the current number of seconds to wait for the remote target responses.

`set remote hardware-watchpoint-limit limit`
`set remote hardware-breakpoint-limit limit`
Restrict GDB to using *limit* remote hardware breakpoint or watchpoints. A limit of -1, the default, is treated as unlimited.

`set remote exec-file filename`
`show remote exec-file`
Select the file used for run with `target extended-remote`. This should be set to a filename valid on the target system. If it is not set, the target will use a default filename (e.g. the last program run).

`set remote interrupt-sequence`
Allow the user to select one of ‘`Ctrl-C`’, `BREAK` or ‘`BREAK-g`’ as the sequence to the remote target in order to interrupt the execution. ‘`Ctrl-C`’ is a default. Some system prefers `BREAK` which is high level of serial line for some certain time. Linux kernel prefers ‘`BREAK-g`’, a.k.a Magic SysRq `g`. It is `BREAK` signal followed by character `g`.

`show interrupt-sequence`
Show which of ‘`Ctrl-C`’, `BREAK` or `BREAK-g` is sent by GDB to interrupt the remote program. `BREAK-g` is `BREAK` signal followed by `g` and also known as Magic SysRq `g`.

set remote interrupt-on-connect

Specify whether interrupt-sequence is sent to remote target when GDB connects to it. This is mostly needed when you debug Linux kernel. Linux kernel expects BREAK followed by g which is known as Magic SysRq g in order to connect GDB.

show interrupt-on-connect

Show whether interrupt-sequence is sent to remote target when GDB connects to it.

set tcp auto-retry on

Enable auto-retry for remote TCP connections. This is useful if the remote debugging agent is launched in parallel with GDB; there is a race condition because the agent may not become ready to accept the connection before GDB attempts to connect. When auto-retry is enabled, if the initial attempt to connect fails, GDB reattempts to establish the connection using the timeout specified by **set tcp connect-timeout**.

set tcp auto-retry off

Do not auto-retry failed TCP connections.

show tcp auto-retry

Show the current auto-retry setting.

set tcp connect-timeout *seconds*

Set the timeout for establishing a TCP connection to the remote target to *seconds*. The timeout affects both polling to retry failed connections (enabled by **set tcp auto-retry on**) and waiting for connections that are merely slow to complete, and represents an approximate cumulative value.

show tcp connect-timeout

Show the current connection timeout setting.

The GDB remote protocol autodetects the packets supported by your debugging stub. If you need to override the autodetection, you can use these commands to enable or disable individual packets. Each packet can be set to ‘on’ (the remote target supports this packet), ‘off’ (the remote target does not support this packet), or ‘auto’ (detect remote target support for this packet). They all default to ‘auto’. For more information about each packet, see [\[Remote Protocol\]](#), page [\(undefined\)](#).

During normal use, you should not have to use any of these commands. If you do, that may be a bug in your remote debugging stub, or a bug in GDB. You may want to report the problem to the GDB developers.

For each packet *name*, the command to enable or disable the packet is **set remote *name*-packet**. The available settings are:

Command Name	Remote Packet	Related Features
fetch-register	p	info registers
set-register	P	set
binary-download	X	load, set

read-aux-vector	qXfer:auxv:read	info auxv
symbol-lookup	qSymbol	Detecting multiple threads
attach	vAttach	attach
verbose-resume	vCont	Stepping or resuming multiple threads
run	vRun	run
software-breakpoint	Z0	break
hardware-breakpoint	Z1	hbreak
write-watchpoint	Z2	watch
read-watchpoint	Z3	rwatch
access-watchpoint	Z4	awatch
target-features	qXfer:features:read	set architecture
library-info	qXfer:libraries:read	info sharedlibrary
memory-map	qXfer:memory-map:read	info mem
read-sdata-object	qXfer:sdata:read	print \$_sdata
read-spu-object	qXfer:spu:read	info spu
write-spu-object	qXfer:spu:write	info spu
read-siginfo-object	qXfer:siginfo:read	print \$_siginfo
write-siginfo-object	qXfer:siginfo:write	set \$_siginfo
threads	qXfer:threads:read	info threads
get-thread-local-storage-address	qGetTLSAddr	Displaying __thread variables

get-thread-information-block-address	qGetTIBAddr	Display MS-Windows Thread Information Block.
search-memory	qSearch:memory	find
supported-packets	qSupported	Remote communications parameters
pass-signals	QPassSignals	handle <i>signal</i>
hostio-close-packet	vFile:close	remote get, remote put
hostio-open-packet	vFile:open	remote get, remote put
hostio-pread-packet	vFile:pread	remote get, remote put
hostio-pwrite-packet	vFile:pwrite	remote get, remote put
hostio-unlink-packet	vFile:unlink	remote delete
noack-packet	QStartNoAckMode	Packet acknowledgment
osdata	qXfer:osdata:read	info os
query-attached	qAttached	Querying remote process attach state.

20.5 Implementing a Remote Stub

The stub files provided with GDB implement the target side of the communication protocol, and the GDB side is implemented in the GDB source file ‘remote.c’. Normally, you can simply allow these subroutines to communicate, and ignore the details. (If you’re implementing your own stub file, you can still ignore the details: start with one of the existing stub files. ‘sparc-stub.c’ is the best organized, and therefore the easiest to read.)

To debug a program running on another machine (the debugging *target* machine), you must first arrange for all the usual prerequisites for the program to run by itself. For example, for a C program, you need:

1. A startup routine to set up the C runtime environment; these usually have a name like

‘`crt0`’. The startup routine may be supplied by your hardware supplier, or you may have to write your own.

2. A C subroutine library to support your program’s subroutine calls, notably managing input and output.
3. A way of getting your program to the other machine—for example, a download program. These are often supplied by the hardware manufacturer, but you may have to write your own from hardware documentation.

The next step is to arrange for your program to use a serial port to communicate with the machine where GDB is running (the *host* machine). In general terms, the scheme looks like this:

On the host,

GDB already understands how to use this protocol; when everything else is set up, you can simply use the ‘`target remote`’ command (see [\[Specifying a Debugging Target\]](#), page [\(undefined\)](#)).

On the target,

you must link with your program a few special-purpose subroutines that implement the GDB remote serial protocol. The file containing these subroutines is called a *debugging stub*.

On certain remote targets, you can use an auxiliary program `gdbserver` instead of linking a stub into your program. See [\[Using the gdbserver Program\]](#), page [\(undefined\)](#), for details.

The debugging stub is specific to the architecture of the remote machine; for example, use ‘`sparc-stub.c`’ to debug programs on SPARC boards.

These working remote stubs are distributed with GDB:

`i386-stub.c`

For Intel 386 and compatible architectures.

`m68k-stub.c`

For Motorola 680x0 architectures.

`sh-stub.c`

For Renesas SH architectures.

`sparc-stub.c`

For SPARC architectures.

`sparcl-stub.c`

For Fujitsu SPARCLITE architectures.

The ‘`README`’ file in the GDB distribution may list other recently added stubs.

20.5.1 What the Stub Can Do for You

The debugging stub for your architecture supplies these three subroutines:

`set_debug_traps`

This routine arranges for `handle_exception` to run when your program stops. You must call this subroutine explicitly near the beginning of your program.

handle_exception

This is the central workhorse, but your program never calls it explicitly—the setup code arranges for **handle_exception** to run when a trap is triggered.

handle_exception takes control when your program stops during execution (for example, on a breakpoint), and mediates communications with GDB on the host machine. This is where the communications protocol is implemented; **handle_exception** acts as the GDB representative on the target machine. It begins by sending summary information on the state of your program, then continues to execute, retrieving and transmitting any information GDB needs, until you execute a GDB command that makes your program resume; at that point, **handle_exception** returns control to your own code on the target machine.

breakpoint

Use this auxiliary subroutine to make your program contain a breakpoint. Depending on the particular situation, this may be the only way for GDB to get control. For instance, if your target machine has some sort of interrupt button, you won't need to call this; pressing the interrupt button transfers control to **handle_exception**—in effect, to GDB. On some machines, simply receiving characters on the serial port may also trigger a trap; again, in that situation, you don't need to call **breakpoint** from your own program—simply running 'target remote' from the host GDB session gets control.

Call **breakpoint** if none of these is true, or if you simply want to make certain your program stops at a predetermined point for the start of your debugging session.

20.5.2 What You Must Do for the Stub

The debugging stubs that come with GDB are set up for a particular chip architecture, but they have no information about the rest of your debugging target machine.

First of all you need to tell the stub how to communicate with the serial port.

int getDebugChar()

Write this subroutine to read a single character from the serial port. It may be identical to **getchar** for your target system; a different name is used to allow you to distinguish the two if you wish.

void putDebugChar(int)

Write this subroutine to write a single character to the serial port. It may be identical to **putchar** for your target system; a different name is used to allow you to distinguish the two if you wish.

If you want GDB to be able to stop your program while it is running, you need to use an interrupt-driven serial driver, and arrange for it to stop when it receives a `^C` ('\003', the control-C character). That is the character which GDB uses to tell the remote system to stop.

Getting the debugging target to return the proper status to GDB probably requires changes to the standard stub; one quick and dirty way is to just execute a breakpoint instruction (the "dirty" part is that GDB reports a **SIGTRAP** instead of a **SIGINT**).

Other routines you need to supply are:

```
void exceptionHandler (int exception_number, void *exception_address)
```

Write this function to install *exception_address* in the exception handling tables. You need to do this because the stub does not have any way of knowing what the exception handling tables on your target system are like (for example, the processor's table might be in ROM, containing entries which point to a table in RAM). *exception_number* is the exception number which should be changed; its meaning is architecture-dependent (for example, different numbers might represent divide by zero, misaligned access, etc). When this exception occurs, control should be transferred directly to *exception_address*, and the processor state (stack, registers, and so on) should be just as it is when a processor exception occurs. So if you want to use a jump instruction to reach *exception_address*, it should be a simple jump, not a jump to subroutine.

For the 386, *exception_address* should be installed as an interrupt gate so that interrupts are masked while the handler runs. The gate should be at privilege level 0 (the most privileged level). The SPARC and 68k stubs are able to mask interrupts themselves without help from `exceptionHandler`.

```
void flush_i_cache()
```

On SPARC and SPARCLITE only, write this subroutine to flush the instruction cache, if any, on your target machine. If there is no instruction cache, this subroutine may be a no-op.

On target machines that have instruction caches, GDB requires this function to make certain that the state of your program is stable.

You must also make sure this library routine is available:

```
void *memset(void *, int, int)
```

This is the standard library function `memset` that sets an area of memory to a known value. If you have one of the free versions of `libc.a`, `memset` can be found there; otherwise, you must either obtain it from your hardware manufacturer, or write your own.

If you do not use the GNU C compiler, you may need other standard library subroutines as well; this varies from one stub to another, but in general the stubs are likely to use any of the common library subroutines which GCC generates as inline code.

20.5.3 Putting it All Together

In summary, when your program is ready to debug, you must follow these steps.

1. Make sure you have defined the supporting low-level routines (see [\(undefined\) \[What You Must Do for the Stub\]](#), page [\(undefined\)](#)):

```
getDebugChar, putDebugChar,  
flush_i_cache, memset, exceptionHandler.
```

2. Insert these lines near the top of your program:

```
set_debug_traps();  
breakpoint();
```

3. For the 680x0 stub only, you need to provide a variable called `exceptionHook`. Normally you just use:

```
void (*exceptionHook)() = 0;
```

but if before calling `set_debug_traps`, you set it to point to a function in your program, that function is called when GDB continues after stopping on a trap (for example, bus error). The function indicated by `exceptionHook` is called with one parameter: an `int` which is the exception number.

4. Compile and link together: your program, the GDB debugging stub for your target architecture, and the supporting subroutines.
5. Make sure you have a serial connection between your target machine and the GDB host, and identify the serial port on the host.
6. Download your program to your target machine (or get it there by whatever means the manufacturer provides), and start it.
7. Start GDB on the host, and connect to the target (see [\[Connecting to a Remote Target\]](#), page [\[undefined\]](#)).

21 Configuration-Specific Information

While nearly all GDB commands are available for all native and cross versions of the debugger, there are some exceptions. This chapter describes things that are only available in certain configurations.

There are three major categories of configurations: native configurations, where the host and target are the same, embedded operating system configurations, which are usually the same for several different processor architectures, and bare embedded processors, which are quite different from each other.

21.1 Native

This section describes details specific to particular native configurations.

21.1.1 HP-UX

On HP-UX systems, if you refer to a function or variable name that begins with a dollar sign, GDB searches for a user or system name first, before it searches for a convenience variable.

21.1.2 BSD libkvm Interface

BSD-derived systems (FreeBSD/NetBSD/OpenBSD) have a kernel memory interface that provides a uniform interface for accessing kernel virtual memory images, including live systems and crash dumps. GDB uses this interface to allow you to debug live kernels and kernel crash dumps on many native BSD configurations. This is implemented as a special `kvm` debugging target. For debugging a live system, load the currently running kernel into GDB and connect to the `kvm` target:

```
(gdb) target kvm
```

For debugging crash dumps, provide the file name of the crash dump as an argument:

```
(gdb) target kvm /var/crash/bsd.0
```

Once connected to the `kvm` target, the following commands are available:

- `kvm pcb` Set current context from the *Process Control Block* (PCB) address.
- `kvm proc` Set current context from `proc` address. This command isn't available on modern FreeBSD systems.

21.1.3 SVR4 Process Information

Many versions of SVR4 and compatible systems provide a facility called `/proc` that can be used to examine the image of a running process using file-system subroutines. If GDB is configured for an operating system with this facility, the command `info proc` is available to report information about the process running your program, or about any process running on your system. `info proc` works only on SVR4 systems that include the `procfs` code. This includes, as of this writing, GNU/Linux, OSF/1 (Digital Unix), Solaris, Irix, and Unixware, but not HP-UX, for example.

```
info proc
```

```
info proc process-id
```

Summarize available information about any running process. If a process ID is specified by `process-id`, display information about that process; otherwise

display information about the program being debugged. The summary includes the debugged process ID, the command line used to invoke it, its current working directory, and its executable file's absolute file name.

On some systems, *process-id* can be of the form '*[pid]/tid*' which specifies a certain thread ID within a process. If the optional *pid* part is missing, it means a thread from the process being debugged (the leading '/' still needs to be present, or else GDB will interpret the number as a process ID rather than a thread ID).

`info proc mappings`

Report the memory address space ranges accessible in the program, with information on whether the process has read, write, or execute access rights to each range. On GNU/Linux systems, each memory range includes the object file which is mapped to that range, instead of the memory access rights to that range.

`info proc stat`

`info proc status`

These subcommands are specific to GNU/Linux systems. They show the process-related information, including the user ID and group ID; how many threads are there in the process; its virtual memory usage; the signals that are pending, blocked, and ignored; its TTY; its consumption of system and user time; its stack size; its 'nice' value; etc. For more information, see the 'proc' man page (type *man 5 proc* from your shell prompt).

`info proc all`

Show all the information about the process described under all of the above `info proc` subcommands.

`set procfs-trace`

This command enables and disables tracing of `procfs` API calls.

`show procfs-trace`

Show the current state of `procfs` API call tracing.

`set procfs-file file`

Tell GDB to write `procfs` API trace to the named *file*. GDB appends the trace info to the previous contents of the file. The default is to display the trace on the standard output.

`show procfs-file`

Show the file to which `procfs` API trace is written.

`proc-trace-entry`

`proc-trace-exit`

`proc-untrace-entry`

`proc-untrace-exit`

These commands enable and disable tracing of entries into and exits from the `syscall` interface.

`info pidlist`

For QNX Neutrino only, this command displays the list of all the processes and all the threads within each process.

`info meminfo`

For QNX Neutrino only, this command displays the list of all mapinfos.

21.1.4 Features for Debugging DJGPP Programs

DJGPP is a port of the GNU development tools to MS-DOS and MS-Windows. DJGPP programs are 32-bit protected-mode programs that use the *DPMI* (DOS Protected-Mode Interface) API to run on top of real-mode DOS systems and their emulations.

GDB supports native debugging of DJGPP programs, and defines a few commands specific to the DJGPP port. This subsection describes those commands.

`info dos` This is a prefix of DJGPP-specific commands which print information about the target system and important OS structures.

`info dos sysinfo`

This command displays assorted information about the underlying platform: the CPU type and features, the OS version and flavor, the DPMI version, and the available conventional and DPMI memory.

`info dos gdt`

`info dos ldt`

`info dos idt`

These 3 commands display entries from, respectively, Global, Local, and Interrupt Descriptor Tables (GDT, LDT, and IDT). The descriptor tables are data structures which store a descriptor for each segment that is currently in use. The segment's selector is an index into a descriptor table; the table entry for that index holds the descriptor's base address and limit, and its attributes and access rights.

A typical DJGPP program uses 3 segments: a code segment, a data segment (used for both data and the stack), and a DOS segment (which allows access to DOS/BIOS data structures and absolute addresses in conventional memory). However, the DPMI host will usually define additional segments in order to support the DPMI environment.

These commands allow to display entries from the descriptor tables. Without an argument, all entries from the specified table are displayed. An argument, which should be an integer expression, means display a single entry whose index is given by the argument. For example, here's a convenient way to display information about the debugged program's data segment:

```
(gdb) info dos ldt $ds
0x13f: base=0x11970000 limit=0x0009ffff 32-Bit Data (Read/Write, Exp-up)
```

This comes in handy when you want to see whether a pointer is outside the data segment's limit (i.e. *garbled*).

`info dos pde`

`info dos pte`

These two commands display entries from, respectively, the Page Directory and the Page Tables. Page Directories and Page Tables are data structures which control how virtual memory addresses are mapped into physical addresses. A Page Table includes an entry for every page of memory that is mapped into the

program's address space; there may be several Page Tables, each one holding up to 4096 entries. A Page Directory has up to 4096 entries, one each for every Page Table that is currently in use.

Without an argument, *info dos pde* displays the entire Page Directory, and *info dos pte* displays all the entries in all of the Page Tables. An argument, an integer expression, given to the *info dos pde* command means display only that entry from the Page Directory table. An argument given to the *info dos pte* command means display entries from a single Page Table, the one pointed to by the specified entry in the Page Directory.

These commands are useful when your program uses *DMA* (Direct Memory Access), which needs physical addresses to program the DMA controller.

These commands are supported only with some DPMI servers.

`info dos address-pte addr`

This command displays the Page Table entry for a specified linear address. The argument *addr* is a linear address which should already have the appropriate segment's base address added to it, because this command accepts addresses which may belong to *any* segment. For example, here's how to display the Page Table entry for the page where a variable *i* is stored:

```
(gdb) info dos address-pte __djgpp_base_address + (char *)&i
Page Table entry for address 0x11a00d30:
Base=0x02698000 Dirty Acc. Not-Cached Write-Back Usr Read-Write +0xd30
```

This says that *i* is stored at offset `0xd30` from the page whose physical base address is `0x02698000`, and shows all the attributes of that page.

Note that you must cast the addresses of variables to a `char *`, since otherwise the value of `__djgpp_base_address`, the base address of all variables and functions in a DJGPP program, will be added using the rules of C pointer arithmetics: if *i* is declared an `int`, GDB will add 4 times the value of `__djgpp_base_address` to the address of *i*.

Here's another example, it displays the Page Table entry for the transfer buffer:

```
(gdb) info dos address-pte *((unsigned *)&_go32_info_block + 3)
Page Table entry for address 0x29110:
Base=0x00029000 Dirty Acc. Not-Cached Write-Back Usr Read-Write +0x110
```

(The `+ 3` offset is because the transfer buffer's address is the 3rd member of the `_go32_info_block` structure.) The output clearly shows that this DPMI server maps the addresses in conventional memory 1:1, i.e. the physical (`0x00029000 + 0x110`) and linear (`0x29110`) addresses are identical.

This command is supported only with some DPMI servers.

In addition to native debugging, the DJGPP port supports remote debugging via a serial data link. The following commands are specific to remote serial debugging in the DJGPP port of GDB.

`set com1base addr`

This command sets the base I/O port address of the 'COM1' serial port.

`set com1irq irq`

This command sets the *Interrupt Request* (IRQ) line to use for the 'COM1' serial port.

There are similar commands ‘`set com2base`’, ‘`set com3irq`’, etc. for setting the port address and the IRQ lines for the other 3 COM ports.

The related commands ‘`show com1base`’, ‘`show com1irq`’ etc. display the current settings of the base address and the IRQ lines used by the COM ports.

`info serial`

This command prints the status of the 4 DOS serial ports. For each port, it prints whether it’s active or not, its I/O base address and IRQ number, whether it uses a 16550-style FIFO, its baudrate, and the counts of various errors encountered so far.

21.1.5 Features for Debugging MS Windows PE Executables

GDB supports native debugging of MS Windows programs, including DLLs with and without symbolic debugging information.

MS-Windows programs that call `SetConsoleMode` to switch off the special meaning of the ‘`Ctrl-C`’ keystroke cannot be interrupted by typing `C-c`. For this reason, GDB on MS-Windows supports `C-BREAK` as an alternative interrupt key sequence, which can be used to interrupt the debuggee even if it ignores `C-c`.

There are various additional Cygwin-specific commands, described in this section. Working with DLLs that have no debugging symbols is described in [\(undefined\) \[Non-debug DLL Symbols\]](#), page [\(undefined\)](#).

`info w32` This is a prefix of MS Windows-specific commands which print information about the target system and important OS structures.

`info w32 selector`

This command displays information returned by the Win32 API `GetThreadSelectorEntry` function. It takes an optional argument that is evaluated to a long value to give the information about this given selector. Without argument, this command displays information about the six segment registers.

`info w32 thread-information-block`

This command displays thread specific information stored in the Thread Information Block (readable on the X86 CPU family using `$fs` selector for 32-bit programs and `$gs` for 64-bit programs).

`info dll` This is a Cygwin-specific alias of `info shared`.

`dll-symbols`

This command loads symbols from a dll similarly to `add-sym` command but without the need to specify a base address.

`set cygwin-exceptions mode`

If `mode` is `on`, GDB will break on exceptions that happen inside the Cygwin DLL. If `mode` is `off`, GDB will delay recognition of exceptions, and may ignore some exceptions which seem to be caused by internal Cygwin DLL “bookkeeping”. This option is meant primarily for debugging the Cygwin DLL itself; the default value is `off` to avoid annoying GDB users with false `SIGSEGV` signals.

show cygwin-exceptions

Displays whether GDB will break on exceptions that happen inside the Cygwin DLL itself.

set new-console mode

If *mode* is **on** the debuggee will be started in a new console on next start. If *mode* is **off**, the debuggee will be started in the same console as the debugger.

show new-console

Displays whether a new console is used when the debuggee is started.

set new-group mode

This boolean value controls whether the debuggee should start a new group or stay in the same group as the debugger. This affects the way the Windows OS handles ‘Ctrl-C’.

show new-group

Displays current value of new-group boolean.

set debugevents

This boolean value adds debug output concerning kernel events related to the debuggee seen by the debugger. This includes events that signal thread and process creation and exit, DLL loading and unloading, console interrupts, and debugging messages produced by the Windows `OutputDebugString` API call.

set debugexec

This boolean value adds debug output concerning execute events (such as resume thread) seen by the debugger.

set debugexceptions

This boolean value adds debug output concerning exceptions in the debuggee seen by the debugger.

set debugmemory

This boolean value adds debug output concerning debuggee memory reads and writes by the debugger.

set shell This boolean value specifies whether the debuggee is called via a shell or directly (default value is on).

show shell

Displays if the debuggee will be started with a shell.

21.1.5.1 Support for DLLs without Debugging Symbols

Very often on windows, some of the DLLs that your program relies on do not include symbolic debugging information (for example, ‘`kernel32.dll`’). When GDB doesn’t recognize any debugging symbols in a DLL, it relies on the minimal amount of symbolic information contained in the DLL’s export table. This section describes working with such symbols, known internally to GDB as “minimal symbols”.

Note that before the debugged program has started execution, no DLLs will have been loaded. The easiest way around this problem is simply to start the program — either by setting a breakpoint or letting the program run once to completion. It is also possible to

force GDB to load a particular DLL before starting the executable — see the shared library information in [\(undefined\) \[Files\], page \(undefined\)](#), or the `dll-symbols` command in [\(undefined\) \[Cygwin Native\], page \(undefined\)](#). Currently, explicitly loading symbols from a DLL with no debugging information will cause the symbol names to be duplicated in GDB’s lookup table, which may adversely affect symbol lookup performance.

21.1.5.2 DLL Name Prefixes

In keeping with the naming conventions used by the Microsoft debugging tools, DLL export symbols are made available with a prefix based on the DLL name, for instance `KERNEL32!CreateFileA`. The plain name is also entered into the symbol table, so `CreateFileA` is often sufficient. In some cases there will be name clashes within a program (particularly if the executable itself includes full debugging symbols) necessitating the use of the fully qualified name when referring to the contents of the DLL. Use single-quotes around the name to avoid the exclamation mark (“!”) being interpreted as a language operator.

Note that the internal name of the DLL may be all upper-case, even though the file name of the DLL is lower-case, or vice-versa. Since symbols within GDB are *case-sensitive* this may cause some confusion. If in doubt, try the `info functions` and `info variables` commands or even `maint print msymbols` (see [\(undefined\) \[Symbols\], page \(undefined\)](#)). Here’s an example:

```
(gdb) info function CreateFileA
All functions matching regular expression "CreateFileA":

Non-debugging symbols:
0x77e885f4 CreateFileA
0x77e885f4 KERNEL32!CreateFileA

(gdb) info function !
All functions matching regular expression "!":

Non-debugging symbols:
0x6100114c cygwin1!__assert
0x61004034 cygwin1!_dll_crt0@0
0x61004240 cygwin1!dll_crt0(per_process *)
[etc...]
```

21.1.5.3 Working with Minimal Symbols

Symbols extracted from a DLL’s export table do not contain very much type information. All that GDB can do is guess whether a symbol refers to a function or variable depending on the linker section that contains the symbol. Also note that the actual contents of the memory contained in a DLL are not available unless the program is running. This means that you cannot examine the contents of a variable or disassemble a function within a DLL without a running program.

Variables are generally treated as pointers and dereferenced automatically. For this reason, it is often necessary to prefix a variable name with the address-of operator (“&”) and provide explicit type information in the command. Here’s an example of the type of problem:

```
(gdb) print 'cygwin1!__argv'
$1 = 268572168
```

```
(gdb) x 'cygwin!__argv'
0x10021610:      "\230y\""
```

And two possible solutions:

```
(gdb) print ((char **) 'cygwin!__argv')[0]
$2 = 0x22fd98 "/cygdrive/c/mydirectory/myprogram"

(gdb) x/2x &'cygwin!__argv'
0x610c0aa8 <cygwin!__argv>:   0x10021608      0x00000000
(gdb) x/x 0x10021608
0x10021608:      0x0022fd98
(gdb) x/s 0x0022fd98
0x22fd98:      "/cygdrive/c/mydirectory/myprogram"
```

Setting a break point within a DLL is possible even before the program starts execution. However, under these circumstances, GDB can't examine the initial instructions of the function in order to skip the function's frame set-up code. You can work around this by using `"*&"` to set the breakpoint at a raw memory address:

```
(gdb) break *&'python22!PyOS_Readline'
Breakpoint 1 at 0x1e04eff0
```

The author of these extensions is not entirely convinced that setting a break point within a shared DLL like `'kernel132.dll'` is completely safe.

21.1.6 Commands Specific to GNU Hurd Systems

This subsection describes GDB commands specific to the GNU Hurd native debugging.

set signals

set sigs This command toggles the state of inferior signal interception by GDB. Mach exceptions, such as breakpoint traps, are not affected by this command. **sigs** is a shorthand alias for **signals**.

show signals

show sigs Show the current state of intercepting inferior's signals.

set signal-thread

set sigthread

This command tells GDB which thread is the `libc` signal thread. That thread is run when a signal is delivered to a running process. **set sigthread** is the shorthand alias of **set signal-thread**.

show signal-thread

show sigthread

These two commands show which thread will run when the inferior is delivered a signal.

set stopped

This command tells GDB that the inferior process is stopped, as with the `SIGSTOP` signal. The stopped process can be continued by delivering a signal to it.

show stopped

This command shows whether GDB thinks the debuggee is stopped.

set exceptions

Use this command to turn off trapping of exceptions in the inferior. When exception trapping is off, neither breakpoints nor single-stepping will work. To restore the default, set exception trapping on.

show exceptions

Show the current state of trapping exceptions in the inferior.

set task pause

This command toggles task suspension when GDB has control. Setting it to on takes effect immediately, and the task is suspended whenever GDB gets control. Setting it to off will take effect the next time the inferior is continued. If this option is set to off, you can use **set thread default pause on** or **set thread pause on** (see below) to pause individual threads.

show task pause

Show the current state of task suspension.

set task detach-suspend-count

This command sets the suspend count the task will be left with when GDB detaches from it.

show task detach-suspend-count

Show the suspend count the task will be left with when detaching.

set task exception-port**set task excp**

This command sets the task exception port to which GDB will forward exceptions. The argument should be the value of the *send rights* of the task. **set task excp** is a shorthand alias.

set noninvasive

This command switches GDB to a mode that is the least invasive as far as interfering with the inferior is concerned. This is the same as using **set task pause**, **set exceptions**, and **set signals** to values opposite to the defaults.

info send-rights**info receive-rights****info port-rights****info port-sets****info dead-names****info ports****info psets**

These commands display information about, respectively, send rights, receive rights, port rights, port sets, and dead names of a task. There are also shorthand aliases: **info ports** for **info port-rights** and **info psets** for **info port-sets**.

set thread pause

This command toggles current thread suspension when GDB has control. Setting it to on takes effect immediately, and the current thread is suspended whenever GDB gets control. Setting it to off will take effect the next time the inferior is

continued. Normally, this command has no effect, since when GDB has control, the whole task is suspended. However, if you used `set task pause off` (see above), this command comes in handy to suspend only the current thread.

show thread pause

This command shows the state of current thread suspension.

set thread run

This command sets whether the current thread is allowed to run.

show thread run

Show whether the current thread is allowed to run.

set thread detach-suspend-count

This command sets the suspend count GDB will leave on a thread when detaching. This number is relative to the suspend count found by GDB when it notices the thread; use `set thread takeover-suspend-count` to force it to an absolute value.

show thread detach-suspend-count

Show the suspend count GDB will leave on the thread when detaching.

set thread exception-port

set thread excp

Set the thread exception port to which to forward exceptions. This overrides the port set by `set task exception-port` (see above). `set thread excp` is the shorthand alias.

set thread takeover-suspend-count

Normally, GDB's thread suspend counts are relative to the value GDB finds when it notices each thread. This command changes the suspend counts to be absolute instead.

set thread default

show thread default

Each of the above `set thread` commands has a `set thread default` counterpart (e.g., `set thread default pause`, `set thread default exception-port`, etc.). The `thread default` variety of commands sets the default thread properties for all threads; you can then change the properties of individual threads with the non-default commands.

21.1.7 QNX Neutrino

GDB provides the following commands specific to the QNX Neutrino target:

set debug nto-debug

When set to on, enables debugging messages specific to the QNX Neutrino support.

show debug nto-debug

Show the current state of QNX Neutrino messages.

21.1.8 Darwin

GDB provides the following commands specific to the Darwin target:

`set debug darwin num`

When set to a non zero value, enables debugging messages specific to the Darwin support. Higher values produce more verbose output.

`show debug darwin`

Show the current state of Darwin messages.

`set debug mach-o num`

When set to a non zero value, enables debugging messages while GDB is reading Darwin object files. (*Mach-O* is the file format used on Darwin for object and executable files.) Higher values produce more verbose output. This is a command to diagnose problems internal to GDB and should not be needed in normal usage.

`show debug mach-o`

Show the current state of Mach-O file messages.

`set mach-exceptions on`

`set mach-exceptions off`

On Darwin, faults are first reported as a Mach exception and are then mapped to a Posix signal. Use this command to turn on trapping of Mach exceptions in the inferior. This might be sometimes useful to better understand the cause of a fault. The default is off.

`show mach-exceptions`

Show the current state of exceptions trapping.

21.2 Embedded Operating Systems

This section describes configurations involving the debugging of embedded operating systems that are available for several different architectures.

GDB includes the ability to debug programs running on various real-time operating systems.

21.2.1 Using GDB with VxWorks

`target vxworks machinename`

A VxWorks system, attached via TCP/IP. The argument *machinename* is the target system's machine name or IP address.

On VxWorks, `load` links *filename* dynamically on the current target system as well as adding its symbols in GDB.

GDB enables developers to spawn and debug tasks running on networked VxWorks targets from a Unix host. Already-running tasks spawned from the VxWorks shell can also be debugged. GDB uses code that runs on both the Unix host and on the VxWorks target. The program `gdb` is installed and executed on the Unix host. (It may be installed with the name `vxgdb`, to distinguish it from a GDB for debugging programs on the host itself.)

VxWorks-timeout args

All VxWorks-based targets now support the option `vxworks-timeout`. This option is set by the user, and `args` represents the number of seconds GDB waits for responses to rpc's. You might use this if your VxWorks target is a slow software simulator or is on the far side of a thin network line.

The following information on connecting to VxWorks was current when this manual was produced; newer releases of VxWorks may use revised procedures.

To use GDB with VxWorks, you must rebuild your VxWorks kernel to include the remote debugging interface routines in the VxWorks library `'rdb.a'`. To do this, define `INCLUDE_RDB` in the VxWorks configuration file `'configAll.h'` and rebuild your VxWorks kernel. The resulting kernel contains `'rdb.a'`, and spawns the source debugging task `tRdbTask` when VxWorks is booted. For more information on configuring and remaking VxWorks, see the manufacturer's manual.

Once you have included `'rdb.a'` in your VxWorks system image and set your Unix execution search path to find GDB, you are ready to run GDB. From your Unix host, run `gdb` (or `vxgdb`, depending on your installation).

GDB comes up showing the prompt:

```
(vxgdb)
```

21.2.1.1 Connecting to VxWorks

The GDB command `target` lets you connect to a VxWorks target on the network. To connect to a target whose host name is `"tt"`, type:

```
(vxgdb) target vxworks tt
```

GDB displays messages like these:

```
Attaching remote machine across net...
Connected to tt.
```

GDB then attempts to read the symbol tables of any object modules loaded into the VxWorks target since it was last booted. GDB locates these files by searching the directories listed in the command search path (see [\(undefined\) \[Your Program's Environment\], page \(undefined\)](#)); if it fails to find an object file, it displays a message such as:

```
prog.o: No such file or directory.
```

When this happens, add the appropriate directory to the search path with the GDB command `path`, and execute the `target` command again.

21.2.1.2 VxWorks Download

If you have connected to the VxWorks target and you want to debug an object that has not yet been loaded, you can use the GDB `load` command to download a file from Unix to VxWorks incrementally. The object file given as an argument to the `load` command is actually opened twice: first by the VxWorks target in order to download the code, then by GDB in order to read the symbol table. This can lead to problems if the current working directories on the two systems differ. If both systems have NFS mounted the same filesystems, you can avoid these problems by using absolute paths. Otherwise, it is simplest to set the working directory on both systems to the directory in which the object file resides, and then to reference the file by its name, without any path. For instance, a program `'prog.o'` may reside in `'vxpath/vw/demo/rdb'` in VxWorks and in `'hostpath/vw/demo/rdb'` on the host. To load this program, type this on VxWorks:

```
-> cd "vxpath/vw/demo/rdb"
```

Then, in GDB, type:

```
(vxgdb) cd hostpath/vw/demo/rdb
(vxgdb) load prog.o
```

GDB displays a response similar to this:

```
Reading symbol data from wherever/vw/demo/rdb/prog.o... done.
```

You can also use the `load` command to reload an object module after editing and recompiling the corresponding source file. Note that this makes GDB delete all currently-defined breakpoints, auto-displays, and convenience variables, and to clear the value history. (This is necessary in order to preserve the integrity of debugger's data structures that reference the target system's symbol table.)

21.2.1.3 Running Tasks

You can also attach to an existing task using the `attach` command as follows:

```
(vxgdb) attach task
```

where *task* is the VxWorks hexadecimal task ID. The task can be running or suspended when you attach to it. Running tasks are suspended at the time of attachment.

21.3 Embedded Processors

This section goes into details specific to particular embedded configurations.

Whenever a specific embedded processor has a simulator, GDB allows to send an arbitrary command to the simulator.

sim command

Send an arbitrary *command* string to the simulator. Consult the documentation for the specific simulator in use for information about acceptable commands.

21.3.1 ARM

target rdi dev

ARM Angel monitor, via RDI library interface to ADP protocol. You may use this target to communicate with both boards running the Angel monitor, or with the EmbeddedICE JTAG debug device.

target rdp dev

ARM Demon monitor.

GDB provides the following ARM-specific commands:

set arm disassembler

This commands selects from a list of disassembly styles. The "`std`" style is the standard style.

show arm disassembler

Show the current disassembly style.

set arm apcs32

This command toggles ARM operation mode between 32-bit and 26-bit.

`show arm apcs32`
 Display the current usage of the ARM 32-bit mode.

`set arm fpu fputype`
 This command sets the ARM floating-point unit (FPU) type. The argument *fputype* can be one of these:

<code>auto</code>	Determine the FPU type by querying the OS ABI.
<code>softfpa</code>	Software FPU, with mixed-endian doubles on little-endian ARM processors.
<code>fpa</code>	GCC-compiled FPA co-processor.
<code>softvfp</code>	Software FPU with pure-endian doubles.
<code>vfp</code>	VFP co-processor.

`show arm fpu`
 Show the current type of the FPU.

`set arm abi`
 This command forces GDB to use the specified ABI.

`show arm abi`
 Show the currently used ABI.

`set arm fallback-mode (arm|thumb|auto)`
 GDB uses the symbol table, when available, to determine whether instructions are ARM or Thumb. This command controls GDB's default behavior when the symbol table is not available. The default is 'auto', which causes GDB to use the current execution mode (from the T bit in the CPSR register).

`show arm fallback-mode`
 Show the current fallback instruction mode.

`set arm force-mode (arm|thumb|auto)`
 This command overrides use of the symbol table to determine whether instructions are ARM or Thumb. The default is 'auto', which causes GDB to use the symbol table and then the setting of 'set arm fallback-mode'.

`show arm force-mode`
 Show the current forced instruction mode.

`set debug arm`
 Toggle whether to display ARM-specific debugging messages from the ARM target support subsystem.

`show debug arm`
 Show whether ARM-specific debugging messages are enabled.

The following commands are available when an ARM target is debugged using the RDI interface:

`rdilogfile [file]`
 Set the filename for the ADP (Angel Debugger Protocol) packet log. With an argument, sets the log file to the specified *file*. With no argument, show the current log file name. The default log file is 'rdi.log'.

`rdilogenable [arg]`

Control logging of ADP packets. With an argument of 1 or "yes" enables logging, with an argument 0 or "no" disables it. With no arguments displays the current setting. When logging is enabled, ADP packets exchanged between GDB and the RDI target device are logged to a file.

`set rdiromatzero`

Tell GDB whether the target has ROM at address 0. If on, vector catching is disabled, so that zero address can be used. If off (the default), vector catching is enabled. For this command to take effect, it needs to be invoked prior to the `target rdi` command.

`show rdiromatzero`

Show the current setting of ROM at zero address.

`set rdiheartbeat`

Enable or disable RDI heartbeat packets. It is not recommended to turn on this option, since it confuses ARM and EPI JTAG interface, as well as the Angel monitor.

`show rdiheartbeat`

Show the setting of RDI heartbeat packets.

`target sim [simargs] ...`

The GDB ARM simulator accepts the following optional arguments.

`--swi-support=type`

Tell the simulator which SWI interfaces to support. *type* may be a comma separated list of the following values. The default value is all.

none

demon

angel

redboot

all

21.3.2 Renesas M32R/D and M32R/SDI

`target m32r dev`

Renesas M32R/D ROM monitor.

`target m32rsdi dev`

Renesas M32R SDI server, connected via parallel port to the board.

The following GDB commands are specific to the M32R monitor:

`set download-path path`

Set the default path for finding downloadable SREC files.

`show download-path`

Show the default path for downloadable SREC files.

`set board-address addr`
Set the IP address for the M32R-EVA target board.

`show board-address`
Show the current IP address of the target board.

`set server-address addr`
Set the IP address for the download server, which is the GDB's host machine.

`show server-address`
Display the IP address of the download server.

`upload [file]`
Upload the specified SREC *file* via the monitor's Ethernet upload capability. If no *file* argument is given, the current executable file is uploaded.

`tload [file]`
Test the `upload` command.

The following commands are available for M32R/SDI:

`sdireset` This command resets the SDI connection.

`sdistatus`
This command shows the SDI connection status.

`debug_chaos`
Instructs the remote that M32R/Chaos debugging is to be used.

`use_debug_dma`
Instructs the remote to use the `DEBUG_DMA` method of accessing memory.

`use_mon_code`
Instructs the remote to use the `MON_CODE` method of accessing memory.

`use_ib_break`
Instructs the remote to set breakpoints by IB break.

`use_dbt_break`
Instructs the remote to set breakpoints by DBT.

21.3.3 M68k

The Motorola m68k configuration includes ColdFire support, and a target command for the following ROM monitor.

`target dbug dev`
dBUG ROM monitor for Motorola ColdFire.

21.3.4 MicroBlaze

The MicroBlaze is a soft-core processor supported on various Xilinx FPGAs, such as Spartan or Virtex series. Boards with these processors usually have JTAG ports which connect to a host system running the Xilinx Embedded Development Kit (EDK) or Software Development Kit (SDK). This host system is used to download the configuration bitstream to the target FPGA. The Xilinx Microprocessor Debugger (XMD) program communicates

with the target board using the JTAG interface and presents a `gdbserver` interface to the board. By default `xmd` uses port 1234. (While it is possible to change this default port, it requires the use of undocumented `xmd` commands. Contact Xilinx support if you need to do this.)

Use these GDB commands to connect to the MicroBlaze target processor.

`target remote :1234`

Use this command to connect to the target if you are running GDB on the same system as `xmd`.

`target remote xmd-host:1234`

Use this command to connect to the target if it is connected to `xmd` running on a different system named `xmd-host`.

`load` Use this command to download a program to the MicroBlaze target.

`set debug microblaze n`

Enable MicroBlaze-specific debugging messages if non-zero.

`show debug microblaze n`

Show MicroBlaze-specific debugging level.

21.3.5 MIPS Embedded

GDB can use the MIPS remote debugging protocol to talk to a MIPS board attached to a serial line. This is available when you configure GDB with ‘`--target=mips-idt-ecoff`’.

Use these GDB commands to specify the connection to your target board:

`target mips port`

To run a program on the board, start up `gdb` with the name of your program as the argument. To connect to the board, use the command ‘`target mips port`’, where `port` is the name of the serial port connected to the board. If the program has not already been downloaded to the board, you may use the `load` command to download it. You can then use all the usual GDB commands.

For example, this sequence connects to the target board through a serial port, and loads and runs a program called `prog` through the debugger:

```
host$ gdb prog
GDB is free software and ...
(gdb) target mips /dev/ttyb
(gdb) load prog
(gdb) run
```

`target mips hostname:portnumber`

On some GDB host configurations, you can specify a TCP connection (for instance, to a serial line managed by a terminal concentrator) instead of a serial port, using the syntax ‘`hostname:portnumber`’.

`target pmon port`

PMON ROM monitor.

`target ddb port`

NEC’s DDB variant of PMON for Vr4300.


```
target lsi port
    LSI variant of PMON.
```

```
target r3900 dev
    Densan DVE-R3900 ROM monitor for Toshiba R3900 Mips.
```

```
target array dev
    Array Tech LSI33K RAID controller board.
```

GDB also supports these special commands for MIPS targets:

```
set mipsfpu double
set mipsfpu single
set mipsfpu none
set mipsfpu auto
show mipsfpu
```

If your target board does not support the MIPS floating point coprocessor, you should use the command `'set mipsfpu none'` (if you need this, you may wish to put the command in your GDB init file). This tells GDB how to find the return value of functions which return floating point values. It also allows GDB to avoid saving the floating point registers when calling functions on the board. If you are using a floating point coprocessor with only single precision floating point support, as on the R4650 processor, use the command `'set mipsfpu single'`. The default double precision floating point coprocessor may be selected using `'set mipsfpu double'`.

In previous versions the only choices were double precision or no floating point, so `'set mipsfpu on'` will select double precision and `'set mipsfpu off'` will select no floating point.

As usual, you can inquire about the `mipsfpu` variable with `'show mipsfpu'`.

```
set timeout seconds
set retransmit-timeout seconds
show timeout
show retransmit-timeout
```

You can control the timeout used while waiting for a packet, in the MIPS remote protocol, with the `set timeout seconds` command. The default is 5 seconds. Similarly, you can control the timeout used while waiting for an acknowledgment of a packet with the `set retransmit-timeout seconds` command. The default is 3 seconds. You can inspect both values with `show timeout` and `show retransmit-timeout`. (These commands are *only* available when GDB is configured for `'--target=mips-idt-ecoff'`.)

The timeout set by `set timeout` does not apply when GDB is waiting for your program to stop. In that case, GDB waits forever because it has no way of knowing how long the program is going to run before stopping.

```
set syn-garbage-limit num
```

Limit the maximum number of characters GDB should ignore when it tries to synchronize with the remote target. The default is 10 characters. Setting the limit to -1 means there's no limit.

show syn-garbage-limit

Show the current limit on the number of characters to ignore when trying to synchronize with the remote system.

set monitor-prompt *prompt*

Tell GDB to expect the specified *prompt* string from the remote monitor. The default depends on the target:

pmon target

 'PMON'

ddb target 'NEC010'

lsi target 'PMON>'

show monitor-prompt

Show the current strings GDB expects as the prompt from the remote monitor.

set monitor-warnings

Enable or disable monitor warnings about hardware breakpoints. This has effect only for the `lsi` target. When on, GDB will display warning messages whose codes are returned by the `lsi` PMON monitor for breakpoint commands.

show monitor-warnings

Show the current setting of printing monitor warnings.

pmon *command*

This command allows sending an arbitrary *command* string to the monitor. The monitor must be in debug mode for this to work.

21.3.6 OpenRISC 1000

See OR1k Architecture document (www.opencores.org) for more information about platform and commands.

target jtag jtag://*host:port*

Connects to remote JTAG server. JTAG remote server can be either an `or1ksim` or JTAG server, connected via parallel port to the board.

Example: `target jtag jtag://localhost:9999`

or1ksim *command*

If connected to `or1ksim` OpenRISC 1000 Architectural Simulator, proprietary commands can be executed.

info or1k spr

Displays spr groups.

info or1k spr *group***info or1k spr *groupno***

Displays register names in selected group.

info or1k spr *group register***info or1k spr *register*****info or1k spr *groupno registerno*****info or1k spr *registerno***

Shows information about specified spr register.

```

spr group register value
spr register value
spr groupno registerno value
spr registerno value

```

Writes *value* to specified spr register.

Some implementations of OpenRISC 1000 Architecture also have hardware trace. It is very similar to GDB trace, except it does not interfere with normal program execution and is thus much faster. Hardware breakpoints/watchpoint triggers can be set using:

```

$LEA/$LDATA      Load effective address/data
$SEA/$SDATA      Store effective address/data
$AEA/$ADATA      Access effective address ($SEA or $LEA) or data ($SDATA/$LDATA)
$FETCH           Fetch data

```

When triggered, it can capture low level data, like: PC, LSEA, LDATA, SDATA, READSPR, WRITESPR, INSTR.

htrace commands:

```

hwatch conditional
    Set hardware watchpoint on combination of Load/Store Effective Address(es)
    or Data. For example:
    hwatch ($LEA == my_var) && ($LDATA < 50) || ($SEA == my_var) &&
    ($SDATA >= 50)
    hwatch ($LEA == my_var) && ($LDATA < 50) || ($SEA == my_var) &&
    ($SDATA >= 50)

htrace info
    Display information about current HW trace configuration.

htrace trigger conditional
    Set starting criteria for HW trace.

htrace qualifier conditional
    Set acquisition qualifier for HW trace.

htrace stop conditional
    Set HW trace stopping criteria.

htrace record [data]*
    Selects the data to be recorded, when qualifier is met and HW trace was trig-
    gered.

htrace enable
htrace disable
    Enables/disables the HW trace.

```

`htrace rewind [filename]`

Clears currently recorded trace data.

If filename is specified, new trace file is made and any newly collected data will be written there.

`htrace print [start [len]]`

Prints trace buffer, using current record configuration.

`htrace mode continuous`

Set continuous trace mode.

`htrace mode suspend`

Set suspend trace mode.

21.3.7 PowerPC Embedded

GDB supports using the DVC (Data Value Compare) register to implement in hardware simple hardware watchpoint conditions of the form:

```
(gdb) watch ADDRESS|VARIABLE \
      if ADDRESS|VARIABLE == CONSTANT EXPRESSION
```

The DVC register will be automatically used whenever GDB detects such pattern in a condition expression. This feature is available in native GDB running on a Linux kernel version 2.6.34 or newer.

GDB provides the following PowerPC-specific commands:

`set powerpc soft-float`

`show powerpc soft-float`

Force GDB to use (or not use) a software floating point calling convention. By default, GDB selects the calling convention based on the selected architecture and the provided executable file.

`set powerpc vector-abi`

`show powerpc vector-abi`

Force GDB to use the specified calling convention for vector arguments and return values. The valid options are ‘auto’; ‘generic’, to avoid vector registers even if they are present; ‘altivec’, to use AltiVec registers; and ‘spe’ to use SPE registers. By default, GDB selects the calling convention based on the selected architecture and the provided executable file.

`target dink32 dev`

DINK32 ROM monitor.

`target ppctest dev`

`target ppctest1 dev`

PPCTEST ROM monitor for PowerPC.

`target sds dev`

SDS monitor, running on a PowerPC board (such as Motorola’s ADS).

The following commands specific to the SDS protocol are supported by GDB:

`set sdstimeout nsec`

Set the timeout for SDS protocol reads to be *nsec* seconds. The default is 2 seconds.

`show sdstimeout`

Show the current value of the SDS timeout.

`sds command`

Send the specified *command* string to the SDS monitor.

21.3.8 HP PA Embedded

`target op50n dev`

OP50N monitor, running on an OKI HPPA board.

`target w89k dev`

W89K monitor, running on a Winbond HPPA board.

21.3.9 Tsquare Sparclet

GDB enables developers to debug tasks running on Sparclet targets from a Unix host. GDB uses code that runs on both the Unix host and on the Sparclet target. The program `gdb` is installed and executed on the Unix host.

`remotetimeout args`

GDB supports the option `remotetimeout`. This option is set by the user, and *args* represents the number of seconds GDB waits for responses.

When compiling for debugging, include the options ‘-g’ to get debug information and ‘-Ttext’ to relocate the program to where you wish to load it on the target. You may also want to add the options ‘-n’ or ‘-N’ in order to reduce the size of the sections. Example:

```
sparclet-aout-gcc prog.c -Ttext 0x12010000 -g -o prog -N
```

You can use `objdump` to verify that the addresses are what you intended:

```
sparclet-aout-objdump --headers --syms prog
```

Once you have set your Unix execution search path to find GDB, you are ready to run GDB. From your Unix host, run `gdb` (or `sparclet-aout-gdb`, depending on your installation).

GDB comes up showing the prompt:

```
(gdb)let)
```

21.3.9.1 Setting File to Debug

The GDB command `file` lets you choose with program to debug.

```
(gdb)let) file prog
```

GDB then attempts to read the symbol table of ‘`prog`’. GDB locates the file by searching the directories listed in the command search path. If the file was compiled with debug information (option ‘-g’), source files will be searched as well. GDB locates the source files by searching the directories listed in the directory search path (see [\(undefined\) \[Your Program’s Environment\], page \(undefined\)](#)). If it fails to find a file, it displays a message such as:

```
prog: No such file or directory.
```

When this happens, add the appropriate directories to the search paths with the GDB commands `path` and `dir`, and execute the `target` command again.

21.3.9.2 Connecting to Sparclet

The GDB command `target` lets you connect to a Sparclet target. To connect to a target on serial port “`ttya`”, type:

```
(gdb) target sparclet /dev/ttya
Remote target sparclet connected to /dev/ttya
main () at ../prog.c:3
```

GDB displays messages like these:

```
Connected to ttya.
```

21.3.9.3 Sparclet Download

Once connected to the Sparclet target, you can use the GDB `load` command to download the file from the host to the target. The file name and load offset should be given as arguments to the `load` command. Since the file format is `aout`, the program must be loaded to the starting address. You can use `objdump` to find out what this value is. The load offset is an offset which is added to the VMA (virtual memory address) of each of the file’s sections. For instance, if the program ‘`prog`’ was linked to text address `0x1201000`, with data at `0x12010160` and bss at `0x12010170`, in GDB, type:

```
(gdb) load prog 0x1201000
Loading section .text, size 0xdb0 vma 0x12010000
```

If the code is loaded at a different address than what the program was linked to, you may need to use the `section` and `add-symbol-file` commands to tell GDB where to map the symbol table.

21.3.9.4 Running and Debugging

You can now begin debugging the task using GDB’s execution control commands, `b`, `step`, `run`, etc. See the GDB manual for the list of commands.

```
(gdb) b main
Breakpoint 1 at 0x1201000: file prog.c, line 3.
(gdb) run
Starting program: prog
Breakpoint 1, main (argc=1, argv=0xefff21c) at prog.c:3
3     char *symarg = 0;
(gdb) step
4     char *execarg = "hello!";
(gdb)
```

21.3.10 Fujitsu Sparclite

`target sparc-lite dev`

Fujitsu sparc-lite boards, used only for the purpose of loading. You must use an additional command to debug the program. For example: `target remote dev` using GDB standard remote protocol.

21.3.11 Zilog Z8000

When configured for debugging Zilog Z8000 targets, GDB includes a Z8000 simulator.

For the Z8000 family, ‘`target sim`’ simulates either the Z8002 (the unsegmented variant of the Z8000 architecture) or the Z8001 (the segmented variant). The simulator recognizes which architecture is appropriate by inspecting the object code.

target sim args

Debug programs on a simulated CPU. If the simulator supports setup options, specify them via *args*.

After specifying this target, you can debug programs for the simulated CPU in the same style as programs for your host computer; use the `file` command to load a new program image, the `run` command to run your program, and so on.

As well as making available all the usual machine registers (see [\[Registers\]](#), page [\[undefined\]](#)), the Z8000 simulator provides three additional items of information as specially named registers:

cycles Counts clock-ticks in the simulator.
insts Counts instructions run in the simulator.
time Execution time in 60ths of a second.

You can refer to these values in GDB expressions with the usual conventions; for example, `'b fputc if $cycles>5000'` sets a conditional breakpoint that suspends only after at least 5000 simulated clock ticks.

21.3.12 Atmel AVR

When configured for debugging the Atmel AVR, GDB supports the following AVR-specific commands:

info io_registers

This command displays information about the AVR I/O registers. For each register, GDB prints its number and value.

21.3.13 CRIS

When configured for debugging CRIS, GDB provides the following CRIS-specific commands:

set cris-version ver

Set the current CRIS version to *ver*, either '10' or '32'. The CRIS version affects register names and sizes. This command is useful in case autodetection of the CRIS version fails.

show cris-version

Show the current CRIS version.

set cris-dwarf2-cfi

Set the usage of DWARF-2 CFI for CRIS debugging. The default is 'on'. Change to 'off' when using `gcc-cris` whose version is below R59.

show cris-dwarf2-cfi

Show the current state of using DWARF-2 CFI.

set cris-mode mode

Set the current CRIS mode to *mode*. It should only be changed when debugging in guru mode, in which case it should be set to 'guru' (the default is 'normal').

show cris-mode

Show the current CRIS mode.

21.3.14 Renesas Super-H

For the Renesas Super-H processor, GDB provides these commands:

regs Show the values of all Super-H registers.

set sh calling-convention *convention*

Set the calling-convention used when calling functions from GDB. Allowed values are ‘gcc’, which is the default setting, and ‘renesas’. With the ‘gcc’ setting, functions are called using the GCC calling convention. If the DWARF-2 information of the called function specifies that the function follows the Renesas calling convention, the function is called using the Renesas calling convention. If the calling convention is set to ‘renesas’, the Renesas calling convention is always used, regardless of the DWARF-2 information. This can be used to override the default of ‘gcc’ if debug information is missing, or the compiler does not emit the DWARF-2 calling convention entry for a function.

show sh calling-convention

Show the current calling convention setting.

21.4 Architectures

This section describes characteristics of architectures that affect all uses of GDB with the architecture, both native and cross.

21.4.1 x86 Architecture-specific Issues

set struct-convention *mode*

Set the convention used by the inferior to return **structs** and **unions** from functions to *mode*. Possible values of *mode* are "pcc", "reg", and "default" (the default). "default" or "pcc" means that **structs** are returned on the stack, while "reg" means that a **struct** or a **union** whose size is 1, 2, 4, or 8 bytes will be returned in a register.

show struct-convention

Show the current setting of the convention to return **structs** from functions.

21.4.2 A29K

set rstack_high_address *address*

On AMD 29000 family processors, registers are saved in a separate *register stack*. There is no way for GDB to determine the extent of this stack. Normally, GDB just assumes that the stack is “large enough”. This may result in GDB referencing memory locations that do not exist. If necessary, you can get around this problem by specifying the ending address of the register stack with the **set rstack_high_address** command. The argument should be an address, which you probably want to precede with ‘0x’ to specify in hexadecimal.

show rstack_high_address

Display the current limit of the register stack, on AMD 29000 family processors.

21.4.3 Alpha

See the following section.

21.4.4 MIPS

Alpha- and MIPS-based computers use an unusual stack frame, which sometimes requires GDB to search backward in the object code to find the beginning of a function.

To improve response time (especially for embedded applications, where GDB may be restricted to a slow serial line for this search) you may want to limit the size of this search, using one of these commands:

set heuristic-fence-post *limit*

Restrict GDB to examining at most *limit* bytes in its search for the beginning of a function. A value of 0 (the default) means there is no limit. However, except for 0, the larger the limit the more bytes **heuristic-fence-post** must search and therefore the longer it takes to run. You should only need to use this command when debugging a stripped executable.

show heuristic-fence-post

Display the current limit.

These commands are available *only* when GDB is configured for debugging programs on Alpha or MIPS processors.

Several MIPS-specific commands are available when debugging MIPS programs:

set mips abi *arg*

Tell GDB which MIPS ABI is used by the inferior. Possible values of *arg* are:

‘auto’ The default ABI associated with the current binary (this is the default).

‘o32’

‘o64’

‘n32’

‘n64’

‘eabi32’

‘eabi64’

‘auto’

show mips abi

Show the MIPS ABI used by GDB to debug the inferior.

set mipsfpu

show mipsfpu

See [\(undefined\)](#) [MIPS Embedded], page [\(undefined\)](#).

set mips mask-address *arg*

This command determines whether the most-significant 32 bits of 64-bit MIPS addresses are masked off. The argument *arg* can be ‘on’, ‘off’, or ‘auto’. The latter is the default setting, which lets GDB determine the correct value.

show mips mask-address

Show whether the upper 32 bits of MIPS addresses are masked off or not.

set remote-mips64-transfers-32bit-regs

This command controls compatibility with 64-bit MIPS targets that transfer data in 32-bit quantities. If you have an old MIPS 64 target that transfers 32 bits for some registers, like SR and FSR, and 64 bits for other registers, set this option to 'on'.

show remote-mips64-transfers-32bit-regs

Show the current setting of compatibility with older MIPS 64 targets.

set debug mips

This command turns on and off debugging messages for the MIPS-specific target code in GDB.

show debug mips

Show the current setting of MIPS debugging messages.

21.4.5 HPPA

When GDB is debugging the HP PA architecture, it provides the following special commands:

set debug hppa

This command determines whether HPPA architecture-specific debugging messages are to be displayed.

show debug hppa

Show whether HPPA debugging messages are displayed.

maint print unwind *address*

This command displays the contents of the unwind table entry at the given *address*.

21.4.6 Cell Broadband Engine SPU architecture

When GDB is debugging the Cell Broadband Engine SPU architecture, it provides the following special commands:

info spu event

Display SPU event facility status. Shows current event mask and pending event status.

info spu signal

Display SPU signal notification facility status. Shows pending signal-control word and signal notification mode of both signal notification channels.

info spu mailbox

Display SPU mailbox facility status. Shows all pending entries, in order of processing, in each of the SPU Write Outbound, SPU Write Outbound Interrupt, and SPU Read Inbound mailboxes.

info spu dma

Display MFC DMA status. Shows all pending commands in the MFC DMA queue. For each entry, opcode, tag, class IDs, effective and local store addresses and transfer size are shown.

`info spu proxydma`

Display MFC Proxy-DMA status. Shows all pending commands in the MFC Proxy-DMA queue. For each entry, opcode, tag, class IDs, effective and local store addresses and transfer size are shown.

When GDB is debugging a combined PowerPC/SPU application on the Cell Broadband Engine, it provides in addition the following special commands:

`set spu stop-on-load arg`

Set whether to stop for new SPE threads. When set to `on`, GDB will give control to the user when a new SPE thread enters its `main` function. The default is `off`.

`show spu stop-on-load`

Show whether to stop for new SPE threads.

`set spu auto-flush-cache arg`

Set whether to automatically flush the software-managed cache. When set to `on`, GDB will automatically cause the SPE software-managed cache to be flushed whenever SPE execution stops. This provides a consistent view of PowerPC memory that is accessed via the cache. If an application does not use the software-managed cache, this option has no effect.

`show spu auto-flush-cache`

Show whether to automatically flush the software-managed cache.

21.4.7 PowerPC

When GDB is debugging the PowerPC architecture, it provides a set of pseudo-registers to enable inspection of 128-bit wide Decimal Floating Point numbers stored in the floating point registers. These values must be stored in two consecutive registers, always starting at an even register like `f0` or `f2`.

The pseudo-registers go from `$d10` through `$d115`, and are formed by joining the even/odd register pairs `f0` and `f1` for `$d10`, `f2` and `f3` for `$d11` and so on.

For POWER7 processors, GDB provides a set of pseudo-registers, the 64-bit wide Extended Floating Point Registers (`'f32'` through `'f63'`).

22 Controlling GDB

You can alter the way GDB interacts with you by using the `set` command. For commands controlling how GDB displays data, see [\(undefined\) \[Print Settings\], page \(undefined\)](#). Other settings are described here.

22.1 Prompt

GDB indicates its readiness to read a command by printing a string called the *prompt*. This string is normally `(gdb)`. You can change the prompt string with the `set prompt` command. For instance, when debugging GDB with GDB, it is useful to change the prompt in one of the GDB sessions so that you can always tell which one you are talking to.

Note: `set prompt` does not add a space for you after the prompt you set. This allows you to set a prompt which ends in a space or a prompt that does not.

`set prompt newprompt`

Directs GDB to use *newprompt* as its prompt string henceforth.

`show prompt`

Prints a line of the form: `Gdb's prompt is: your-prompt`

22.2 Command Editing

GDB reads its input commands via the *Readline* interface. This GNU library provides consistent behavior for programs which provide a command line interface to the user. Advantages are GNU Emacs-style or *vi*-style inline editing of commands, *cs**h*-like history substitution, and a storage and recall of command history across debugging sessions.

You may control the behavior of command line editing in GDB with the command `set`.

`set editing`

`set editing on`

Enable command line editing (enabled by default).

`set editing off`

Disable command line editing.

`show editing`

Show whether command line editing is enabled.

See [\(undefined\) \[Command Line Editing\], page \(undefined\)](#), for more details about the *Readline* interface. Users unfamiliar with GNU Emacs or *vi* are encouraged to read that chapter.

22.3 Command History

GDB can keep track of the commands you type during your debugging sessions, so that you can be certain of precisely what happened. Use these commands to manage the GDB command history facility.

GDB uses the GNU History library, a part of the *Readline* package, to provide the history facility. See [\(undefined\) \[Using History Interactively\], page \(undefined\)](#), for the detailed description of the History library.

To issue a command to GDB without affecting certain aspects of the state which is seen by users, prefix it with ‘`server`’ (see [\(undefined\) \[Server Prefix\], page \(undefined\)](#)). This means that this command will not affect the command history, nor will it affect GDB’s notion of which command to repeat if RET is pressed on a line by itself.

The server prefix does not affect the recording of values into the value history; to print a value without recording it into the value history, use the `output` command instead of the `print` command.

Here is the description of GDB commands related to command history.

`set history filename fname`

Set the name of the GDB command history file to *fname*. This is the file where GDB reads an initial command history list, and where it writes the command history from this session when it exits. You can access this list through history expansion or through the history command editing characters listed below. This file defaults to the value of the environment variable `GDBHISTFILE`, or to ‘`./gdb_history`’ (‘`./_gdb_history`’ on MS-DOS) if this variable is not set.

`set history save`

`set history save on`

Record command history in a file, whose name may be specified with the `set history filename` command. By default, this option is disabled.

`set history save off`

Stop recording command history in a file.

`set history size size`

Set the number of commands which GDB keeps in its history list. This defaults to the value of the environment variable `HISTSIZE`, or to 256 if this variable is not set.

History expansion assigns special meaning to the character `!`. See [\(undefined\) \[Event Designators\], page \(undefined\)](#), for more details.

Since `!` is also the logical not operator in C, history expansion is off by default. If you decide to enable history expansion with the `set history expansion on` command, you may sometimes need to follow `!` (when it is used as logical not, in an expression) with a space or a tab to prevent it from being expanded. The readline history facilities do not attempt substitution on the strings `!=` and `!C`, even when history expansion is enabled.

The commands to control history expansion are:

`set history expansion on`

`set history expansion`

Enable history expansion. History expansion is off by default.

`set history expansion off`

Disable history expansion.

```
show history
```

```
show history filename
```

```
show history save
```

```
show history size
```

```
show history expansion
```

These commands display the state of the GDB history parameters. `show history` by itself displays all four states.

```
show commands
```

Display the last ten commands in the command history.

```
show commands n
```

Print ten commands centered on command number *n*.

```
show commands +
```

Print ten commands just after the commands last printed.

22.4 Screen Size

Certain commands to GDB may produce large amounts of information output to the screen. To help you read all of it, GDB pauses and asks you for input at the end of each page of output. Type `RET` when you want to continue the output, or `q` to discard the remaining output. Also, the screen width setting determines when to wrap lines of output. Depending on what is being printed, GDB tries to break the line at a readable place, rather than simply letting it overflow onto the following line.

Normally GDB knows the size of the screen from the terminal driver software. For example, on Unix GDB uses the termcap data base together with the value of the `TERM` environment variable and the `stty rows` and `stty cols` settings. If this is not correct, you can override it with the `set height` and `set width` commands:

```
set height lpp
```

```
show height
```

```
set width cpl
```

```
show width
```

These `set` commands specify a screen height of *lpp* lines and a screen width of *cpl* characters. The associated `show` commands display the current settings.

If you specify a height of zero lines, GDB does not pause during output no matter how long the output is. This is useful if output is to a file or to an editor buffer.

Likewise, you can specify `'set width 0'` to prevent GDB from wrapping its output.

```
set pagination on
```

```
set pagination off
```

Turn the output pagination on or off; the default is on. Turning pagination off is the alternative to `set height 0`. Note that running GDB with the `'--batch'` option (see [\(undefined\) \[Mode Options\], page \(undefined\)](#)) also automatically disables pagination.

```
show pagination
```

Show the current pagination mode.

22.5 Numbers

You can always enter numbers in octal, decimal, or hexadecimal in GDB by the usual conventions: octal numbers begin with ‘0’, decimal numbers end with ‘.’, and hexadecimal numbers begin with ‘0x’. Numbers that neither begin with ‘0’ or ‘0x’, nor end with a ‘.’ are, by default, entered in base 10; likewise, the default display for numbers—when no particular format is specified—is base 10. You can change the default base for both input and output with the commands described below.

`set input-radix base`

Set the default base for numeric input. Supported choices for *base* are decimal 8, 10, or 16. *base* must itself be specified either unambiguously or using the current input radix; for example, any of

```
set input-radix 012
set input-radix 10.
set input-radix 0xa
```

sets the input base to decimal. On the other hand, ‘`set input-radix 10`’ leaves the input radix unchanged, no matter what it was, since ‘10’, being without any leading or trailing signs of its base, is interpreted in the current radix. Thus, if the current radix is 16, ‘10’ is interpreted in hex, i.e. as 16 decimal, which doesn’t change the radix.

`set output-radix base`

Set the default base for numeric display. Supported choices for *base* are decimal 8, 10, or 16. *base* must itself be specified either unambiguously or using the current input radix.

`show input-radix`

Display the current default base for numeric input.

`show output-radix`

Display the current default base for numeric display.

`set radix [base]`

`show radix`

These commands set and show the default base for both input and output of numbers. `set radix` sets the radix of input and output to the same base; without an argument, it resets the radix back to its default value of 10.

22.6 Configuring the Current ABI

GDB can determine the *ABI* (Application Binary Interface) of your application automatically. However, sometimes you need to override its conclusions. Use these commands to manage GDB’s view of the current ABI.

One GDB configuration can debug binaries for multiple operating system targets, either via remote debugging or native emulation. GDB will autodetect the *OS ABI* (Operating System ABI) in use, but you can override its conclusion using the `set osabi` command. One example where this is useful is in debugging of binaries which use an alternate C library (e.g. `uclibc` for GNU/Linux) which does not have the same identifying marks that the standard C library for your platform provides.

`show osabi`

Show the OS ABI currently in use.

`set osabi` With no argument, show the list of registered available OS ABI's.

`set osabi abi`

Set the current OS ABI to *abi*.

Generally, the way that an argument of type `float` is passed to a function depends on whether the function is prototyped. For a prototyped (i.e. ANSI/ISO style) function, `float` arguments are passed unchanged, according to the architecture's convention for `float`. For unprototyped (i.e. K&R style) functions, `float` arguments are first promoted to type `double` and then passed.

Unfortunately, some forms of debug information do not reliably indicate whether a function is prototyped. If GDB calls a function that is not marked as prototyped, it consults `set coerce-float-to-double`.

`set coerce-float-to-double`

`set coerce-float-to-double on`

Arguments of type `float` will be promoted to `double` when passed to an unprototyped function. This is the default setting.

`set coerce-float-to-double off`

Arguments of type `float` will be passed directly to unprototyped functions.

`show coerce-float-to-double`

Show the current setting of promoting `float` to `double`.

GDB needs to know the ABI used for your program's C++ objects. The correct C++ ABI depends on which C++ compiler was used to build your application. GDB only fully supports programs with a single C++ ABI; if your program contains code using multiple C++ ABI's or if GDB can not identify your program's ABI correctly, you can tell GDB which ABI to use. Currently supported ABI's include "gnu-v2", for g++ versions before 3.0, "gnu-v3", for g++ versions 3.0 and later, and "hpaCC" for the HP ANSI C++ compiler. Other C++ compilers may use the "gnu-v2" or "gnu-v3" ABI's as well. The default setting is "auto".

`show cp-abi`

Show the C++ ABI currently in use.

`set cp-abi`

With no argument, show the list of supported C++ ABI's.

`set cp-abi abi`

`set cp-abi auto`

Set the current C++ ABI to *abi*, or return to automatic detection.

22.7 Optional Warnings and Messages

By default, GDB is silent about its inner workings. If you are running on a slow machine, you may want to use the `set verbose` command. This makes GDB tell you when it does a lengthy internal operation, so you will not think it has crashed.

Currently, the messages controlled by `set verbose` are those which announce that the symbol table for a source file is being read; see `symbol-file` in [\(undefined\)](#) [Commands to Specify Files], page [\(undefined\)](#).

`set verbose on`
Enables GDB output of certain informational messages.

`set verbose off`
Disables GDB output of certain informational messages.

`show verbose`
Displays whether `set verbose` is on or off.

By default, if GDB encounters bugs in the symbol table of an object file, it is silent; but if you are debugging a compiler, you may find this information useful (see [\(undefined\)](#) [Errors Reading Symbol Files], page [\(undefined\)](#)).

`set complaints limit`
Permits GDB to output *limit* complaints about each type of unusual symbols before becoming silent about the problem. Set *limit* to zero to suppress all complaints; set it to a large number to prevent complaints from being suppressed.

`show complaints`
Displays how many symbol complaints GDB is permitted to produce.

By default, GDB is cautious, and asks what sometimes seems to be a lot of stupid questions to confirm certain commands. For example, if you try to run a program which is already running:

```
(gdb) run
The program being debugged has been started already.
Start it from the beginning? (y or n)
```

If you are willing to unflinchingly face the consequences of your own commands, you can disable this “feature”:

`set confirm off`
Disables confirmation requests. Note that running GDB with the ‘`--batch`’ option (see [\(undefined\)](#) [Mode Options], page [\(undefined\)](#)) also automatically disables confirmation requests.

`set confirm on`
Enables confirmation requests (the default).

`show confirm`
Displays state of confirmation requests.

If you need to debug user-defined commands or sourced files you may find it useful to enable *command tracing*. In this mode each command will be printed as it is executed, prefixed with one or more ‘+’ symbols, the quantity denoting the call depth of each command.

`set trace-commands on`
Enable command tracing.

`set trace-commands off`
Disable command tracing.

`show trace-commands`
Display the current state of command tracing.

22.8 Optional Messages about Internal Happenings

GDB has commands that enable optional debugging messages from various GDB subsystems; normally these commands are of interest to GDB maintainers, or when reporting a bug. This section documents those commands.

`set exec-done-display`

Turns on or off the notification of asynchronous commands' completion. When on, GDB will print a message when an asynchronous command finishes its execution. The default is off.

`show exec-done-display`

Displays the current setting of asynchronous command completion notification.

`set debug arch`

Turns on or off display of `gdbarch` debugging info. The default is off

`show debug arch`

Displays the current state of displaying `gdbarch` debugging info.

`set debug aix-thread`

Display debugging messages about inner workings of the AIX thread module.

`show debug aix-thread`

Show the current state of AIX thread debugging info display.

`set debug dwarf2-die`

Dump DWARF2 DIEs after they are read in. The value is the number of nesting levels to print. A value of zero turns off the display.

`show debug dwarf2-die`

Show the current state of DWARF2 DIE debugging.

`set debug displaced`

Turns on or off display of GDB debugging info for the displaced stepping support. The default is off.

`show debug displaced`

Displays the current state of displaying GDB debugging info related to displaced stepping.

`set debug event`

Turns on or off display of GDB event debugging info. The default is off.

`show debug event`

Displays the current state of displaying GDB event debugging info.

`set debug expression`

Turns on or off display of debugging info about GDB expression parsing. The default is off.

`show debug expression`

Displays the current state of displaying debugging info about GDB expression parsing.

`set debug frame`
Turns on or off display of GDB frame debugging info. The default is off.

`show debug frame`
Displays the current state of displaying GDB frame debugging info.

`set debug gnu-nat`
Turns on or off debugging messages from the GNU/Hurd debug support.

`show debug gnu-nat`
Show the current state of GNU/Hurd debugging messages.

`set debug infrun`
Turns on or off display of GDB debugging info for running the inferior. The default is off. `infrun.c` contains GDB's runtime state machine used for implementing operations such as single-stepping the inferior.

`show debug infrun`
Displays the current state of GDB inferior debugging.

`set debug lin-lwp`
Turns on or off debugging messages from the Linux LWP debug support.

`show debug lin-lwp`
Show the current state of Linux LWP debugging messages.

`set debug lin-lwp-async`
Turns on or off debugging messages from the Linux LWP async debug support.

`show debug lin-lwp-async`
Show the current state of Linux LWP async debugging messages.

`set debug observer`
Turns on or off display of GDB observer debugging. This includes info such as the notification of observable events.

`show debug observer`
Displays the current state of observer debugging.

`set debug overload`
Turns on or off display of GDB C++ overload debugging info. This includes info such as ranking of functions, etc. The default is off.

`show debug overload`
Displays the current state of displaying GDB C++ overload debugging info.

`set debug parser`
Turns on or off the display of expression parser debugging output. Internally, this sets the `yydebug` variable in the expression parser. See [section "Tracing Your Parser" in *Bison*](#), for details. The default is off.

`show debug parser`
Show the current state of expression parser debugging.

`set debug remote`
Turns on or off display of reports on all packets sent back and forth across the serial line to the remote machine. The info is printed on the GDB standard output stream. The default is off.

`show debug remote`
Displays the state of display of remote packets.

`set debug serial`
Turns on or off display of GDB serial debugging info. The default is off.

`show debug serial`
Displays the current state of displaying GDB serial debugging info.

`set debug solib-frv`
Turns on or off debugging messages for FR-V shared-library code.

`show debug solib-frv`
Display the current state of FR-V shared-library code debugging messages.

`set debug target`
Turns on or off display of GDB target debugging info. This info includes what is going on at the target level of GDB, as it happens. The default is 0. Set it to 1 to track events, and to 2 to also track the value of large memory transfers. Changes to this flag do not take effect until the next time you connect to a target or use the `run` command.

`show debug target`
Displays the current state of displaying GDB target debugging info.

`set debug timestamp`
Turns on or off display of timestamps with GDB debugging info. When enabled, seconds and microseconds are displayed before each debugging message.

`show debug timestamp`
Displays the current state of displaying timestamps with GDB debugging info.

`set debugvarobj`
Turns on or off display of GDB variable object debugging info. The default is off.

`show debugvarobj`
Displays the current state of displaying GDB variable object debugging info.

`set debug xml`
Turns on or off debugging messages for built-in XML parsers.

`show debug xml`
Displays the current state of XML debugging messages.

22.9 Other Miscellaneous Settings

`set interactive-mode`
If `on`, forces GDB to operate interactively. If `off`, forces GDB to operate non-interactively. If `auto` (the default), GDB guesses which mode to use, based on whether the debugger was started in a terminal or not.

In the vast majority of cases, the debugger should be able to guess correctly which mode should be used. But this setting can be useful in certain specific cases, such as running a MinGW GDB inside a cygwin window.

`show interactive-mode`

Displays whether the debugger is operating in interactive mode or not.

23 Extending GDB

GDB provides two mechanisms for extension. The first is based on composition of GDB commands, and the second is based on the Python scripting language.

To facilitate the use of these extensions, GDB is capable of evaluating the contents of a file. When doing so, GDB can recognize which scripting language is being used by looking at the filename extension. Files with an unrecognized filename extension are always treated as a GDB Command Files. See [\(undefined\) \[Command files\], page \(undefined\)](#).

You can control how GDB evaluates these files with the following setting:

```
set script-extension off
```

All scripts are always evaluated as GDB Command Files.

```
set script-extension soft
```

The debugger determines the scripting language based on filename extension. If this scripting language is supported, GDB evaluates the script using that language. Otherwise, it evaluates the file as a GDB Command File.

```
set script-extension strict
```

The debugger determines the scripting language based on filename extension, and evaluates the script using that language. If the language is not supported, then the evaluation fails.

```
show script-extension
```

Display the current value of the `script-extension` option.

23.1 Canned Sequences of Commands

Aside from breakpoint commands (see [\(undefined\) \[Breakpoint Command Lists\], page \(undefined\)](#)), GDB provides two ways to store sequences of commands for execution as a unit: user-defined commands and command files.

23.1.1 User-defined Commands

A *user-defined command* is a sequence of GDB commands to which you assign a new name as a command. This is done with the `define` command. User commands may accept up to 10 arguments separated by whitespace. Arguments are accessed within the user command via `$arg0...$arg9`. A trivial example:

```
define adder
  print $arg0 + $arg1 + $arg2
end
```

To execute the command use:

```
adder 1 2 3
```

This defines the command `adder`, which prints the sum of its three arguments. Note the arguments are text substitutions, so they may reference variables, use complex expressions, or even perform inferior functions calls.

In addition, `$argc` may be used to find out how many arguments have been passed. This expands to a number in the range 0...10.

```

define adder
  if $argc == 2
    print $arg0 + $arg1
  end
  if $argc == 3
    print $arg0 + $arg1 + $arg2
  end
end

```

define *commandname*

Define a command named *commandname*. If there is already a command by that name, you are asked to confirm that you want to redefine it. *commandname* may be a bare command name consisting of letters, numbers, dashes, and underscores. It may also start with any predefined prefix command. For example, ‘define target my-target’ creates a user-defined ‘target my-target’ command.

The definition of the command is made up of other GDB command lines, which are given following the `define` command. The end of these commands is marked by a line containing `end`.

document *commandname*

Document the user-defined command *commandname*, so that it can be accessed by `help`. The command *commandname* must already be defined. This command reads lines of documentation just as `define` reads the lines of the command definition, ending with `end`. After the `document` command is finished, `help` on command *commandname* displays the documentation you have written.

You may use the `document` command again to change the documentation of a command. Redefining the command with `define` does not change the documentation.

dont-repeat

Used inside a user-defined command, this tells GDB that this command should not be repeated when the user hits RET (see [\(undefined\) \[Command Syntax\]](#), page [\(undefined\)](#)).

help user-defined

List all user-defined commands, with the first line of the documentation (if any) for each.

show user

show user *commandname*

Display the GDB commands used to define *commandname* (but not its documentation). If no *commandname* is given, display the definitions for all user-defined commands.

show max-user-call-depth

set max-user-call-depth

The value of `max-user-call-depth` controls how many recursion levels are allowed in user-defined commands before GDB suspects an infinite recursion and aborts the command.

In addition to the above commands, user-defined commands frequently use control flow commands, described in [\(undefined\) \[Command Files\], page \(undefined\)](#).

When user-defined commands are executed, the commands of the definition are not printed. An error in any command stops execution of the user-defined command.

If used interactively, commands that would ask for confirmation proceed without asking when used inside a user-defined command. Many GDB commands that normally print messages to say what they are doing omit the messages when used in a user-defined command.

23.1.2 User-defined Command Hooks

You may define *hooks*, which are a special kind of user-defined command. Whenever you run the command ‘foo’, if the user-defined command ‘hook-foo’ exists, it is executed (with no arguments) before that command.

A hook may also be defined which is run after the command you executed. Whenever you run the command ‘foo’, if the user-defined command ‘hookpost-foo’ exists, it is executed (with no arguments) after that command. Post-execution hooks may exist simultaneously with pre-execution hooks, for the same command.

It is valid for a hook to call the command which it hooks. If this occurs, the hook is not re-executed, thereby avoiding infinite recursion.

In addition, a pseudo-command, ‘stop’ exists. Defining (‘hook-stop’) makes the associated commands execute every time execution stops in your program: before breakpoint commands are run, displays are printed, or the stack frame is printed.

For example, to ignore SIGALRM signals while single-stepping, but treat them normally during normal execution, you could define:

```
define hook-stop
handle SIGALRM nopass
end

define hook-run
handle SIGALRM pass
end

define hook-continue
handle SIGALRM pass
end
```

As a further example, to hook at the beginning and end of the `echo` command, and to add extra text to the beginning and end of the message, you could define:

```
define hook-echo
echo <<<---
end

define hookpost-echo
echo --->>>\n
end

(gdb) echo Hello World
<<<---Hello World--->>>
(gdb)
```

You can define a hook for any single-word command in GDB, but not for command aliases; you should define a hook for the basic command name, e.g. `backtrace` rather than

bt. You can hook a multi-word command by adding `hook-` or `hookpost-` to the last word of the command, e.g. `define target hook-remote` to add a hook to `target remote`.

If an error occurs during the execution of your hook, execution of GDB commands stops and GDB issues a prompt (before the command that you actually typed had a chance to run).

If you try to define a hook which does not match any known command, you get a warning from the `define` command.

23.1.3 Command Files

A command file for GDB is a text file made of lines that are GDB commands. Comments (lines starting with `#`) may also be included. An empty line in a command file does nothing; it does not mean to repeat the last command, as it would from the terminal.

You can request the execution of a command file with the `source` command. Note that the `source` command is also used to evaluate scripts that are not Command Files. The exact behavior can be configured using the `script-extension` setting. See [\[Extending GDB\], page](#) [\(undefined\)](#).

```
source [-s] [-v] filename
```

Execute the command file *filename*.

The lines in a command file are generally executed sequentially, unless the order of execution is changed by one of the *flow-control commands* described below. The commands are not printed as they are executed. An error in any command terminates execution of the command file and control is returned to the console.

GDB first searches for *filename* in the current directory. If the file is not found there, and *filename* does not specify a directory, then GDB also looks for the file on the source search path (specified with the `directory` command); except that `$cdir` is not searched because the compilation directory is not relevant to scripts.

If `-s` is specified, then GDB searches for *filename* on the search path even if *filename* specifies a directory. The search is done by appending *filename* to each element of the search path. So, for example, if *filename* is `mylib/myscript` and the search path contains `/home/user` then GDB will look for the script `/home/user/mylib/myscript`. The search is also done if *filename* is an absolute path. For example, if *filename* is `/tmp/myscript` and the search path contains `/home/user` then GDB will look for the script `/home/user/tmp/myscript`. For DOS-like systems, if *filename* contains a drive specification, it is stripped before concatenation. For example, if *filename* is `d:myscript` and the search path contains `c:/tmp` then GDB will look for the script `c:/tmp/myscript`.

If `-v`, for verbose mode, is given then GDB displays each command as it is executed. The option must be given before *filename*, and is interpreted as part of the filename anywhere else.

Commands that would ask for confirmation if used interactively proceed without asking when used in a command file. Many GDB commands that normally print messages to say what they are doing omit the messages when called from command files.

GDB also accepts command input from standard input. In this mode, normal output goes to standard output and error output goes to standard error. Errors in a command file supplied on standard input do not terminate execution of the command file—execution continues with the next command.

```
gdb < cmds > log 2>&1
```

(The syntax above will vary depending on the shell used.) This example will execute commands from the file ‘cmds’. All output and errors would be directed to ‘log’.

Since commands stored on command files tend to be more general than commands typed interactively, they frequently need to deal with complicated situations, such as different or unexpected values of variables and symbols, changes in how the program being debugged is built, etc. GDB provides a set of flow-control commands to deal with these complexities. Using these commands, you can write complex scripts that loop over data structures, execute commands conditionally, etc.

if

else This command allows to include in your script conditionally executed commands. The **if** command takes a single argument, which is an expression to evaluate. It is followed by a series of commands that are executed only if the expression is true (its value is nonzero). There can then optionally be an **else** line, followed by a series of commands that are only executed if the expression was false. The end of the list is marked by a line containing **end**.

while This command allows to write loops. Its syntax is similar to **if**: the command takes a single argument, which is an expression to evaluate, and must be followed by the commands to execute, one per line, terminated by an **end**. These commands are called the *body* of the loop. The commands in the body of **while** are executed repeatedly as long as the expression evaluates to true.

loop_break

This command exits the **while** loop in whose body it is included. Execution of the script continues after that **while** **end** line.

loop_continue

This command skips the execution of the rest of the body of commands in the **while** loop in whose body it is included. Execution branches to the beginning of the **while** loop, where it evaluates the controlling expression.

end

Terminate the block of commands that are the body of **if**, **else**, or **while** flow-control commands.

23.1.4 Commands for Controlled Output

During the execution of a command file or a user-defined command, normal GDB output is suppressed; the only output that appears is what is explicitly printed by the commands in the definition. This section describes three commands useful for generating exactly the output you want.

echo text

Print *text*. Nonprinting characters can be included in *text* using C escape sequences, such as ‘\n’ to print a newline. **No newline is printed unless you specify one.** In addition to the standard C escape sequences, a backslash followed by a space stands for a space. This is useful for displaying a string with spaces at the beginning or the end, since leading and trailing spaces are otherwise trimmed from all arguments. To print ‘ **and foo =** ’, use the command ‘**echo \ and foo = **’.

A backslash at the end of *text* can be used, as in C, to continue the command onto subsequent lines. For example,

```
echo This is some text\n\  
which is continued\n\  
onto several lines.\n
```

produces the same output as

```
echo This is some text\n  
echo which is continued\n  
echo onto several lines.\n
```

`output expression`

Print the value of *expression* and nothing but that value: no newlines, no '\$nn = '. The value is not entered in the value history either. See [\(undefined\) \[Expressions\], page \(undefined\)](#), for more information on expressions.

`output/fmt expression`

Print the value of *expression* in format *fmt*. You can use the same formats as for `print`. See [\(undefined\) \[Output Formats\], page \(undefined\)](#), for more information.

`printf template, expressions...`

Print the values of one or more *expressions* under the control of the string *template*. To print several values, make *expressions* be a comma-separated list of individual expressions, which may be either numbers or pointers. Their values are printed as specified by *template*, exactly as a C program would do by executing the code below:

```
printf (template, expressions...);
```

As in C `printf`, ordinary characters in *template* are printed verbatim, while *conversion specification* introduced by the '%' character cause subsequent *expressions* to be evaluated, their values converted and formatted according to type and style information encoded in the conversion specifications, and then printed.

For example, you can print two values in hex like this:

```
printf "foo, bar-foo = 0x%x, 0x%x\n", foo, bar-foo
```

`printf` supports all the standard C conversion specifications, including the flags and modifiers between the '%' character and the conversion letter, with the following exceptions:

- The argument-ordering modifiers, such as '2\$', are not supported.
- The modifier '*' is not supported for specifying precision or width.
- The 'r' flag (for separation of digits into groups according to LC_NUMERIC) is not supported.
- The type modifiers 'hh', 'j', 't', and 'z' are not supported.
- The conversion letter 'n' (as in '%n') is not supported.
- The conversion letters 'a' and 'A' are not supported.

Note that the 'll' type modifier is supported only if the underlying C implementation used to build GDB supports the `long long int` type, and the 'L' type modifier is supported only if `long double` type is available.

As in C, `printf` supports simple backslash-escape sequences, such as `\n`, `\t`, `\\`, `\"`, `\a`, and `\f`, that consist of backslash followed by a single character. Octal and hexadecimal escape sequences are not supported.

Additionally, `printf` supports conversion specifications for DFP (*Decimal Floating Point*) types using the following length modifiers together with a floating point specifier. letters:

- ‘H’ for printing `Decimal32` types.
- ‘D’ for printing `Decimal64` types.
- ‘DD’ for printing `Decimal128` types.

If the underlying C implementation used to build GDB has support for the three length modifiers for DFP types, other modifiers such as width and precision will also be available for GDB to use.

In case there is no such C support, no additional modifiers will be available and the value will be printed in the standard way.

Here’s an example of printing DFP types using the above conversion letters:

```
printf "D32: %Hf - D64: %Df - D128: %DDf\n",1.2345df,1.2E10dd,1.2E1dl
```

`eval template, expressions...`

Convert the values of one or more *expressions* under the control of the string *template* to a command line, and call it.

23.2 Scripting GDB using Python

You can script GDB using the [Python programming language](#). This feature is available only if GDB was configured using `--with-python`.

Python scripts used by GDB should be installed in `data-directory/python`, where *data-directory* is the data directory as determined at GDB startup (see [\[Data Files\]](#), page [\[undefined\]](#)). This directory, known as the *python directory*, is automatically added to the Python Search Path in order to allow the Python interpreter to locate all scripts installed at this location.

23.2.1 Python Commands

GDB provides one command for accessing the Python interpreter, and one related setting:

`python [code]`

The `python` command can be used to evaluate Python code.

If given an argument, the `python` command will evaluate the argument as a Python command. For example:

```
(gdb) python print 23
23
```

If you do not provide an argument to `python`, it will act as a multi-line command, like `define`. In this case, the Python script is made up of subsequent command lines, given after the `python` command. This command list is terminated using a line containing `end`. For example:

```
(gdb) python
Type python script
```

```

End with a line saying just "end".
>print 23
>end
23

```

`maint set python print-stack`

By default, GDB will print a stack trace when an error occurs in a Python script. This can be controlled using `maint set python print-stack`: if `on`, the default, then Python stack printing is enabled; if `off`, then Python stack printing is disabled.

It is also possible to execute a Python script from the GDB interpreter:

`source 'script-name'`

The script name must end with `.py` and GDB must be configured to recognize the script language based on filename extension using the `script-extension` setting. See [\(undefined\) \[Extending GDB\], page \(undefined\)](#).

`python execfile ("script-name")`

This method is based on the `execfile` Python built-in function, and thus is always available.

23.2.2 Python API

At startup, GDB overrides Python's `sys.stdout` and `sys.stderr` to print using GDB's output-paging streams. A Python program which outputs to one of these streams may have its output interrupted by the user (see [\(undefined\) \[Screen Size\], page \(undefined\)](#)). In this situation, a Python `KeyboardInterrupt` exception is thrown.

23.2.2.1 Basic Python

GDB introduces a new Python module, named `gdb`. All methods and classes added by GDB are placed in this module. GDB automatically `imports` the `gdb` module for use in all scripts evaluated by the `python` command.

PYTHONDIR [Variable]

A string containing the python directory (see [\(undefined\) \[Python\], page \(undefined\)](#)).

execute *command* [*from_tty*] [*to_string*] [Function]

Evaluate *command*, a string, as a GDB CLI command. If a GDB exception happens while *command* runs, it is translated as described in [\(undefined\) \[Exception Handling\], page \(undefined\)](#).

from_tty specifies whether GDB ought to consider this command as having originated from the user invoking it interactively. It must be a boolean value. If omitted, it defaults to `False`.

By default, any output produced by *command* is sent to GDB's standard output. If the *to_string* parameter is `True`, then output will be collected by `gdb.execute` and returned as a string. The default is `False`, in which case the return value is `None`. If *to_string* is `True`, the GDB virtual terminal will be temporarily set to unlimited width and height, and its pagination will be disabled; see [\(undefined\) \[Screen Size\], page \(undefined\)](#).

breakpoints [Function]
Return a sequence holding all of GDB's breakpoints. See [\(undefined\) \[Breakpoints In Python\], page \(undefined\)](#), for more information.

parameter *parameter* [Function]
Return the value of a GDB parameter. *parameter* is a string naming the parameter to look up; *parameter* may contain spaces if the parameter has a multi-part name. For example, 'print object' is a valid parameter name.
If the named parameter does not exist, this function throws a `RuntimeError`. Otherwise, the parameter's value is converted to a Python value of the appropriate type, and returned.

history *number* [Function]
Return a value from GDB's value history (see [\(undefined\) \[Value History\], page \(undefined\)](#)). *number* indicates which history element to return. If *number* is negative, then GDB will take its absolute value and count backward from the last element (i.e., the most recent element) to find the value to return. If *number* is zero, then GDB will return the most recent element. If the element specified by *number* doesn't exist in the value history, a `RuntimeError` exception will be raised.
If no exception is raised, the return value is always an instance of `gdb.Value` (see [\(undefined\) \[Values From Inferior\], page \(undefined\)](#)).

parse_and_eval *expression* [Function]
Parse *expression* as an expression in the current language, evaluate it, and return the result as a `gdb.Value`. *expression* must be a string.
This function can be useful when implementing a new command (see [\(undefined\) \[Commands In Python\], page \(undefined\)](#)), as it provides a way to parse the command's argument as an expression. It is also useful simply to compute values, for example, it is the only way to get the value of a convenience variable (see [\(undefined\) \[Convenience Vars\], page \(undefined\)](#)) as a `gdb.Value`.

write *string* [Function]
Print a string to GDB's paginated standard output stream. Writing to `sys.stdout` or `sys.stderr` will automatically call this function.

flush [Function]
Flush GDB's paginated standard output stream. Flushing `sys.stdout` or `sys.stderr` will automatically call this function.

target_charset [Function]
Return the name of the current target character set (see [\(undefined\) \[Character Sets\], page \(undefined\)](#)). This differs from `gdb.parameter('target-charset')` in that 'auto' is never returned.

target_wide_charset [Function]
Return the name of the current target wide character set (see [\(undefined\) \[Character Sets\], page \(undefined\)](#)). This differs from `gdb.parameter('target-wide-charset')` in that 'auto' is never returned.

23.2.2.2 Exception Handling

When executing the `python` command, Python exceptions uncaught within the Python code are translated to calls to GDB error-reporting mechanism. If the command that called `python` does not handle the error, GDB will terminate it and print an error message containing the Python exception name, the associated value, and the Python call stack backtrace at the point where the exception was raised. Example:

```
(gdb) python print foo
Traceback (most recent call last):
  File "<string>", line 1, in <module>
NameError: name 'foo' is not defined
```

GDB errors that happen in GDB commands invoked by Python code are converted to Python `RuntimeError` exceptions. User interrupt (via `C-c` or by typing `q` at a pagination prompt) is translated to a Python `KeyboardInterrupt` exception. If you catch these exceptions in your Python code, your exception handler will see `RuntimeError` or `KeyboardInterrupt` as the exception type, the GDB error message as its value, and the Python call stack backtrace at the Python statement closest to where the GDB error occurred as the traceback.

When implementing GDB commands in Python via `gdb.Command`, it is useful to be able to throw an exception that doesn't cause a traceback to be printed. For example, the user may have invoked the command incorrectly. Use the `gdb.GdbError` exception to handle this case. Example:

```
(gdb) python
>class HelloWorld (gdb.Command):
>  """Greet the whole world."""
>  def __init__ (self):
>    super (HelloWorld, self).__init__ ("hello-world", gdb.COMMAND_OBSCURE)
>  def invoke (self, args, from_tty):
>    argv = gdb.string_to_argv (args)
>    if len (argv) != 0:
>      raise gdb.GdbError ("hello-world takes no arguments")
>    print "Hello, World!"
>HelloWorld ()
>end
(gdb) hello-world 42
hello-world takes no arguments
```

23.2.2.3 Values From Inferior

GDB provides values it obtains from the inferior program in an object of type `gdb.Value`. GDB uses this object for its internal bookkeeping of the inferior's values, and for fetching values when necessary.

Inferior values that are simple scalars can be used directly in Python expressions that are valid for the value's data type. Here's an example for an integer or floating-point value `some_val`:

```
bar = some_val + 2
```

As result of this, `bar` will also be a `gdb.Value` object whose values are of the same type as those of `some_val`.

Inferior values that are structures or instances of some class can be accessed using the Python *dictionary syntax*. For example, if `some_val` is a `gdb.Value` instance holding a structure, you can access its `foo` element with:

```
bar = some_val['foo']
```

Again, `bar` will also be a `gdb.Value` object.

The following attributes are provided:

address	[Instance Variable of <code>Value</code>]
If this object is addressable, this read-only attribute holds a <code>gdb.Value</code> object representing the address. Otherwise, this attribute holds <code>None</code> .	
is_optimized_out	[Instance Variable of <code>Value</code>]
This read-only boolean attribute is true if the compiler optimized out this value, thus it is not available for fetching from the inferior.	
type	[Instance Variable of <code>Value</code>]
The type of this <code>gdb.Value</code> . The value of this attribute is a <code>gdb.Type</code> object.	

The following methods are provided:

cast <i>type</i>	[Method on <code>Value</code>]
Return a new instance of <code>gdb.Value</code> that is the result of casting this instance to the type described by <i>type</i> , which must be a <code>gdb.Type</code> object. If the cast cannot be performed for some reason, this method throws an exception.	
dereference	[Method on <code>Value</code>]
For pointer data types, this method returns a new <code>gdb.Value</code> object whose contents is the object pointed to by the pointer. For example, if <code>foo</code> is a C pointer to an <code>int</code> , declared in your C program as	
<pre>int *foo;</pre>	
then you can use the corresponding <code>gdb.Value</code> to access what <code>foo</code> points to like this:	
<pre>bar = foo.dereference ()</pre>	
The result <code>bar</code> will be a <code>gdb.Value</code> object holding the value pointed to by <code>foo</code> .	
string [<i>encoding</i>] [<i>errors</i>] [<i>length</i>]	[Method on <code>Value</code>]
If this <code>gdb.Value</code> represents a string, then this method converts the contents to a Python string. Otherwise, this method will throw an exception. Strings are recognized in a language-specific way; whether a given <code>gdb.Value</code> represents a string is determined by the current language.	
For C-like languages, a value is a string if it is a pointer to or an array of characters or ints. The string is assumed to be terminated by a zero of the appropriate width. However if the optional <i>length</i> argument is given, the string will be converted to that given length, ignoring any embedded zeros that the string may contain.	
If the optional <i>encoding</i> argument is given, it must be a string naming the encoding of the string in the <code>gdb.Value</code> , such as "ascii", "iso-8859-6" or "utf-8". It accepts the same encodings as the corresponding argument	

to Python's `string.decode` method, and the Python codec machinery will be used to convert the string. If *encoding* is not given, or if *encoding* is the empty string, then either the `target-charset` (see [\(undefined\) \[Character Sets\]](#), page [\(undefined\)](#)) will be used, or a language-specific encoding will be used, if the current language is able to supply one.

The optional *errors* argument is the same as the corresponding argument to Python's `string.decode` method.

If the optional *length* argument is given, the string will be fetched and converted to the given length.

`lazy_string` [*encoding*] [*length*] [Method on Value]

If this `gdb.Value` represents a string, then this method converts the contents to a `gdb.LazyString` (see [\(undefined\) \[Lazy Strings In Python\]](#), page [\(undefined\)](#)). Otherwise, this method will throw an exception.

If the optional *encoding* argument is given, it must be a string naming the encoding of the `gdb.LazyString`. Some examples are: 'ascii', 'iso-8859-6' or 'utf-8'. If the *encoding* argument is an encoding that GDB does recognize, GDB will raise an error.

When a lazy string is printed, the GDB encoding machinery is used to convert the string during printing. If the optional *encoding* argument is not provided, or is an empty string, GDB will automatically select the encoding most suitable for the string type. For further information on encoding in GDB please see [\(undefined\) \[Character Sets\]](#), page [\(undefined\)](#).

If the optional *length* argument is given, the string will be fetched and encoded to the length of characters specified. If the *length* argument is not provided, the string will be fetched and encoded until a null of appropriate width is found.

23.2.2.4 Types In Python

GDB represents types from the inferior using the class `gdb.Type`.

The following type-related functions are available in the `gdb` module:

`lookup_type` *name* [*block*] [Function]

This function looks up a type by name. *name* is the name of the type to look up. It must be a string.

If *block* is given, then *name* is looked up in that scope. Otherwise, it is searched for globally.

Ordinarily, this function will return an instance of `gdb.Type`. If the named type cannot be found, it will throw an exception.

An instance of `Type` has the following attributes:

`code` [Instance Variable of Type]

The type code for this type. The type code will be one of the `TYPE_CODE_*` constants defined below.

- sizeof** [Instance Variable of Type]
The size of this type, in target `char` units. Usually, a target's `char` type will be an 8-bit byte. However, on some unusual platforms, this type may have a different size.
- tag** [Instance Variable of Type]
The tag name for this type. The tag name is the name after `struct`, `union`, or `enum` in C and C++; not all languages have this concept. If this type has no tag name, then `None` is returned.

The following methods are provided:

- fields** [Method on Type]
For structure and union types, this method returns the fields. Range types have two fields, the minimum and maximum values. Enum types have one field per enum constant. Function and method types have one field per parameter. The base types of C++ classes are also represented as fields. If the type has no fields, or does not fit into one of these categories, an empty sequence will be returned.
Each field is an object, with some pre-defined attributes:
- bitpos** This attribute is not available for `static` fields (as in C++ or Java). For non-`static` fields, the value is the bit position of the field.
- name** The name of the field, or `None` for anonymous fields.
- artificial** This is `True` if the field is artificial, usually meaning that it was provided by the compiler and not the user. This attribute is always provided, and is `False` if the field is not artificial.
- is_base_class** This is `True` if the field represents a base class of a C++ structure. This attribute is always provided, and is `False` if the field is not a base class of the type that is the argument of `fields`, or if that type was not a C++ class.
- bitsize** If the field is packed, or is a bitfield, then this will have a non-zero value, which is the size of the field in bits. Otherwise, this will be zero; in this case the field's size is given by its type.
- type** The type of the field. This is usually an instance of `Type`, but it can be `None` in some situations.
- const** [Method on Type]
Return a new `gdb.Type` object which represents a `const`-qualified variant of this type.
- volatile** [Method on Type]
Return a new `gdb.Type` object which represents a `volatile`-qualified variant of this type.

- unqualified** [Method on `Type`]
Return a new `gdb.Type` object which represents an unqualified variant of this type. That is, the result is neither `const` nor `volatile`.
- range** [Method on `Type`]
Return a Python `Tuple` object that contains two elements: the low bound of the argument type and the high bound of that type. If the type does not have a range, GDB will raise a `RuntimeError` exception.
- reference** [Method on `Type`]
Return a new `gdb.Type` object which represents a reference to this type.
- pointer** [Method on `Type`]
Return a new `gdb.Type` object which represents a pointer to this type.
- strip_typedefs** [Method on `Type`]
Return a new `gdb.Type` that represents the real type, after removing all layers of typedefs.
- target** [Method on `Type`]
Return a new `gdb.Type` object which represents the target type of this type.
For a pointer type, the target type is the type of the pointed-to object. For an array type (meaning C-like arrays), the target type is the type of the elements of the array. For a function or method type, the target type is the type of the return value. For a complex type, the target type is the type of the elements. For a typedef, the target type is the aliased type.
If the type does not have a target, this method will throw an exception.
- template_argument** *n* [*block*] [Method on `Type`]
If this `gdb.Type` is an instantiation of a template, this will return a new `gdb.Type` which represents the type of the *n*th template argument.
If this `gdb.Type` is not a template type, this will throw an exception. Ordinarily, only C++ code will have template types.
If *block* is given, then *name* is looked up in that scope. Otherwise, it is searched for globally.

Each type has a code, which indicates what category this type falls into. The available type categories are represented by constants defined in the `gdb` module:

- `TYPE_CODE_PTR`
The type is a pointer.
- `TYPE_CODE_ARRAY`
The type is an array.
- `TYPE_CODE_STRUCT`
The type is a structure.
- `TYPE_CODE_UNION`
The type is a union.

TYPE_CODE_ENUM	The type is an enum.
TYPE_CODE_FLAGS	A bit flags type, used for things such as status registers.
TYPE_CODE_FUNC	The type is a function.
TYPE_CODE_INT	The type is an integer type.
TYPE_CODE_FLT	A floating point type.
TYPE_CODE_VOID	The special type <code>void</code> .
TYPE_CODE_SET	A Pascal set type.
TYPE_CODE_RANGE	A range type, that is, an integer type with bounds.
TYPE_CODE_STRING	A string type. Note that this is only used for certain languages with language-defined string types; C strings are not represented this way.
TYPE_CODE_BITSTRING	A string of bits.
TYPE_CODE_ERROR	An unknown or erroneous type.
TYPE_CODE_METHOD	A method type, as found in C++ or Java.
TYPE_CODE_METHODPTR	A pointer-to-member-function.
TYPE_CODE_MEMBERPTR	A pointer-to-member.
TYPE_CODE_REF	A reference type.
TYPE_CODE_CHAR	A character type.
TYPE_CODE_BOOL	A boolean type.
TYPE_CODE_COMPLEX	A complex float type.
TYPE_CODE_TYPEDEF	A typedef to some other type.

`TYPE_CODE_NAMESPACE`

A C++ namespace.

`TYPE_CODE_DECFLOAT`

A decimal floating point type.

`TYPE_CODE_INTERNAL_FUNCTION`

A function internal to GDB. This is the type used to represent convenience functions.

23.2.2.5 Pretty Printing API

An example output is provided (see [\(undefined\) \[Pretty Printing\], page \(undefined\)](#)).

A pretty-printer is just an object that holds a value and implements a specific interface, defined here.

`children` (*self*) [Operation on pretty printer]

GDB will call this method on a pretty-printer to compute the children of the pretty-printer’s value.

This method must return an object conforming to the Python iterator protocol. Each item returned by the iterator must be a tuple holding two elements. The first element is the “name” of the child; the second element is the child’s value. The value can be any Python object which is convertible to a GDB value.

This method is optional. If it does not exist, GDB will act as though the value has no children.

`display_hint` (*self*) [Operation on pretty printer]

The CLI may call this method and use its result to change the formatting of a value. The result will also be supplied to an MI consumer as a ‘`displayhint`’ attribute of the variable being printed.

This method is optional. If it does exist, this method must return a string.

Some display hints are predefined by GDB:

‘`array`’ Indicate that the object being printed is “array-like”. The CLI uses this to respect parameters such as `set print elements` and `set print array`.

‘`map`’ Indicate that the object being printed is “map-like”, and that the children of this value can be assumed to alternate between keys and values.

‘`string`’ Indicate that the object being printed is “string-like”. If the printer’s `to_string` method returns a Python string of some kind, then GDB will call its internal language-specific string-printing function to format the string. For the CLI this means adding quotation marks, possibly escaping some characters, respecting `set print elements`, and the like.

`to_string` (*self*) [Operation on pretty printer]

GDB will call this method to display the string representation of the value passed to the object’s constructor.

When printing from the CLI, if the `to_string` method exists, then GDB will prepend its result to the values returned by `children`. Exactly how this formatting is done

is dependent on the display hint, and may change as more hints are added. Also, depending on the print settings (see [Print Settings](#), page [Print Settings](#)), the CLI may print just the result of `to_string` in a stack trace, omitting the result of `children`.

If this method returns a string, it is printed verbatim.

Otherwise, if this method returns an instance of `gdb.Value`, then GDB prints this value. This may result in a call to another pretty-printer.

If instead the method returns a Python value which is convertible to a `gdb.Value`, then GDB performs the conversion and prints the resulting value. Again, this may result in a call to another pretty-printer. Python scalars (integers, floats, and booleans) and strings are convertible to `gdb.Value`; other types are not.

Finally, if this method returns `None` then no further operations are performed in this method and nothing is printed.

If the result is not one of these types, an exception is raised.

GDB provides a function which can be used to look up the default pretty-printer for a `gdb.Value`:

`default_visualizer value` [Function]

This function takes a `gdb.Value` object as an argument. If a pretty-printer for this value exists, then it is returned. If no such printer exists, then this returns `None`.

23.2.2.6 Selecting Pretty-Printers

The Python list `gdb.pretty_printers` contains an array of functions or callable objects that have been registered via addition as a pretty-printer. Each `gdb.Progspace` contains a `pretty_printers` attribute. Each `gdb.Objfile` also contains a `pretty_printers` attribute.

A function on one of these lists is passed a single `gdb.Value` argument and should return a pretty-printer object conforming to the interface definition above (see [Pretty Printing API](#), page [Pretty Printing API](#)). If a function cannot create a pretty-printer for the value, it should return `None`.

GDB first checks the `pretty_printers` attribute of each `gdb.Objfile` in the current program space and iteratively calls each enabled function (see [Disabling Pretty-Printers](#), page [Disabling Pretty-Printers](#)) in the list for that `gdb.Objfile` until it receives a pretty-printer object. If no pretty-printer is found in the objfile lists, GDB then searches the pretty-printer list of the current program space, calling each enabled function until an object is returned. After these lists have been exhausted, it tries the global `gdb.pretty_printers` list, again calling each enabled function until an object is returned.

The order in which the objfiles are searched is not specified. For a given list, functions are always invoked from the head of the list, and iterated over sequentially until the end of the list, or a printer object is returned.

Here is an example showing how a `std::string` printer might be written:

```
class StdStringPrinter:
    "Print a std::string"

    def __init__(self, val):
```

```

        self.val = val

    def to_string (self):
        return self.val['_M_dataplus']['_M_p']

    def display_hint (self):
        return 'string'

```

And here is an example showing how a lookup function for the printer example above might be written.

```

def str_lookup_function (val):

    lookup_tag = val.type.tag
    regex = re.compile ("^std::basic_string<char,.*>$")
    if lookup_tag == None:
        return None
    if regex.match (lookup_tag):
        return StdStringPrinter (val)

    return None

```

The example lookup function extracts the value's type, and attempts to match it to a type that it can pretty-print. If it is a type the printer can pretty-print, it will return a printer object. If not, it returns None.

We recommend that you put your core pretty-printers into a Python package. If your pretty-printers are for use with a library, we further recommend embedding a version number into the package name. This practice will enable GDB to load multiple versions of your pretty-printers at the same time, because they will have different names.

You should write auto-loaded code (see [\(undefined\) \[Auto-loading\], page \(undefined\)](#)) such that it can be evaluated multiple times without changing its meaning. An ideal auto-load file will consist solely of imports of your printer modules, followed by a call to a register pretty-printers with the current objfile.

Taken as a whole, this approach will scale nicely to multiple inferiors, each potentially using a different library version. Embedding a version number in the Python package name will ensure that GDB is able to load both sets of printers simultaneously. Then, because the search for pretty-printers is done by objfile, and because your auto-loaded code took care to register your library's printers with a specific objfile, GDB will find the correct printers for the specific version of the library used by each inferior.

To continue the `std::string` example (see [\(undefined\) \[Pretty Printing API\], page \(undefined\)](#)), this code might appear in `gdb.libstdcxx.v6`:

```

def register_printers (objfile):
    objfile.pretty_printers.add (str_lookup_function)

```

And then the corresponding contents of the auto-load file would be:

```

import gdb.libstdcxx.v6
gdb.libstdcxx.v6.register_printers (gdb.current_objfile ())

```

23.2.2.7 Disabling Pretty-Printers

For various reasons a pretty-printer may not work. For example, the underlying data structure may have changed and the pretty-printer is out of date.

The consequences of a broken pretty-printer are severe enough that GDB provides support for enabling and disabling individual printers. For example, if `print frame-arguments` is on, a backtrace can become highly illegible if any argument is printed with a broken printer.

Pretty-printers are enabled and disabled by attaching an `enabled` attribute to the registered function or callable object. If this attribute is present and its value is `False`, the printer is disabled, otherwise the printer is enabled.

23.2.2.8 Inferiors In Python

Programs which are being run under GDB are called inferiors (see [\(undefined\) \[Inferiors and Programs\]](#), page [\(undefined\)](#)). Python scripts can access information about and manipulate inferiors controlled by GDB via objects of the `gdb.Inferior` class.

The following inferior-related functions are available in the `gdb` module:

`inferiors` [Function]
Return a tuple containing all inferior objects.

A `gdb.Inferior` object has the following attributes:

`num` [Instance Variable of Inferior]
ID of inferior, as assigned by GDB.

`pid` [Instance Variable of Inferior]
Process ID of the inferior, as assigned by the underlying operating system.

`was_attached` [Instance Variable of Inferior]
Boolean signaling whether the inferior was created using ‘attach’, or started by GDB itself.

A `gdb.Inferior` object has the following methods:

`threads` [Method on Inferior]
This method returns a tuple holding all the threads which are valid when it is called. If there are no valid threads, the method will return an empty tuple.

`read_memory address length` [Method on Inferior]
Read *length* bytes of memory from the inferior, starting at *address*. Returns a buffer object, which behaves much like an array or a string. It can be modified and given to the `gdb.write_memory` function.

`write_memory address buffer [length]` [Method on Inferior]
Write the contents of *buffer* to the inferior, starting at *address*. The *buffer* parameter must be a Python object which supports the buffer protocol, i.e., a string, an array or the object returned from `gdb.read_memory`. If given, *length* determines the number of bytes from *buffer* to be written.

`search_memory address length pattern` [Method on Inferior]
Search a region of the inferior memory starting at *address* with the given *length* using the search pattern supplied in *pattern*. The *pattern* parameter must be a Python object which supports the buffer protocol, i.e., a

string, an array or the object returned from `gdb.read_memory`. Returns a Python `Long` containing the address where the pattern was found, or `None` if the pattern could not be found.

23.2.2.9 Threads In Python

Python scripts can access information about, and manipulate inferior threads controlled by GDB, via objects of the `gdb.InferiorThread` class.

The following thread-related functions are available in the `gdb` module:

`selected_thread` [Function]
 This function returns the thread object for the selected thread. If there is no selected thread, this will return `None`.

A `gdb.InferiorThread` object has the following attributes:

`num` [Instance Variable of `InferiorThread`]
 ID of the thread, as assigned by GDB.

`ptid` [Instance Variable of `InferiorThread`]
 ID of the thread, as assigned by the operating system. This attribute is a tuple containing three integers. The first is the Process ID (PID); the second is the Lightweight Process ID (LWPID), and the third is the Thread ID (TID). Either the LWPID or TID may be 0, which indicates that the operating system does not use that identifier.

A `gdb.InferiorThread` object has the following methods:

`switch` [Method on `InferiorThread`]
 This changes GDB's currently selected thread to the one represented by this object.

`is_stopped` [Method on `InferiorThread`]
 Return a Boolean indicating whether the thread is stopped.

`is_running` [Method on `InferiorThread`]
 Return a Boolean indicating whether the thread is running.

`is_exited` [Method on `InferiorThread`]
 Return a Boolean indicating whether the thread is exited.

23.2.2.10 Commands In Python

You can implement new GDB CLI commands in Python. A CLI command is implemented using an instance of the `gdb.Command` class, most commonly using a subclass.

`__init__` *name* *command_class* [*completer_class*] [Method on `Command`]
 [*prefix*]
 The object initializer for `Command` registers the new command with GDB. This initializer is normally invoked from the subclass' own `__init__` method.

name is the name of the command. If *name* consists of multiple words, then the initial words are looked for as prefix commands. In this case, if one of the prefix commands does not exist, an exception is raised.

There is no support for multi-line commands.

command_class should be one of the ‘COMMAND_’ constants defined below. This argument tells GDB how to categorize the new command in the help system.

completer_class is an optional argument. If given, it should be one of the ‘COMPLETE_’ constants defined below. This argument tells GDB how to perform completion for this command. If not given, GDB will attempt to complete using the object’s `complete` method (see below); if no such method is found, an error will occur when completion is attempted.

prefix is an optional argument. If `True`, then the new command is a prefix command; sub-commands of this command may be registered.

The help text for the new command is taken from the Python documentation string for the command’s class, if there is one. If no documentation string is provided, the default value “This command is not documented.” is used.

dont_repeat [Method on Command]

By default, a GDB command is repeated when the user enters a blank line at the command prompt. A command can suppress this behavior by invoking the `dont_repeat` method. This is similar to the user command `dont-repeat`, see [\(undefined\) \[Define\]](#), page [\(undefined\)](#).

invoke *argument from_tty* [Method on Command]

This method is called by GDB when this command is invoked.

argument is a string. It is the argument to the command, after leading and trailing whitespace has been stripped.

from_tty is a boolean argument. When true, this means that the command was entered by the user at the terminal; when false it means that the command came from elsewhere.

If this method throws an exception, it is turned into a GDB `error` call. Otherwise, the return value is ignored.

To break *argument* up into an argv-like string use `gdb.string_to_argv`. This function behaves identically to GDB’s internal argument lexer `buildargv`. It is recommended to use this for consistency. Arguments are separated by spaces and may be quoted. Example:

```
print gdb.string_to_argv ("1 2\ \\\"3 '4 \"5' \"6 '7\"")
['1', '2 "3', '4 "5', "6 '7"]
```

complete *text word* [Method on Command]

This method is called by GDB when the user attempts completion on this command. All forms of completion are handled by this method, that is, the TAB and M-? key bindings (see [\(undefined\) \[Completion\]](#), page [\(undefined\)](#)), and the `complete` command (see [\(undefined\) \[Help\]](#), page [\(undefined\)](#)).

The arguments *text* and *word* are both strings. *text* holds the complete command line up to the cursor’s location. *word* holds the last word of the command line; this is computed using a word-breaking heuristic.

The `complete` method can return several values:

- If the return value is a sequence, the contents of the sequence are used as the completions. It is up to `complete` to ensure that the contents actually do complete the word. A zero-length sequence is allowed, it means that there were no completions available. Only string elements of the sequence are used; other elements in the sequence are ignored.
- If the return value is one of the ‘`COMPLETE_`’ constants defined below, then the corresponding GDB-internal completion function is invoked, and its result is used.
- All other results are treated as though there were no available completions.

When a new command is registered, it must be declared as a member of some general class of commands. This is used to classify top-level commands in the on-line help system; note that prefix commands are not listed under their own category but rather that of their top-level command. The available classifications are represented by constants defined in the `gdb` module:

COMMAND_NONE

The command does not belong to any particular class. A command in this category will not be displayed in any of the help categories.

COMMAND_RUNNING

The command is related to running the inferior. For example, `start`, `step`, and `continue` are in this category. Type `help running` at the GDB prompt to see a list of commands in this category.

COMMAND_DATA

The command is related to data or variables. For example, `call`, `find`, and `print` are in this category. Type `help data` at the GDB prompt to see a list of commands in this category.

COMMAND_STACK

The command has to do with manipulation of the stack. For example, `backtrace`, `frame`, and `return` are in this category. Type `help stack` at the GDB prompt to see a list of commands in this category.

COMMAND_FILES

This class is used for file-related commands. For example, `file`, `list` and `section` are in this category. Type `help files` at the GDB prompt to see a list of commands in this category.

COMMAND_SUPPORT

This should be used for “support facilities”, generally meaning things that are useful to the user when interacting with GDB, but not related to the state of the inferior. For example, `help`, `make`, and `shell` are in this category. Type `help support` at the GDB prompt to see a list of commands in this category.

COMMAND_STATUS

The command is an ‘`info`’-related command, that is, related to the state of GDB itself. For example, `info`, `macro`, and `show` are in this category. Type `help status` at the GDB prompt to see a list of commands in this category.

COMMAND_BREAKPOINTS

The command has to do with breakpoints. For example, `break`, `clear`, and `delete` are in this category. Type `help breakpoints` at the GDB prompt to see a list of commands in this category.

COMMAND_TRACEPOINTS

The command has to do with tracepoints. For example, `trace`, `actions`, and `tfind` are in this category. Type `help tracepoints` at the GDB prompt to see a list of commands in this category.

COMMAND_OBSCURE

The command is only used in unusual circumstances, or is not of general interest to users. For example, `checkpoint`, `fork`, and `stop` are in this category. Type `help obscure` at the GDB prompt to see a list of commands in this category.

COMMAND_MAINTENANCE

The command is only useful to GDB maintainers. The `maintenance` and `flushregs` commands are in this category. Type `help internals` at the GDB prompt to see a list of commands in this category.

A new command can use a predefined completion function, either by specifying it via an argument at initialization, or by returning it from the `complete` method. These predefined completion constants are all defined in the `gdb` module:

COMPLETE_NONE

This constant means that no completion should be done.

COMPLETE_FILENAME

This constant means that filename completion should be performed.

COMPLETE_LOCATION

This constant means that location completion should be done. See [\[Specify Location\]](#), page [\[undefined\]](#).

COMPLETE_COMMAND

This constant means that completion should examine GDB command names.

COMPLETE_SYMBOL

This constant means that completion should be done using symbol names as the source.

The following code snippet shows how a trivial CLI command can be implemented in Python:

```
class HelloWorld (gdb.Command):
    """Greet the whole world."""

    def __init__ (self):
        super (HelloWorld, self).__init__ ("hello-world", gdb.COMMAND_OBSCURE)

    def invoke (self, arg, from_tty):
        print "Hello, World!"

HelloWorld ()
```

The last line instantiates the class, and is necessary to trigger the registration of the command with GDB. Depending on how the Python code is read into GDB, you may need to import the `gdb` module explicitly.

23.2.2.11 Parameters In Python

You can implement new GDB parameters using Python. A new parameter is implemented as an instance of the `gdb.Parameter` class.

Parameters are exposed to the user via the `set` and `show` commands. See [\(undefined\) \[Help\], page \(undefined\)](#).

There are many parameters that already exist and can be set in GDB. Two examples are: `set follow fork` and `set charset`. Setting these parameters influences certain behavior in GDB. Similarly, you can define parameters that can be used to influence behavior in custom Python scripts and commands.

`__init__` *name command-class parameter-class* [Method on Parameter]
[enum-sequence]

The object initializer for `Parameter` registers the new parameter with GDB. This initializer is normally invoked from the subclass' own `__init__` method.

name is the name of the new parameter. If *name* consists of multiple words, then the initial words are looked for as prefix parameters. An example of this can be illustrated with the `set print` set of parameters. If *name* is `print foo`, then `print` will be searched as the prefix parameter. In this case the parameter can subsequently be accessed in GDB as `set print foo`.

If *name* consists of multiple words, and no prefix parameter group can be found, an exception is raised.

command-class should be one of the 'COMMAND_' constants (see [\(undefined\) \[Commands In Python\], page \(undefined\)](#)). This argument tells GDB how to categorize the new parameter in the help system.

parameter-class should be one of the 'PARAM_' constants defined below. This argument tells GDB the type of the new parameter; this information is used for input validation and completion.

If *parameter-class* is `PARAM_ENUM`, then *enum-sequence* must be a sequence of strings. These strings represent the possible values for the parameter.

If *parameter-class* is not `PARAM_ENUM`, then the presence of a fourth argument will cause an exception to be thrown.

The help text for the new parameter is taken from the Python documentation string for the parameter's class, if there is one. If there is no documentation string, a default value is used.

`set_doc` [Instance Variable of Parameter]

If this attribute exists, and is a string, then its value is used as the help text for this parameter's `set` command. The value is examined when `Parameter.__init__` is invoked; subsequent changes have no effect.

show_doc [Instance Variable of Parameter]
If this attribute exists, and is a string, then its value is used as the help text for this parameter's **show** command. The value is examined when `Parameter.__init__` is invoked; subsequent changes have no effect.

value [Instance Variable of Parameter]
The **value** attribute holds the underlying value of the parameter. It can be read and assigned to just as any other attribute. GDB does validation when assignments are made.

When a new parameter is defined, its type must be specified. The available types are represented by constants defined in the `gdb` module:

PARAM_BOOLEAN
The value is a plain boolean. The Python boolean values, `True` and `False` are the only valid values.

PARAM_AUTO_BOOLEAN
The value has three possible states: `true`, `false`, and `'auto'`. In Python, `true` and `false` are represented using boolean constants, and `'auto'` is represented using `None`.

PARAM_UINTEGER
The value is an unsigned integer. The value of 0 should be interpreted to mean "unlimited".

PARAM_INTEGER
The value is a signed integer. The value of 0 should be interpreted to mean "unlimited".

PARAM_STRING
The value is a string. When the user modifies the string, any escape sequences, such as `'\t'`, `'\f'`, and octal escapes, are translated into corresponding characters and encoded into the current host charset.

PARAM_STRING_NOESCAPE
The value is a string. When the user modifies the string, escapes are passed through untranslated.

PARAM_OPTIONAL_FILENAME
The value is either a filename (a string), or `None`.

PARAM_FILENAME
The value is a filename. This is just like `PARAM_STRING_NOESCAPE`, but uses file names for completion.

PARAM_ZINTEGER
The value is an integer. This is like `PARAM_INTEGER`, except 0 is interpreted as itself.

PARAM_ENUM
The value is a string, which must be one of a collection string constants provided when the parameter is created.

23.2.2.12 Writing new convenience functions

You can implement new convenience functions (see [\(undefined\)](#) [Convenience Vars], page [\(undefined\)](#)) in Python. A convenience function is an instance of a subclass of the class `gdb.Function`.

`__init__ name` [Method on Function]

The initializer for `Function` registers the new function with GDB. The argument *name* is the name of the function, a string. The function will be visible to the user as a convenience variable of type `internal function`, whose name is the same as the given *name*.

The documentation for the new function is taken from the documentation string for the new class.

`invoke *args` [Method on Function]

When a convenience function is evaluated, its arguments are converted to instances of `gdb.Value`, and then the function's `invoke` method is called. Note that GDB does not predetermine the arity of convenience functions. Instead, all available arguments are passed to `invoke`, following the standard Python calling convention. In particular, a convenience function can have default values for parameters without ill effect.

The return value of this method is used as its value in the enclosing expression. If an ordinary Python value is returned, it is converted to a `gdb.Value` following the usual rules.

The following code snippet shows how a trivial convenience function can be implemented in Python:

```
class Greet (gdb.Function):
    """Return string to greet someone.
    Takes a name as argument."""

    def __init__ (self):
        super (Greet, self).__init__ ("greet")

    def invoke (self, name):
        return "Hello, %s!" % name.string ()

Greet ()
```

The last line instantiates the class, and is necessary to trigger the registration of the function with GDB. Depending on how the Python code is read into GDB, you may need to import the `gdb` module explicitly.

23.2.2.13 Program Spaces In Python

A program space, or *progspace*, represents a symbolic view of an address space. It consists of all of the objfiles of the program. See [\(undefined\)](#) [Objfiles In Python], page [\(undefined\)](#). See [\(undefined\)](#) [Inferiors and Programs], page [\(undefined\)](#), for more details about program spaces.

The following progspace-related functions are available in the `gdb` module:

`current_progspace` [Function]

This function returns the program space of the currently selected inferior. See [\(undefined\)](#) [Inferiors and Programs], page [\(undefined\)](#).

progspace [Function]

Return a sequence of all the progspace currently known to GDB.

Each progspace is represented by an instance of the `gdb.Progspace` class.

filename [Instance Variable of Progspace]

The file name of the progspace as a string.

pretty_printers [Instance Variable of Progspace]

The `pretty_printers` attribute is a list of functions. It is used to look up pretty-printers. A `Value` is passed to each function in order; if the function returns `None`, then the search continues. Otherwise, the return value should be an object which is used to format the value. See [\(undefined\) \[Pretty Printing API\], page \(undefined\)](#), for more information.

23.2.2.14 Objfiles In Python

GDB loads symbols for an inferior from various symbol-containing files (see [\(undefined\) \[Files\], page \(undefined\)](#)). These include the primary executable file, any shared libraries used by the inferior, and any separate debug info files (see [\(undefined\) \[Separate Debug Files\], page \(undefined\)](#)). GDB calls these symbol-containing files *objfiles*.

The following objfile-related functions are available in the `gdb` module:

current_objfile [Function]

When auto-loading a Python script (see [\(undefined\) \[Auto-loading\], page \(undefined\)](#)), GDB sets the “current objfile” to the corresponding objfile. This function returns the current objfile. If there is no current objfile, this function returns `None`.

objfiles [Function]

Return a sequence of all the objfiles current known to GDB. See [\(undefined\) \[Objfiles In Python\], page \(undefined\)](#).

Each objfile is represented by an instance of the `gdb.Objfile` class.

filename [Instance Variable of Objfile]

The file name of the objfile as a string.

pretty_printers [Instance Variable of Objfile]

The `pretty_printers` attribute is a list of functions. It is used to look up pretty-printers. A `Value` is passed to each function in order; if the function returns `None`, then the search continues. Otherwise, the return value should be an object which is used to format the value. See [\(undefined\) \[Pretty Printing API\], page \(undefined\)](#), for more information.

23.2.2.15 Accessing inferior stack frames from Python.

When the debugged program stops, GDB is able to analyze its call stack (see [\(undefined\) \[Stack frames\], page \(undefined\)](#)). The `gdb.Frame` class represents a frame in the stack. A `gdb.Frame` object is only valid while its corresponding frame exists in the inferior’s stack. If you try to use an invalid frame object, GDB will throw a `RuntimeError` exception.

Two `gdb.Frame` objects can be compared for equality with the `==` operator, like:


```
(gdb) python print gdb.newest_frame() == gdb.selected_frame ()
True
```

The following frame-related functions are available in the `gdb` module:

`selected_frame` [Function]
Return the selected frame object. (see [<undefined> \[Selecting a Frame\]](#), page [<undefined>](#)).

`frame_stop_reason_string reason` [Function]
Return a string explaining the reason why GDB stopped unwinding frames, as expressed by the given *reason* code (an integer, see the `unwind_stop_reason` method further down in this section).

A `gdb.Frame` object has the following methods:

`is_valid` [Method on Frame]
Returns true if the `gdb.Frame` object is valid, false if not. A frame object can become invalid if the frame it refers to doesn't exist anymore in the inferior. All `gdb.Frame` methods will throw an exception if it is invalid at the time the method is called.

`name` [Method on Frame]
Returns the function name of the frame, or `None` if it can't be obtained.

`type` [Method on Frame]
Returns the type of the frame. The value can be one of `gdb.NORMAL_FRAME`, `gdb.DUMMY_FRAME`, `gdb.SIGTRAMP_FRAME` or `gdb.SENTINEL_FRAME`.

`unwind_stop_reason` [Method on Frame]
Return an integer representing the reason why it's not possible to find more frames toward the outermost frame. Use `gdb.frame_stop_reason_string` to convert the value returned by this function to a string.

`pc` [Method on Frame]
Returns the frame's resume address.

`block` [Method on Frame]
Return the frame's code block. See [<undefined> \[Blocks In Python\]](#), page [<undefined>](#).

`function` [Method on Frame]
Return the symbol for the function corresponding to this frame. See [<undefined> \[Symbols In Python\]](#), page [<undefined>](#).

`older` [Method on Frame]
Return the frame that called this frame.

`newer` [Method on Frame]
Return the frame called by this frame.

- `find_sal` [Method on Frame]
Return the frame's syntab and line object. See [\(undefined\) \[Symbol Tables In Python\]](#), page [\(undefined\)](#).
- `read_var variable [block]` [Method on Frame]
Return the value of *variable* in this frame. If the optional argument *block* is provided, search for the variable from that block; otherwise start at the frame's current block (which is determined by the frame's current program counter). *variable* must be a string or a `gdb.Symbol` object. *block* must be a `gdb.Block` object.
- `select` [Method on Frame]
Set this frame to be the selected frame. See [\(undefined\) \[Examining the Stack\]](#), page [\(undefined\)](#).

23.2.2.16 Accessing frame blocks from Python.

Within each frame, GDB maintains information on each block stored in that frame. These blocks are organized hierarchically, and are represented individually in Python as a `gdb.Block`. Please see [\(undefined\) \[Frames In Python\]](#), page [\(undefined\)](#), for a more in-depth discussion on frames. Furthermore, see [\(undefined\) \[Examining the Stack\]](#), page [\(undefined\)](#), for more detailed technical information on GDB's book-keeping of the stack.

The following block-related functions are available in the `gdb` module:

- `block_for_pc pc` [Function]
Return the `gdb.Block` containing the given *pc* value. If the block cannot be found for the *pc* value specified, the function will return `None`.

A `gdb.Block` object has the following attributes:

- `start` [Instance Variable of Block]
The start address of the block. This attribute is not writable.
- `end` [Instance Variable of Block]
The end address of the block. This attribute is not writable.
- `function` [Instance Variable of Block]
The name of the block represented as a `gdb.Symbol`. If the block is not named, then this attribute holds `None`. This attribute is not writable.
- `superblock` [Instance Variable of Block]
The block containing this block. If this parent block does not exist, this attribute holds `None`. This attribute is not writable.

23.2.2.17 Python representation of Symbols.

GDB represents every variable, function and type as an entry in a symbol table. See [\(undefined\) \[Examining the Symbol Table\]](#), page [\(undefined\)](#). Similarly, Python represents these symbols in GDB with the `gdb.Symbol` object.

The following symbol-related functions are available in the `gdb` module:

`lookup_symbol name [block] [domain]` [Function]

This function searches for a symbol by name. The search scope can be restricted to the parameters defined in the optional domain and block arguments.

name is the name of the symbol. It must be a string. The optional *block* argument restricts the search to symbols visible in that *block*. The *block* argument must be a `gdb.Block` object. The optional *domain* argument restricts the search to the domain type. The *domain* argument must be a domain constant defined in the `gdb` module and described later in this chapter.

A `gdb.Symbol` object has the following attributes:

<code>symtab</code>	[Instance Variable of Symbol]
The symbol table in which the symbol appears. This attribute is represented as a <code>gdb.Symtab</code> object. See (undefined) [Symbol Tables In Python] , page (undefined) . This attribute is not writable.	
<code>name</code>	[Instance Variable of Symbol]
The name of the symbol as a string. This attribute is not writable.	
<code>linkage_name</code>	[Instance Variable of Symbol]
The name of the symbol, as used by the linker (i.e., may be mangled). This attribute is not writable.	
<code>print_name</code>	[Instance Variable of Symbol]
The name of the symbol in a form suitable for output. This is either <code>name</code> or <code>linkage_name</code> , depending on whether the user asked GDB to display demangled or mangled names.	
<code>addr_class</code>	[Instance Variable of Symbol]
The address class of the symbol. This classifies how to find the value of a symbol. Each address class is a constant defined in the <code>gdb</code> module and described later in this chapter.	
<code>is_argument</code>	[Instance Variable of Symbol]
True if the symbol is an argument of a function.	
<code>is_constant</code>	[Instance Variable of Symbol]
True if the symbol is a constant.	
<code>is_function</code>	[Instance Variable of Symbol]
True if the symbol is a function or a method.	
<code>is_variable</code>	[Instance Variable of Symbol]
True if the symbol is a variable.	

The available domain categories in `gdb.Symbol` are represented as constants in the `gdb` module:

`SYMBOL_UNDEF_DOMAIN`

This is used when a domain has not been discovered or none of the following domains apply. This usually indicates an error either in the symbol information or in GDB's handling of symbols.

SYMBOL_VAR_DOMAIN

This domain contains variables, function names, typedef names and enum type values.

SYMBOL_STRUCT_DOMAIN

This domain holds struct, union and enum type names.

SYMBOL_LABEL_DOMAIN

This domain contains names of labels (for gotos).

SYMBOL_VARIABLES_DOMAIN

This domain holds a subset of the **SYMBOLS_VAR_DOMAIN**; it contains everything minus functions and types.

SYMBOL_FUNCTION_DOMAIN

This domain contains all functions.

SYMBOL_TYPES_DOMAIN

This domain contains all types.

The available address class categories in `gdb.Symbol` are represented as constants in the `gdb` module:

SYMBOL_LOC_UNDEF

If this is returned by address class, it indicates an error either in the symbol information or in GDB's handling of symbols.

SYMBOL_LOC_CONST

Value is constant int.

SYMBOL_LOC_STATIC

Value is at a fixed address.

SYMBOL_LOC_REGISTER

Value is in a register.

SYMBOL_LOC_ARG

Value is an argument. This value is at the offset stored within the symbol inside the frame's argument list.

SYMBOL_LOC_REF_ARG

Value address is stored in the frame's argument list. Just like **LOC_ARG** except that the value's address is stored at the offset, not the value itself.

SYMBOL_LOC_REGPARAM_ADDR

Value is a specified register. Just like **LOC_REGISTER** except the register holds the address of the argument instead of the argument itself.

SYMBOL_LOC_LOCAL

Value is a local variable.

SYMBOL_LOC_TYPEDEF

Value not used. Symbols in the domain **SYMBOL_STRUCT_DOMAIN** all have this class.

`SYMBOL_LOC_BLOCK`

Value is a block.

`SYMBOL_LOC_CONST_BYTES`

Value is a byte-sequence.

`SYMBOL_LOC_UNRESOLVED`

Value is at a fixed address, but the address of the variable has to be determined from the minimal symbol table whenever the variable is referenced.

`SYMBOL_LOC_OPTIMIZED_OUT`

The value does not actually exist in the program.

`SYMBOL_LOC_COMPUTED`

The value's address is a computed location.

23.2.2.18 Symbol table representation in Python.

Access to symbol table data maintained by GDB on the inferior is exposed to Python via two objects: `gdb.Symtab_and_line` and `gdb.Symtab`. Symbol table and line data for a frame is returned from the `find_sal` method in `gdb.Frame` object. See [\(undefined\) \[Frames In Python\]](#), page [\(undefined\)](#).

For more information on GDB's symbol table management, see [\(undefined\) \[Examining the Symbol Table\]](#), page [\(undefined\)](#), for more information.

A `gdb.Symtab_and_line` object has the following attributes:

<code>symtab</code>	[Instance Variable of <code>Symtab_and_line</code>]
The symbol table object (<code>gdb.Symtab</code>) for this frame. This attribute is not writable.	
<code>pc</code>	[Instance Variable of <code>Symtab_and_line</code>]
Indicates the current program counter address. This attribute is not writable.	
<code>line</code>	[Instance Variable of <code>Symtab_and_line</code>]
Indicates the current line number for this object. This attribute is not writable.	

A `gdb.Symtab` object has the following attributes:

<code>filename</code>	[Instance Variable of <code>Symtab</code>]
The symbol table's source filename. This attribute is not writable.	
<code>objfile</code>	[Instance Variable of <code>Symtab</code>]
The symbol table's backing object file. See (undefined) [Objfiles In Python] , page (undefined) . This attribute is not writable.	

The following methods are provided:

<code>fullname</code>	[Method on <code>Symtab</code>]
Return the symbol table's source absolute file name.	

23.2.2.19 Manipulating breakpoints using Python

Python code can manipulate breakpoints via the `gdb.Breakpoint` class.

`__init__ spec [type] [wp-class]` [Method on `Breakpoint`]

Create a new breakpoint. *spec* is a string naming the location of the breakpoint, or an expression that defines a watchpoint. The contents can be any location recognized by the `break` command, or in the case of a watchpoint, by the `watch` command. The optional *type* denotes the breakpoint to create from the types defined later in this chapter. This argument can be either: `BP_BREAKPOINT` or `BP_WATCHPOINT`. *type* defaults to `BP_BREAKPOINT`. The optional *wp-class* argument defines the class of watchpoint to create, if *type* is defined as `BP_WATCHPOINT`. If a watchpoint class is not provided, it is assumed to be a `WP_WRITE` class.

The available watchpoint types represented by constants are defined in the `gdb` module:

`WP_READ` Read only watchpoint.

`WP_WRITE` Write only watchpoint.

`WP_ACCESS`
Read/Write watchpoint.

`is_valid` [Method on `Breakpoint`]

Return `True` if this `Breakpoint` object is valid, `False` otherwise. A `Breakpoint` object can become invalid if the user deletes the breakpoint. In this case, the object still exists, but the underlying breakpoint does not. In the cases of watchpoint scope, the watchpoint remains valid even if execution of the inferior leaves the scope of that watchpoint.

`enabled` [Instance Variable of `Breakpoint`]

This attribute is `True` if the breakpoint is enabled, and `False` otherwise. This attribute is writable.

`silent` [Instance Variable of `Breakpoint`]

This attribute is `True` if the breakpoint is silent, and `False` otherwise. This attribute is writable.

Note that a breakpoint can also be silent if it has commands and the first command is `silent`. This is not reported by the `silent` attribute.

`thread` [Instance Variable of `Breakpoint`]

If the breakpoint is thread-specific, this attribute holds the thread id. If the breakpoint is not thread-specific, this attribute is `None`. This attribute is writable.

`task` [Instance Variable of `Breakpoint`]

If the breakpoint is Ada task-specific, this attribute holds the Ada task id. If the breakpoint is not task-specific (or the underlying language is not Ada), this attribute is `None`. This attribute is writable.

`ignore_count` [Instance Variable of `Breakpoint`]

This attribute holds the ignore count for the breakpoint, an integer. This attribute is writable.

number [Instance Variable of `Breakpoint`]
 This attribute holds the breakpoint's number — the identifier used by the user to manipulate the breakpoint. This attribute is not writable.

type [Instance Variable of `Breakpoint`]
 This attribute holds the breakpoint's type — the identifier used to determine the actual breakpoint type or use-case. This attribute is not writable.

The available types are represented by constants defined in the `gdb` module:

`BP_BREAKPOINT`
 Normal code breakpoint.

`BP_WATCHPOINT`
 Watchpoint breakpoint.

`BP_HARDWARE_WATCHPOINT`
 Hardware assisted watchpoint.

`BP_READ_WATCHPOINT`
 Hardware assisted read watchpoint.

`BP_ACCESS_WATCHPOINT`
 Hardware assisted access watchpoint.

hit_count [Instance Variable of `Breakpoint`]
 This attribute holds the hit count for the breakpoint, an integer. This attribute is writable, but currently it can only be set to zero.

location [Instance Variable of `Breakpoint`]
 This attribute holds the location of the breakpoint, as specified by the user. It is a string. If the breakpoint does not have a location (that is, it is a watchpoint) the attribute's value is `None`. This attribute is not writable.

expression [Instance Variable of `Breakpoint`]
 This attribute holds a breakpoint expression, as specified by the user. It is a string. If the breakpoint does not have an expression (the breakpoint is not a watchpoint) the attribute's value is `None`. This attribute is not writable.

condition [Instance Variable of `Breakpoint`]
 This attribute holds the condition of the breakpoint, as specified by the user. It is a string. If there is no condition, this attribute's value is `None`. This attribute is writable.

commands [Instance Variable of `Breakpoint`]
 This attribute holds the commands attached to the breakpoint. If there are commands, this attribute's value is a string holding all the commands, separated by newlines. If there are no commands, this attribute is `None`. This attribute is not writable.

23.2.2.20 Python representation of lazy strings.

A *lazy string* is a string whose contents is not retrieved or encoded until it is needed.

A `gdb.LazyString` is represented in GDB as an `address` that points to a region of memory, an `encoding` that will be used to encode that region of memory, and a `length` to delimit the region of memory that represents the string. The difference between a `gdb.LazyString` and a string wrapped within a `gdb.Value` is that a `gdb.LazyString` will be treated differently by GDB when printing. A `gdb.LazyString` is retrieved and encoded during printing, while a `gdb.Value` wrapping a string is immediately retrieved and encoded on creation.

A `gdb.LazyString` object has the following functions:

`value` [Method on `LazyString`]

Convert the `gdb.LazyString` to a `gdb.Value`. This value will point to the string in memory, but will lose all the delayed retrieval, encoding and handling that GDB applies to a `gdb.LazyString`.

`address` [Instance Variable of `LazyString`]

This attribute holds the address of the string. This attribute is not writable.

`length` [Instance Variable of `LazyString`]

This attribute holds the length of the string in characters. If the length is -1, then the string will be fetched and encoded up to the first null of appropriate width. This attribute is not writable.

`encoding` [Instance Variable of `LazyString`]

This attribute holds the encoding that will be applied to the string when the string is printed by GDB. If the encoding is not set, or contains an empty string, then GDB will select the most appropriate encoding when the string is printed. This attribute is not writable.

`type` [Instance Variable of `LazyString`]

This attribute holds the type that is represented by the lazy string's type. For a lazy string this will always be a pointer type. To resolve this to the lazy string's character type, use the type's `target` method. See [\(undefined\)](#) [Types In Python], [page \(undefined\)](#). This attribute is not writable.

23.2.3 Auto-loading

When a new object file is read (for example, due to the `file` command, or because the inferior has loaded a shared library), GDB will look for Python support scripts in several ways: `'objfile-gdb.py'` and `.debug_gdb_scripts` section.

The auto-loading feature is useful for supplying application-specific debugging commands and scripts.

Auto-loading can be enabled or disabled.

```
maint set python auto-load [yes|no]
```

Enable or disable the Python auto-loading feature.

```
maint show python auto-load
```

Show whether Python auto-loading is enabled or disabled.

When reading an auto-loaded file, GDB sets the *current objfile*. This is available via the `gdb.current_objfile` function (see [\[Objfiles In Python\]](#), page [\(undefined\)](#)). This can be useful for registering objfile-specific pretty-printers.

23.2.3.1 The ‘*objfile-gdb.py*’ file

When a new object file is read, GDB looks for a file named ‘*objfile-gdb.py*’, where *objfile* is the object file’s real name, formed by ensuring that the file name is absolute, following all symlinks, and resolving `.` and `..` components. If this file exists and is readable, GDB will evaluate it as a Python script.

If this file does not exist, and if the parameter `debug-file-directory` is set (see [\(undefined\) \[Separate Debug Files\]](#), page [\(undefined\)](#)), then GDB will look for *real-name* in all of the directories mentioned in the value of `debug-file-directory`.

Finally, if this file does not exist, then GDB will look for a file named ‘*data-directory/python/auto-load/real-name*’, where *data-directory* is GDB’s data directory (available via `show data-directory`, see [\(undefined\) \[Data Files\]](#), page [\(undefined\)](#)), and *real-name* is the object file’s real name, as described above.

GDB does not track which files it has already auto-loaded this way. GDB will load the associated script every time the corresponding *objfile* is opened. So your ‘*-gdb.py*’ file should be careful to avoid errors if it is evaluated more than once.

23.2.3.2 The `.debug_gdb_scripts` section

For systems using file formats like ELF and COFF, when GDB loads a new object file it will look for a special section named ‘`.debug_gdb_scripts`’. If this section exists, its contents is a list of names of scripts to load.

GDB will look for each specified script file first in the current directory and then along the source search path (see [\(undefined\) \[Specifying Source Directories\]](#), page [\(undefined\)](#)), except that ‘`$cdir`’ is not searched, since the compilation directory is not relevant to scripts.

Entries can be placed in section `.debug_gdb_scripts` with, for example, this GCC macro:

```
/* Note: The "MS" section flags are to remove duplicates. */
#define DEFINE_GDB_SCRIPT(script_name) \
    asm("\n\
    .pushsection \".debug_gdb_scripts\", \"MS\",@progbits,1\n\
    .byte 1\n\
    .asciz \"\" script_name \"\"\n\
    .popsection \n\
    ");
```

Then one can reference the macro in a header or source file like this:

```
DEFINE_GDB_SCRIPT ("my-app-scripts.py")
```

The script name may include directories if desired.

If the macro is put in a header, any application or library using this header will get a reference to the specified script.

23.2.3.3 Which flavor to choose?

Given the multiple ways of auto-loading Python scripts, it might not always be clear which one to choose. This section provides some guidance.

Benefits of the ‘-gdb.py’ way:

- Can be used with file formats that don’t support multiple sections.
- Ease of finding scripts for public libraries.

Scripts specified in the `.debug_gdb_scripts` section are searched for in the source search path. For publicly installed libraries, e.g., ‘libstdc++’, there typically isn’t a source directory in which to find the script.

- Doesn’t require source code additions.

Benefits of the `.debug_gdb_scripts` way:

- Works with static linking.

Scripts for libraries done the ‘-gdb.py’ way require an objfile to trigger their loading. When an application is statically linked the only objfile available is the executable, and it is cumbersome to attach all the scripts from all the input libraries to the executable’s ‘-gdb.py’ script.

- Works with classes that are entirely inlined.

Some classes can be entirely inlined, and thus there may not be an associated shared library to attach a ‘-gdb.py’ script to.

- Scripts needn’t be copied out of the source tree.

In some circumstances, apps can be built out of large collections of internal libraries, and the build infrastructure necessary to install the ‘-gdb.py’ scripts in a place where GDB can find them is cumbersome. It may be easier to specify the scripts in the `.debug_gdb_scripts` section as relative paths, and add a path to the top of the source tree to the source search path.

24 Command Interpreters

GDB supports multiple command interpreters, and some command infrastructure to allow users or user interface writers to switch between interpreters or run commands in other interpreters.

GDB currently supports two command interpreters, the console interpreter (sometimes called the command-line interpreter or CLI) and the machine interface interpreter (or GDB/MI). This manual describes both of these interfaces in great detail.

By default, GDB will start with the console interpreter. However, the user may choose to start GDB with another interpreter by specifying the `-i` or `--interpreter` startup options. Defined interpreters include:

- console** The traditional console or command-line interpreter. This is the most often used interpreter with GDB. With no interpreter specified at runtime, GDB will use this interpreter.
- mi** The newest GDB/MI interface (currently `mi2`). Used primarily by programs wishing to use GDB as a backend for a debugger GUI or an IDE. For more information, see [\[The GDB/MI Interface\]](#), page [\[The GDB/MI Interface\]](#).
- mi2** The current GDB/MI interface.
- mi1** The GDB/MI interface included in GDB 5.1, 5.2, and 5.3.

The interpreter being used by GDB may not be dynamically switched at runtime. Although possible, this could lead to a very precarious situation. Consider an IDE using GDB/MI. If a user enters the command `interpreter-set console` in a console view, GDB would switch to using the console interpreter, rendering the IDE inoperable!

Although you may only choose a single interpreter at startup, you may execute commands in any interpreter from the current interpreter using the appropriate command. If you are running the console interpreter, simply use the `interpreter-exec` command:

```
interpreter-exec mi "-data-list-register-names"
```

GDB/MI has a similar command, although it is only available in versions of GDB which support GDB/MI version 2 (or greater).

25 GDB Text User Interface

The GDB Text User Interface (TUI) is a terminal interface which uses the `curses` library to show the source file, the assembly output, the program registers and GDB commands in separate text windows. The TUI mode is supported only on platforms where a suitable version of the `curses` library is available.

The TUI mode is enabled by default when you invoke GDB as either `'gdbtui'` or `'gdb -tui'`. You can also switch in and out of TUI mode while GDB runs by using various TUI commands and key bindings, such as `C-x C-a`. See [\(undefined\) \[TUI Key Bindings\]](#), page [\(undefined\)](#).

25.1 TUI Overview

In TUI mode, GDB can display several text windows:

<i>command</i>	This window is the GDB command window with the GDB prompt and the GDB output. The GDB input is still managed using readline.
<i>source</i>	The source window shows the source file of the program. The current line and active breakpoints are displayed in this window.
<i>assembly</i>	The assembly window shows the disassembly output of the program.
<i>register</i>	This window shows the processor registers. Registers are highlighted when their values change.

The source and assembly windows show the current program position by highlighting the current line and marking it with a `'>'` marker. Breakpoints are indicated with two markers. The first marker indicates the breakpoint type:

B	Breakpoint which was hit at least once.
b	Breakpoint which was never hit.
H	Hardware breakpoint which was hit at least once.
h	Hardware breakpoint which was never hit.

The second marker indicates whether the breakpoint is enabled or not:

+	Breakpoint is enabled.
-	Breakpoint is disabled.

The source, assembly and register windows are updated when the current thread changes, when the frame changes, or when the program counter changes.

These windows are not all visible at the same time. The command window is always visible. The others can be arranged in several layouts:

- source only,
- assembly only,
- source and assembly,
- source and registers, or
- assembly and registers.

A status line above the command window shows the following information:

<i>target</i>	Indicates the current GDB target. (see [Specifying a Debugging Target] , page (undefined)).
<i>process</i>	Gives the current process or thread number. When no process is being debugged, this field is set to <code>No process</code> .
<i>function</i>	Gives the current function name for the selected frame. The name is demangled if demangling is turned on (see [Print Settings] , page (undefined)). When there is no symbol corresponding to the current program counter, the string <code>??</code> is displayed.
<i>line</i>	Indicates the current line number for the selected frame. When the current line number is not known, the string <code>??</code> is displayed.
<i>pc</i>	Indicates the current program counter address.

25.2 TUI Key Bindings

The TUI installs several key bindings in the readline keymaps (see [\[Command Line Editing\]](#), page [\(undefined\)](#)). The following key bindings are installed for both TUI mode and the GDB standard mode.

<code>C-x C-a</code>	
<code>C-x a</code>	
<code>C-x A</code>	Enter or leave the TUI mode. When leaving the TUI mode, the curses window management stops and GDB operates using its standard mode, writing on the terminal directly. When reentering the TUI mode, control is given back to the curses windows. The screen is then refreshed.
<code>C-x 1</code>	Use a TUI layout with only one window. The layout will either be ‘ <code>source</code> ’ or ‘ <code>assembly</code> ’. When the TUI mode is not active, it will switch to the TUI mode. Think of this key binding as the Emacs <code>C-x 1</code> binding.
<code>C-x 2</code>	Use a TUI layout with at least two windows. When the current layout already has two windows, the next layout with two windows is used. When a new layout is chosen, one window will always be common to the previous layout and the new one. Think of it as the Emacs <code>C-x 2</code> binding.
<code>C-x o</code>	Change the active window. The TUI associates several key bindings (like scrolling and arrow keys) with the active window. This command gives the focus to the next TUI window. Think of it as the Emacs <code>C-x o</code> binding.
<code>C-x s</code>	Switch in and out of the TUI SingleKey mode that binds single keys to GDB commands (see [TUI Single Key Mode] , page (undefined)).

The following key bindings only work in the TUI mode:

PGUP	Scroll the active window one page up.
PGDN	Scroll the active window one page down.

UP	Scroll the active window one line up.
DOWN	Scroll the active window one line down.
LEFT	Scroll the active window one column left.
RIGHT	Scroll the active window one column right.
<i>C-L</i>	Refresh the screen.

Because the arrow keys scroll the active window in the TUI mode, they are not available for their normal use by readline unless the command window has the focus. When another window is active, you must use other readline key bindings such as *C-p*, *C-n*, *C-b* and *C-f* to control the command window.

25.3 TUI Single Key Mode

The TUI also provides a *SingleKey* mode, which binds several frequently used GDB commands to single keys. Type *C-x s* to switch into this mode, where the following key bindings are used:

<i>c</i>	continue
<i>d</i>	down
<i>f</i>	finish
<i>n</i>	next
<i>q</i>	exit the SingleKey mode.
<i>r</i>	run
<i>s</i>	step
<i>u</i>	up
<i>v</i>	info locals
<i>w</i>	where

Other keys temporarily switch to the GDB command prompt. The key that was pressed is inserted in the editing buffer so that it is possible to type most GDB commands without interaction with the TUI SingleKey mode. Once the command is entered the TUI SingleKey mode is restored. The only way to permanently leave this mode is by typing *q* or *C-x s*.

25.4 TUI-specific Commands

The TUI has specific commands to control the text windows. These commands are always available, even when GDB is not in the TUI mode. When GDB is in the standard mode, most of these commands will automatically switch to the TUI mode.

Note that if GDB's `stdout` is not connected to a terminal, or GDB has been started with the machine interface interpreter (see [\(undefined\) \[The GDB/MI Interface\]](#), page [\(undefined\)](#)), most of these commands will fail with an error, because it would not be possible or desirable to enable curses window management.

`info win` List and give the size of all displayed windows.

`layout next`
Display the next layout.

`layout prev`
Display the previous layout.

`layout src`
Display the source window only.

`layout asm`
Display the assembly window only.

`layout split`
Display the source and assembly window.

`layout regs`
Display the register window together with the source or assembly window.

`focus next`
Make the next window active for scrolling.

`focus prev`
Make the previous window active for scrolling.

`focus src` Make the source window active for scrolling.

`focus asm` Make the assembly window active for scrolling.

`focus regs`
Make the register window active for scrolling.

`focus cmd` Make the command window active for scrolling.

`refresh` Refresh the screen. This is similar to typing *C-L*.

`tui reg float`
Show the floating point registers in the register window.

`tui reg general`
Show the general registers in the register window.

`tui reg next`
Show the next register group. The list of register groups as well as their order is target specific. The predefined register groups are the following: **general**, **float**, **system**, **vector**, **all**, **save**, **restore**.

`tui reg system`
Show the system registers in the register window.

`update` Update the source window and the current execution point.

`winheight name +count`
`winheight name -count`
Change the height of the window *name* by *count* lines. Positive counts increase the height, while negative counts decrease it.

`tabset nchars`
Set the width of tab stops to be *nchars* characters.

25.5 TUI Configuration Variables

Several configuration variables control the appearance of TUI windows.

`set tui border-kind kind`

Select the border appearance for the source, assembly and register windows. The possible values are the following:

- `space` Use a space character to draw the border.
- `ascii` Use ASCII characters ‘+’, ‘-’ and ‘|’ to draw the border.
- `acs` Use the Alternate Character Set to draw the border. The border is drawn using character line graphics if the terminal supports them.

`set tui border-mode mode`

`set tui active-border-mode mode`

Select the display attributes for the borders of the inactive windows or the active window. The *mode* can be one of the following:

- `normal` Use normal attributes to display the border.
- `standout` Use standout mode.
- `reverse` Use reverse video mode.
- `half` Use half bright mode.
- `half-standout`
 Use half bright and standout mode.
- `bold` Use extra bright or bold mode.
- `bold-standout`
 Use extra bright or bold and standout mode.

26 Using GDB under GNU Emacs

A special interface allows you to use GNU Emacs to view (and edit) the source files for the program you are debugging with GDB.

To use this interface, use the command `M-x gdb` in Emacs. Give the executable file you want to debug as an argument. This command starts GDB as a subprocess of Emacs, with input and output through a newly created Emacs buffer.

Running GDB under Emacs can be just like running GDB normally except for two things:

- All “terminal” input and output goes through an Emacs buffer, called the GUD buffer. This applies both to GDB commands and their output, and to the input and output done by the program you are debugging.

This is useful because it means that you can copy the text of previous commands and input them again; you can even use parts of the output in this way.

All the facilities of Emacs’ Shell mode are available for interacting with your program. In particular, you can send signals the usual way—for example, `C-c C-c` for an interrupt, `C-c C-z` for a stop.

- GDB displays source code through Emacs.

Each time GDB displays a stack frame, Emacs automatically finds the source file for that frame and puts an arrow (`=>`) at the left margin of the current line. Emacs uses a separate buffer for source display, and splits the screen to show both your GDB session and the source.

Explicit GDB `list` or search commands still produce output as usual, but you probably have no reason to use them from Emacs.

We call this *text command mode*. Emacs 22.1, and later, also uses a graphical mode, enabled by default, which provides further buffers that can control the execution and describe the state of your program. See [section “GDB Graphical Interface” in *The GNU Emacs Manual*](#).

If you specify an absolute file name when prompted for the `M-x gdb` argument, then Emacs sets your current working directory to where your program resides. If you only specify the file name, then Emacs sets your current working directory to the directory associated with the previous buffer. In this case, GDB may find your program by searching your environment’s `PATH` variable, but on some operating systems it might not find the source. So, although the GDB input and output session proceeds normally, the auxiliary buffer does not display the current source and line of execution.

The initial working directory of GDB is printed on the top line of the GUD buffer and this serves as a default for the commands that specify files for GDB to operate on. See [\(undefined\) \[Commands to Specify Files\], page \(undefined\)](#).

By default, `M-x gdb` calls the program called `'gdb'`. If you need to call GDB by a different name (for example, if you keep several configurations around, with different names) you can customize the Emacs variable `gud-gdb-command-name` to run the one you want.

In the GUD buffer, you can use these special Emacs commands in addition to the standard Shell mode commands:

`C-h m` Describe the features of Emacs’ GUD Mode.

- `C-c C-s` Execute to another source line, like the GDB `step` command; also update the display window to show the current file and location.
- `C-c C-n` Execute to next source line in this function, skipping all function calls, like the GDB `next` command. Then update the display window to show the current file and location.
- `C-c C-i` Execute one instruction, like the GDB `stepi` command; update display window accordingly.
- `C-c C-f` Execute until exit from the selected stack frame, like the GDB `finish` command.
- `C-c C-r` Continue execution of your program, like the GDB `continue` command.
- `C-c <` Go up the number of frames indicated by the numeric argument (see [section “Numeric Arguments” in *The GNU Emacs Manual*](#)), like the GDB `up` command.
- `C-c >` Go down the number of frames indicated by the numeric argument, like the GDB `down` command.

In any source file, the Emacs command `C-x SPC` (`gud-break`) tells GDB to set a break-point on the source line point is on.

In text command mode, if you type `M-x speedbar`, Emacs displays a separate frame which shows a backtrace when the GUD buffer is current. Move point to any frame in the stack and type RET to make it become the current frame and display the associated source in the source buffer. Alternatively, click `Mouse-2` to make the selected frame become the current one. In graphical mode, the speedbar displays watch expressions.

If you accidentally delete the source-display buffer, an easy way to get it back is to type the command `f` in the GDB buffer, to request a frame display; when you run under Emacs, this recreates the source buffer if necessary to show you the context of the current frame.

The source files displayed in Emacs are in ordinary Emacs buffers which are visiting the source files in the usual way. You can edit the files with these buffers if you wish; but keep in mind that GDB communicates with Emacs in terms of line numbers. If you add or delete lines from the text, the line numbers that GDB knows cease to correspond properly with the code.

A more detailed description of Emacs’ interaction with GDB is given in the Emacs manual (see [section “Debuggers” in *The GNU Emacs Manual*](#)).

27 The GDB/MI Interface

Function and Purpose

GDB/MI is a line based machine oriented text interface to GDB and is activated by specifying using the ‘`--interpreter`’ command line option (see [\(undefined\) \[Mode Options\]](#), page [\(undefined\)](#)). It is specifically intended to support the development of systems which use the debugger as just one small component of a larger system.

This chapter is a specification of the GDB/MI interface. It is written in the form of a reference manual.

Note that GDB/MI is still under construction, so some of the features described below are incomplete and subject to change (see [\(undefined\) \[GDB/MI Development and Front Ends\]](#), page [\(undefined\)](#)).

Notation and Terminology

This chapter uses the following notation:

- | separates two alternatives.
- [*something*] indicates that *something* is optional: it may or may not be given.
- (*group*)* means that *group* inside the parentheses may repeat zero or more times.
- (*group*)+ means that *group* inside the parentheses may repeat one or more times.
- "*string*" means a literal *string*.

27.3 GDB/MI General Design

Interaction of a GDB/MI frontend with GDB involves three parts—commands sent to GDB, responses to those commands and notifications. Each command results in exactly one response, indicating either successful completion of the command, or an error. For the commands that do not resume the target, the response contains the requested information. For the commands that resume the target, the response only indicates whether the target was successfully resumed. Notifications is the mechanism for reporting changes in the state of the target, or in GDB state, that cannot conveniently be associated with a command and reported as part of that command response.

The important examples of notifications are:

- Exec notifications. These are used to report changes in target state—when a target is resumed, or stopped. It would not be feasible to include this information in response of resuming commands, because one resume commands can result in multiple events in different threads. Also, quite some time may pass before any event happens in the target, while a frontend needs to know whether the resuming command itself was successfully executed.
- Console output, and status notifications. Console output notifications are used to report output of CLI commands, as well as diagnostics for other commands. Status notifications are used to report the progress of a long-running operation. Naturally, including this information in command response would mean no output is produced until the command is finished, which is undesirable.

- General notifications. Commands may have various side effects on the GDB or target state beyond their official purpose. For example, a command may change the selected thread. Although such changes can be included in command response, using notification allows for more orthogonal frontend design.

There's no guarantee that whenever an MI command reports an error, GDB or the target are in any specific state, and especially, the state is not reverted to the state before the MI command was processed. Therefore, whenever an MI command results in an error, we recommend that the frontend refreshes all the information shown in the user interface.

27.3.1 Context management

In most cases when GDB accesses the target, this access is done in context of a specific thread and frame (see [\[Frames\]](#), page [\[undefined\]](#)). Often, even when accessing global data, the target requires that a thread be specified. The CLI interface maintains the selected thread and frame, and supplies them to target on each command. This is convenient, because a command line user would not want to specify that information explicitly on each command, and because user interacts with GDB via a single terminal, so no confusion is possible as to what thread and frame are the current ones.

In the case of MI, the concept of selected thread and frame is less useful. First, a frontend can easily remember this information itself. Second, a graphical frontend can have more than one window, each one used for debugging a different thread, and the frontend might want to access additional threads for internal purposes. This increases the risk that by relying on implicitly selected thread, the frontend may be operating on a wrong one. Therefore, each MI command should explicitly specify which thread and frame to operate on. To make it possible, each MI command accepts the `--thread` and `--frame` options, the value to each is GDB identifier for thread and frame to operate on.

Usually, each top-level window in a frontend allows the user to select a thread and a frame, and remembers the user selection for further operations. However, in some cases GDB may suggest that the current thread be changed. For example, when stopping on a breakpoint it is reasonable to switch to the thread where breakpoint is hit. For another example, if the user issues the CLI `thread` command via the frontend, it is desirable to change the frontend's selected thread to the one specified by user. GDB communicates the suggestion to change current thread using the `=thread-selected` notification. No such notification is available for the selected frame at the moment.

Note that historically, MI shares the selected thread with CLI, so frontends used the `-thread-select` to execute commands in the right context. However, getting this to work right is cumbersome. The simplest way is for frontend to emit `-thread-select` command before every command. This doubles the number of commands that need to be sent. The alternative approach is to suppress `-thread-select` if the selected thread in GDB is supposed to be identical to the thread the frontend wants to operate on. However, getting this optimization right can be tricky. In particular, if the frontend sends several commands to GDB, and one of the commands changes the selected thread, then the behaviour of subsequent commands will change. So, a frontend should either wait for response from such problematic commands, or explicitly add `-thread-select` for all subsequent commands. No frontend is known to do this exactly right, so it is suggested to just always pass the `--thread` and `--frame` options.

27.3.2 Asynchronous command execution and non-stop mode

On some targets, GDB is capable of processing MI commands even while the target is running. This is called *asynchronous command execution* (see [\(undefined\) \[Background Execution\]](#), page [\(undefined\)](#)). The frontend may specify a preference for asynchronous execution using the `-gdb-set target-async 1` command, which should be emitted before either running the executable or attaching to the target. After the frontend has started the executable or attached to the target, it can find if asynchronous execution is enabled using the `-list-target-features` command.

Even if GDB can accept a command while target is running, many commands that access the target do not work when the target is running. Therefore, asynchronous command execution is most useful when combined with non-stop mode (see [\(undefined\) \[Non-Stop Mode\]](#), page [\(undefined\)](#)). Then, it is possible to examine the state of one thread, while other threads are running.

When a given thread is running, MI commands that try to access the target in the context of that thread may not work, or may work only on some targets. In particular, commands that try to operate on thread's stack will not work, on any target. Commands that read memory, or modify breakpoints, may work or not work, depending on the target. Note that even commands that operate on global state, such as `print`, `set`, and breakpoint commands, still access the target in the context of a specific thread, so frontend should try to find a stopped thread and perform the operation on that thread (using the `--thread` option).

Which commands will work in the context of a running thread is highly target dependent. However, the two commands `-exec-interrupt`, to stop a thread, and `-thread-info`, to find the state of a thread, will always work.

27.3.3 Thread groups

GDB may be used to debug several processes at the same time. On some platforms, GDB may support debugging of several hardware systems, each one having several cores with several different processes running on each core. This section describes the MI mechanism to support such debugging scenarios.

The key observation is that regardless of the structure of the target, MI can have a global list of threads, because most commands that accept the `--thread` option do not need to know what process that thread belongs to. Therefore, it is not necessary to introduce neither additional `--process` option, nor an notion of the current process in the MI interface. The only strictly new feature that is required is the ability to find how the threads are grouped into processes.

To allow the user to discover such grouping, and to support arbitrary hierarchy of machines/cores/processes, MI introduces the concept of a *thread group*. Thread group is a collection of threads and other thread groups. A thread group always has a string identifier, a type, and may have additional attributes specific to the type. A new command, `-list-thread-groups`, returns the list of top-level thread groups, which correspond to processes that GDB is debugging at the moment. By passing an identifier of a thread group to the `-list-thread-groups` command, it is possible to obtain the members of specific thread group.

To allow the user to easily discover processes, and other objects, he wishes to debug, a concept of *available thread group* is introduced. Available thread group is a thread group that GDB is not debugging, but that can be attached to, using the `-target-attach` command. The list of available top-level thread groups can be obtained using `'-list-thread-groups --available'`. In general, the content of a thread group may be only retrieved only after attaching to that thread group.

Thread groups are related to inferiors (see [\(undefined\) \[Inferiors and Programs\], page \(undefined\)](#)). Each inferior corresponds to a thread group of a special type `'process'`, and some additional operations are permitted on such thread groups.

27.4 GDB/MI Command Syntax

27.4.1 GDB/MI Input Syntax

```

command ↦
    cli-command | mi-command

cli-command ↦
    [ token ] cli-command nl, where cli-command is any existing GDB CLI command.

mi-command ↦
    [ token ] "-" operation ( " " option )* [ " --" ] ( " " parameter )* nl

token ↦ "any sequence of digits"

option ↦
    "-" parameter [ " " parameter ]

parameter ↦
    non-blank-sequence | c-string

operation ↦
    any of the operations described in this chapter

non-blank-sequence ↦
    anything, provided it doesn't contain special characters such as "-", nl, "" and of course " "

c-string ↦
    "" seven-bit-iso-c-string-content ""

nl ↦ CR | CR-LF

```

Notes:

- The CLI commands are still handled by the MI interpreter; their output is described below.
- The *token*, when present, is passed back when the command finishes.
- Some MI commands accept optional arguments as part of the parameter list. Each option is identified by a leading '-' (dash) and may be followed by an optional argument parameter. Options occur first in the parameter list and can be delimited from normal parameters using '--' (this is useful when some parameters begin with a dash).

Pragmatics:

- We want easy access to the existing CLI syntax (for debugging).
- We want it to be easy to spot a MI operation.

27.4.2 GDB/MI Output Syntax

The output from GDB/MI consists of zero or more out-of-band records followed, optionally, by a single result record. This result record is for the most recent command. The sequence of output records is terminated by ‘(gdb)’.

If an input command was prefixed with a *token* then the corresponding output for that command will also be prefixed by that same *token*.

```

output ↦
    ( out-of-band-record ) * [ result-record ] "(gdb)" nl

result-record ↦
    [ token ] "^" result-class ( "," result ) * nl

out-of-band-record ↦
    async-record | stream-record

async-record ↦
    exec-async-output | status-async-output | notify-async-output

exec-async-output ↦
    [ token ] "*" async-output

status-async-output ↦
    [ token ] "+" async-output

notify-async-output ↦
    [ token ] "=" async-output

async-output ↦
    async-class ( "," result ) * nl

result-class ↦
    "done" | "running" | "connected" | "error" | "exit"

async-class ↦
    "stopped" | others (where others will be added depending on the needs—this
    is still in development).

result ↦
    variable "=" value

variable ↦
    string

value ↦
    const | tuple | list

const ↦
    c-string

tuple ↦
    "{" | "{" result ( "," result ) * "}"

list ↦
    "[" | "[" value ( "," value ) * "]" | "[" result ( "," result ) * "]"

```

```

stream-record ↦
    console-stream-output | target-stream-output | log-stream-output
console-stream-output ↦
    "~" c-string
target-stream-output ↦
    "@" c-string
log-stream-output ↦
    "&" c-string
nl ↦      CR | CR-LF
token ↦   any sequence of digits.

```

Notes:

- All output sequences end in a single line containing a period.
- The *token* is from the corresponding request. Note that for all async output, while the token is allowed by the grammar and may be output by future versions of GDB for select async output messages, it is generally omitted. Frontends should treat all async output as reporting general changes in the state of the target and there should be no need to associate async output to any prior command.
- *status-async-output* contains on-going status information about the progress of a slow operation. It can be discarded. All status output is prefixed by '+’.
- *exec-async-output* contains asynchronous state change on the target (stopped, started, disappeared). All async output is prefixed by '*’.
- *notify-async-output* contains supplementary information that the client should handle (e.g., a new breakpoint information). All notify output is prefixed by '='.
- *console-stream-output* is output that should be displayed as is in the console. It is the textual response to a CLI command. All the console output is prefixed by '~’.
- *target-stream-output* is the output produced by the target program. All the target output is prefixed by '@’.
- *log-stream-output* is output text coming from GDB’s internals, for instance messages that should be displayed as part of an error log. All the log output is prefixed by '&’.
- New GDB/MI commands should only output *lists* containing *values*.

See [\(undefined\)](#) [GDB/MI Stream Records], page [\(undefined\)](#), for more details about the various output records.

27.5 GDB/MI Compatibility with CLI

For the developers convenience CLI commands can be entered directly, but there may be some unexpected behaviour. For example, commands that query the user will behave as if the user replied yes, breakpoint command lists are not executed and some CLI commands, such as `if`, `when` and `define`, prompt for further input with '>', which is not valid MI output.

This feature may be removed at some stage in the future and it is recommended that front ends use the `-interpreter-exec` command (see [\(undefined\)](#) [-interpreter-exec], page [\(undefined\)](#)).

27.6 GDB/MI Development and Front Ends

The application which takes the MI output and presents the state of the program being debugged to the user is called a *front end*.

Although GDB/MI is still incomplete, it is currently being used by a variety of front ends to GDB. This makes it difficult to introduce new functionality without breaking existing usage. This section tries to minimize the problems by describing how the protocol might change.

Some changes in MI need not break a carefully designed front end, and for these the MI version will remain unchanged. The following is a list of changes that may occur within one level, so front ends should parse MI output in a way that can handle them:

- New MI commands may be added.
- New fields may be added to the output of any MI command.
- The range of values for fields with specified values, e.g., `in_scope` (see [\(undefined\) \[-var-update\]](#), [page \(undefined\)](#)) may be extended.

If the changes are likely to break front ends, the MI version level will be increased by one. This will allow the front end to parse the output according to the MI version. Apart from `mi0`, new versions of GDB will not support old versions of MI and it will be the responsibility of the front end to work with the new one.

The best way to avoid unexpected changes in MI that might break your front end is to make your project known to GDB developers and follow development on gdb@sourceware.org and gdb-patches@sourceware.org.

27.7 GDB/MI Output Records

27.7.1 GDB/MI Result Records

In addition to a number of out-of-band notifications, the response to a GDB/MI command includes one of the following result indications:

`^done` [`," results`]

The synchronous operation was successful, `results` are the return values.

`^running`

This result record is equivalent to `^done`. Historically, it was output instead of `^done` if the command has resumed the target. This behaviour is maintained for backward compatibility, but all frontends should treat `^done` and `^running` identically and rely on the `*running` output record to determine which threads are resumed.

`^connected`

GDB has connected to a remote target.

`^error` `," c-string`

The operation failed. The `c-string` contains the corresponding error message.

`^exit` GDB has terminated.

27.7.2 GDB/MI Stream Records

GDB internally maintains a number of output streams: the console, the target, and the log. The output intended for each of these streams is funneled through the GDB/MI interface using *stream records*.

Each stream record begins with a unique *prefix character* which identifies its stream (see [\(undefined\) \[GDB/MI Output Syntax\], page \(undefined\)](#)). In addition to the prefix, each stream record contains a *string-output*. This is either raw text (with an implicit new line) or a quoted C string (which does not contain an implicit newline).

"~" *string-output*

The console output stream contains text that should be displayed in the CLI console window. It contains the textual responses to CLI commands.

"@" *string-output*

The target output stream contains any textual output from the running target. This is only present when GDB's event loop is truly asynchronous, which is currently only the case for remote targets.

"&" *string-output*

The log stream contains debugging messages being produced by GDB's internals.

27.7.3 GDB/MI Async Records

Async records are used to notify the GDB/MI client of additional changes that have occurred. Those changes can either be a consequence of GDB/MI commands (e.g., a breakpoint modified) or a result of target activity (e.g., target stopped).

The following is the list of possible *async* records:

*running,thread-id="*thread*"

The target is now running. The *thread* field tells which specific thread is now running, and can be 'all' if all threads are running. The frontend should assume that no interaction with a running thread is possible after this notification is produced. The frontend should not assume that this notification is output only once for any command. GDB may emit this notification several times, either for different threads, because it cannot resume all threads together, or even for a single thread, if the thread must be stepped through some code before letting it run freely.

*stopped,reason="*reason*",thread-id="*id*",stopped-threads="*stopped*",core="*core*"

The target has stopped. The *reason* field can have one of the following values:

breakpoint-hit

A breakpoint was reached.

watchpoint-trigger

A watchpoint was triggered.

read-watchpoint-trigger

A read watchpoint was triggered.

access-watchpoint-trigger

An access watchpoint was triggered.

<code>function-finished</code>	An <code>-exec-finish</code> or similar CLI command was accomplished.
<code>location-reached</code>	An <code>-exec-until</code> or similar CLI command was accomplished.
<code>watchpoint-scope</code>	A watchpoint has gone out of scope.
<code>end-stepping-range</code>	An <code>-exec-next</code> , <code>-exec-next-instruction</code> , <code>-exec-step</code> , <code>-exec-step-instruction</code> or similar CLI command was accomplished.
<code>exited-signalled</code>	The inferior exited because of a signal.
<code>exited</code>	The inferior exited.
<code>exited-normally</code>	The inferior exited normally.
<code>signal-received</code>	A signal was received by the inferior.

The *id* field identifies the thread that directly caused the stop – for example by hitting a breakpoint. Depending on whether all-stop mode is in effect (see [\(undefined\) \[All-Stop Mode\], page \(undefined\)](#)), GDB may either stop all threads, or only the thread that directly triggered the stop. If all threads are stopped, the *stopped* field will have the value of "all". Otherwise, the value of the *stopped* field will be a list of thread identifiers. Presently, this list will always include a single thread, but frontend should be prepared to see several threads in the list. The *core* field reports the processor core on which the stop event has happened. This field may be absent if such information is not available.

`=thread-group-added,id="id"`

`=thread-group-removed,id="id"`

A thread group was either added or removed. The *id* field contains the GDB identifier of the thread group. When a thread group is added, it generally might not be associated with a running process. When a thread group is removed, its *id* becomes invalid and cannot be used in any way.

`=thread-group-started,id="id",pid="pid"`

A thread group became associated with a running program, either because the program was just started or the thread group was attached to a program. The *id* field contains the GDB identifier of the thread group. The *pid* field contains process identifier, specific to the operating system.

`=thread-group-exited,id="id"`

A thread group is no longer associated with a running program, either because the program has exited, or because it was detached from. The *id* field contains the GDB identifier of the thread group.

`=thread-created,id="id",group-id="gid"`

`=thread-exited,id="id",group-id="gid"`

A thread either was created, or has exited. The *id* field contains the GDB identifier of the thread. The *gid* field identifies the thread group this thread belongs to.

`=thread-selected,id="id"`

Informs that the selected thread was changed as result of the last command. This notification is not emitted as result of `-thread-select` command but is emitted whenever an MI command that is not documented to change the selected thread actually changes it. In particular, invoking, directly or indirectly (via user-defined command), the CLI `thread` command, will generate this notification.

We suggest that in response to this notification, front ends highlight the selected thread and cause subsequent commands to apply to that thread.

`=library-loaded,...`

Reports that a new library file was loaded by the program. This notification has 4 fields—*id*, *target-name*, *host-name*, and *symbols-loaded*. The *id* field is an opaque identifier of the library. For remote debugging case, *target-name* and *host-name* fields give the name of the library file on the target, and on the host respectively. For native debugging, both those fields have the same value. The *symbols-loaded* field reports if the debug symbols for this library are loaded. The *thread-group* field, if present, specifies the id of the thread group in whose context the library was loaded. If the field is absent, it means the library was loaded in the context of all present thread groups.

`=library-unloaded,...`

Reports that a library was unloaded by the program. This notification has 3 fields—*id*, *target-name* and *host-name* with the same meaning as for the `=library-loaded` notification. The *thread-group* field, if present, specifies the id of the thread group in whose context the library was unloaded. If the field is absent, it means the library was unloaded in the context of all present thread groups.

27.7.4 GDB/MI Frame Information

Response from many MI commands includes an information about stack frame. This information is a tuple that may have the following fields:

level	The level of the stack frame. The innermost frame has the level of zero. This field is always present.
func	The name of the function corresponding to the frame. This field may be absent if GDB is unable to determine the function name.
addr	The code address for the frame. This field is always present.
file	The name of the source files that correspond to the frame's code address. This field may be absent.
line	The source line corresponding to the frames' code address. This field may be absent.

from The name of the binary file (either executable or shared library) the corresponds to the frame's code address. This field may be absent.

27.7.5 GDB/MI Thread Information

Whenever GDB has to report an information about a thread, it uses a tuple with the following fields:

id The numeric id assigned to the thread by GDB. This field is always present.

target-id Target-specific string identifying the thread. This field is always present.

details Additional information about the thread provided by the target. It is supposed to be human-readable and not interpreted by the frontend. This field is optional.

state Either 'stopped' or 'running', depending on whether the thread is presently running. This field is always present.

core The value of this field is an integer number of the processor core the thread was last seen on. This field is optional.

27.8 Simple Examples of GDB/MI Interaction

This subsection presents several simple examples of interaction using the GDB/MI interface. In these examples, '->' means that the following line is passed to GDB/MI as input, while '<-' means the output received from GDB/MI.

Note the line breaks shown in the examples are here only for readability, they don't appear in the real output.

Setting a Breakpoint

Setting a breakpoint generates synchronous output which contains detailed information of the breakpoint.

```
-> -break-insert main
<- ^done,bkpt={number="1",type="breakpoint",disp="keep",
    enabled="y",addr="0x08048564",func="main",file="myprog.c",
    fullname="/home/nickrob/myprog.c",line="68",times="0"}
<- (gdb)
```

Program Execution

Program execution generates asynchronous records and MI gives the reason that execution stopped.

```
-> -exec-run
<- ^running
<- (gdb)
<- *stopped,reason="breakpoint-hit",disp="keep",bkptno="1",thread-id="0",
    frame={addr="0x08048564",func="main",
    args=[{name="argc",value="1"},{name="argv",value="0xbfc4d4d4"}]},
    file="myprog.c",fullname="/home/nickrob/myprog.c",line="68"}
<- (gdb)
-> -exec-continue
<- ^running
<- (gdb)
<- *stopped,reason="exited-normally"
<- (gdb)
```


Quitting GDB

Quitting GDB just prints the result class ‘`^exit`’.

```
-> (gdb)
<- -gdb-exit
<- ^exit
```

Please note that ‘`^exit`’ is printed immediately, but it might take some time for GDB to actually exit. During that time, GDB performs necessary cleanups, including killing programs being debugged or disconnecting from debug hardware, so the frontend should wait till GDB exits and should only forcibly kill GDB if it fails to exit in reasonable time.

A Bad Command

Here’s what happens if you pass a non-existent command:

```
-> -rubbish
<- ^error,msg="Undefined MI command: rubbish"
<- (gdb)
```

27.9 GDB/MI Command Description Format

The remaining sections describe blocks of commands. Each block of commands is laid out in a fashion similar to this section.

Motivation

The motivation for this collection of commands.

Introduction

A brief introduction to this collection of commands as a whole.

Commands

For each command in the block, the following is described:

Synopsis

```
-command args...
```

Result

GDB Command

The corresponding GDB CLI command(s), if any.

Example

Example(s) formatted for readability. Some of the described commands have not been implemented yet and these are labeled N.A. (not available).

27.10 GDB/MI Breakpoint Commands

This section documents GDB/MI commands for manipulating breakpoints.

The `-break-after` Command

Synopsis

```
-break-after number count
```

The breakpoint number *number* is not in effect until it has been hit *count* times. To see how this is reflected in the output of the ‘`-break-list`’ command, see the description of the ‘`-break-list`’ command below.

GDB Command

The corresponding GDB command is ‘`ignore`’.

Example

```
(gdb)
-break-insert main
^done,bkpt={number="1",type="breakpoint",disp="keep",
enabled="y",addr="0x000100d0",func="main",file="hello.c",
fullname="/home/foo/hello.c",line="5",times="0"}
(gdb)
-break-after 1 3
~
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}]},
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",times="0",ignore="3"}]}
```

The `-break-commands` Command

Synopsis

```
-break-commands number [ command1 ... commandN ]
```

Specifies the CLI commands that should be executed when breakpoint *number* is hit. The parameters *command1* to *commandN* are the commands. If no command is specified, any previously-set commands are cleared. See [\(undefined\) \[Break Commands\], page \(undefined\)](#). Typical use of this functionality is tracing a program, that is, printing of values of some variables whenever breakpoint is hit and then continuing.

GDB Command

The corresponding GDB command is ‘`commands`’.

Example

```
(gdb)
-break-insert main
^done,bkpt={number="1",type="breakpoint",disp="keep",
enabled="y",addr="0x000100d0",func="main",file="hello.c",
```

```

fullname="/home/foo/hello.c",line="5",times="0"}
(gdb)
-break-commands 1 "print v" "continue"
^done
(gdb)

```

The `-break-condition` Command

Synopsis

```
-break-condition number expr
```

Breakpoint *number* will stop the program only if the condition in *expr* is true. The condition becomes part of the ‘`-break-list`’ output (see the description of the ‘`-break-list`’ command below).

GDB Command

The corresponding GDB command is ‘`condition`’.

Example

```

(gdb)
-break-condition 1 1
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",cond="1",times="0",ignore="3"}]}
(gdb)

```

The `-break-delete` Command

Synopsis

```
-break-delete ( breakpoint )+
```

Delete the breakpoint(s) whose number(s) are specified in the argument list. This is obviously reflected in the breakpoint list.

GDB Command

The corresponding GDB command is ‘`delete`’.

Example

```

(gdb)
-break-delete 1
^done
(gdb)
-break-list

```

```

^done,BreakpointTable={nr_rows="0",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[]}
(gdb)

```

The `-break-disable` Command

Synopsis

```
-break-disable ( breakpoint )+
```

Disable the named *breakpoint*(s). The field ‘enabled’ in the break list is now set to ‘n’ for the named *breakpoint*(s).

GDB Command

The corresponding GDB command is ‘disable’.

Example

```

(gdb)
-break-disable 2
^done
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="2",type="breakpoint",disp="keep",enabled="n",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",times="0"}]}
(gdb)

```

The `-break-enable` Command

Synopsis

```
-break-enable ( breakpoint )+
```

Enable (previously disabled) *breakpoint*(s).

GDB Command

The corresponding GDB command is ‘enable’.

Example

```

(gdb)
-break-enable 2
^done
(gdb)

```

```

-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="2",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",times="0"}]}
(gdb)

```

The `-break-info` Command

Synopsis

```
-break-info breakpoint
```

Get information about a single breakpoint.

GDB Command

The corresponding GDB command is ‘`info break breakpoint`’.

Example

N.A.

The `-break-insert` Command

Synopsis

```

-break-insert [ -t ] [ -h ] [ -f ] [ -d ] [ -a ]
[ -c condition ] [ -i ignore-count ]
[ -p thread ] [ location ]

```

If specified, *location*, can be one of:

- function
- filename:linenum
- filename:function
- *address

The possible optional parameters of this command are:

‘`-t`’ Insert a temporary breakpoint.

‘`-h`’ Insert a hardware breakpoint.

‘`-c condition`’
 Make the breakpoint conditional on *condition*.

‘`-i ignore-count`’
 Initialize the *ignore-count*.

‘`-f`’ If *location* cannot be parsed (for example if it refers to unknown files or functions), create a pending breakpoint. Without this flag, GDB will report an error, and won’t create a breakpoint, if *location* cannot be parsed.

- ‘-d’ Create a disabled breakpoint.
- ‘-a’ Create a tracepoint. See [\(undefined\) \[Tracepoints\], page \(undefined\)](#). When this parameter is used together with ‘-h’, a fast tracepoint is created.

Result

The result is in the form:

```
^done,bkpt={number="number",type="type",disp="del"|"keep",
enabled="y"|"n",addr="hex",func="funcname",file="filename",
fullname="full_filename",line="lineno",[thread="threadno,]
times="times"}
```

where *number* is the GDB number for this breakpoint, *funcname* is the name of the function where the breakpoint was inserted, *filename* is the name of the source file which contains this function, *lineno* is the source line number within that file and *times* the number of times that the breakpoint has been hit (always 0 for -break-insert but may be greater for -break-info or -break-list which use the same output).

Note: this format is open to change.

GDB Command

The corresponding GDB commands are ‘break’, ‘tbreak’, ‘hbreak’, ‘thbreak’, and ‘rbreak’.

Example

```
(gdb)
-break-insert main
^done,bkpt={number="1",addr="0x0001072c",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="4",times="0"}
(gdb)
-break-insert -t foo
^done,bkpt={number="2",addr="0x00010774",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="11",times="0"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x0001072c",func="main",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="4",times="0"},
bkpt={number="2",type="breakpoint",disp="del",enabled="y",
addr="0x00010774",func="foo",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="11",times="0"}]}
(gdb)
-break-insert -r foo.*
^int foo(int, int);
^done,bkpt={number="3",addr="0x00010774",file="recursive2.c",
"fullname="/home/foo/recursive2.c,line="11",times="0"}
(gdb)
```

The -break-list Command

Synopsis

`-break-list`

Displays the list of inserted breakpoints, showing the following fields:

- 'Number' number of the breakpoint
- 'Type' type of the breakpoint: 'breakpoint' or 'watchpoint'
- 'Disposition'
 should the breakpoint be deleted or disabled when it is hit: 'keep' or 'nokeep'
- 'Enabled' is the breakpoint enabled or no: 'y' or 'n'
- 'Address' memory location at which the breakpoint is set
- 'What' logical location of the breakpoint, expressed by function name, file name, line number
- 'Times' number of times the breakpoint has been hit

If there are no breakpoints or watchpoints, the `BreakpointTable` body field is an empty list.

GDB Command

The corresponding GDB command is 'info break'.

Example

```
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}]},
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x000100d0",func="main",file="hello.c",line="5",times="0"},
bkpt={number="2",type="breakpoint",disp="keep",enabled="y",
addr="0x00010114",func="foo",file="hello.c",fullname="/home/foo/hello.c",
line="13",times="0"}]}
```

Here's an example of the result when there are no breakpoints:

```
(gdb)
-break-list
^done,BreakpointTable={nr_rows="0",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}]},
body=[]}
```

The `-break-passcount` Command

Synopsis

```
-break-passcount tracepoint-number passcount
```

Set the passcount for tracepoint *tracepoint-number* to *passcount*. If the breakpoint referred to by *tracepoint-number* is not a tracepoint, error is emitted. This corresponds to CLI command ‘passcount’.

The -break-watch Command

Synopsis

```
-break-watch [ -a | -r ]
```

Create a watchpoint. With the ‘-a’ option it will create an access watchpoint, i.e., a watchpoint that triggers either on a read from or on a write to the memory location. With the ‘-r’ option, the watchpoint created is a *read* watchpoint, i.e., it will trigger only when the memory location is accessed for reading. Without either of the options, the watchpoint created is a regular watchpoint, i.e., it will trigger when the memory location is accessed for writing. See [\[Setting Watchpoints\]](#), page [\(undefined\)](#).

Note that ‘-break-list’ will report a single list of watchpoints and breakpoints inserted.

GDB Command

The corresponding GDB commands are ‘watch’, ‘awatch’, and ‘rwatch’.

Example

Setting a watchpoint on a variable in the `main` function:

```
(gdb)
-break-watch x
^done,wpt={number="2",exp="x"}
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",wpt={number="2",exp="x"},
value={old="-268439212",new="55"},
frame={func="main",args=[],file="recursive2.c",
fullname="/home/foo/bar/recursive2.c",line="5"}
(gdb)
```

Setting a watchpoint on a variable local to a function. GDB will stop the program execution twice: first for the variable changing value, then for the watchpoint going out of scope.

```
(gdb)
-break-watch C
^done,wpt={number="5",exp="C"}
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",
wpt={number="5",exp="C"},value={old="-276895068",new="3"},
frame={func="callee4",args=[],
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="13"}
(gdb)
```



```
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-scope",wpnum="5",
frame={func="callee3",args=[{name="strarg",
value="0x11940 \A string argument.\""}]},
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)
```

Listing breakpoints and watchpoints, at different points in the program execution. Note that once the watchpoint goes out of scope, it is deleted.

```
(gdb)
-break-watch C
^done,wpt={number="2",exp="C"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}]},
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x00010734",func="callee4",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c",line="8",times="1"},
bkpt={number="2",type="watchpoint",disp="keep",
enabled="y",addr="",what="C",times="0"}]}
(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",wpt={number="2",exp="C"},
value={old="-276895068",new="3"},
frame={func="callee4",args=[]},
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="13"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}]},
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x00010734",func="callee4",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c",line="8",times="1"},
bkpt={number="2",type="watchpoint",disp="keep",
enabled="y",addr="",what="C",times="-5"}]}
(gdb)
-exec-continue
^running
```

```

^done,reason="watchpoint-scope",wpnum="2",
frame={func="callee3",args=[{name="strarg",
value="0x11940 \A string argument.\\"}],
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x00010734",func="callee4",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c",line="8",
times="1"}]}
(gdb)

```

27.11 GDB/MI Program Context

The `-exec-arguments` Command

Synopsis

```
-exec-arguments args
```

Set the inferior program arguments, to be used in the next ‘`-exec-run`’.

GDB Command

The corresponding GDB command is ‘`set args`’.

Example

```

(gdb)
-exec-arguments -v word
^done
(gdb)

```

The `-environment-cd` Command

Synopsis

```
-environment-cd pathdir
```

Set GDB’s working directory.

GDB Command

The corresponding GDB command is ‘`cd`’.

Example

```

(gdb)
-environment-cd /kwikemart/marge/ezannoni/flathead-dev/devo/gdb
^done
(gdb)

```

The `-environment-directory` Command

Synopsis

```
-environment-directory [ -r ] [ pathdir ]+
```

Add directories *pathdir* to beginning of search path for source files. If the `-r` option is used, the search path is reset to the default search path. If directories *pathdir* are supplied in addition to the `-r` option, the search path is first reset and then addition occurs as normal. Multiple directories may be specified, separated by blanks. Specifying multiple directories in a single command results in the directories added to the beginning of the search path in the same order they were presented in the command. If blanks are needed as part of a directory name, double-quotes should be used around the name. In the command output, the path will show up separated by the system directory-separator character. The directory-separator character must not be used in any directory name. If no directories are specified, the current search path is displayed.

GDB Command

The corresponding GDB command is `'dir'`.

Example

```
(gdb)
-environment-directory /kwikemart/marge/ezannoni/flathead-dev/devo/gdb
^done,source-path="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb:$cdir:$cwd"
(gdb)
-environment-directory ""
^done,source-path="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb:$cdir:$cwd"
(gdb)
-environment-directory -r /home/jjohnstn/src/gdb /usr/src
^done,source-path="/home/jjohnstn/src/gdb:/usr/src:$cdir:$cwd"
(gdb)
-environment-directory -r
^done,source-path="$cdir:$cwd"
(gdb)
```

The `-environment-path` Command

Synopsis

```
-environment-path [ -r ] [ pathdir ]+
```

Add directories *pathdir* to beginning of search path for object files. If the `-r` option is used, the search path is reset to the original search path that existed at gdb start-up. If directories *pathdir* are supplied in addition to the `-r` option, the search path is first reset and then addition occurs as normal. Multiple directories may be specified, separated by blanks. Specifying multiple directories in a single command results in the directories added to the beginning of the search path in the same order they were presented in the command. If blanks are needed as part of a directory name, double-quotes should be used around the name. In the command output, the path will show up separated by the system directory-separator character. The directory-separator character must not be used in any directory name. If no directories are specified, the current path is displayed.

GDB Command

The corresponding GDB command is ‘path’.

Example

```
(gdb)
-environment-path
^done,path="/usr/bin"
(gdb)
-environment-path /kwikemart/marge/ezannoni/flathead-dev/ppc-eabi/gdb /bin
^done,path="/kwikemart/marge/ezannoni/flathead-dev/ppc-eabi/gdb:/bin:/usr/bin"
(gdb)
-environment-path -r /usr/local/bin
^done,path="/usr/local/bin:/usr/bin"
(gdb)
```

The -environment-pwd Command

Synopsis

```
-environment-pwd
```

Show the current working directory.

GDB Command

The corresponding GDB command is ‘pwd’.

Example

```
(gdb)
-environment-pwd
^done,cwd="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb"
(gdb)
```

27.12 GDB/MI Thread Commands

The -thread-info Command

Synopsis

```
-thread-info [ thread-id ]
```

Reports information about either a specific thread, if the *thread-id* parameter is present, or about all threads. When printing information about all threads, also reports the current thread.

GDB Command

The ‘info thread’ command prints the same information about all threads.

Example

```
-thread-info
^done,threads=[
{id="2",target-id="Thread 0xb7e14b90 (LWP 21257)",
  frame={level="0",addr="0xffffe410",func="__kernel_vsyscall",args=[]},state="running"},
{id="1",target-id="Thread 0xb7e156b0 (LWP 21254)",
```

```

    frame={level="0",addr="0x0804891f",func="foo",args=[{name="i",value="10"}],
           file="/tmp/a.c",fullname="/tmp/a.c",line="158"},state="running"},
current-thread-id="1"
(gdb)

```

The ‘state’ field may have the following values:

stopped The thread is stopped. Frame information is available for stopped threads.
running The thread is running. There’s no frame information for running threads.

The `-thread-list-ids` Command

Synopsis

```
-thread-list-ids
```

Produces a list of the currently known GDB thread ids. At the end of the list it also prints the total number of such threads.

This command is retained for historical reasons, the `-thread-info` command should be used instead.

GDB Command

Part of ‘info threads’ supplies the same information.

Example

```

(gdb)
-thread-list-ids
^done,thread-ids={thread-id="3",thread-id="2",thread-id="1"},
current-thread-id="1",number-of-threads="3"
(gdb)

```

The `-thread-select` Command

Synopsis

```
-thread-select threadnum
```

Make *threadnum* the current thread. It prints the number of the new current thread, and the topmost frame for that thread.

This command is deprecated in favor of explicitly using the ‘`--thread`’ option to each command.

GDB Command

The corresponding GDB command is ‘`thread`’.

Example

```

(gdb)
-exec-next
^running
(gdb)
*stopped,reason="end-stepping-range",thread-id="2",line="187",
file="../../../../devo/gdb/testsuite/gdb.threads/linux-dp.c"
(gdb)
-thread-list-ids

```

```

^done,
thread-ids={thread-id="3",thread-id="2",thread-id="1"},
number-of-threads="3"
(gdb)
-thread-select 3
^done,new-thread-id="3",
frame={level="0",func="vprintf",
args=[{name="format",value="0x8048e9c \">%s%c %d %c\n\""},
{name="arg",value="0x2"}],file="vprintf.c",line="31"}
(gdb)

```

27.13 GDB/MI Program Execution

These are the asynchronous commands which generate the out-of-band record ‘*stopped’. Currently GDB only really executes asynchronously with remote targets and this interaction is mimicked in other cases.

The `-exec-continue` Command

Synopsis

```
-exec-continue [--reverse] [--all|--thread-group N]
```

Resumes the execution of the inferior program, which will continue to execute until it reaches a debugger stop event. If the ‘--reverse’ option is specified, execution resumes in reverse until it reaches a stop event. Stop events may include

- breakpoints or watchpoints
- signals or exceptions
- the end of the process (or its beginning under ‘--reverse’)
- the end or beginning of a replay log if one is being used.

In all-stop mode (see [<undefined> \[All-Stop Mode\], page <undefined>](#)), may resume only one thread, or all threads, depending on the value of the ‘scheduler-locking’ variable. If ‘--all’ is specified, all threads (in all inferiors) will be resumed. The ‘--all’ option is ignored in all-stop mode. If the ‘--thread-group’ options is specified, then all threads in that thread group are resumed.

GDB Command

The corresponding GDB corresponding is ‘continue’.

Example

```

-exec-continue
^running
(gdb)
@Hello world
*stopped,reason="breakpoint-hit",disp="keep",bkptno="2",frame={
func="foo",args=[],file="hello.c",fullname="/home/foo/bar/hello.c",
line="13"}
(gdb)

```

The `-exec-finish` Command

Synopsis

```
-exec-finish [--reverse]
```

Resumes the execution of the inferior program until the current function is exited. Displays the results returned by the function. If the ‘`--reverse`’ option is specified, resumes the reverse execution of the inferior program until the point where current function was called.

GDB Command

The corresponding GDB command is ‘`finish`’.

Example

Function returning void.

```
-exec-finish
^running
(gdb)
@hello from foo
*stopped,reason="function-finished",frame={func="main",args=[],
file="hello.c",fullname="/home/foo/bar/hello.c",line="7"}
(gdb)
```

Function returning other than void. The name of the internal GDB variable storing the result is printed, together with the value itself.

```
-exec-finish
^running
(gdb)
*stopped,reason="function-finished",frame={addr="0x000107b0",func="foo",
args=[{name="a",value="1"},{name="b",value="9"}]},
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
gdb-result-var="$1",return-value="0"
(gdb)
```

The `-exec-interrupt` Command

Synopsis

```
-exec-interrupt [--all|--thread-group N]
```

Interrupts the background execution of the target. Note how the token associated with the stop message is the one for the execution command that has been interrupted. The token for the interrupt itself only appears in the ‘`^done`’ output. If the user is trying to interrupt a non-running program, an error message will be printed.

Note that when asynchronous execution is enabled, this command is asynchronous just like other execution commands. That is, first the ‘`^done`’ response will be printed, and the target stop will be reported after that using the ‘`*stopped`’ notification.

In non-stop mode, only the context thread is interrupted by default. All threads (in all inferiors) will be interrupted if the ‘`--all`’ option is specified. If the ‘`--thread-group`’ option is specified, all threads in that group will be interrupted.

GDB Command

The corresponding GDB command is ‘`interrupt`’.

Example

```
(gdb)
111-exec-continue
111^running

(gdb)
222-exec-interrupt
222^done
(gdb)
111*stopped,signal-name="SIGINT",signal-meaning="Interrupt",
frame={addr="0x00010140",func="foo",args=[],file="try.c",
fullname="/home/foo/bar/try.c",line="13"}
(gdb)

(gdb)
-exec-interrupt
^error,msg="mi_cmd_exec_interrupt: Inferior not executing."
(gdb)
```

The `-exec-jump` Command

Synopsis

```
-exec-jump location
```

Resumes execution of the inferior program at the location specified by parameter. See [\(undefined\) \[Specify Location\], page \(undefined\)](#), for a description of the different forms of *location*.

GDB Command

The corresponding GDB command is ‘`jump`’.

Example

```
-exec-jump foo.c:10
*running,thread-id="all"
^running
```

The `-exec-next` Command

Synopsis

```
-exec-next [--reverse]
```

Resumes execution of the inferior program, stopping when the beginning of the next source line is reached.

If the ‘`--reverse`’ option is specified, resumes reverse execution of the inferior program, stopping at the beginning of the previous source line. If you issue this command on the first line of a function, it will take you back to the caller of that function, to the source line where the function was called.

GDB Command

The corresponding GDB command is ‘`next`’.

Example

```
-exec-next
^running
(gdb)
*stopped,reason="end-stepping-range",line="8",file="hello.c"
(gdb)
```

The `-exec-next-instruction` Command

Synopsis

```
-exec-next-instruction [--reverse]
```

Executes one machine instruction. If the instruction is a function call, continues until the function returns. If the program stops at an instruction in the middle of a source line, the address will be printed as well.

If the ‘`--reverse`’ option is specified, resumes reverse execution of the inferior program, stopping at the previous instruction. If the previously executed instruction was a return from another function, it will continue to execute in reverse until the call to that function (from the current stack frame) is reached.

GDB Command

The corresponding GDB command is ‘`nexti`’.

Example

```
(gdb)
-exec-next-instruction
^running

(gdb)
*stopped,reason="end-stepping-range",
addr="0x000100d4",line="5",file="hello.c"
(gdb)
```

The `-exec-return` Command

Synopsis

```
-exec-return
```

Makes current function return immediately. Doesn’t execute the inferior. Displays the new current frame.

GDB Command

The corresponding GDB command is ‘`return`’.

Example

```
(gdb)
200-break-insert callee4
200^done,bkpt={number="1",addr="0x00010734",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",line="8"}
(gdb)
000-exec-run
000^running
```

```
(gdb)
000*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",
frame={func="callee4",args=[],
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="8"}
(gdb)
205-break-delete
205^done
(gdb)
111-exec-return
111^done,frame={level="0",func="callee3",
args=[{name="strarg",
value="0x11940 \"A string argument.\""}],
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)
```

The `-exec-run` Command

Synopsis

```
-exec-run [--all | --thread-group N]
```

Starts execution of the inferior from the beginning. The inferior executes until either a breakpoint is encountered or the program exits. In the latter case the output will include an exit code, if the program has exited exceptionally.

When no option is specified, the current inferior is started. If the ‘`--thread-group`’ option is specified, it should refer to a thread group of type ‘`process`’, and that thread group will be started. If the ‘`--all`’ option is specified, then all inferiors will be started.

GDB Command

The corresponding GDB command is ‘`run`’.

Examples

```
(gdb)
-break-insert main
^done,bkpt={number="1",addr="0x0001072c",file="recursive2.c",line="4"}
(gdb)
-exec-run
^running
(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",
frame={func="main",args=[],file="recursive2.c",
fullname="/home/foo/bar/recursive2.c",line="4"}
(gdb)
```

Program exited normally:

```
(gdb)
-exec-run
^running
(gdb)
x = 55
*stopped,reason="exited-normally"
(gdb)
```

Program exited exceptionally:

```
(gdb)
-exec-run
^running
(gdb)
x = 55
*stopped,reason="exited",exit-code="01"
(gdb)
```

Another way the program can terminate is if it receives a signal such as `SIGINT`. In this case, GDB/MI displays this:

```
(gdb)
*stopped,reason="exited-signalled",signal-name="SIGINT",
signal-meaning="Interrupt"
```

The `-exec-step` Command

Synopsis

```
-exec-step [--reverse]
```

Resumes execution of the inferior program, stopping when the beginning of the next source line is reached, if the next source line is not a function call. If it is, stop at the first instruction of the called function. If the `--reverse` option is specified, resumes reverse execution of the inferior program, stopping at the beginning of the previously executed source line.

GDB Command

The corresponding GDB command is `step`.

Example

Stepping into a function:

```
-exec-step
^running
(gdb)
*stopped,reason="end-stepping-range",
frame={func="foo",args=[{name="a",value="10"},
{name="b",value="0"}],file="recursive2.c",
fullname="/home/foo/bar/recursive2.c",line="11"}
(gdb)
```

Regular stepping:

```
-exec-step
^running
(gdb)
*stopped,reason="end-stepping-range",line="14",file="recursive2.c"
(gdb)
```

The `-exec-step-instruction` Command

Synopsis

```
-exec-step-instruction [--reverse]
```

Resumes the inferior which executes one machine instruction. If the `--reverse` option is specified, resumes reverse execution of the inferior program, stopping at the previously executed instruction. The output, once GDB has stopped, will vary depending on whether

we have stopped in the middle of a source line or not. In the former case, the address at which the program stopped will be printed as well.

GDB Command

The corresponding GDB command is ‘stepi’.

Example

```
(gdb)
-exec-step-instruction
^running

(gdb)
*stopped,reason="end-stepping-range",
frame={func="foo",args=[],file="try.c",
fullname="/home/foo/bar/try.c",line="10"}
(gdb)
-exec-step-instruction
^running

(gdb)
*stopped,reason="end-stepping-range",
frame={addr="0x000100f4",func="foo",args=[],file="try.c",
fullname="/home/foo/bar/try.c",line="10"}
(gdb)
```

The -exec-until Command

Synopsis

```
-exec-until [ location ]
```

Executes the inferior until the *location* specified in the argument is reached. If there is no argument, the inferior executes until a source line greater than the current one is reached. The reason for stopping in this case will be ‘location-reached’.

GDB Command

The corresponding GDB command is ‘until’.

Example

```
(gdb)
-exec-until recursive2.c:6
^running
(gdb)
x = 55
*stopped,reason="location-reached",frame={func="main",args=[],
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="6"}
(gdb)
```

27.14 GDB/MI Stack Manipulation Commands

The -stack-info-frame Command

Synopsis

```
-stack-info-frame
```

Get info on the selected frame.

GDB Command

The corresponding GDB command is ‘`info frame`’ or ‘`frame`’ (without arguments).

Example

```
(gdb)
-stack-info-frame
^done,frame={level="1",addr="0x0001076c",func="callee3",
file="../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="17"}
(gdb)
```

The `-stack-info-depth` Command

Synopsis

```
-stack-info-depth [ max-depth ]
```

Return the depth of the stack. If the integer argument *max-depth* is specified, do not count beyond *max-depth* frames.

GDB Command

There’s no equivalent GDB command.

Example

For a stack with frame levels 0 through 11:

```
(gdb)
-stack-info-depth
^done,depth="12"
(gdb)
-stack-info-depth 4
^done,depth="4"
(gdb)
-stack-info-depth 12
^done,depth="12"
(gdb)
-stack-info-depth 11
^done,depth="11"
(gdb)
-stack-info-depth 13
^done,depth="12"
(gdb)
```

The `-stack-list-arguments` Command

Synopsis

```
-stack-list-arguments print-values
[ low-frame high-frame ]
```

Display a list of the arguments for the frames between *low-frame* and *high-frame* (inclusive). If *low-frame* and *high-frame* are not provided, list the arguments for the whole call stack. If the two arguments are equal, show the single frame at the corresponding level. It is an error if *low-frame* is larger than the actual number of frames. On the other hand,

high-frame may be larger than the actual number of frames, in which case only existing frames will be returned.

If *print-values* is 0 or *--no-values*, print only the names of the variables; if it is 1 or *--all-values*, print also their values; and if it is 2 or *--simple-values*, print the name, type and value for simple data types, and the name and type for arrays, structures and unions.

Use of this command to obtain arguments in a single frame is deprecated in favor of the *'-stack-list-variables'* command.

GDB Command

GDB does not have an equivalent command. *gdbtk* has a *'gdb_get_args'* command which partially overlaps with the functionality of *'-stack-list-arguments'*.

Example

```
(gdb)
-stack-list-frames
^done,
stack=[
frame={level="0",addr="0x00010734",func="callee4",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="8"},
frame={level="1",addr="0x0001076c",func="callee3",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="17"},
frame={level="2",addr="0x0001078c",func="callee2",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="22"},
frame={level="3",addr="0x000107b4",func="callee1",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="27"},
frame={level="4",addr="0x000107e0",func="main",
file="../../../../devo/gdb/testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="32"}]
(gdb)
-stack-list-arguments 0
^done,
stack-args=[
frame={level="0",args=[]},
frame={level="1",args=[name="strarg"]},
frame={level="2",args=[name="intarg",name="strarg"]},
frame={level="3",args=[name="intarg",name="strarg",name="fltarg"]},
frame={level="4",args=[]}]
(gdb)
-stack-list-arguments 1
^done,
stack-args=[
frame={level="0",args=[]},
frame={level="1",
args=[{name="strarg",value="0x11940 \"A string argument.\""}]},
frame={level="2",args=[
{name="intarg",value="2"},
{name="strarg",value="0x11940 \"A string argument.\""}]},
frame={level="3",args=[
{name="intarg",value="2"},
```

```

{name="strarg",value="0x11940 \A string argument.\""},
{name="fltarg",value="3.5"}]],
frame={level="4",args=[]}
(gdb)
-stack-list-arguments 0 2 2
^done,stack-args=[frame={level="2",args=[name="intarg",name="strarg"]}]]
(gdb)
-stack-list-arguments 1 2 2
^done,stack-args=[frame={level="2",
args=[{name="intarg",value="2"},
{name="strarg",value="0x11940 \A string argument.\""}]]]
(gdb)

```

The `-stack-list-frames` Command

Synopsis

```
-stack-list-frames [ low-frame high-frame ]
```

List the frames currently on the stack. For each frame it displays the following info:

‘*level*’ The frame number, 0 being the topmost frame, i.e., the innermost function.
‘*addr*’ The `$pc` value for that frame.
‘*func*’ Function name.
‘*file*’ File name of the source file where the function lives.
‘*line*’ Line number corresponding to the `$pc`.

If invoked without arguments, this command prints a backtrace for the whole stack. If given two integer arguments, it shows the frames whose levels are between the two arguments (inclusive). If the two arguments are equal, it shows the single frame at the corresponding level. It is an error if *low-frame* is larger than the actual number of frames. On the other hand, *high-frame* may be larger than the actual number of frames, in which case only existing frames will be returned.

GDB Command

The corresponding GDB commands are ‘`backtrace`’ and ‘`where`’.

Example

Full stack backtrace:

```

(gdb)
-stack-list-frames
^done,stack=
[frame={level="0",addr="0x0001076c",func="foo",
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="11"},
frame={level="1",addr="0x000107a4",func="foo",
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="2",addr="0x000107a4",func="foo",
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="3",addr="0x000107a4",func="foo",
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="4",addr="0x000107a4",func="foo",
file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="5",addr="0x000107a4",func="foo",

```

```

    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="6",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="7",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="8",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="9",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="10",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="11",addr="0x00010738",func="main",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="4"}]
(gdb)

```

Show frames between *low_frame* and *high_frame*:

```

(gdb)
-stack-list-frames 3 5
^done,stack=
[frame={level="3",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="4",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"},
frame={level="5",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"}]
(gdb)

```

Show a single frame:

```

(gdb)
-stack-list-frames 3 3
^done,stack=
[frame={level="3",addr="0x000107a4",func="foo",
    file="recursive2.c",fullname="/home/foo/bar/recursive2.c",line="14"}]
(gdb)

```

The `-stack-list-locals` Command

Synopsis

```
-stack-list-locals print-values
```

Display the local variable names for the selected frame. If *print-values* is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions. In this last case, a frontend can immediately display the value of simple data types and create variable objects for other data types when the user wishes to explore their values in more detail.

This command is deprecated in favor of the `'-stack-list-variables'` command.

GDB Command

`'info locals'` in GDB, `'gdb_get_locals'` in gdbtk.

Example

```

(gdb)
-stack-list-locals 0
^done,locals=[name="A",name="B",name="C"]

```



```
(gdb)
-stack-list-locals --all-values
^done,locals=[{name="A",value="1"},{name="B",value="2"},
  {name="C",value="{1, 2, 3}"}]
-stack-list-locals --simple-values
^done,locals=[{name="A",type="int",value="1"},
  {name="B",type="int",value="2"},{name="C",type="int [3]"}]
(gdb)
```

The `-stack-list-variables` Command

Synopsis

```
-stack-list-variables print-values
```

Display the names of local variables and function arguments for the selected frame. If *print-values* is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions.

Example

```
(gdb)
-stack-list-variables --thread 1 --frame 0 --all-values
^done,variables=[{name="x",value="11"},{name="s",value="{a = 1, b = 2}"}]
(gdb)
```

The `-stack-select-frame` Command

Synopsis

```
-stack-select-frame framenum
```

Change the selected frame. Select a different frame *framenum* on the stack.

This command is deprecated in favor of passing the `--frame` option to every command.

GDB Command

The corresponding GDB commands are `'frame'`, `'up'`, `'down'`, `'select-frame'`, `'up-silent'`, and `'down-silent'`.

Example

```
(gdb)
-stack-select-frame 2
^done
(gdb)
```

27.15 GDB/MI Variable Objects

Introduction to Variable Objects

Variable objects are "object-oriented" MI interface for examining and changing values of expressions. Unlike some other MI interfaces that work with expressions, variable objects are specifically designed for simple and efficient presentation in the frontend. A variable object is identified by string name. When a variable object is created, the frontend specifies the expression for that variable object. The expression can be a simple variable, or it can

be an arbitrary complex expression, and can even involve CPU registers. After creating a variable object, the frontend can invoke other variable object operations—for example to obtain or change the value of a variable object, or to change display format.

Variable objects have hierarchical tree structure. Any variable object that corresponds to a composite type, such as structure in C, has a number of child variable objects, for example corresponding to each element of a structure. A child variable object can itself have children, recursively. Recursion ends when we reach leaf variable objects, which always have built-in types. Child variable objects are created only by explicit request, so if a frontend is not interested in the children of a particular variable object, no child will be created.

For a leaf variable object it is possible to obtain its value as a string, or set the value from a string. String value can be also obtained for a non-leaf variable object, but it's generally a string that only indicates the type of the object, and does not list its contents. Assignment to a non-leaf variable object is not allowed.

A frontend does not need to read the values of all variable objects each time the program stops. Instead, MI provides an update command that lists all variable objects whose values has changed since the last update operation. This considerably reduces the amount of data that must be transferred to the frontend. As noted above, children variable objects are created on demand, and only leaf variable objects have a real value. As result, gdb will read target memory only for leaf variables that frontend has created.

The automatic update is not always desirable. For example, a frontend might want to keep a value of some expression for future reference, and never update it. For another example, fetching memory is relatively slow for embedded targets, so a frontend might want to disable automatic update for the variables that are either not visible on the screen, or “closed”. This is possible using so called “frozen variable objects”. Such variable objects are never implicitly updated.

Variable objects can be either *fixed* or *floating*. For the fixed variable object, the expression is parsed when the variable object is created, including associating identifiers to specific variables. The meaning of expression never changes. For a floating variable object the values of variables whose names appear in the expressions are re-evaluated every time in the context of the current frame. Consider this example:

```
void do_work(...)
{
    struct work_state state;

    if (...)
        do_work(...);
}
```

If a fixed variable object for the `state` variable is created in this function, and we enter the recursive call, the the variable object will report the value of `state` in the top-level `do_work` invocation. On the other hand, a floating variable object will report the value of `state` in the current frame.

If an expression specified when creating a fixed variable object refers to a local variable, the variable object becomes bound to the thread and frame in which the variable object is created. When such variable object is updated, GDB makes sure that the thread/frame combination the variable object is bound to still exists, and re-evaluates the variable object in context of that thread/frame.

The following is the complete set of GDB/MI operations defined to access this functionality:

Operation	Description
<code>-enable-pretty-printing</code>	enable Python-based pretty-printing
<code>-var-create</code>	create a variable object
<code>-var-delete</code>	delete the variable object and/or its children
<code>-var-set-format</code>	set the display format of this variable
<code>-var-show-format</code>	show the display format of this variable
<code>-var-info-num-children</code>	tells how many children this object has
<code>-var-list-children</code>	return a list of the object's children
<code>-var-info-type</code>	show the type of this variable object
<code>-var-info-expression</code>	print parent-relative expression that this variable object represents
<code>-var-info-path-expression</code>	print full expression that this variable object represents
<code>-var-show-attributes</code>	is this variable editable? does it exist here?
<code>-var-evaluate-expression</code>	get the value of this variable
<code>-var-assign</code>	set the value of this variable
<code>-var-update</code>	update the variable and its children
<code>-var-set-frozen</code>	set frozenness attribute
<code>-var-set-update-range</code>	set range of children to display on update

In the next subsection we describe each operation in detail and suggest how it can be used.

Description And Use of Operations on Variable Objects

The `-enable-pretty-printing` Command

```
-enable-pretty-printing
```

GDB allows Python-based visualizers to affect the output of the MI variable object commands. However, because there was no way to implement this in a fully backward-compatible way, a front end must request that this functionality be enabled.

Once enabled, this feature cannot be disabled.

Note that if Python support has not been compiled into GDB, this command will still succeed (and do nothing).

This feature is currently (as of GDB 7.0) experimental, and may work differently in future versions of GDB.

The `-var-create` Command

Synopsis

```
-var-create {name | "-"}
           {frame-addr | "*" | "@"} expression
```

This operation creates a variable object, which allows the monitoring of a variable, the result of an expression, a memory cell or a CPU register.

The *name* parameter is the string by which the object can be referenced. It must be unique. If ‘-’ is specified, the varobj system will generate a string “varNNNNNN” automatically. It will be unique provided that one does not specify *name* of that format. The command fails if a duplicate name is found.

The frame under which the expression should be evaluated can be specified by *frame-addr*. A ‘*’ indicates that the current frame should be used. A ‘@’ indicates that a floating variable object must be created.

expression is any expression valid on the current language set (must not begin with a ‘*’), or one of the following:

- ‘**addr*’, where *addr* is the address of a memory cell
- ‘**addr-addr*’ — a memory address range (TBD)
- ‘\$*regname*’ — a CPU register name

A varobj’s contents may be provided by a Python-based pretty-printer. In this case the varobj is known as a *dynamic varobj*. Dynamic varobjs have slightly different semantics in some cases. If the `-enable-pretty-printing` command is not sent, then GDB will never create a dynamic varobj. This ensures backward compatibility for existing clients.

Result

This operation returns attributes of the newly-created varobj. These are:

‘name’	The name of the varobj.
‘numchild’	The number of children of the varobj. This number is not necessarily reliable for a dynamic varobj. Instead, you must examine the ‘has_more’ attribute.
‘value’	The varobj’s scalar value. For a varobj whose type is some sort of aggregate (e.g., a <code>struct</code>), or for a dynamic varobj, this value will not be interesting.
‘type’	The varobj’s type. This is a string representation of the type, as would be printed by the GDB CLI.
‘thread-id’	If a variable object is bound to a specific thread, then this is the thread’s identifier.
‘has_more’	For a dynamic varobj, this indicates whether there appear to be any children available. For a non-dynamic varobj, this will be 0.
‘dynamic’	This attribute will be present and have the value ‘1’ if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.
‘displayhint’	A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object’s <code>display_hint</code> method. See (undefined) [Pretty Printing API], page (undefined) .

Typical output will look like this:

```
name="name",numchild="N",type="type",thread-id="M",
has_more="has_more"
```

The `-var-delete` Command

Synopsis

```
-var-delete [ -c ] name
```

Deletes a previously created variable object and all of its children. With the ‘-c’ option, just deletes the children.

Returns an error if the object *name* is not found.

The `-var-set-format` Command

Synopsis

```
-var-set-format name format-spec
```

Sets the output format for the value of the object *name* to be *format-spec*.

The syntax for the *format-spec* is as follows:

```
format-spec ↦
{binary | decimal | hexadecimal | octal | natural}
```

The natural format is the default format chosen automatically based on the variable type (like decimal for an `int`, hex for pointers, etc.).

For a variable with children, the format is set only on the variable itself, and the children are not affected.

The `-var-show-format` Command

Synopsis

```
-var-show-format name
```

Returns the format used to display the value of the object *name*.

```
format ↦
format-spec
```

The `-var-info-num-children` Command

Synopsis

```
-var-info-num-children name
```

Returns the number of children of a variable object *name*:

```
numchild=n
```

Note that this number is not completely reliable for a dynamic varobj. It will return the current number of children, but more children may be available.

The `-var-list-children` Command

Synopsis

```
-var-list-children [print-values] name [from to]
```

Return a list of the children of the specified variable object and create variable objects for them, if they do not already exist. With a single argument or if *print-values* has a value of 0 or `--no-values`, print only the names of the variables; if *print-values* is 1 or

`--all-values`, also print their values; and if it is 2 or `--simple-values` print the name and value for simple data types and just the name for arrays, structures and unions.

from and *to*, if specified, indicate the range of children to report. If *from* or *to* is less than zero, the range is reset and all children will be reported. Otherwise, children starting at *from* (zero-based) and up to and excluding *to* will be reported.

If a child range is requested, it will only affect the current call to `-var-list-children`, but not future calls to `-var-update`. For this, you must instead use `-var-set-update-range`. The intent of this approach is to enable a front end to implement any update approach it likes; for example, scrolling a view may cause the front end to request more children with `-var-list-children`, and then the front end could call `-var-set-update-range` with a different range to ensure that future updates are restricted to just the visible items.

For each child the following results are returned:

<i>name</i>	Name of the variable object created for this child.
<i>exp</i>	The expression to be shown to the user by the front end to designate this child. For example this may be the name of a structure member. For a dynamic varobj, this value cannot be used to form an expression. There is no way to do this at all with a dynamic varobj. For C/C++ structures there are several pseudo children returned to designate access qualifiers. For these pseudo children <i>exp</i> is ‘public’, ‘private’, or ‘protected’. In this case the type and value are not present. A dynamic varobj will not report the access qualifying pseudo-children, regardless of the language. This information is not available at all with a dynamic varobj.
<i>numchild</i>	Number of children this child has. For a dynamic varobj, this will be 0.
<i>type</i>	The type of the child.
<i>value</i>	If values were requested, this is the value.
<i>thread-id</i>	If this variable object is associated with a thread, this is the thread id. Otherwise this result is not present.
<i>frozen</i>	If the variable object is frozen, this variable will be present with a value of 1.

The result may have its own attributes:

‘displayhint’

A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object’s `display_hint` method. See [\(undefined\) \[Pretty Printing API\], page \(undefined\)](#).

‘has_more’

This is an integer attribute which is nonzero if there are children remaining after the end of the selected range.

Example

```
(gdb)
-var-list-children n
^done,numchild=n,children=[child={name=name,exp=exp,
numchild=n,type=type},(repeats N times)]
(gdb)
-var-list-children --all-values n
^done,numchild=n,children=[child={name=name,exp=exp,
numchild=n,value=value,type=type},(repeats N times)]
```

The `-var-info-type` Command

Synopsis

```
-var-info-type name
```

Returns the type of the specified variable *name*. The type is returned as a string in the same format as it is output by the GDB CLI:

```
type=typename
```

The `-var-info-expression` Command

Synopsis

```
-var-info-expression name
```

Returns a string that is suitable for presenting this variable object in user interface. The string is generally not valid expression in the current language, and cannot be evaluated.

For example, if *a* is an array, and variable object *A* was created for *a*, then we'll get this output:

```
(gdb) -var-info-expression A.1
^done,lang="C",exp="1"
```

Here, the values of *lang* can be {"C" | "C++" | "Java"}.

Note that the output of the `-var-list-children` command also includes those expressions, so the `-var-info-expression` command is of limited use.

The `-var-info-path-expression` Command

Synopsis

```
-var-info-path-expression name
```

Returns an expression that can be evaluated in the current context and will yield the same value that a variable object has. Compare this with the `-var-info-expression` command, which result can be used only for UI presentation. Typical use of the `-var-info-path-expression` command is creating a watchpoint from a variable object.

This command is currently not valid for children of a dynamic varobj, and will give an error when invoked on one.

For example, suppose *C* is a C++ class, derived from class *Base*, and that the *Base* class has a member called *m_size*. Assume a variable *c* is has the type of *C* and a variable object *C* was created for variable *c*. Then, we'll get this output:

```
(gdb) -var-info-path-expression C.Base.public.m_size
^done,path_expr=((Base)c).m_size
```

The `-var-show-attributes` Command

Synopsis

```
-var-show-attributes name
```

List attributes of the specified variable object *name*:

```
status=attr [ ( ,attr )* ]
```

where *attr* is { { *editable* | *noneditable* } | TBD }.

The `-var-evaluate-expression` Command

Synopsis

```
-var-evaluate-expression [-f format-spec] name
```

Evaluates the expression that is represented by the specified variable object and returns its value as a string. The format of the string can be specified with the ‘-f’ option. The possible values of this option are the same as for `-var-set-format` (see [\(undefined\) \[-var-set-format\]](#), page [\(undefined\)](#)). If the ‘-f’ option is not specified, the current display format will be used. The current display format can be changed using the `-var-set-format` command.

```
value=value
```

Note that one must invoke `-var-list-children` for a variable before the value of a child variable can be evaluated.

The `-var-assign` Command

Synopsis

```
-var-assign name expression
```

Assigns the value of *expression* to the variable object specified by *name*. The object must be ‘*editable*’. If the variable’s value is altered by the assign, the variable will show up in any subsequent `-var-update` list.

Example

```
(gdb)
-var-assign var1 3
^done,value="3"
(gdb)
-var-update *
^done,changelist=[{name="var1",in_scope="true",type_changed="false"}]
(gdb)
```

The `-var-update` Command

Synopsis

```
-var-update [print-values] {name | "*"}
```

Reevaluate the expressions corresponding to the variable object *name* and all its direct and indirect children, and return the list of variable objects whose values have changed; *name* must be a root variable object. Here, “changed” means that the result of `-var-evaluate-expression` before and after the `-var-update` is different. If ‘*’ is used as the

variable object names, all existing variable objects are updated, except for frozen ones (see [\(undefined\) \[-var-set-frozen\]](#), page [\(undefined\)](#)). The option *print-values* determines whether both names and values, or just names are printed. The possible values of this option are the same as for `-var-list-children` (see [\(undefined\) \[-var-list-children\]](#), page [\(undefined\)](#)). It is recommended to use the `--all-values` option, to reduce the number of MI commands needed on each program stop.

With the `*` parameter, if a variable object is bound to a currently running thread, it will not be updated, without any diagnostic.

If `-var-set-update-range` was previously used on a varobj, then only the selected range of children will be reported.

`-var-update` reports all the changed varobjs in a tuple named `'changelist'`.

Each item in the change list is itself a tuple holding:

<code>'name'</code>	The name of the varobj.						
<code>'value'</code>	If values were requested for this update, then this field will be present and will hold the value of the varobj.						
<code>'in_scope'</code>	This field is a string which may take one of three values: <table> <tr> <td><code>"true"</code></td> <td>The variable object's current value is valid.</td> </tr> <tr> <td><code>"false"</code></td> <td>The variable object does not currently hold a valid value but it may hold one in the future if its associated expression comes back into scope.</td> </tr> <tr> <td><code>"invalid"</code></td> <td>The variable object no longer holds a valid value. This can occur when the executable file being debugged has changed, either through recompilation or by using the GDB <code>file</code> command. The front end should normally choose to delete these variable objects.</td> </tr> </table>	<code>"true"</code>	The variable object's current value is valid.	<code>"false"</code>	The variable object does not currently hold a valid value but it may hold one in the future if its associated expression comes back into scope.	<code>"invalid"</code>	The variable object no longer holds a valid value. This can occur when the executable file being debugged has changed, either through recompilation or by using the GDB <code>file</code> command. The front end should normally choose to delete these variable objects.
<code>"true"</code>	The variable object's current value is valid.						
<code>"false"</code>	The variable object does not currently hold a valid value but it may hold one in the future if its associated expression comes back into scope.						
<code>"invalid"</code>	The variable object no longer holds a valid value. This can occur when the executable file being debugged has changed, either through recompilation or by using the GDB <code>file</code> command. The front end should normally choose to delete these variable objects.						

In the future new values may be added to this list so the front should be prepared for this possibility. See [\(undefined\) \[GDB/MI Development and Front Ends\]](#), page [\(undefined\)](#).

<code>'type_changed'</code>	This is only present if the varobj is still valid. If the type changed, then this will be the string <code>'true'</code> ; otherwise it will be <code>'false'</code> .
-----------------------------	--

<code>'new_type'</code>	If the varobj's type changed, then this field will be present and will hold the new type.
-------------------------	---

<code>'new_num_children'</code>	For a dynamic varobj, if the number of children changed, or if the type changed, this will be the new number of children.
---------------------------------	---

The `'numchild'` field in other varobj responses is generally not valid for a dynamic varobj – it will show the number of children that GDB knows about, but because dynamic varobjs lazily instantiate their children, this will not reflect the number of children which may be available.

The `'new_num_children'` attribute only reports changes to the number of children known by GDB. This is the only way to detect whether an update has removed children (which necessarily can only happen at the end of the update range).

`'displayhint'`

The display hint, if any.

`'has_more'`

This is an integer value, which will be 1 if there are more children available outside the varobj's update range.

`'dynamic'`

This attribute will be present and have the value '1' if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.

`'new_children'`

If new children were added to a dynamic varobj within the selected update range (as set by `-var-set-update-range`), then they will be listed in this attribute.

Example

```
(gdb)
-var-assign var1 3
^done,value="3"
(gdb)
-var-update --all-values var1
^done,changelist=[{name="var1",value="3",in_scope="true",
type_changed="false"}]
(gdb)
```

The `-var-set-frozen` Command

Synopsis

```
-var-set-frozen name flag
```

Set the frozenness flag on the variable object *name*. The *flag* parameter should be either '1' to make the variable frozen or '0' to make it unfrozen. If a variable object is frozen, then neither itself, nor any of its children, are implicitly updated by `-var-update` of a parent variable or by `-var-update *`. Only `-var-update` of the variable itself will update its value and values of its children. After a variable object is unfrozen, it is implicitly updated by all subsequent `-var-update` operations. Unfreezing a variable does not update it, only subsequent `-var-update` does.

Example

```
(gdb)
-var-set-frozen V 1
^done
(gdb)
```

The `-var-set-update-range` command

Synopsis

```
-var-set-update-range name from to
```

Set the range of children to be returned by future invocations of `-var-update`.

from and *to* indicate the range of children to report. If *from* or *to* is less than zero, the range is reset and all children will be reported. Otherwise, children starting at *from* (zero-based) and up to and excluding *to* will be reported.

Example

```
(gdb)
-var-set-update-range V 1 2
^done
```

The `-var-set-visualizer` command

Synopsis

```
-var-set-visualizer name visualizer
```

Set a visualizer for the variable object *name*.

visualizer is the visualizer to use. The special value ‘None’ means to disable any visualizer in use.

If not ‘None’, *visualizer* must be a Python expression. This expression must evaluate to a callable object which accepts a single argument. GDB will call this object with the value of the varobj *name* as an argument (this is done so that the same Python pretty-printing code can be used for both the CLI and MI). When called, this object must return an object which conforms to the pretty-printing interface (see [\(undefined\) \[Pretty Printing API\], page \(undefined\)](#)).

The pre-defined function `gdb.default_visualizer` may be used to select a visualizer by following the built-in process (see [\(undefined\) \[Selecting Pretty-Printers\], page \(undefined\)](#)). This is done automatically when a varobj is created, and so ordinarily is not needed.

This feature is only available if Python support is enabled. The MI command `-list-features` (see [\(undefined\) \[GDB/MI Miscellaneous Commands\], page \(undefined\)](#)) can be used to check this.

Example

Resetting the visualizer:

```
(gdb)
-var-set-visualizer V None
^done
```

Reselecting the default (type-based) visualizer:

```
(gdb)
-var-set-visualizer V gdb.default_visualizer
^done
```

Suppose `SomeClass` is a visualizer class. A lambda expression can be used to instantiate this class for a varobj:

```
(gdb)
-var-set-visualizer V "lambda val: SomeClass()"
^done
```

27.16 GDB/MI Data Manipulation

This section describes the GDB/MI commands that manipulate data: examine memory and registers, evaluate expressions, etc.

The `-data-disassemble` Command

Synopsis

```
-data-disassemble
  [ -s start-addr -e end-addr ]
  | [ -f filename -l linenum [ -n lines ] ]
  -- mode
```

Where:

`'start-addr'`

is the beginning address (or `$pc`)

`'end-addr'`

is the end address

`'filename'`

is the name of the file to disassemble

`'linenum'` is the line number to disassemble around

`'lines'` is the number of disassembly lines to be produced. If it is -1, the whole function will be disassembled, in case no `end-addr` is specified. If `end-addr` is specified as a non-zero value, and `lines` is lower than the number of disassembly lines between `start-addr` and `end-addr`, only `lines` lines are displayed; if `lines` is higher than the number of lines between `start-addr` and `end-addr`, only the lines up to `end-addr` are displayed.

`'mode'`

is either 0 (meaning only disassembly) or 1 (meaning mixed source and disassembly).

Result

The output for each instruction is composed of four fields:

- Address
- Func-name
- Offset
- Instruction

Note that whatever included in the instruction field, is not manipulated directly by GDB/MI, i.e., it is not possible to adjust its format.

GDB Command

There's no direct mapping from this command to the CLI.

Example

Disassemble from the current value of `$pc` to `$pc + 20`:

```
(gdb)
-data-disassemble -s $pc -e "$pc + 20" -- 0
^done,
asm_insns=[
{address="0x000107c0",func-name="main",offset="4",
inst="mov 2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi %hi(0x11800), %o2"},
{address="0x000107c8",func-name="main",offset="12",
inst="or %o2, 0x140, %o1\t! 0x11940 <_lib_version+8>"},
{address="0x000107cc",func-name="main",offset="16",
inst="sethi %hi(0x11800), %o2"},
{address="0x000107d0",func-name="main",offset="20",
inst="or %o2, 0x168, %o4\t! 0x11968 <_lib_version+48>"}]
(gdb)
```

Disassemble the whole main function. Line 32 is part of main.

```
-data-disassemble -f basics.c -l 32 -- 0
^done,asm_insns=[
{address="0x000107bc",func-name="main",offset="0",
inst="save %sp, -112, %sp"},
{address="0x000107c0",func-name="main",offset="4",
inst="mov 2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi %hi(0x11800), %o2"},
[...]
{address="0x0001081c",func-name="main",offset="96",inst="ret "},
{address="0x00010820",func-name="main",offset="100",inst="restore "}]
(gdb)
```

Disassemble 3 instructions from the start of main:

```
(gdb)
-data-disassemble -f basics.c -l 32 -n 3 -- 0
^done,asm_insns=[
{address="0x000107bc",func-name="main",offset="0",
inst="save %sp, -112, %sp"},
{address="0x000107c0",func-name="main",offset="4",
inst="mov 2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi %hi(0x11800), %o2"}]
(gdb)
```

Disassemble 3 instructions from the start of main in mixed mode:

```
(gdb)
-data-disassemble -f basics.c -l 32 -n 3 -- 1
^done,asm_insns=[
src_and_asm_line={line="31",
file="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb/ \
testsuite/gdb.mi/basics.c",line_asm_insn=[
{address="0x000107bc",func-name="main",offset="0",
inst="save %sp, -112, %sp"}]},
src_and_asm_line={line="32",
file="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb/ \
testsuite/gdb.mi/basics.c",line_asm_insn=[
{address="0x000107c0",func-name="main",offset="4",
inst="mov 2, %o0"},
{address="0x000107c4",func-name="main",offset="8",
inst="sethi %hi(0x11800), %o2"}]}]
(gdb)
```

The `-data-evaluate-expression` Command

Synopsis

```
-data-evaluate-expression expr
```

Evaluate *expr* as an expression. The expression could contain an inferior function call. The function call will execute synchronously. If the expression contains spaces, it must be enclosed in double quotes.

GDB Command

The corresponding GDB commands are `'print'`, `'output'`, and `'call'`. In `gdbtk` only, there's a corresponding `'gdb_eval'` command.

Example

In the following example, the numbers that precede the commands are the *tokens* described in [\(undefined\) \[GDB/MI Command Syntax\], page \(undefined\)](#). Notice how GDB/MI returns the same tokens in its output.

```
211-data-evaluate-expression A
211^done,value="1"
(gdb)
311-data-evaluate-expression &A
311^done,value="0xefff7c"
(gdb)
411-data-evaluate-expression A+3
411^done,value="4"
(gdb)
511-data-evaluate-expression "A + 3"
511^done,value="4"
(gdb)
```

The `-data-list-changed-registers` Command

Synopsis

```
-data-list-changed-registers
```

Display a list of the registers that have changed.

GDB Command

GDB doesn't have a direct analog for this command; `gdbtk` has the corresponding command `'gdb_changed_register_list'`.

Example

On a PPC MBX board:

```
(gdb)
-exec-continue
^running

(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",frame={
func="main",args=[],file="try.c",fullname="/home/foo/bar/try.c",
line="5"}
(gdb)
```

```
-data-list-changed-registers
^done,changed-registers=["0","1","2","4","5","6","7","8","9",
"10","11","13","14","15","16","17","18","19","20","21","22","23",
"24","25","26","27","28","30","31","64","65","66","67","69"]
(gdb)
```

The `-data-list-register-names` Command

Synopsis

```
-data-list-register-names [ ( regno )+ ]
```

Show a list of register names for the current target. If no arguments are given, it shows a list of the names of all the registers. If integer numbers are given as arguments, it will print a list of the names of the registers corresponding to the arguments. To ensure consistency between a register name and its number, the output list may include empty register names.

GDB Command

GDB does not have a command which corresponds to ‘`-data-list-register-names`’. In `gdbtk` there is a corresponding command ‘`gdb_regnames`’.

Example

For the PPC MBX board:

```
(gdb)
-data-list-register-names
^done,register-names=["r0","r1","r2","r3","r4","r5","r6","r7",
"r8","r9","r10","r11","r12","r13","r14","r15","r16","r17","r18",
"r19","r20","r21","r22","r23","r24","r25","r26","r27","r28","r29",
"r30","r31","f0","f1","f2","f3","f4","f5","f6","f7","f8","f9",
"f10","f11","f12","f13","f14","f15","f16","f17","f18","f19","f20",
"f21","f22","f23","f24","f25","f26","f27","f28","f29","f30","f31",
"", "pc","ps","cr","lr","ctr","xer"]
(gdb)
-data-list-register-names 1 2 3
^done,register-names=["r1","r2","r3"]
(gdb)
```

The `-data-list-register-values` Command

Synopsis

```
-data-list-register-values fmt [ ( regno )*]
```

Display the registers’ contents. *fmt* is the format according to which the registers’ contents are to be returned, followed by an optional list of numbers specifying the registers to display. A missing list of numbers indicates that the contents of all the registers must be returned.

Allowed formats for *fmt* are:

x	Hexadecimal
o	Octal
t	Binary
d	Decimal

r Raw
N Natural

GDB Command

The corresponding GDB commands are ‘info reg’, ‘info all-reg’, and (in gdbtk) ‘gdb_fetch_registers’.

Example

For a PPC MBX board (note: line breaks are for readability only, they don’t appear in the actual output):

```
(gdb)
-data-list-register-values r 64 65
^done,register-values=[{number="64",value="0xfe00a300"},
{number="65",value="0x00029002"}]
(gdb)
-data-list-register-values x
^done,register-values=[{number="0",value="0xfe0043c8"},
{number="1",value="0x3fff88"},{number="2",value="0xffffffff"},
{number="3",value="0x0"},{number="4",value="0xa"},
{number="5",value="0x3fff68"},{number="6",value="0x3fff58"},
{number="7",value="0xfe011e98"},{number="8",value="0x2"},
{number="9",value="0xfa202820"},{number="10",value="0xfa202808"},
{number="11",value="0x1"},{number="12",value="0x0"},
{number="13",value="0x4544"},{number="14",value="0xffdffff"},
{number="15",value="0xffffffff"},{number="16",value="0xffffeff"},
{number="17",value="0xfffffed"},{number="18",value="0xffffffe"},
{number="19",value="0xffffffff"},{number="20",value="0xffffffff"},
{number="21",value="0xffffffff"},{number="22",value="0xffffffff7"},
{number="23",value="0xffffffff"},{number="24",value="0xffffffff"},
{number="25",value="0xffffffff"},{number="26",value="0xffffffb"},
{number="27",value="0xffffffff"},{number="28",value="0xf7bffff"},
{number="29",value="0x0"},{number="30",value="0xfe010000"},
{number="31",value="0x0"},{number="32",value="0x0"},
{number="33",value="0x0"},{number="34",value="0x0"},
{number="35",value="0x0"},{number="36",value="0x0"},
{number="37",value="0x0"},{number="38",value="0x0"},
{number="39",value="0x0"},{number="40",value="0x0"},
{number="41",value="0x0"},{number="42",value="0x0"},
{number="43",value="0x0"},{number="44",value="0x0"},
{number="45",value="0x0"},{number="46",value="0x0"},
{number="47",value="0x0"},{number="48",value="0x0"},
{number="49",value="0x0"},{number="50",value="0x0"},
{number="51",value="0x0"},{number="52",value="0x0"},
{number="53",value="0x0"},{number="54",value="0x0"},
{number="55",value="0x0"},{number="56",value="0x0"},
{number="57",value="0x0"},{number="58",value="0x0"},
{number="59",value="0x0"},{number="60",value="0x0"},
{number="61",value="0x0"},{number="62",value="0x0"},
{number="63",value="0x0"},{number="64",value="0xfe00a300"},
{number="65",value="0x29002"},{number="66",value="0x202f04b5"},
{number="67",value="0xfe0043b0"},{number="68",value="0xfe00b3e4"},
{number="69",value="0x20002b03"}]
(gdb)
```

The -data-read-memory Command

Synopsis

```
-data-read-memory [ -o byte-offset ]
  address word-format word-size
  nr-rows nr-cols [ aschar ]
```

where:

‘*address*’ An expression specifying the address of the first memory word to be read. Complex expressions containing embedded white space should be quoted using the C convention.

‘*word-format*’

The format to be used to print the memory words. The notation is the same as for GDB’s `print` command (see [\(undefined\) \[Output Formats\]](#), page [\(undefined\)](#)).

‘*word-size*’

The size of each memory word in bytes.

‘*nr-rows*’ The number of rows in the output table.

‘*nr-cols*’ The number of columns in the output table.

‘*aschar*’ If present, indicates that each row should include an ASCII dump. The value of *aschar* is used as a padding character when a byte is not a member of the printable ASCII character set (printable ASCII characters are those whose code is between 32 and 126, inclusively).

‘*byte-offset*’

An offset to add to the *address* before fetching memory.

This command displays memory contents as a table of *nr-rows* by *nr-cols* words, each word being *word-size* bytes. In total, $nr-rows * nr-cols * word-size$ bytes are read (returned as ‘*total-bytes*’). Should less than the requested number of bytes be returned by the target, the missing words are identified using ‘N/A’. The number of bytes read from the target is returned in ‘*nr-bytes*’ and the starting address used to read memory in ‘*addr*’.

The address of the next/previous row or page is available in ‘*next-row*’ and ‘*prev-row*’, ‘*next-page*’ and ‘*prev-page*’.

GDB Command

The corresponding GDB command is ‘`x`’. `gdbtk` has ‘`gdb_get_mem`’ memory read command.

Example

Read six bytes of memory starting at `bytes+6` but then offset by `-6` bytes. Format as three rows of two columns. One byte per word. Display each word in hex.

```
(gdb)
9-data-read-memory -o -6 -- bytes+6 x 1 3 2
9^done,addr="0x00001390",nr-bytes="6",total-bytes="6",
next-row="0x00001396",prev-row="0x0000138e",next-page="0x00001396",
prev-page="0x0000138a",memory=[
{addr="0x00001390",data=["0x00","0x01"]},
{addr="0x00001392",data=["0x02","0x03"]},
{addr="0x00001394",data=["0x04","0x05"]}]
```

```
(gdb)
```

Read two bytes of memory starting at address `shorts + 64` and display as a single word formatted in decimal.

```
(gdb)
5~data-read-memory shorts+64 d 2 1 1
5^done,addr="0x00001510",nr-bytes="2",total-bytes="2",
next-row="0x00001512",prev-row="0x0000150e",
next-page="0x00001512",prev-page="0x0000150e",memory=[
{addr="0x00001510",data=["128"]}]]
(gdb)
```

Read thirty two bytes of memory starting at `bytes+16` and format as eight rows of four columns. Include a string encoding with ‘x’ used as the non-printable character.

```
(gdb)
4~data-read-memory bytes+16 x 1 8 4 x
4^done,addr="0x000013a0",nr-bytes="32",total-bytes="32",
next-row="0x000013c0",prev-row="0x0000139c",
next-page="0x000013c0",prev-page="0x00001380",memory=[
{addr="0x000013a0",data=["0x10","0x11","0x12","0x13"],ascii="xxxx"},
{addr="0x000013a4",data=["0x14","0x15","0x16","0x17"],ascii="xxxx"},
{addr="0x000013a8",data=["0x18","0x19","0x1a","0x1b"],ascii="xxxx"},
{addr="0x000013ac",data=["0x1c","0x1d","0x1e","0x1f"],ascii="xxxx"},
{addr="0x000013b0",data=["0x20","0x21","0x22","0x23"],ascii=" !\#"},
{addr="0x000013b4",data=["0x24","0x25","0x26","0x27"],ascii="$%&'"},
{addr="0x000013b8",data=["0x28","0x29","0x2a","0x2b"],ascii="()*+"},
{addr="0x000013bc",data=["0x2c","0x2d","0x2e","0x2f"],ascii=",-./"}]]
(gdb)
```

27.17 GDB/MI Tracepoint Commands

The commands defined in this section implement MI support for tracepoints. For detailed introduction, see [\(undefined\) \[Tracepoints\]](#), page [\(undefined\)](#).

The `-trace-find` Command

Synopsis

```
-trace-find mode [parameters...]
```

Find a trace frame using criteria defined by *mode* and *parameters*. The following table lists permissible modes and their parameters. For details of operation, see [\(undefined\) \[tfind\]](#), page [\(undefined\)](#).

- | | |
|---------------------|--|
| ‘none’ | No parameters are required. Stops examining trace frames. |
| ‘frame-number’ | An integer is required as parameter. Selects tracepoint frame with that index. |
| ‘tracepoint-number’ | An integer is required as parameter. Finds next trace frame that corresponds to tracepoint with the specified number. |
| ‘pc’ | An address is required as parameter. Finds next trace frame that corresponds to any tracepoint at the specified address. |

‘pc-inside-range’

Two addresses are required as parameters. Finds next trace frame that corresponds to a tracepoint at an address inside the specified range. Both bounds are considered to be inside the range.

‘pc-outside-range’

Two addresses are required as parameters. Finds next trace frame that corresponds to a tracepoint at an address outside the specified range. Both bounds are considered to be inside the range.

‘line’

Line specification is required as parameter. See [\(undefined\) \[Specify Location\]](#), page [\(undefined\)](#). Finds next trace frame that corresponds to a tracepoint at the specified location.

If ‘none’ was passed as *mode*, the response does not have fields. Otherwise, the response may have the following fields:

‘found’ This field has either ‘0’ or ‘1’ as the value, depending on whether a matching tracepoint was found.

‘traceframe’

The index of the found traceframe. This field is present iff the ‘found’ field has value of ‘1’.

‘tracepoint’

The index of the found tracepoint. This field is present iff the ‘found’ field has value of ‘1’.

‘frame’

The information about the frame corresponding to the found trace frame. This field is present only if a trace frame was found. See [\(undefined\) \[GDB/MI Frame Information\]](#), page [\(undefined\)](#), for description of this field.

GDB Command

The corresponding GDB command is ‘tfind’.

-trace-define-variable**Synopsis**

```
-trace-define-variable name [ value ]
```

Create trace variable *name* if it does not exist. If *value* is specified, sets the initial value of the specified trace variable to that value. Note that the *name* should start with the ‘\$’ character.

GDB Command

The corresponding GDB command is ‘tvariable’.

-trace-list-variables**Synopsis**

```
-trace-list-variables
```

Return a table of all defined trace variables. Each element of the table has the following fields:

- 'name' The name of the trace variable. This field is always present.
- 'initial' The initial value. This is a 64-bit signed integer. This field is always present.
- 'current' The value the trace variable has at the moment. This is a 64-bit signed integer. This field is absent iff current value is not defined, for example if the trace was never run, or is presently running.

GDB Command

The corresponding GDB command is 'tvariables'.

Example

```
(gdb)
-trace-list-variables
^done,trace-variables={nr_rows="1",nr_cols="3",
hdr=[{width="15",alignment="-1",col_name="name",colhdr="Name"},
{width="11",alignment="-1",col_name="initial",colhdr="Initial"},
{width="11",alignment="-1",col_name="current",colhdr="Current"}]},
body=[variable={name="$trace_timestamp",initial="0"}
variable={name="$foo",initial="10",current="15"}]}
```

-trace-save

Synopsis

```
-trace-save [-r ] filename
```

Saves the collected trace data to *filename*. Without the '-r' option, the data is downloaded from the target and saved in a local file. With the '-r' option the target is asked to perform the save.

GDB Command

The corresponding GDB command is 'tsave'.

-trace-start

Synopsis

```
-trace-start
```

Starts a tracing experiments. The result of this command does not have any fields.

GDB Command

The corresponding GDB command is 'tstart'.

-trace-status

Synopsis

```
-trace-status
```

Obtains the status of a tracing experiment. The result may include the following fields:

‘supported’

May have a value of either ‘0’, when no tracing operations are supported, ‘1’, when all tracing operations are supported, or ‘file’ when examining trace file. In the latter case, examining of trace frame is possible but new tracing experiment cannot be started. This field is always present.

‘running’ May have a value of either ‘0’ or ‘1’ depending on whether tracing experiment is in progress on target. This field is present if ‘supported’ field is not ‘0’.

‘stop-reason’

Report the reason why the tracing was stopped last time. This field may be absent iff tracing was never stopped on target yet. The value of ‘request’ means the tracing was stopped as result of the `-trace-stop` command. The value of ‘overflow’ means the tracing buffer is full. The value of ‘disconnection’ means tracing was automatically stopped when GDB has disconnected. The value of ‘passcount’ means tracing was stopped when a tracepoint was passed a maximal number of times for that tracepoint. This field is present if ‘supported’ field is not ‘0’.

‘stopping-tracepoint’

The number of tracepoint whose passcount as exceeded. This field is present iff the ‘stop-reason’ field has the value of ‘passcount’.

‘frames’**‘frames-created’**

The ‘frames’ field is a count of the total number of trace frames in the trace buffer, while ‘frames-created’ is the total created during the run, including ones that were discarded, such as when a circular trace buffer filled up. Both fields are optional.

‘buffer-size’**‘buffer-free’**

These fields tell the current size of the tracing buffer and the remaining space. These fields are optional.

‘circular’

The value of the circular trace buffer flag. 1 means that the trace buffer is circular and old trace frames will be discarded if necessary to make room, 0 means that the trace buffer is linear and may fill up.

‘disconnected’

The value of the disconnected tracing flag. 1 means that tracing will continue after GDB disconnects, 0 means that the trace run will stop.

GDB Command

The corresponding GDB command is ‘`tstatus`’.

-trace-stop**Synopsis**

`-trace-stop`

Stops a tracing experiment. The result of this command has the same fields as `-trace-status`, except that the ‘supported’ and ‘running’ fields are not output.

GDB Command

The corresponding GDB command is ‘tstop’.

27.18 GDB/MI Symbol Query Commands

The `-symbol-list-lines` Command

Synopsis

```
-symbol-list-lines filename
```

Print the list of lines that contain code and their associated program addresses for the given source filename. The entries are sorted in ascending PC order.

GDB Command

There is no corresponding GDB command.

Example

```
(gdb)
-symbol-list-lines basics.c
^done,lines=[{pc="0x08048554",line="7"},{pc="0x0804855a",line="8"}]
(gdb)
```

27.19 GDB/MI File Commands

This section describes the GDB/MI commands to specify executable file names and to read in and obtain symbol table information.

The `-file-exec-and-symbols` Command

Synopsis

```
-file-exec-and-symbols file
```

Specify the executable file to be debugged. This file is the one from which the symbol table is also read. If no file is specified, the command clears the executable and symbol information. If breakpoints are set when using this command with no arguments, GDB will produce error messages. Otherwise, no output is produced, except a completion notification.

GDB Command

The corresponding GDB command is ‘file’.

Example

```
(gdb)
-file-exec-and-symbols /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

The `-file-exec-file` Command

Synopsis

```
-file-exec-file file
```

Specify the executable file to be debugged. Unlike ‘-file-exec-and-symbols’, the symbol table is *not* read from this file. If used without argument, GDB clears the information about the executable file. No output is produced, except a completion notification.

GDB Command

The corresponding GDB command is ‘exec-file’.

Example

```
(gdb)
-file-exec-file /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

The -file-list-exec-source-file Command

Synopsis

```
-file-list-exec-source-file
```

List the line number, the current source file, and the absolute path to the current source file for the current executable. The macro information field has a value of ‘1’ or ‘0’ depending on whether or not the file includes preprocessor macro information.

GDB Command

The GDB equivalent is ‘info source’

Example

```
(gdb)
123-file-list-exec-source-file
123^done,line="1",file="foo.c",fullname="/home/bar/foo.c,macro-info="1"
(gdb)
```

The -file-list-exec-source-files Command

Synopsis

```
-file-list-exec-source-files
```

List the source files for the current executable.

It will always output the filename, but only when GDB can find the absolute file name of a source file, will it output the fullname.

GDB Command

The GDB equivalent is ‘info sources’. gdbtk has an analogous command ‘gdb_listfiles’.

Example

```
(gdb)
-file-list-exec-source-files
^done,files=[
{file=foo.c,fullname=/home/foo.c},
```

```
{file=/home/bar.c,fullname=/home/bar.c},
{file=gdb_could_not_find_fullpath.c}]
(gdb)
```

The `-file-symbol-file` Command

Synopsis

```
-file-symbol-file file
```

Read symbol table info from the specified *file* argument. When used without arguments, clears GDB's symbol table info. No output is produced, except for a completion notification.

GDB Command

The corresponding GDB command is `'symbol-file'`.

Example

```
(gdb)
-file-symbol-file /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

27.20 GDB/MI Target Manipulation Commands

The `-target-attach` Command

Synopsis

```
-target-attach pid | gid | file
```

Attach to a process *pid* or a file *file* outside of GDB, or a thread group *gid*. If attaching to a thread group, the id previously returned by `'-list-thread-groups --available'` must be used.

GDB Command

The corresponding GDB command is `'attach'`.

Example

```
(gdb)
-target-attach 34
=thread-created,id="1"
*stopped,thread-id="1",frame={addr="0xb7f7e410",func="bar",args=[]}
^done
(gdb)
```

The `-target-detach` Command

Synopsis

```
-target-detach [ pid | gid ]
```

Detach from the remote target which normally resumes its execution. If either *pid* or *gid* is specified, detaches from either the specified process, or specified thread group. There's no output.

GDB Command

The corresponding GDB command is ‘detach’.

Example

```
(gdb)
-target-detach
^done
(gdb)
```

The -target-disconnect Command

Synopsis

```
-target-disconnect
```

Disconnect from the remote target. There’s no output and the target is generally not resumed.

GDB Command

The corresponding GDB command is ‘disconnect’.

Example

```
(gdb)
-target-disconnect
^done
(gdb)
```

The -target-download Command

Synopsis

```
-target-download
```

Loads the executable onto the remote target. It prints out an update message every half second, which includes the fields:

‘section’ The name of the section.

‘section-sent’
The size of what has been sent so far for that section.

‘section-size’
The size of the section.

‘total-sent’
The total size of what was sent so far (the current and the previous sections).

‘total-size’
The size of the overall executable to download.

Each message is sent as status record (see [\(undefined\)](#) [GDB/MI Output Syntax], page [\(undefined\)](#)).

In addition, it prints the name and size of the sections, as they are downloaded. These messages include the following fields:

‘section’ The name of the section.

‘section-size’

The size of the section.

‘total-size’

The size of the overall executable to download.

At the end, a summary is printed.

GDB Command

The corresponding GDB command is ‘load’.

Example

Note: each status message appears on a single line. Here the messages have been broken down so that they can fit onto a page.

```
(gdb)
-target-download
+download,{section=".text",section-size="6668",total-size="9880"}
+download,{section=".text",section-sent="512",section-size="6668",
total-sent="512",total-size="9880"}
+download,{section=".text",section-sent="1024",section-size="6668",
total-sent="1024",total-size="9880"}
+download,{section=".text",section-sent="1536",section-size="6668",
total-sent="1536",total-size="9880"}
+download,{section=".text",section-sent="2048",section-size="6668",
total-sent="2048",total-size="9880"}
+download,{section=".text",section-sent="2560",section-size="6668",
total-sent="2560",total-size="9880"}
+download,{section=".text",section-sent="3072",section-size="6668",
total-sent="3072",total-size="9880"}
+download,{section=".text",section-sent="3584",section-size="6668",
total-sent="3584",total-size="9880"}
+download,{section=".text",section-sent="4096",section-size="6668",
total-sent="4096",total-size="9880"}
+download,{section=".text",section-sent="4608",section-size="6668",
total-sent="4608",total-size="9880"}
+download,{section=".text",section-sent="5120",section-size="6668",
total-sent="5120",total-size="9880"}
+download,{section=".text",section-sent="5632",section-size="6668",
total-sent="5632",total-size="9880"}
+download,{section=".text",section-sent="6144",section-size="6668",
total-sent="6144",total-size="9880"}
+download,{section=".text",section-sent="6656",section-size="6668",
total-sent="6656",total-size="9880"}
+download,{section=".init",section-size="28",total-size="9880"}
+download,{section=".fini",section-size="28",total-size="9880"}
+download,{section=".data",section-size="3156",total-size="9880"}
+download,{section=".data",section-sent="512",section-size="3156",
total-sent="7236",total-size="9880"}
+download,{section=".data",section-sent="1024",section-size="3156",
total-sent="7748",total-size="9880"}
+download,{section=".data",section-sent="1536",section-size="3156",
total-sent="8260",total-size="9880"}
+download,{section=".data",section-sent="2048",section-size="3156",
total-sent="8772",total-size="9880"}
```

```
+download,{section=".data",section-sent="2560",section-size="3156",
total-sent="9284",total-size="9880"}
+download,{section=".data",section-sent="3072",section-size="3156",
total-sent="9796",total-size="9880"}
^done,address="0x10004",load-size="9880",transfer-rate="6586",
write-rate="429"
(gdb)
```

GDB Command

No equivalent.

Example

N.A.

The `-target-select` Command

Synopsis

```
-target-select type parameters ...
```

Connect GDB to the remote target. This command takes two args:

`'type'` The type of target, for instance `'remote'`, etc.

`'parameters'`

Device names, host names and the like. See [\[Commands for Managing Targets\]](#), page [\[undefined\]](#), for more details.

The output is a connection notification, followed by the address at which the target program is, in the following form:

```
^connected,addr="address",func="function name",
args=[arg list]
```

GDB Command

The corresponding GDB command is `'target'`.

Example

```
(gdb)
-target-select remote /dev/ttya
^connected,addr="0xfe00a300",func="??",args=[]
(gdb)
```

27.21 GDB/MI File Transfer Commands

The `-target-file-put` Command

Synopsis

```
-target-file-put hostfile targetfile
```

Copy file *hostfile* from the host system (the machine running GDB) to *targetfile* on the target system.

GDB Command

The corresponding GDB command is `'remote put'`.

Example

```
(gdb)
-target-file-put localfile remotefile
^done
(gdb)
```

The `-target-file-get` Command

Synopsis

```
-target-file-get targetfile hostfile
```

Copy file *targetfile* from the target system to *hostfile* on the host system.

GDB Command

The corresponding GDB command is ‘remote get’.

Example

```
(gdb)
-target-file-get remotefile localfile
^done
(gdb)
```

The `-target-file-delete` Command

Synopsis

```
-target-file-delete targetfile
```

Delete *targetfile* from the target system.

GDB Command

The corresponding GDB command is ‘remote delete’.

Example

```
(gdb)
-target-file-delete remotefile
^done
(gdb)
```

27.22 Miscellaneous GDB/MI Commands

The `-gdb-exit` Command

Synopsis

```
-gdb-exit
```

Exit GDB immediately.

GDB Command

Approximately corresponds to ‘quit’.

Example

```
(gdb)
-gdb-exit
^exit
```

The `-gdb-set` Command

Synopsis

```
-gdb-set
```

Set an internal GDB variable.

GDB Command

The corresponding GDB command is `'set'`.

Example

```
(gdb)
-gdb-set $foo=3
^done
(gdb)
```

The `-gdb-show` Command

Synopsis

```
-gdb-show
```

Show the current value of a GDB variable.

GDB Command

The corresponding GDB command is `'show'`.

Example

```
(gdb)
-gdb-show annotate
^done,value="0"
(gdb)
```

The `-gdb-version` Command

Synopsis

```
-gdb-version
```

Show version information for GDB. Used mostly in testing.

GDB Command

The GDB equivalent is `'show version'`. GDB by default shows this information when you start an interactive session.

Example

```
(gdb)
-gdb-version
```

```

~GNU gdb 5.2.1
~Copyright 2000 Free Software Foundation, Inc.
~GDB is free software, covered by the GNU General Public License, and
~you are welcome to change it and/or distribute copies of it under
~ certain conditions.
~Type "show copying" to see the conditions.
~There is absolutely no warranty for GDB.  Type "show warranty" for
~ details.
~This GDB was configured as
  "--host=sparc-sun-solaris2.5.1 --target=ppc-eabi".
^done
(gdb)

```

The `-list-features` Command

Returns a list of particular features of the MI protocol that this version of gdb implements. A feature can be a command, or a new field in an output of some command, or even an important bugfix. While a frontend can sometimes detect presence of a feature at runtime, it is easier to perform detection at debugger startup.

The command returns a list of strings, with each string naming an available feature. Each returned string is just a name, it does not have any internal structure. The list of possible feature names is given below.

Example output:

```

(gdb) -list-features
^done,result=["feature1","feature2"]

```

The current list of features is:

`'frozen-varobjs'`

Indicates presence of the `-var-set-frozen` command, as well as possible presence of the `frozen` field in the output of `-varobj-create`.

`'pending-breakpoints'`

Indicates presence of the `'-f'` option to the `-break-insert` command.

`'python'`

Indicates presence of Python scripting support, Python-based pretty-printing commands, and possible presence of the `'display_hint'` field in the output of `-var-list-children`

`'thread-info'`

Indicates presence of the `-thread-info` command.

The `-list-target-features` Command

Returns a list of particular features that are supported by the target. Those features affect the permitted MI commands, but unlike the features reported by the `-list-features` command, the features depend on which target GDB is using at the moment. Whenever a target can change, due to commands such as `-target-select`, `-target-attach` or `-exec-run`, the list of target features may change, and the frontend should obtain it again. Example output:

```

(gdb) -list-features
^done,result=["async"]

```

The current list of features is:

- ‘**async**’ Indicates that the target is capable of asynchronous command execution, which means that GDB will accept further commands while the target is running.
- ‘**reverse**’ Indicates that the target is capable of reverse execution. See [\(undefined\) \[Reverse Execution\]](#), page [\(undefined\)](#), for more information.

The `-list-thread-groups` Command

Synopsis

```
-list-thread-groups [ --available ] [ --recurse 1 ] [ group ... ]
```

Lists thread groups (see [\(undefined\) \[Thread groups\]](#), page [\(undefined\)](#)). When a single thread group is passed as the argument, lists the children of that group. When several thread groups are passed, lists information about those thread groups. Without any parameters, lists information about all top-level thread groups.

Normally, thread groups that are being debugged are reported. With the ‘`--available`’ option, GDB reports thread groups available on the target.

The output of this command may have either a ‘`threads`’ result or a ‘`groups`’ result. The ‘`thread`’ result has a list of tuples as value, with each tuple describing a thread (see [\(undefined\) \[GDB/MI Thread Information\]](#), page [\(undefined\)](#)). The ‘`groups`’ result has a list of tuples as value, each tuple describing a thread group. If top-level groups are requested (that is, no parameter is passed), or when several groups are passed, the output always has a ‘`groups`’ result. The format of the ‘`group`’ result is described below.

To reduce the number of roundtrips it’s possible to list thread groups together with their children, by passing the ‘`--recurse`’ option and the recursion depth. Presently, only recursion depth of 1 is permitted. If this option is present, then every reported thread group will also include its children, either as ‘`group`’ or ‘`threads`’ field.

In general, any combination of option and parameters is permitted, with the following caveats:

- When a single thread group is passed, the output will typically be the ‘`threads`’ result. Because threads may not contain anything, the ‘`recurse`’ option will be ignored.
- When the ‘`--available`’ option is passed, limited information may be available. In particular, the list of threads of a process might be inaccessible. Further, specifying specific thread groups might not give any performance advantage over listing all thread groups. The frontend should assume that ‘`-list-thread-groups --available`’ is always an expensive operation and cache the results.

The ‘`groups`’ result is a list of tuples, where each tuple may have the following fields:

<code>id</code>	Identifier of the thread group. This field is always present. The identifier is an opaque string; frontends should not try to convert it to an integer, even though it might look like one.
<code>type</code>	The type of the thread group. At present, only ‘ <code>process</code> ’ is a valid type.
<code>pid</code>	The target-specific process identifier. This field is only present for thread groups of type ‘ <code>process</code> ’ and only if the process exists.
<code>num_children</code>	The number of children this thread group has. This field may be absent for an available thread group.

- threads** This field has a list of tuples as value, each tuple describing a thread. It may be present if the ‘--recurse’ option is specified, and it’s actually possible to obtain the threads.
- cores** This field is a list of integers, each identifying a core that one thread of the group is running on. This field may be absent if such information is not available.
- executable** The name of the executable file that corresponds to this thread group. The field is only present for thread groups of type ‘process’, and only if there is a corresponding executable file.

Example

```
gdb
~list-thread-groups
^done,groups=[{id="17",type="process",pid="yyy",num_children="2"}]
~list-thread-groups 17
^done,threads=[{id="2",target-id="Thread 0xb7e14b90 (LWP 21257)",
  frame={level="0",addr="0xffffe410",func="_kernel_vsyscall",args=[],state="running"},
{id="1",target-id="Thread 0xb7e156b0 (LWP 21254)",
  frame={level="0",addr="0x0804891f",func="foo",args=[{name="i",value="10"}],
  file="/tmp/a.c",fullname="/tmp/a.c",line="158"},state="running"}]}]
~list-thread-groups --available
^done,groups=[{id="17",type="process",pid="yyy",num_children="2",cores=[1,2]}]
~list-thread-groups --available --recurse 1
^done,groups=[{id="17", types="process",pid="yyy",num_children="2",cores=[1,2],
  threads=[{id="1",target-id="Thread 0xb7e14b90",cores=[1]},
  {id="2",target-id="Thread 0xb7e14b90",cores=[2]}]},...]
~list-thread-groups --available --recurse 1 17 18
^done,groups=[{id="17", types="process",pid="yyy",num_children="2",cores=[1,2],
  threads=[{id="1",target-id="Thread 0xb7e14b90",cores=[1]},
  {id="2",target-id="Thread 0xb7e14b90",cores=[2]}]},...]
```

The -add-inferior Command

Synopsis

```
-add-inferior
```

Creates a new inferior (see [\(undefined\) \[Inferiors and Programs\], page \(undefined\)](#)). The created inferior is not associated with any executable. Such association may be established with the ‘-file-exec-and-symbols’ command (see [\(undefined\) \[GDB/MI File Commands\], page \(undefined\)](#)). The command response has a single field, ‘thread-group’, whose value is the identifier of the thread group corresponding to the new inferior.

Example

```
gdb
~add-inferior
^done,thread-group="i3"
```

The -interpreter-exec Command

Synopsis

```
-interpreter-exec interpreter command
```

Execute the specified *command* in the given *interpreter*.

GDB Command

The corresponding GDB command is ‘`interpreter-exec`’.

Example

```
(gdb)
-interpreter-exec console "break main"
&"During symbol reading, couldn't parse type; debugger out of date?.\n"
&"During symbol reading, bad structure-type format.\n"
~"Breakpoint 1 at 0x8074fc6: file ../../src/gdb/main.c, line 743.\n"
^done
(gdb)
```

The `-inferior-tty-set` Command

Synopsis

```
-inferior-tty-set /dev/pts/1
```

Set terminal for future runs of the program being debugged.

GDB Command

The corresponding GDB command is ‘`set inferior-tty`’ /dev/pts/1.

Example

```
(gdb)
-inferior-tty-set /dev/pts/1
^done
(gdb)
```

The `-inferior-tty-show` Command

Synopsis

```
-inferior-tty-show
```

Show terminal for future runs of program being debugged.

GDB Command

The corresponding GDB command is ‘`show inferior-tty`’.

Example

```
(gdb)
-inferior-tty-set /dev/pts/1
^done
(gdb)
-inferior-tty-show
^done,inferior_tty_terminal="/dev/pts/1"
(gdb)
```

The `-enable-timings` Command

Synopsis

```
-enable-timings [yes | no]
```

Toggle the printing of the wallclock, user and system times for an MI command as a field in its output. This command is to help frontend developers optimize the performance of their code. No argument is equivalent to ‘yes’.

GDB Command

No equivalent.

Example

```
(gdb)
-enable-timings
^done
(gdb)
-break-insert main
^done,bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x080484ed",func="main",file="myprog.c",
fullname="/home/nickrob/myprog.c",line="73",times="0"},
time={wallclock="0.05185",user="0.00800",system="0.00000"}
(gdb)
-enable-timings no
^done
(gdb)
-exec-run
^running
(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",thread-id="0",
frame={addr="0x080484ed",func="main",args=[{name="argc",value="1"},
{name="argv",value="0xbfb60364"}],file="myprog.c",
fullname="/home/nickrob/myprog.c",line="73"}
(gdb)
```


28 GDB Annotations

This chapter describes annotations in GDB. Annotations were designed to interface GDB to graphical user interfaces or other similar programs which want to interact with GDB at a relatively high level.

The annotation mechanism has largely been superseded by GDB/MI (see [\(undefined\) \[GDB/MI\], page \(undefined\)](#)).

28.1 What is an Annotation?

Annotations start with a newline character, two ‘`control-z`’ characters, and the name of the annotation. If there is no additional information associated with this annotation, the name of the annotation is followed immediately by a newline. If there is additional information, the name of the annotation is followed by a space, the additional information, and a newline. The additional information cannot contain newline characters.

Any output not beginning with a newline and two ‘`control-z`’ characters denotes literal output from GDB. Currently there is no need for GDB to output a newline followed by two ‘`control-z`’ characters, but if there was such a need, the annotations could be extended with an ‘`escape`’ annotation which means those three characters as output.

The annotation *level*, which is specified using the ‘`--annotate`’ command line option (see [\(undefined\) \[Mode Options\], page \(undefined\)](#)), controls how much information GDB prints together with its prompt, values of expressions, source lines, and other types of output. Level 0 is for no annotations, level 1 is for use when GDB is run as a subprocess of GNU Emacs, level 3 is the maximum annotation suitable for programs that control GDB, and level 2 annotations have been made obsolete (see [section “Limitations of the Annotation Interface” in GDB’s Obsolete Annotations](#)).

`set annotate level`

The GDB command `set annotate` sets the level of annotations to the specified *level*.

`show annotate`

Show the current annotation level.

This chapter describes level 3 annotations.

A simple example of starting up GDB with annotations is:

```
$ gdb --annotate=3
GNU gdb 6.0
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License,
and you are welcome to change it and/or distribute copies of it
under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB. Type "show warranty"
for details.
This GDB was configured as "i386-pc-linux-gnu"

^Z^Zpre-prompt
(gdb)
^Z^Zprompt
quit
```

```

^Z^Zpost-prompt
$

```

Here ‘quit’ is input to GDB; the rest is output from GDB. The three lines beginning ‘^Z^Z’ (where ‘^Z’ denotes a ‘control-z’ character) are annotations; the rest is output from GDB.

28.2 The Server Prefix

If you prefix a command with ‘`server`’ then it will not affect the command history, nor will it affect GDB’s notion of which command to repeat if RET is pressed on a line by itself. This means that commands can be run behind a user’s back by a front-end in a transparent manner.

The `server` prefix does not affect the recording of values into the value history; to print a value without recording it into the value history, use the `output` command instead of the `print` command.

Using this prefix also disables confirmation requests (see [confirmation requests](#), page [undefined](#)).

28.3 Annotation for GDB Input

When GDB prompts for input, it annotates this fact so it is possible to know when to send output, when the output from a given command is over, etc.

Different kinds of input each have a different *input type*. Each input type has three annotations: a `pre-` annotation, which denotes the beginning of any prompt which is being output, a plain annotation, which denotes the end of the prompt, and then a `post-` annotation which denotes the end of any echo which may (or may not) be associated with the input. For example, the `prompt` input type features the following annotations:

```

^Z^Zpre-prompt
^Z^Zprompt
^Z^Zpost-prompt

```

The input types are

- `prompt` When GDB is prompting for a command (the main GDB prompt).
- `commands` When GDB prompts for a set of commands, like in the `commands` command. The annotations are repeated for each command which is input.
- `overload-choice` When GDB wants the user to select between various overloaded functions.
- `query` When GDB wants the user to confirm a potentially dangerous operation.
- `prompt-for-continue` When GDB is asking the user to press return to continue. Note: Don’t expect this to work well; instead use `set height 0` to disable prompting. This is because the counting of lines is buggy in the presence of annotations.

28.4 Errors

`^Z^Zquit`

This annotation occurs right before GDB responds to an interrupt.

`^Z^Zerror`

This annotation occurs right before GDB responds to an error.

Quit and error annotations indicate that any annotations which GDB was in the middle of may end abruptly. For example, if a `value-history-begin` annotation is followed by a `error`, one cannot expect to receive the matching `value-history-end`. One cannot expect not to receive it either, however; an error annotation does not necessarily mean that GDB is immediately returning all the way to the top level.

A quit or error annotation may be preceded by

`^Z^Zerror-begin`

Any output between that and the quit or error annotation is the error message.

Warning messages are not yet annotated.

28.5 Invalidation Notices

The following annotations say that certain pieces of state may have changed.

`^Z^Zframes-invalid`

The frames (for example, output from the `backtrace` command) may have changed.

`^Z^Zbreakpoints-invalid`

The breakpoints may have changed. For example, the user just added or deleted a breakpoint.

28.6 Running the Program

When the program starts executing due to a GDB command such as `step` or `continue`,

`^Z^Zstarting`

is output. When the program stops,

`^Z^Zstopped`

is output. Before the `stopped` annotation, a variety of annotations describe how the program stopped.

`^Z^Zexited exit-status`

The program exited, and *exit-status* is the exit status (zero for successful exit, otherwise nonzero).

`^Z^Zsignalled`

The program exited with a signal. After the `^Z^Zsignalled`, the annotation continues:

```

intro-text
^Z^Zsignal-name
name
^Z^Zsignal-name-end
middle-text
^Z^Zsignal-string

```

```

    string
    ^Z^Zsignal-string-end
    end-text

```

where *name* is the name of the signal, such as SIGILL or SIGSEGV, and *string* is the explanation of the signal, such as Illegal Instruction or Segmentation fault. *intro-text*, *middle-text*, and *end-text* are for the user's benefit and have no particular format.

^Z^Zsignal

The syntax of this annotation is just like `signalled`, but GDB is just saying that the program received the signal, not that it was terminated with it.

^Z^Zbreakpoint *number*

The program hit breakpoint number *number*.

^Z^Zwatchpoint *number*

The program hit watchpoint number *number*.

28.7 Displaying Source

The following annotation is used instead of displaying source code:

```

    ^Z^Zsource filename:line:character:middle:addr

```

where *filename* is an absolute file name indicating which source file, *line* is the line number within that file (where 1 is the first line in the file), *character* is the character position within the file (where 0 is the first character in the file) (for most debug formats this will necessarily point to the beginning of a line), *middle* is 'middle' if *addr* is in the middle of the line, or 'beg' if *addr* is at the beginning of the line, and *addr* is the address in the target program associated with the source which is being displayed. *addr* is in the form '0x' followed by one or more lowercase hex digits (note that this does not depend on the language).

29 JIT Compilation Interface

This chapter documents GDB's *just-in-time* (JIT) compilation interface. A JIT compiler is a program or library that generates native executable code at runtime and executes it, usually in order to achieve good performance while maintaining platform independence.

Programs that use JIT compilation are normally difficult to debug because portions of their code are generated at runtime, instead of being loaded from object files, which is where GDB normally finds the program's symbols and debug information. In order to debug programs that use JIT compilation, GDB has an interface that allows the program to register in-memory symbol files with GDB at runtime.

If you are using GDB to debug a program that uses this interface, then it should work transparently so long as you have not stripped the binary. If you are developing a JIT compiler, then the interface is documented in the rest of this chapter. At this time, the only known client of this interface is the LLVM JIT.

Broadly speaking, the JIT interface mirrors the dynamic loader interface. The JIT compiler communicates with GDB by writing data into a global variable and calling a function at a well-known symbol. When GDB attaches, it reads a linked list of symbol files from the global variable to find existing code, and puts a breakpoint in the function so that it can find out about additional code.

29.1 JIT Declarations

These are the relevant struct declarations that a C program should include to implement the interface:

```
typedef enum
{
    JIT_NOACTION = 0,
    JIT_REGISTER_FN,
    JIT_UNREGISTER_FN
} jit_actions_t;

struct jit_code_entry
{
    struct jit_code_entry *next_entry;
    struct jit_code_entry *prev_entry;
    const char *symfile_addr;
    uint64_t symfile_size;
};

struct jit_descriptor
{
    uint32_t version;
    /* This type should be jit_actions_t, but we use uint32_t
       to be explicit about the bitwidth. */
    uint32_t action_flag;
    struct jit_code_entry *relevant_entry;
    struct jit_code_entry *first_entry;
};

/* GDB puts a breakpoint in this function. */
void __attribute__((noinline)) __jit_debug_register_code() { };
```



```
/* Make sure to specify the version statically, because the
   debugger may check the version before we can set it. */
struct jit_descriptor __jit_debug_descriptor = { 1, 0, 0, 0 };
```

If the JIT is multi-threaded, then it is important that the JIT synchronize any modifications to this global data properly, which can easily be done by putting a global mutex around modifications to these structures.

29.2 Registering Code

To register code with GDB, the JIT should follow this protocol:

- Generate an object file in memory with symbols and other desired debug information. The file must include the virtual addresses of the sections.
- Create a code entry for the file, which gives the start and size of the symbol file.
- Add it to the linked list in the JIT descriptor.
- Point the `relevant_entry` field of the descriptor at the entry.
- Set `action_flag` to `JIT_REGISTER` and call `__jit_debug_register_code`.

When GDB is attached and the breakpoint fires, GDB uses the `relevant_entry` pointer so it doesn't have to walk the list looking for new code. However, the linked list must still be maintained in order to allow GDB to attach to a running process and still find the symbol files.

29.3 Unregistering Code

If code is freed, then the JIT should use the following protocol:

- Remove the code entry corresponding to the code from the linked list.
- Point the `relevant_entry` field of the descriptor at the code entry.
- Set `action_flag` to `JIT_UNREGISTER` and call `__jit_debug_register_code`.

If the JIT frees or recompiles code without unregistering it, then GDB and the JIT will leak the memory used for the associated symbol files.

30 Reporting Bugs in GDB

Your bug reports play an essential role in making GDB reliable.

Reporting a bug may help you by bringing a solution to your problem, or it may not. But in any case the principal function of a bug report is to help the entire community by making the next version of GDB work better. Bug reports are your contribution to the maintenance of GDB.

In order for a bug report to serve its purpose, you must include the information that enables us to fix the bug.

30.1 Have You Found a Bug?

If you are not sure whether you have found a bug, here are some guidelines:

- If the debugger gets a fatal signal, for any input whatever, that is a GDB bug. Reliable debuggers never crash.
- If GDB produces an error message for valid input, that is a bug. (Note that if you're cross debugging, the problem may also be somewhere in the connection to the target.)
- If GDB does not produce an error message for invalid input, that is a bug. However, you should note that your idea of "invalid input" might be our idea of "an extension" or "support for traditional practice".
- If you are an experienced user of debugging tools, your suggestions for improvement of GDB are welcome in any case.

30.2 How to Report Bugs

A number of companies and individuals offer support for GNU products. If you obtained GDB from a support organization, we recommend you contact that organization first.

You can find contact information for many support companies and individuals in the file 'etc/SERVICE' in the GNU Emacs distribution.

In any event, we also recommend that you submit bug reports for GDB. The preferred method is to submit them directly using [GDB's Bugs web page](#). Alternatively, the [e-mail gateway](#) can be used.

Do not send bug reports to 'info-gdb', or to 'help-gdb', or to any newsgroups. Most users of GDB do not want to receive bug reports. Those that do have arranged to receive 'bug-gdb'.

The mailing list 'bug-gdb' has a newsgroup 'gnu.gdb.bug' which serves as a repeater. The mailing list and the newsgroup carry exactly the same messages. Often people think of posting bug reports to the newsgroup instead of mailing them. This appears to work, but it has one problem which can be crucial: a newsgroup posting often lacks a mail path back to the sender. Thus, if we need to ask for more information, we may be unable to reach you. For this reason, it is better to send bug reports to the mailing list.

The fundamental principle of reporting bugs usefully is this: **report all the facts**. If you are not sure whether to state a fact or leave it out, state it!

Often people omit facts because they think they know what causes the problem and assume that some details do not matter. Thus, you might assume that the name of the

variable you use in an example does not matter. Well, probably it does not, but one cannot be sure. Perhaps the bug is a stray memory reference which happens to fetch from the location where that name is stored in memory; perhaps, if the name were different, the contents of that location would fool the debugger into doing the right thing despite the bug. Play it safe and give a specific, complete example. That is the easiest thing for you to do, and the most helpful.

Keep in mind that the purpose of a bug report is to enable us to fix the bug. It may be that the bug has been reported previously, but neither you nor we can know that unless your bug report is complete and self-contained.

Sometimes people give a few sketchy facts and ask, “Does this ring a bell?” Those bug reports are useless, and we urge everyone to *refuse to respond to them* except to chide the sender to report bugs properly.

To enable us to fix the bug, you should include all these things:

- The version of GDB. GDB announces it if you start with no arguments; you can also print it at any time using `show version`.

Without this, we will not know whether there is any point in looking for the bug in the current version of GDB.

- The type of machine you are using, and the operating system name and version number.
- What compiler (and its version) was used to compile GDB—e.g. “gcc-2.8.1”.
- What compiler (and its version) was used to compile the program you are debugging—e.g. “gcc-2.8.1”, or “HP92453-01 A.10.32.03 HP C Compiler”. For GCC, you can say `gcc --version` to get this information; for other compilers, see the documentation for those compilers.

- The command arguments you gave the compiler to compile your example and observe the bug. For example, did you use ‘-O’? To guarantee you will not omit something important, list them all. A copy of the Makefile (or the output from make) is sufficient.

If we were to try to guess the arguments, we would probably guess wrong and then we might not encounter the bug.

- A complete input script, and all necessary source files, that will reproduce the bug.
- A description of what behavior you observe that you believe is incorrect. For example, “It gets a fatal signal.”

Of course, if the bug is that GDB gets a fatal signal, then we will certainly notice it. But if the bug is incorrect output, we might not notice unless it is glaringly wrong. You might as well not give us a chance to make a mistake.

Even if the problem you experience is a fatal signal, you should still say so explicitly. Suppose something strange is going on, such as, your copy of GDB is out of synch, or you have encountered a bug in the C library on your system. (This has happened!) Your copy might crash and ours would not. If you told us to expect a crash, then when ours fails to crash, we would know that the bug was not happening for us. If you had not told us to expect a crash, then we would not be able to draw any conclusion from our observations.

To collect all this information, you can use a session recording program such as `script`, which is available on many Unix systems. Just run your GDB session inside `script` and then include the ‘`typescript`’ file with your bug report.

Another way to record a GDB session is to run GDB inside Emacs and then save the entire buffer to a file.

- If you wish to suggest changes to the GDB source, send us context diffs. If you even discuss something in the GDB source, refer to it by context, not by line number.

The line numbers in our development sources will not match those in your sources. Your line numbers would convey no useful information to us.

Here are some things that are not necessary:

- A description of the envelope of the bug.

Often people who encounter a bug spend a lot of time investigating which changes to the input file will make the bug go away and which changes will not affect it.

This is often time consuming and not very useful, because the way we will find the bug is by running a single example under the debugger with breakpoints, not by pure deduction from a series of examples. We recommend that you save your time for something else.

Of course, if you can find a simpler example to report *instead* of the original one, that is a convenience for us. Errors in the output will be easier to spot, running under the debugger will take less time, and so on.

However, simplification is not vital; if you do not want to do this, report the bug anyway and send us the entire test case you used.

- A patch for the bug.

A patch for the bug does help us if it is a good one. But do not omit the necessary information, such as the test case, on the assumption that a patch is all we need. We might see problems with your patch and decide to fix the problem another way, or we might not understand it at all.

Sometimes with a program as complicated as GDB it is very hard to construct an example that will make the program follow a certain path through the code. If you do not send us the example, we will not be able to construct one, so we will not be able to verify that the bug is fixed.

And if we cannot understand what bug you are trying to fix, or why your patch should be an improvement, we will not install it. A test case will help us to understand.

- A guess about what the bug is or what it depends on.

Such guesses are usually wrong. Even we cannot guess right about such things without first using the debugger to find the facts.

31 Command Line Editing

This chapter describes the basic features of the GNU command line editing interface.

31.1 Introduction to Line Editing

The following paragraphs describe the notation used to represent keystrokes.

The text *C-k* is read as ‘Control-K’ and describes the character produced when the K key is pressed while the Control key is depressed.

The text *M-k* is read as ‘Meta-K’ and describes the character produced when the Meta key (if you have one) is depressed, and the K key is pressed. The Meta key is labeled ALT on many keyboards. On keyboards with two keys labeled ALT (usually to either side of the space bar), the ALT on the left side is generally set to work as a Meta key. The ALT key on the right may also be configured to work as a Meta key or may be configured as some other modifier, such as a Compose key for typing accented characters.

If you do not have a Meta or ALT key, or another key working as a Meta key, the identical keystroke can be generated by typing ESC *first*, and then typing K. Either process is known as *metafying* the K key.

The text *M-C-k* is read as ‘Meta-Control-k’ and describes the character produced by *metafying* *C-k*.

In addition, several keys have their own names. Specifically, DEL, ESC, LFD, SPC, RET, and TAB all stand for themselves when seen in this text, or in an init file (see [\(undefined\)](#) [Readline Init File], page [\(undefined\)](#)). If your keyboard lacks a LFD key, typing C-J will produce the desired character. The RET key may be labeled RETURN or ENTER on some keyboards.

31.2 Readline Interaction

Often during an interactive session you type in a long line of text, only to notice that the first word on the line is misspelled. The Readline library gives you a set of commands for manipulating the text as you type it in, allowing you to just fix your typo, and not forcing you to retype the majority of the line. Using these editing commands, you move the cursor to the place that needs correction, and delete or insert the text of the corrections. Then, when you are satisfied with the line, you simply press RET. You do not have to be at the end of the line to press RET; the entire line is accepted regardless of the location of the cursor within the line.

31.2.1 Readline Bare Essentials

In order to enter characters into the line, simply type them. The typed character appears where the cursor was, and then the cursor moves one space to the right. If you mistype a character, you can use your erase character to back up and delete the mistyped character.

Sometimes you may mistype a character, and not notice the error until you have typed several other characters. In that case, you can type *C-b* to move the cursor to the left, and then correct your mistake. Afterwards, you can move the cursor to the right with *C-f*.

When you add text in the middle of a line, you will notice that characters to the right of the cursor are ‘pushed over’ to make room for the text that you have inserted. Likewise,

when you delete text behind the cursor, characters to the right of the cursor are ‘pulled back’ to fill in the blank space created by the removal of the text. A list of the bare essentials for editing the text of an input line follows.

C-b Move back one character.

C-f Move forward one character.

DEL or **BACKSPACE**

 Delete the character to the left of the cursor.

C-d Delete the character underneath the cursor.

Printing characters

 Insert the character into the line at the cursor.

C-_ or **C-x C-u**

 Undo the last editing command. You can undo all the way back to an empty line.

(Depending on your configuration, the **BACKSPACE** key be set to delete the character to the left of the cursor and the **DEL** key set to delete the character underneath the cursor, like **C-d**, rather than the character to the left of the cursor.)

31.2.2 Readline Movement Commands

The above table describes the most basic keystrokes that you need in order to do editing of the input line. For your convenience, many other commands have been added in addition to **C-b**, **C-f**, **C-d**, and **DEL**. Here are some commands for moving more rapidly about the line.

C-a Move to the start of the line.

C-e Move to the end of the line.

M-f Move forward a word, where a word is composed of letters and digits.

M-b Move backward a word.

C-l Clear the screen, reprinting the current line at the top.

Notice how **C-f** moves forward a character, while **M-f** moves forward a word. It is a loose convention that control keystrokes operate on characters while meta keystrokes operate on words.

31.2.3 Readline Killing Commands

Killing text means to delete the text from the line, but to save it away for later use, usually by *yanking* (re-inserting) it back into the line. (‘Cut’ and ‘paste’ are more recent jargon for ‘kill’ and ‘yank’.)

If the description for a command says that it ‘kills’ text, then you can be sure that you can get the text back in a different (or the same) place later.

When you use a kill command, the text is saved in a *kill-ring*. Any number of consecutive kills save all of the killed text together, so that when you yank it back, you get it all. The kill ring is not line specific; the text that you killed on a previously typed line is available to be yanked back later, when you are typing another line.

Here is the list of commands for killing text.

C-k	Kill the text from the current cursor position to the end of the line.
M-d	Kill from the cursor to the end of the current word, or, if between words, to the end of the next word. Word boundaries are the same as those used by <i>M-f</i> .
M-DEL	Kill from the cursor the start of the current word, or, if between words, to the start of the previous word. Word boundaries are the same as those used by <i>M-b</i> .
C-w	Kill from the cursor to the previous whitespace. This is different than <i>M-DEL</i> because the word boundaries differ.

Here is how to *yank* the text back into the line. Yanking means to copy the most-recently-killed text from the kill buffer.

C-y	Yank the most recently killed text back into the buffer at the cursor.
M-y	Rotate the kill-ring, and yank the new top. You can only do this if the prior command is <i>C-y</i> or <i>M-y</i> .

31.2.4 Readline Arguments

You can pass numeric arguments to Readline commands. Sometimes the argument acts as a repeat count, other times it is the *sign* of the argument that is significant. If you pass a negative argument to a command which normally acts in a forward direction, that command will act in a backward direction. For example, to kill text back to the start of the line, you might type ‘M-- C-k’.

The general way to pass numeric arguments to a command is to type meta digits before the command. If the first ‘digit’ typed is a minus sign (‘-’), then the sign of the argument will be negative. Once you have typed one meta digit to get the argument started, you can type the remainder of the digits, and then the command. For example, to give the *C-d* command an argument of 10, you could type ‘M-1 0 C-d’, which will delete the next ten characters on the input line.

31.2.5 Searching for Commands in the History

Readline provides commands for searching through the command history for lines containing a specified string. There are two search modes: *incremental* and *non-incremental*.

Incremental searches begin before the user has finished typing the search string. As each character of the search string is typed, Readline displays the next entry from the history matching the string typed so far. An incremental search requires only as many characters as needed to find the desired history entry. To search backward in the history for a particular string, type *C-r*. Typing *C-s* searches forward through the history. The characters present in the value of the `isearch-terminators` variable are used to terminate an incremental search. If that variable has not been assigned a value, the ESC and *C-J* characters will terminate an incremental search. *C-g* will abort an incremental search and restore the original line. When the search is terminated, the history entry containing the search string becomes the current line.

To find other matching entries in the history list, type *C-r* or *C-s* as appropriate. This will search backward or forward in the history for the next entry matching the search string typed so far. Any other key sequence bound to a Readline command will terminate the

search and execute that command. For instance, a RET will terminate the search and accept the line, thereby executing the command from the history list. A movement command will terminate the search, make the last line found the current line, and begin editing.

Readline remembers the last incremental search string. If two `C-rs` are typed without any intervening characters defining a new search string, any remembered search string is used.

Non-incremental searches read the entire search string before starting to search for matching history lines. The search string may be typed by the user or be part of the contents of the current line.

31.3 Readline Init File

Although the Readline library comes with a set of Emacs-like keybindings installed by default, it is possible to use a different set of keybindings. Any user can customize programs that use Readline by putting commands in an *inputrc* file, conventionally in his home directory. The name of this file is taken from the value of the environment variable `INPUTRC`. If that variable is unset, the default is `~/inputrc`.

When a program which uses the Readline library starts up, the init file is read, and the key bindings are set.

In addition, the `C-x C-r` command re-reads this init file, thus incorporating any changes that you might have made to it.

31.3.1 Readline Init File Syntax

There are only a few basic constructs allowed in the Readline init file. Blank lines are ignored. Lines beginning with a `#` are comments. Lines beginning with a `$` indicate conditional constructs (see [\(undefined\) \[Conditional Init Constructs\], page \(undefined\)](#)). Other lines denote variable settings and key bindings.

Variable Settings

You can modify the run-time behavior of Readline by altering the values of variables in Readline using the `set` command within the init file. The syntax is simple:

```
set variable value
```

Here, for example, is how to change from the default Emacs-like key binding to use `vi` line editing commands:

```
set editing-mode vi
```

Variable names and values, where appropriate, are recognized without regard to case. Unrecognized variable names are ignored.

Boolean variables (those that can be set to on or off) are set to on if the value is null or empty, *on* (case-insensitive), or 1. Any other value results in the variable being set to off.

A great deal of run-time behavior is changeable with the following variables.

`bell-style`

Controls what happens when Readline wants to ring the terminal bell. If set to `none`, Readline never rings the bell. If set to

`'visible'`, Readline uses a visible bell if one is available. If set to `'audible'` (the default), Readline attempts to ring the terminal's bell.

bind-tty-special-chars

If set to `'on'`, Readline attempts to bind the control characters treated specially by the kernel's terminal driver to their Readline equivalents.

comment-begin

The string to insert at the beginning of the line when the `insert-comment` command is executed. The default value is `"#"`.

completion-ignore-case

If set to `'on'`, Readline performs filename matching and completion in a case-insensitive fashion. The default value is `'off'`.

completion-query-items

The number of possible completions that determines when the user is asked whether the list of possibilities should be displayed. If the number of possible completions is greater than this value, Readline will ask the user whether or not he wishes to view them; otherwise, they are simply listed. This variable must be set to an integer value greater than or equal to 0. A negative value means Readline should never ask. The default limit is 100.

convert-meta

If set to `'on'`, Readline will convert characters with the eighth bit set to an ASCII key sequence by stripping the eighth bit and prefixing an ESC character, converting them to a meta-prefixed key sequence. The default value is `'on'`.

disable-completion

If set to `'On'`, Readline will inhibit word completion. Completion characters will be inserted into the line as if they had been mapped to `self-insert`. The default is `'off'`.

editing-mode

The `editing-mode` variable controls which default set of key bindings is used. By default, Readline starts up in Emacs editing mode, where the keystrokes are most similar to Emacs. This variable can be set to either `'emacs'` or `'vi'`.

enable-keypad

When set to `'on'`, Readline will try to enable the application keypad when it is called. Some systems need this to enable the arrow keys. The default is `'off'`.

expand-tilde

If set to `'on'`, tilde expansion is performed when Readline attempts word completion. The default is `'off'`.

history-preserve-point

If set to 'on', the history code attempts to place point at the same location on each history line retrieved with `previous-history` or `next-history`. The default is 'off'.

horizontal-scroll-mode

This variable can be set to either 'on' or 'off'. Setting it to 'on' means that the text of the lines being edited will scroll horizontally on a single screen line when they are longer than the width of the screen, instead of wrapping onto a new screen line. By default, this variable is set to 'off'.

input-meta

If set to 'on', Readline will enable eight-bit input (it will not clear the eighth bit in the characters it reads), regardless of what the terminal claims it can support. The default value is 'off'. The name `meta-flag` is a synonym for this variable.

isearch-terminators

The string of characters that should terminate an incremental search without subsequently executing the character as a command (see [\(undefined\) \[Searching\], page \(undefined\)](#)). If this variable has not been given a value, the characters ESC and `C-J` will terminate an incremental search.

keymap

Sets Readline's idea of the current keymap for key binding commands. Acceptable keymap names are `emacs`, `emacs-standard`, `emacs-meta`, `emacs-ctlx`, `vi`, `vi-move`, `vi-command`, and `vi-insert`. `vi` is equivalent to `vi-command`; `emacs` is equivalent to `emacs-standard`. The default value is `emacs`. The value of the `editing-mode` variable also affects the default keymap.

mark-directories

If set to 'on', completed directory names have a slash appended. The default is 'on'.

mark-modified-lines

This variable, when set to 'on', causes Readline to display an asterisk (*) at the start of history lines which have been modified. This variable is 'off' by default.

mark-symlinked-directories

If set to 'on', completed names which are symbolic links to directories have a slash appended (subject to the value of `mark-directories`). The default is 'off'.

match-hidden-files

This variable, when set to 'on', causes Readline to match files whose names begin with a '.' (hidden files) when performing filename completion, unless the leading '.' is supplied by the user in the filename to be completed. This variable is 'on' by default.

output-meta

If set to 'on', Readline will display characters with the eighth bit set directly rather than as a meta-prefixed escape sequence. The default is 'off'.

page-completions

If set to 'on', Readline uses an internal `more`-like pager to display a screenful of possible completions at a time. This variable is 'on' by default.

print-completions-horizontally

If set to 'on', Readline will display completions with matches sorted horizontally in alphabetical order, rather than down the screen. The default is 'off'.

show-all-if-ambiguous

This alters the default behavior of the completion functions. If set to 'on', words which have more than one possible completion cause the matches to be listed immediately instead of ringing the bell. The default value is 'off'.

show-all-if-unmodified

This alters the default behavior of the completion functions in a fashion similar to *show-all-if-ambiguous*. If set to 'on', words which have more than one possible completion without any possible partial completion (the possible completions don't share a common prefix) cause the matches to be listed immediately instead of ringing the bell. The default value is 'off'.

visible-stats

If set to 'on', a character denoting a file's type is appended to the filename when listing possible completions. The default is 'off'.

Key Bindings

The syntax for controlling key bindings in the init file is simple. First you need to find the name of the command that you want to change. The following sections contain tables of the command name, the default keybinding, if any, and a short description of what the command does.

Once you know the name of the command, simply place on a line in the init file the name of the key you wish to bind the command to, a colon, and then the name of the command. The name of the key can be expressed in different ways, depending on what you find most comfortable.

In addition to command names, readline allows keys to be bound to a string that is inserted when the key is pressed (a *macro*).

keyname: *function-name* or *macro*

keyname is the name of a key spelled out in English. For example:

```
Control-u: universal-argument
Meta-Rubout: backward-kill-word
Control-o: "> output"
```

In the above example, `C-u` is bound to the function `universal-argument`, `M-DEL` is bound to the function `backward-kill-word`, and `C-o` is bound to run the macro expressed on the right hand side (that is, to insert the text `> output` into the line).

A number of symbolic character names are recognized while processing this key binding syntax: `DEL`, `ESC`, `ESCAPE`, `LFD`, `NEWLINE`, `RET`, `RETURN`, `RUBOUT`, `SPACE`, `SPC`, and `TAB`.

`"keyseq"`: *function-name* or *macro*

`keyseq` differs from `keyname` above in that strings denoting an entire key sequence can be specified, by placing the key sequence in double quotes. Some GNU Emacs style key escapes can be used, as in the following example, but the special character names are not recognized.

```
"\C-u": universal-argument
"\C-x\C-r": re-read-init-file
"\e[11~": "Function Key 1"
```

In the above example, `C-u` is again bound to the function `universal-argument` (just as it was in the first example), `C-x C-r` is bound to the function `re-read-init-file`, and `ESC [1 1 ~` is bound to insert the text `Function Key 1`.

The following GNU Emacs style escape sequences are available when specifying key sequences:

<code>\C-</code>	control prefix
<code>\M-</code>	meta prefix
<code>\e</code>	an escape character
<code>\\</code>	backslash
<code>\"</code>	", a double quotation mark
<code>\'</code>	', a single quote or apostrophe

In addition to the GNU Emacs style escape sequences, a second set of backslash escapes is available:

<code>\a</code>	alert (bell)
<code>\b</code>	backspace
<code>\d</code>	delete
<code>\f</code>	form feed
<code>\n</code>	newline
<code>\r</code>	carriage return
<code>\t</code>	horizontal tab
<code>\v</code>	vertical tab

<code>\nnn</code>	the eight-bit character whose value is the octal value <i>nnn</i> (one to three digits)
<code>\xHH</code>	the eight-bit character whose value is the hexadecimal value <i>HH</i> (one or two hex digits)

When entering the text of a macro, single or double quotes must be used to indicate a macro definition. Unquoted text is assumed to be a function name. In the macro body, the backslash escapes described above are expanded. Backslash will quote any other character in the macro text, including ‘”’ and ‘’’. For example, the following binding will make ‘`C-x \`’ insert a single ‘\’ into the line:

```
"\C-x\\": "\\\"
```

31.3.2 Conditional Init Constructs

Readline implements a facility similar in spirit to the conditional compilation features of the C preprocessor which allows key bindings and variable settings to be performed as the result of tests. There are four parser directives used.

\$if The `$if` construct allows bindings to be made based on the editing mode, the terminal being used, or the application using Readline. The text of the test extends to the end of the line; no characters are required to isolate it.

mode The `mode=` form of the `$if` directive is used to test whether Readline is in `emacs` or `vi` mode. This may be used in conjunction with the ‘`set keymap`’ command, for instance, to set bindings in the `emacs-standard` and `emacs-ctlx` keymaps only if Readline is starting out in `emacs` mode.

term The `term=` form may be used to include terminal-specific key bindings, perhaps to bind the key sequences output by the terminal’s function keys. The word on the right side of the ‘=’ is tested against both the full name of the terminal and the portion of the terminal name before the first ‘-’. This allows `sun` to match both `sun` and `sun-cmd`, for instance.

application

The *application* construct is used to include application-specific settings. Each program using the Readline library sets the *application name*, and you can test for a particular value. This could be used to bind key sequences to functions useful for a specific program. For instance, the following command adds a key sequence that quotes the current or previous word in Bash:

```
$if Bash
# Quote the current or previous word
"\C-xq": "\eb\\"\ef\"
$endif
```

\$endif This command, as seen in the previous example, terminates an `$if` command.

\$else Commands in this branch of the `$if` directive are executed if the test fails.

\$include This directive takes a single filename as an argument and reads commands and bindings from that file. For example, the following directive reads from `'/etc/inputrc'`:

```
$include /etc/inputrc
```

31.3.3 Sample Init File

Here is an example of an *inputrc* file. This illustrates key binding, variable assignment, and conditional syntax.

```
# This file controls the behaviour of line input editing for
# programs that use the GNU Readline library. Existing
# programs include FTP, Bash, and GDB.
#
# You can re-read the inputrc file with C-x C-r.
# Lines beginning with '#' are comments.
#
# First, include any systemwide bindings and variable
# assignments from /etc/Inputrc
$include /etc/Inputrc

#
# Set various bindings for emacs mode.

set editing-mode emacs

$if mode=emacs

Meta-Control-h: backward-kill-word Text after the function name is ignored

#
# Arrow keys in keypad mode
#
#"M-OD":      backward-char
#"M-OC":      forward-char
#"M-OA":      previous-history
#"M-OB":      next-history
#
# Arrow keys in ANSI mode
#
"\M-[D":      backward-char
"\M-[C":      forward-char
"\M-[A":      previous-history
"\M-[B":      next-history
#
# Arrow keys in 8 bit keypad mode
#
#"M-\C-OD":   backward-char
#"M-\C-OC":   forward-char
#"M-\C-OA":   previous-history
#"M-\C-OB":   next-history
#
# Arrow keys in 8 bit ANSI mode
#
#"M-\C-[D":   backward-char
#"M-\C-[C":   forward-char
```



```

#\M-\C-[A":      previous-history
#\M-\C-[B":      next-history

C-q: quoted-insert

$endif

# An old-style binding.  This happens to be the default.
TAB: complete

# Macros that are convenient for shell interaction
$if Bash
# edit the path
"\C-xp": "PATH=${PATH}\e\C-e\C-a\ef\C-f"
# prepare to type a quoted word --
# insert open and close double quotes
# and move to just after the open quote
"\C-x\"": "\""\C-b"
# insert a backslash (testing backslash escapes
# in sequences and macros)
"\C-x\\": "\\\"
# Quote the current or previous word
"\C-xq": "\eb\"\ef\"
# Add a binding to refresh the line, which is unbound
"\C-xr": redraw-current-line
# Edit variable on current line.
#\M-\C-v": "\C-a\C-k\C-y\M-\C-e\C-a\C-y="
$endif

# use a visible bell if one is available
set bell-style visible

# don't strip characters to 7 bits when reading
set input-meta on

# allow iso-latin1 characters to be inserted rather
# than converted to prefix-meta sequences
set convert-meta off

# display characters with the eighth bit set directly
# rather than as meta-prefixed characters
set output-meta on

# if there are more than 150 possible completions for
# a word, ask the user if he wants to see all of them
set completion-query-items 150

```

```
# For FTP
$if Ftp
"\C-xg": "get \M-?"
"\C-xt": "put \M-?"
"\M-." : yank-last-arg
$endif
```

31.4 Bindable Readline Commands

This section describes Readline commands that may be bound to key sequences. Command names without an accompanying key sequence are unbound by default.

In the following descriptions, *point* refers to the current cursor position, and *mark* refers to a cursor position saved by the `set-mark` command. The text between the point and mark is referred to as the *region*.

31.4.1 Commands For Moving

`beginning-of-line (C-a)`

Move to the start of the current line.

`end-of-line (C-e)`

Move to the end of the line.

`forward-char (C-f)`

Move forward a character.

`backward-char (C-b)`

Move back a character.

`forward-word (M-f)`

Move forward to the end of the next word. Words are composed of letters and digits.

`backward-word (M-b)`

Move back to the start of the current or previous word. Words are composed of letters and digits.

`clear-screen (C-l)`

Clear the screen and redraw the current line, leaving the current line at the top of the screen.

`redraw-current-line ()`

Refresh the current line. By default, this is unbound.

31.4.2 Commands For Manipulating The History

`accept-line (Newline or Return)`

Accept the line regardless of where the cursor is. If this line is non-empty, it may be added to the history list for future recall with `add_history()`. If this line is a modified history line, the history line is restored to its original state.

`previous-history (C-p)`

Move ‘back’ through the history list, fetching the previous command.

next-history (C-n)

Move ‘forward’ through the history list, fetching the next command.

beginning-of-history (M-<)

Move to the first line in the history.

end-of-history (M->)

Move to the end of the input history, i.e., the line currently being entered.

reverse-search-history (C-r)

Search backward starting at the current line and moving ‘up’ through the history as necessary. This is an incremental search.

forward-search-history (C-s)

Search forward starting at the current line and moving ‘down’ through the the history as necessary. This is an incremental search.

non-incremental-reverse-search-history (M-p)

Search backward starting at the current line and moving ‘up’ through the history as necessary using a non-incremental search for a string supplied by the user.

non-incremental-forward-search-history (M-n)

Search forward starting at the current line and moving ‘down’ through the the history as necessary using a non-incremental search for a string supplied by the user.

history-search-forward ()

Search forward through the history for the string of characters between the start of the current line and the point. This is a non-incremental search. By default, this command is unbound.

history-search-backward ()

Search backward through the history for the string of characters between the start of the current line and the point. This is a non-incremental search. By default, this command is unbound.

yank-nth-arg (M-C-y)

Insert the first argument to the previous command (usually the second word on the previous line) at point. With an argument *n*, insert the *n*th word from the previous command (the words in the previous command begin with word 0). A negative argument inserts the *n*th word from the end of the previous command. Once the argument *n* is computed, the argument is extracted as if the ‘!*n*’ history expansion had been specified.

yank-last-arg (M-. or M-_)

Insert last argument to the previous command (the last word of the previous history entry). With an argument, behave exactly like **yank-nth-arg**. Successive calls to **yank-last-arg** move back through the history list, inserting the last argument of each line in turn. The history expansion facilities are used to extract the last argument, as if the ‘!\$’ history expansion had been specified.

31.4.3 Commands For Changing Text

`delete-char (C-d)`

Delete the character at point. If point is at the beginning of the line, there are no characters in the line, and the last character typed was not bound to `delete-char`, then return EOF.

`backward-delete-char (Rubout)`

Delete the character behind the cursor. A numeric argument means to kill the characters instead of deleting them.

`forward-backward-delete-char ()`

Delete the character under the cursor, unless the cursor is at the end of the line, in which case the character behind the cursor is deleted. By default, this is not bound to a key.

`quoted-insert (C-q or C-v)`

Add the next character typed to the line verbatim. This is how to insert key sequences like `C-q`, for example.

`tab-insert (M-TAB)`

Insert a tab character.

`self-insert (a, b, A, 1, !, ...)`

Insert yourself.

`transpose-chars (C-t)`

Drag the character before the cursor forward over the character at the cursor, moving the cursor forward as well. If the insertion point is at the end of the line, then this transposes the last two characters of the line. Negative arguments have no effect.

`transpose-words (M-t)`

Drag the word before point past the word after point, moving point past that word as well. If the insertion point is at the end of the line, this transposes the last two words on the line.

`upcase-word (M-u)`

Uppercase the current (or following) word. With a negative argument, uppercase the previous word, but do not move the cursor.

`downcase-word (M-l)`

Lowercase the current (or following) word. With a negative argument, lowercase the previous word, but do not move the cursor.

`capitalize-word (M-c)`

Capitalize the current (or following) word. With a negative argument, capitalize the previous word, but do not move the cursor.

`overwrite-mode ()`

Toggle overwrite mode. With an explicit positive numeric argument, switches to overwrite mode. With an explicit non-positive numeric argument, switches to insert mode. This command affects only `emacs` mode; `vi` mode does overwrite differently. Each call to `readline()` starts in insert mode.

In overwrite mode, characters bound to **self-insert** replace the text at point rather than pushing the text to the right. Characters bound to **backward-delete-char** replace the character before point with a space.

By default, this command is unbound.

31.4.4 Killing And Yanking

kill-line (C-k)

Kill the text from point to the end of the line.

backward-kill-line (C-x Rubout)

Kill backward to the beginning of the line.

unix-line-discard (C-u)

Kill backward from the cursor to the beginning of the current line.

kill-whole-line ()

Kill all characters on the current line, no matter where point is. By default, this is unbound.

kill-word (M-d)

Kill from point to the end of the current word, or if between words, to the end of the next word. Word boundaries are the same as **forward-word**.

backward-kill-word (M-DEL)

Kill the word behind point. Word boundaries are the same as **backward-word**.

unix-word-rubout (C-w)

Kill the word behind point, using white space as a word boundary. The killed text is saved on the kill-ring.

unix-filename-rubout ()

Kill the word behind point, using white space and the slash character as the word boundaries. The killed text is saved on the kill-ring.

delete-horizontal-space ()

Delete all spaces and tabs around point. By default, this is unbound.

kill-region ()

Kill the text in the current region. By default, this command is unbound.

copy-region-as-kill ()

Copy the text in the region to the kill buffer, so it can be yanked right away. By default, this command is unbound.

copy-backward-word ()

Copy the word before point to the kill buffer. The word boundaries are the same as **backward-word**. By default, this command is unbound.

copy-forward-word ()

Copy the word following point to the kill buffer. The word boundaries are the same as **forward-word**. By default, this command is unbound.

yank (C-y)

Yank the top of the kill ring into the buffer at point.

`yank-pop` (M-y)

Rotate the kill-ring, and yank the new top. You can only do this if the prior command is `yank` or `yank-pop`.

31.4.5 Specifying Numeric Arguments

`digit-argument` (*M-0*, *M-1*, ... *M--*)

Add this digit to the argument already accumulating, or start a new argument. *M--* starts a negative argument.

`universal-argument` ()

This is another way to specify an argument. If this command is followed by one or more digits, optionally with a leading minus sign, those digits define the argument. If the command is followed by digits, executing `universal-argument` again ends the numeric argument, but is otherwise ignored. As a special case, if this command is immediately followed by a character that is neither a digit or minus sign, the argument count for the next command is multiplied by four. The argument count is initially one, so executing this function the first time makes the argument count four, a second time makes the argument count sixteen, and so on. By default, this is not bound to a key.

31.4.6 Letting Readline Type For You

`complete` (TAB)

Attempt to perform completion on the text before point. The actual completion performed is application-specific. The default is filename completion.

`possible-completions` (M-?)

List the possible completions of the text before point.

`insert-completions` (M-*)

Insert all completions of the text before point that would have been generated by `possible-completions`.

`menu-complete` ()

Similar to `complete`, but replaces the word to be completed with a single match from the list of possible completions. Repeated execution of `menu-complete` steps through the list of possible completions, inserting each match in turn. At the end of the list of completions, the bell is rung (subject to the setting of `bell-style`) and the original text is restored. An argument of *n* moves *n* positions forward in the list of matches; a negative argument may be used to move backward through the list. This command is intended to be bound to TAB, but is unbound by default.

`delete-char-or-list` ()

Deletes the character under the cursor if not at the beginning or end of the line (like `delete-char`). If at the end of the line, behaves identically to `possible-completions`. This command is unbound by default.

31.4.7 Keyboard Macros

`start-kbd-macro` (C-x ())

Begin saving the characters typed into the current keyboard macro.

`end-kbd-macro (C-x)`
 Stop saving the characters typed into the current keyboard macro and save the definition.

`call-last-kbd-macro (C-x e)`
 Re-execute the last keyboard macro defined, by making the characters in the macro appear as if typed at the keyboard.

31.4.8 Some Miscellaneous Commands

`re-read-init-file (C-x C-r)`
 Read in the contents of the *inputrc* file, and incorporate any bindings or variable assignments found there.

`abort (C-g)`
 Abort the current editing command and ring the terminal's bell (subject to the setting of `bell-style`).

`do-uppercase-version (M-a, M-b, M-x, ...)`
 If the metafiled character *x* is lowercase, run the command that is bound to the corresponding uppercase character.

`prefix-meta (ESC)`
 Metafile the next character typed. This is for keyboards without a meta key. Typing `'ESC f'` is equivalent to typing *M-f*.

`undo (C-_ or C-x C-u)`
 Incremental undo, separately remembered for each line.

`revert-line (M-r)`
 Undo all changes made to this line. This is like executing the `undo` command enough times to get back to the beginning.

`tilde-expand (M-~)`
 Perform tilde expansion on the current word.

`set-mark (C-@)`
 Set the mark to the point. If a numeric argument is supplied, the mark is set to that position.

`exchange-point-and-mark (C-x C-x)`
 Swap the point with the mark. The current cursor position is set to the saved position, and the old cursor position is saved as the mark.

`character-search (C-])`
 A character is read and point is moved to the next occurrence of that character. A negative count searches for previous occurrences.

`character-search-backward (M-C-])`
 A character is read and point is moved to the previous occurrence of that character. A negative count searches for subsequent occurrences.

`insert-comment (M-#)`
 Without a numeric argument, the value of the `comment-begin` variable is inserted at the beginning of the current line. If a numeric argument is supplied,

this command acts as a toggle: if the characters at the beginning of the line do not match the value of `comment-begin`, the value is inserted, otherwise the characters in `comment-begin` are deleted from the beginning of the line. In either case, the line is accepted as if a newline had been typed.

`dump-functions` ()

Print all of the functions and their key bindings to the Readline output stream. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an *inputrc* file. This command is unbound by default.

`dump-variables` ()

Print all of the settable variables and their values to the Readline output stream. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an *inputrc* file. This command is unbound by default.

`dump-macros` ()

Print all of the Readline key sequences bound to macros and the strings they output. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an *inputrc* file. This command is unbound by default.

`emacs-editing-mode` (C-e)

When in `vi` command mode, this causes a switch to `emacs` editing mode.

`vi-editing-mode` (M-C-j)

When in `emacs` editing mode, this causes a switch to `vi` editing mode.

31.5 Readline vi Mode

While the Readline library does not have a full set of `vi` editing functions, it does contain enough to allow simple editing of the line. The Readline `vi` mode behaves as specified in the POSIX 1003.2 standard.

In order to switch interactively between `emacs` and `vi` editing modes, use the command `M-C-j` (bound to `emacs-editing-mode` when in `vi` mode and to `vi-editing-mode` in `emacs` mode). The Readline default is `emacs` mode.

When you enter a line in `vi` mode, you are already placed in ‘insertion’ mode, as if you had typed an ‘i’. Pressing ESC switches you into ‘command’ mode, where you can edit the text of the line with the standard `vi` movement keys, move to previous history lines with ‘k’ and subsequent lines with ‘j’, and so forth.

32 Using History Interactively

This chapter describes how to use the GNU History Library interactively, from a user's standpoint. It should be considered a user's guide. For information on using the GNU History Library in other programs, see the GNU Readline Library Manual.

32.1 History Expansion

The History library provides a history expansion feature that is similar to the history expansion provided by `csh`. This section describes the syntax used to manipulate the history information.

History expansions introduce words from the history list into the input stream, making it easy to repeat commands, insert the arguments to a previous command into the current input line, or fix errors in previous commands quickly.

History expansion takes place in two parts. The first is to determine which line from the history list should be used during substitution. The second is to select portions of that line for inclusion into the current one. The line selected from the history is called the *event*, and the portions of that line that are acted upon are called *words*. Various *modifiers* are available to manipulate the selected words. The line is broken into words in the same fashion that Bash does, so that several words surrounded by quotes are considered one word. History expansions are introduced by the appearance of the history expansion character, which is `!` by default.

32.1.1 Event Designators

An event designator is a reference to a command line entry in the history list.

- `!` Start a history substitution, except when followed by a space, tab, the end of the line, or `=`.
- `!n` Refer to command line *n*.
- `!-n` Refer to the command *n* lines back.
- `!!` Refer to the previous command. This is a synonym for `!-1`.
- `!string` Refer to the most recent command starting with *string*.
- `!string[?]`
Refer to the most recent command containing *string*. The trailing `?` may be omitted if the *string* is followed immediately by a newline.
- `^string1^string2^`
Quick Substitution. Repeat the last command, replacing *string1* with *string2*. Equivalent to `!!:s/string1/string2/`.
- `!#` The entire command line typed so far.

32.1.2 Word Designators

Word designators are used to select desired words from the event. A `:` separates the event specification from the word designator. It may be omitted if the word designator begins with a `^`, `$`, `*`, `-`, or `%`. Words are numbered from the beginning of the line, with the

first word being denoted by 0 (zero). Words are inserted into the current line separated by single spaces.

For example,

- !! designates the preceding command. When you type this, the preceding command is repeated in toto.
- !!: \$ designates the last argument of the preceding command. This may be shortened to !\$.
- !fi:2 designates the second argument of the most recent command starting with the letters `fi`.

Here are the word designators:

- 0 (zero) The 0th word. For many applications, this is the command word.
- n* The *n*th word.
- ^ The first argument; that is, word 1.
- \$ The last argument.
- % The word matched by the most recent ‘*?string?*’ search.
- x-y* A range of words; ‘-*y*’ abbreviates ‘0-*y*’.
- * All of the words, except the 0th. This is a synonym for ‘1-*\$*’. It is not an error to use ‘*’ if there is just one word in the event; the empty string is returned in that case.
- x** Abbreviates ‘*x*-*\$*’
- x-* Abbreviates ‘*x*-*\$*’ like ‘*x**’, but omits the last word.

If a word designator is supplied without an event specification, the previous command is used as the event.

32.1.3 Modifiers

After the optional word designator, you can add a sequence of one or more of the following modifiers, each preceded by a ‘:’.

- h** Remove a trailing pathname component, leaving only the head.
- t** Remove all leading pathname components, leaving the tail.
- r** Remove a trailing suffix of the form ‘.*suffix*’, leaving the basename.
- e** Remove all but the trailing suffix.
- p** Print the new command but do not execute it.

s/old/new/

Substitute *new* for the first occurrence of *old* in the event line. Any delimiter may be used in place of ‘/’. The delimiter may be quoted in *old* and *new* with a single backslash. If ‘&’ appears in *new*, it is replaced by *old*. A single backslash will quote the ‘&’. The final delimiter is optional if it is the last character on the input line.

- &** Repeat the previous substitution.
- g**
- a** Cause changes to be applied over the entire event line. Used in conjunction with 's', as in `gs/old/new/`, or with '&'.
- G** Apply the following 's' modifier once to each word in the event.

Appendix A Formatting Documentation

The GDB 4 release includes an already-formatted reference card, ready for printing with PostScript or Ghostscript, in the ‘gdb’ subdirectory of the main source directory¹. If you can use PostScript or Ghostscript with your printer, you can print the reference card immediately with ‘refcard.ps’.

The release also includes the source for the reference card. You can format it, using T_EX, by typing:

```
make refcard.dvi
```

The GDB reference card is designed to print in *landscape* mode on US “letter” size paper; that is, on a sheet 11 inches wide by 8.5 inches high. You will need to specify this form of printing as an option to your DVI output program.

All the documentation for GDB comes as part of the machine-readable distribution. The documentation is written in Texinfo format, which is a documentation system that uses a single source file to produce both on-line information and a printed manual. You can use one of the Info formatting commands to create the on-line version of the documentation and T_EX (or `texi2roff`) to typeset the printed version.

GDB includes an already formatted copy of the on-line Info version of this manual in the ‘gdb’ subdirectory. The main Info file is ‘gdb-7.2/gdb/gdb.info’, and it refers to subordinate files matching ‘gdb.info*’ in the same directory. If necessary, you can print out these files, or read them with any editor; but they are easier to read using the `info` subsystem in GNU Emacs or the standalone `info` program, available as part of the GNU Texinfo distribution.

If you want to format these Info files yourself, you need one of the Info formatting programs, such as `texinfo-format-buffer` or `makeinfo`.

If you have `makeinfo` installed, and are in the top level GDB source directory (‘gdb-7.2’, in the case of version 7.2), you can make the Info file by typing:

```
cd gdb
make gdb.info
```

If you want to typeset and print copies of this manual, you need T_EX, a program to print its DVI output files, and ‘`texinfo.tex`’, the Texinfo definitions file.

T_EX is a typesetting program; it does not print files directly, but produces output files called DVI files. To print a typeset document, you need a program to print DVI files. If your system has T_EX installed, chances are it has such a program. The precise command to use depends on your system; `lpr -d` is common; another (for PostScript devices) is `dvips`. The DVI print command may require a file name without any extension or a ‘.dvi’ extension.

T_EX also requires a macro definitions file called ‘`texinfo.tex`’. This file tells T_EX how to typeset a document written in Texinfo format. On its own, T_EX cannot either read or typeset a Texinfo file. ‘`texinfo.tex`’ is distributed with GDB and is located in the ‘`gdb-version-number/texinfo`’ directory.

If you have T_EX and a DVI printer program installed, you can typeset and print this manual. First switch to the ‘gdb’ subdirectory of the main source directory (for example, to ‘gdb-7.2/gdb’) and type:

¹ In ‘gdb-7.2/gdb/refcard.ps’ of the version 7.2 release.

```
make gdb.dvi
```

Then give 'gdb.dvi' to your DVI printing program.

Appendix B Installing GDB

B.1 Requirements for Building GDB

Building GDB requires various tools and packages to be available. Other packages will be used only if they are found.

Tools/Packages Necessary for Building GDB

ISO C90 compiler

GDB is written in ISO C90. It should be buildable with any working C90 compiler, e.g. GCC.

Tools/Packages Optional for Building GDB

Expat GDB can use the Expat XML parsing library. This library may be included with your operating system distribution; if it is not, you can get the latest version from <http://expat.sourceforge.net>. The ‘`configure`’ script will search for this library in several standard locations; if it is installed in an unusual path, you can use the ‘`--with-libexpat-prefix`’ option to specify its location.

Expat is used for:

- Remote protocol memory maps (see [\[Memory Map Format\]](#), page [\(undefined\)](#))
- Target descriptions (see [\[Target Descriptions\]](#), page [\(undefined\)](#))
- Remote shared library lists (see [\[Library List Format\]](#), page [\(undefined\)](#))
- MS-Windows shared libraries (see [\[Shared Libraries\]](#), page [\(undefined\)](#))

zlib GDB will use the ‘`zlib`’ library, if available, to read compressed debug sections. Some linkers, such as GNU gold, are capable of producing binaries with compressed debug sections. If GDB is compiled with ‘`zlib`’, it will be able to read the debug information in such binaries.

The ‘`zlib`’ library is likely included with your operating system distribution; if it is not, you can get the latest version from <http://zlib.net>.

iconv GDB’s features related to character sets (see [\[Character Sets\]](#), page [\(undefined\)](#)) require a functioning `iconv` implementation. If you are on a GNU system, then this is provided by the GNU C Library. Some other systems also provide a working `iconv`.

On systems with `iconv`, you can install GNU Libiconv. If you have previously installed Libiconv, you can use the ‘`--with-libiconv-prefix`’ option to configure.

GDB’s top-level ‘`configure`’ and ‘`Makefile`’ will arrange to build Libiconv if a directory named ‘`libiconv`’ appears in the top-most source directory. If

Libiconv is built this way, and if the operating system does not provide a suitable iconv implementation, then the just-built library will automatically be used by GDB. One easy way to set this up is to download GNU Libiconv, unpack it, and then rename the directory holding the Libiconv source code to ‘libiconv’.

B.2 Invoking the GDB ‘configure’ Script

GDB comes with a ‘configure’ script that automates the process of preparing GDB for installation; you can then use `make` to build the `gdb` program.¹

The GDB distribution includes all the source code you need for GDB in a single directory, whose name is usually composed by appending the version number to ‘gdb’.

For example, the GDB version 7.2 distribution is in the ‘gdb-7.2’ directory. That directory contains:

```
gdb-7.2/configure (and supporting files)
    script for configuring GDB and all its supporting libraries

gdb-7.2/gdb
    the source specific to GDB itself

gdb-7.2/bfd
    source for the Binary File Descriptor library

gdb-7.2/include
    GNU include files

gdb-7.2/libiberty
    source for the ‘-liberty’ free software library

gdb-7.2/opcodes
    source for the library of opcode tables and disassemblers

gdb-7.2/readline
    source for the GNU command-line interface

gdb-7.2/glob
    source for the GNU filename pattern-matching subroutine

gdb-7.2/mmalloc
    source for the GNU memory-mapped malloc package
```

The simplest way to configure and build GDB is to run ‘configure’ from the ‘gdb-*version-number*’ source directory, which in this example is the ‘gdb-7.2’ directory.

First switch to the ‘gdb-*version-number*’ source directory if you are not already in it; then run ‘configure’. Pass the identifier for the platform on which GDB will run as an argument.

For example:

```
cd gdb-7.2
./configure host
make
```

¹ If you have a more recent version of GDB than 7.2, look at the ‘README’ file in the sources; we may have improved the installation procedures since publishing this manual.

where *host* is an identifier such as ‘sun4’ or ‘decstation’, that identifies the platform where GDB will run. (You can often leave off *host*; ‘configure’ tries to guess the correct value by examining your system.)

Running ‘configure *host*’ and then running `make` builds the ‘bfd’, ‘readline’, ‘mmalloc’, and ‘libiberty’ libraries, then `gdb` itself. The configured source files, and the binaries, are left in the corresponding source directories.

‘configure’ is a Bourne-shell (`/bin/sh`) script; if your system does not recognize this automatically when you run a different shell, you may need to run `sh` on it explicitly:

```
sh configure host
```

If you run ‘configure’ from a directory that contains source directories for multiple libraries or programs, such as the ‘gdb-7.2’ source directory for version 7.2, ‘configure’ creates configuration files for every directory level underneath (unless you tell it not to, with the ‘--norecursion’ option).

You should run the ‘configure’ script from the top directory in the source tree, the ‘gdb-*version-number*’ directory. If you run ‘configure’ from one of the subdirectories, you will configure only that subdirectory. That is usually not what you want. In particular, if you run the first ‘configure’ from the ‘gdb’ subdirectory of the ‘gdb-*version-number*’ directory, you will omit the configuration of ‘bfd’, ‘readline’, and other sibling directories of the ‘gdb’ subdirectory. This leads to build errors about missing include files such as ‘bfd/bfd.h’.

You can install `gdb` anywhere; it has no hardwired paths. However, you should make sure that the shell on your path (named by the ‘SHELL’ environment variable) is publicly readable. Remember that GDB uses the shell to start your program—some systems refuse to let GDB debug child processes whose programs are not readable.

B.3 Compiling GDB in Another Directory

If you want to run GDB versions for several host or target machines, you need a different `gdb` compiled for each combination of host and target. ‘configure’ is designed to make this easy by allowing you to generate each configuration in a separate subdirectory, rather than in the source directory. If your `make` program handles the ‘VPATH’ feature (GNU `make` does), running `make` in each of these directories builds the `gdb` program specified there.

To build `gdb` in a separate directory, run ‘configure’ with the ‘--srcdir’ option to specify where to find the source. (You also need to specify a path to find ‘configure’ itself from your working directory. If the path to ‘configure’ would be the same as the argument to ‘--srcdir’, you can leave out the ‘--srcdir’ option; it is assumed.)

For example, with version 7.2, you can build GDB in a separate directory for a Sun 4 like this:

```
cd gdb-7.2
mkdir ../gdb-sun4
cd ../gdb-sun4
../gdb-7.2/configure sun4
make
```

When ‘configure’ builds a configuration using a remote source directory, it creates a tree for the binaries with the same structure (and using the same names) as the tree under the source directory. In the example, you’d find the Sun 4 library ‘libiberty.a’ in the directory ‘gdb-sun4/libiberty’, and GDB itself in ‘gdb-sun4/gdb’.

Make sure that your path to the ‘`configure`’ script has just one instance of ‘`gdb`’ in it. If your path to ‘`configure`’ looks like ‘`../gdb-7.2/gdb/configure`’, you are configuring only one subdirectory of GDB, not the whole package. This leads to build errors about missing include files such as ‘`bfd/bfd.h`’.

One popular reason to build several GDB configurations in separate directories is to configure GDB for cross-compiling (where GDB runs on one machine—the *host*—while debugging programs that run on another machine—the *target*). You specify a cross-debugging target by giving the ‘`--target=target`’ option to ‘`configure`’.

When you run `make` to build a program or library, you must run it in a configured directory—whatever directory you were in when you called ‘`configure`’ (or one of its subdirectories).

The Makefile that ‘`configure`’ generates in each source directory also runs recursively. If you type `make` in a source directory such as ‘`gdb-7.2`’ (or in a separate configured directory configured with ‘`--srcdir=dirname/gdb-7.2`’), you will build all the required libraries, and then build GDB.

When you have multiple hosts or targets configured in separate directories, you can run `make` on them in parallel (for example, if they are NFS-mounted on each of the hosts); they will not interfere with each other.

B.4 Specifying Names for Hosts and Targets

The specifications used for hosts and targets in the ‘`configure`’ script are based on a three-part naming scheme, but some short predefined aliases are also supported. The full naming scheme encodes three pieces of information in the following pattern:

```
architecture-vendor-os
```

For example, you can use the alias `sun4` as a *host* argument, or as the value for *target* in a `--target=target` option. The equivalent full name is ‘`sparc-sun-sunos4`’.

The ‘`configure`’ script accompanying GDB does not provide any query facility to list all supported host and target names or aliases. ‘`configure`’ calls the Bourne shell script `config.sub` to map abbreviations to full names; you can read the script, if you wish, or you can use it to test your guesses on abbreviations—for example:

```
% sh config.sub i386-linux
i386-pc-linux-gnu
% sh config.sub alpha-linux
alpha-unknown-linux-gnu
% sh config.sub hp9k700
hppa1.1-hp-hpux
% sh config.sub sun4
sparc-sun-sunos4.1.1
% sh config.sub sun3
m68k-sun-sunos4.1.1
% sh config.sub i986v
Invalid configuration 'i986v': machine 'i986v' not recognized
```

`config.sub` is also distributed in the GDB source directory (‘`gdb-7.2`’, for version 7.2).

B.5 ‘configure’ Options

Here is a summary of the ‘configure’ options and arguments that are most often useful for building GDB. ‘configure’ also has several other options not listed here. See Info file ‘configure.info’, node ‘What Configure Does’, for a full explanation of ‘configure’.

```
configure [--help]
          [--prefix=dir]
          [--exec-prefix=dir]
          [--srcdir=dirname]
          [--norecursion] [--rm]
          [--target=target]
          host
```

You may introduce options with a single ‘-’ rather than ‘--’ if you prefer; but you may abbreviate option names if you use ‘--’.

`--help` Display a quick summary of how to invoke ‘configure’.

`--prefix=dir`
 Configure the source to install programs and files under directory ‘*dir*’.

`--exec-prefix=dir`
 Configure the source to install programs under directory ‘*dir*’.

`--srcdir=dirname`
Warning: using this option requires GNU make, or another make that implements the VPATH feature.

Use this option to make configurations in directories separate from the GDB source directories. Among other things, you can use this to build (or maintain) several configurations simultaneously, in separate directories. ‘configure’ writes configuration-specific files in the current directory, but arranges for them to use the source in the directory *dirname*. ‘configure’ creates directories under the working directory in parallel to the source directories below *dirname*.

`--norecursion`
 Configure only the directory level where ‘configure’ is executed; do not propagate configuration to subdirectories.

`--target=target`
 Configure GDB for cross-debugging programs running on the specified *target*. Without this option, GDB is configured to debug programs that run on the same machine (*host*) as GDB itself.

There is no convenient way to generate a list of all available targets.

`host ...` Configure GDB to run on the specified *host*.

There is no convenient way to generate a list of all available hosts.

There are many other options available as well, but they are generally needed for special purposes only.

B.6 System-wide configuration and settings

GDB can be configured to have a system-wide init file; this file will be read and executed at startup (see [\[What GDB does during startup\]](#), page [\[undefined\]](#)).

Here is the corresponding configure option:

`--with-system-gdbinit=file`

Specify that the default location of the system-wide init file is *file*.

If GDB has been configured with the option ‘`--prefix=$prefix`’, it may be subject to relocation. Two possible cases:

- If the default location of this init file contains ‘`$prefix`’, it will be subject to relocation. Suppose that the configure options are ‘`--prefix=$prefix --with-system-gdbinit=$prefix/etc/gdbinit`’; if GDB is moved from ‘`$prefix`’ to ‘`$install`’, the system init file is looked for as ‘`$install/etc/gdbinit`’ instead of ‘`$prefix/etc/gdbinit`’.
- By contrast, if the default location does not contain the prefix, it will not be relocated. E.g. if GDB has been configured with ‘`--prefix=/usr/local --with-system-gdbinit=/usr/share/gdb/gdbinit`’, then GDB will always look for ‘`/usr/share/gdb/gdbinit`’, wherever GDB is installed.

Appendix C Maintenance Commands

In addition to commands intended for GDB users, GDB includes a number of commands intended for GDB developers, that are not documented elsewhere in this manual. These commands are provided here for reference. (For commands that turn on debugging messages, see [\(undefined\) \[Debugging Output\], page \(undefined\)](#).)

maint agent expression

maint agent-*eval* expression

Translate the given *expression* into remote agent bytecodes. This command is useful for debugging the Agent Expression mechanism (see [\(undefined\) \[Agent Expressions\], page \(undefined\)](#)). The ‘agent’ version produces an expression useful for data collection, such as by breakpoints, while ‘maint agent-*eval*’ produces an expression that evaluates directly to a result. For instance, a collection expression for `globa + globb` will include bytecodes to record four bytes of memory at each of the addresses of `globa` and `globb`, while discarding the result of the addition, while an evaluation expression will do the addition and return the sum.

maint info breakpoints

Using the same format as ‘info breakpoints’, display both the breakpoints you’ve set explicitly, and those GDB is using for internal purposes. Internal breakpoints are shown with negative breakpoint numbers. The type column identifies what kind of breakpoint is shown:

breakpoint

Normal, explicitly set breakpoint.

watchpoint

Normal, explicitly set watchpoint.

longjmp Internal breakpoint, used to handle correctly stepping through `longjmp` calls.

longjmp resume

Internal breakpoint at the target of a `longjmp`.

until Temporary internal breakpoint used by the GDB `until` command.

finish Temporary internal breakpoint used by the GDB `finish` command.

shlib events

Shared library events.

set displaced-stepping

show displaced-stepping

Control whether or not GDB will do *displaced stepping* if the target supports it. Displaced stepping is a way to single-step over breakpoints without removing them from the inferior, by executing an out-of-line copy of the instruction that was originally at the breakpoint location. It is also known as out-of-line single-stepping.

`set displaced-stepping on`
 If the target architecture supports it, GDB will use displaced stepping to step over breakpoints.

`set displaced-stepping off`
 GDB will not use displaced stepping to step over breakpoints, even if such is supported by the target architecture.

`set displaced-stepping auto`
 This is the default mode. GDB will use displaced stepping only if non-stop mode is active (see [\(undefined\) \[Non-Stop Mode\]](#), page [\(undefined\)](#)) and the target architecture supports displaced stepping.

`maint check-symtabs`
 Check the consistency of `psymtabs` and `symtabs`.

`maint cplus first_component name`
 Print the first C++ class/namespace component of *name*.

`maint cplus namespace`
 Print the list of possible C++ namespaces.

`maint demangle name`
 Demangle a C++ or Objective-C mangled *name*.

`maint deprecate command [replacement]`
`maint undepricate command`
 Deprecate or undepricate the named *command*. Deprecated commands cause GDB to issue a warning when you use them. The optional argument *replacement* says which newer command should be used in favor of the deprecated one; if it is given, GDB will mention the replacement as part of the warning.

`maint dump-me`
 Cause a fatal signal in the debugger and force it to dump its core. This is supported only on systems which support aborting a program with the `SIGQUIT` signal.

`maint internal-error [message-text]`
`maint internal-warning [message-text]`
 Cause GDB to call the internal function `internal_error` or `internal_warning` and hence behave as though an internal error or internal warning has been detected. In addition to reporting the internal problem, these functions give the user the opportunity to either quit GDB or create a core file of the current GDB session.

These commands take an optional parameter *message-text* that is used as the text of the error or warning message.

Here's an example of using `internal-error`:

```
(gdb) maint internal-error testing, 1, 2
.../maint.c:121: internal-error: testing, 1, 2
A problem internal to GDB has been detected. Further
debugging may prove unreliable.
```

```

Quit this debugging session? (y or n) n
Create a core file? (y or n) n
(gdb)

```

```

maint set internal-error action [ask|yes|no]
maint show internal-error action
maint set internal-warning action [ask|yes|no]
maint show internal-warning action

```

When GDB reports an internal problem (error or warning) it gives the user the opportunity to both quit GDB and create a core file of the current GDB session. These commands let you override the default behaviour for each particular *action*, described in the table below.

‘quit’ You can specify that GDB should always (yes) or never (no) quit. The default is to ask the user what to do.

‘corefile’ You can specify that GDB should always (yes) or never (no) create a core file. The default is to ask the user what to do.

```

maint packet text

```

If GDB is talking to an inferior via the serial protocol, then this command sends the string *text* to the inferior, and displays the response packet. GDB supplies the initial ‘\$’ character, the terminating ‘#’ character, and the checksum.

```

maint print architecture [file]

```

Print the entire architecture configuration. The optional argument *file* names the file where the output goes.

```

maint print c-tdesc

```

Print the current target description (see [\(undefined\) \[Target Descriptions\], page \(undefined\)](#)) as a C source file. The created source file can be used in GDB when an XML parser is not available to parse the description.

```

maint print dummy-frames

```

Prints the contents of GDB’s internal dummy-frame stack.

```

(gdb) b add
...
(gdb) print add(2,3)
Breakpoint 2, add (a=2, b=3) at ...
58 return (a + b);
The program being debugged stopped while in a function called from GDB.
...
(gdb) maint print dummy-frames
0x1a57c80: pc=0x01014068 fp=0x0200bddc sp=0x0200bdd6
top=0x0200bdd4 id={stack=0x200bddc,code=0x101405c}
call_lo=0x01014000 call_hi=0x01014001
(gdb)

```

Takes an optional file parameter.

```

maint print registers [file]
maint print raw-registers [file]
maint print cooked-registers [file]
maint print register-groups [file]

```

Print GDB’s internal register data structures.

The command `maint print raw-registers` includes the contents of the raw register cache; the command `maint print cooked-registers` includes the (cooked) value of all registers, including registers which aren't available on the target nor visible to user; and the command `maint print register-groups` includes the groups that each register is a member of. See [section “Registers” in GDB Internals](#).

These commands take an optional parameter, a file name to which to write the information.

`maint print reggroups [file]`

Print GDB's internal register group data structures. The optional argument *file* tells to what file to write the information.

The register groups info looks like this:

```
(gdb) maint print reggroups
Group      Type
general    user
float      user
all        user
vector     user
system     user
save       internal
restore    internal
```

`flushregs`

This command forces GDB to flush its internal register cache.

`maint print objfiles`

Print a dump of all known object files. For each object file, this command prints its name, address in memory, and all of its psymtabs and symtabs.

`maint print section-scripts [regex]`

Print a dump of scripts specified in the `.debug_gdb_section` section. If *regex* is specified, only print scripts loaded by object files matching *regex*. For each script, this command prints its name as specified in the objfile, and the full path if known. See [\[.debug_gdb_scripts section\]](#), page [\[undefined\]](#).

`maint print statistics`

This command prints, for each object file in the program, various data about that object file followed by the byte cache (*bcache*) statistics for the object file. The objfile data includes the number of minimal, partial, full, and stabs symbols, the number of types defined by the objfile, the number of as yet unexpanded psym tables, the number of line tables and string tables, and the amount of memory used by the various tables. The bcache statistics include the counts, sizes, and counts of duplicates of all and unique objects, max, average, and median entry size, total memory used and its overhead and savings, and various measures of the hash table size and chain lengths.

`maint print target-stack`

A *target* is an interface between the debugger and a particular kind of file or process. Targets can be stacked in *strata*, so that more than one target can potentially respond to a request. In particular, memory accesses will walk down

the stack of targets until they find a target that is interested in handling that particular address.

This command prints a short description of each layer that was pushed on the *target stack*, starting from the top layer down to the bottom one.

maint print type *expr*

Print the type chain for a type specified by *expr*. The argument can be either a type name or a symbol. If it is a symbol, the type of that symbol is described. The type chain produced by this command is a recursive definition of the data type as stored in GDB's data structures, including its flags and contained types.

maint set dwarf2 always-disassemble

maint show dwarf2 always-disassemble

Control the behavior of **info address** when using DWARF debugging information.

The default is **off**, which means that GDB should try to describe a variable's location in an easily readable format. When **on**, GDB will instead display the DWARF location expression in an assembly-like format. Note that some locations are too complex for GDB to describe simply; in this case you will always see the disassembly form.

Here is an example of the resulting disassembly:

```
(gdb) info addr argc
Symbol "argc" is a complex DWARF expression:
1: DW_OP_fbreg 0
```

For more information on these expressions, see [the DWARF standard](#).

maint set dwarf2 max-cache-age

maint show dwarf2 max-cache-age

Control the DWARF 2 compilation unit cache.

In object files with inter-compilation-unit references, such as those produced by the GCC option `'-feliminate-dwarf2-dups'`, the DWARF 2 reader needs to frequently refer to previously read compilation units. This setting controls how long a compilation unit will remain in the cache if it is not referenced. A higher limit means that cached compilation units will be stored in memory longer, and more total memory will be used. Setting it to zero disables caching, which will slow down GDB startup, but reduce memory consumption.

maint set profile

maint show profile

Control profiling of GDB.

Profiling will be disabled until you use the `'maint set profile'` command to enable it. When you enable profiling, the system will begin collecting timing and execution count data; when you disable profiling or exit GDB, the results will be written to a log file. Remember that if you use profiling, GDB will overwrite the profiling log file (often called `'gmon.out'`). If you have a record of important profiling data in a `'gmon.out'` file, be sure to move it to a safe location.

Configuring with `'--enable-profiling'` arranges for GDB to be compiled with the `'-pg'` compiler option.

maint set show-debug-regs

maint show show-debug-regs

Control whether to show variables that mirror the hardware debug registers. Use **ON** to enable, **OFF** to disable. If enabled, the debug registers values are shown when GDB inserts or removes a hardware breakpoint or watchpoint, and when the inferior triggers a hardware-assisted breakpoint or watchpoint.

maint set show-all-tib

maint show show-all-tib

Control whether to show all non zero areas within a 1k block starting at thread local base, when using the ‘**info w32 thread-information-block**’ command.

maint space

Control whether to display memory usage for each command. If set to a nonzero value, GDB will display how much memory each command took, following the command’s own output. This can also be requested by invoking GDB with the ‘**--statistics**’ command-line switch (see [\(undefined\)](#) [Mode Options], page [\(undefined\)](#)).

maint time

Control whether to display the execution time for each command. If set to a nonzero value, GDB will display how much time it took to execute each command, following the command’s own output. The time is not printed for the commands that run the target, since there’s no mechanism currently to compute how much time was spend by GDB and how much time was spend by the program been debugged. it’s not possibly currently This can also be requested by invoking GDB with the ‘**--statistics**’ command-line switch (see [\(undefined\)](#) [Mode Options], page [\(undefined\)](#)).

maint translate-address [*section*] *addr*

Find the symbol stored at the location specified by the address *addr* and an optional section name *section*. If found, GDB prints the name of the closest symbol and an offset from the symbol’s location to the specified address. This is similar to the **info address** command (see [\(undefined\)](#) [Symbols], page [\(undefined\)](#)), except that this command also allows to find symbols in other sections.

If section was not specified, the section in which the symbol was found is also printed. For dynamically linked executables, the name of executable or shared library containing the symbol is printed as well.

The following command is useful for non-interactive invocations of GDB, such as in the test suite.

set watchdog nsec

Set the maximum number of seconds GDB will wait for the target operation to finish. If this time expires, GDB reports an error and the command is aborted.

show watchdog

Show the current setting of the target wait timeout.

Appendix D GDB Remote Serial Protocol

D.1 Overview

There may be occasions when you need to know something about the protocol—for example, if there is only one serial port to your target machine, you might want your program to do something special if it recognizes a packet meant for GDB.

In the examples below, ‘->’ and ‘<-’ are used to indicate transmitted and received data, respectively.

All GDB commands and responses (other than acknowledgments and notifications, see [\(undefined\) \[Notification Packets\]](#), page [\(undefined\)](#)) are sent as a *packet*. A *packet* is introduced with the character ‘\$’, the actual *packet-data*, and the terminating character ‘#’ followed by a two-digit *checksum*:

```
$packet-data#checksum
```

The two-digit *checksum* is computed as the modulo 256 sum of all characters between the leading ‘\$’ and the trailing ‘#’ (an eight bit unsigned checksum).

Implementors should note that prior to GDB 5.0 the protocol specification also included an optional two-digit *sequence-id*:

```
$sequence-id:packet-data#checksum
```

That *sequence-id* was appended to the acknowledgment. GDB has never output *sequence-ids*. Stubs that handle packets added since GDB 5.0 must not accept *sequence-id*.

When either the host or the target machine receives a packet, the first response expected is an acknowledgment: either ‘+’ (to indicate the package was received correctly) or ‘-’ (to request retransmission):

```
-> $packet-data#checksum
<- +
```

The ‘+’/‘-’ acknowledgments can be disabled once a connection is established. See [\(undefined\) \[Packet Acknowledgment\]](#), page [\(undefined\)](#), for details.

The host (GDB) sends *commands*, and the target (the debugging stub incorporated in your program) sends a *response*. In the case of step and continue *commands*, the response is only sent when the operation has completed, and the target has again stopped all threads in all attached processes. This is the default all-stop mode behavior, but the remote protocol also supports GDB’s non-stop execution mode; see [\(undefined\) \[Remote Non-Stop\]](#), page [\(undefined\)](#), for details.

packet-data consists of a sequence of characters with the exception of ‘#’ and ‘\$’ (see ‘X’ packet for additional exceptions).

Fields within the packet should be separated using ‘,’ ‘;’ or ‘:’. Except where otherwise noted all numbers are represented in HEX with leading zeros suppressed.

Implementors should note that prior to GDB 5.0, the character ‘:’ could not appear as the third character in a packet (as it would potentially conflict with the *sequence-id*).

Binary data in most packets is encoded either as two hexadecimal digits per byte of binary data. This allowed the traditional remote protocol to work over connections which were only seven-bit clean. Some packets designed more recently assume an eight-bit clean connection, and use a more efficient encoding to send and receive binary data.

The binary data representation uses 7d (ASCII ‘}’) as an escape character. Any escaped byte is transmitted as the escape character followed by the original character XORed with 0x20. For example, the byte 0x7d would be transmitted as the two bytes 0x7d 0x5d. The bytes 0x23 (ASCII ‘#’), 0x24 (ASCII ‘\$’), and 0x7d (ASCII ‘}’) must always be escaped. Responses sent by the stub must also escape 0x2a (ASCII ‘*’), so that it is not interpreted as the start of a run-length encoded sequence (described next).

Response *data* can be run-length encoded to save space. Run-length encoding replaces runs of identical characters with one instance of the repeated character, followed by a ‘*’ and a repeat count. The repeat count is itself sent encoded, to avoid binary characters in *data*: a value of n is sent as $n+29$. For a repeat count greater or equal to 3, this produces a printable ASCII character, e.g. a space (ASCII code 32) for a repeat count of 3. (This is because run-length encoding starts to win for counts 3 or more.) Thus, for example, ‘0* ’ is a run-length encoding of “0000”: the space character after ‘*’ means repeat the leading 0 32 - 29 = 3 more times.

The printable characters ‘#’ and ‘\$’ or with a numeric value greater than 126 must not be used. Runs of six repeats (‘#’) or seven repeats (‘\$’) can be expanded using a repeat count of only five (‘”). For example, ‘00000000’ can be encoded as ‘0*"00’.

The error response returned for some packets includes a two character error number. That number is not well defined.

For any *command* not supported by the stub, an empty response (‘\$#00’) should be returned. That way it is possible to extend the protocol. A newer GDB can tell if a packet is supported based on that response.

A stub is required to support the ‘g’, ‘G’, ‘m’, ‘M’, ‘c’, and ‘s’ *commands*. All other *commands* are optional.

D.2 Packets

The following table provides a complete list of all currently defined *commands* and their corresponding response *data*. See [\[File-I/O Remote Protocol Extension\]](#), page [\(undefined\)](#), for details about the File I/O extension of the remote protocol.

Each packet’s description has a template showing the packet’s overall syntax, followed by an explanation of the packet’s meaning. We include spaces in some of the templates for clarity; these are not part of the packet’s syntax. No GDB packet uses spaces to separate its components. For example, a template like ‘foo bar baz’ describes a packet beginning with the three ASCII bytes ‘foo’, followed by a *bar*, followed directly by a *baz*. GDB does not transmit a space character between the ‘foo’ and the *bar*, or between the *bar* and the *baz*.

Several packets and replies include a *thread-id* field to identify a thread. Normally these are positive numbers with a target-specific interpretation, formatted as big-endian hex strings. A *thread-id* can also be a literal ‘-1’ to indicate all threads, or ‘0’ to pick any thread.

In addition, the remote protocol supports a multiprocess feature in which the *thread-id* syntax is extended to optionally include both process and thread ID fields, as ‘ppid.tid’. The *pid* (process) and *tid* (thread) components each have the format described above: a positive number with target-specific interpretation formatted as a big-endian hex string,

literal ‘-1’ to indicate all processes or threads (respectively), or ‘0’ to indicate an arbitrary process or thread. Specifying just a process, as ‘*ppid*’, is equivalent to ‘*ppid*.-1’. It is an error to specify all processes but a specific thread, such as ‘*p-1.tid*’. Note that the ‘*p*’ prefix is *not* used for those packets and replies explicitly documented to include a process ID, rather than a *thread-id*.

The multiprocess *thread-id* syntax extensions are only used if both GDB and the stub report support for the ‘multiprocess’ feature using ‘qSupported’. See [\(undefined\) \[multiprocess extensions\]](#), page [\(undefined\)](#), for more information.

Note that all packet forms beginning with an upper- or lower-case letter, other than those described here, are reserved for future use.

Here are the packet descriptions.

- ‘!’ Enable extended mode. In extended mode, the remote server is made persistent. The ‘R’ packet is used to restart the program being debugged.
Reply:
‘OK’ The remote target both supports and has enabled extended mode.
- ‘?’ Indicate the reason the target halted. The reply is the same as for step and continue. This packet has a special interpretation when the target is in non-stop mode; see [\(undefined\) \[Remote Non-Stop\]](#), page [\(undefined\)](#).
Reply: See [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#), for the reply specifications.
- ‘A *arglen, argnum, arg, ...*’
Initialized `argv[]` array passed into program. *arglen* specifies the number of bytes in the hex encoded byte stream *arg*. See `gdbserver` for more details.
Reply:
‘OK’ The arguments were set.
‘E *NW*’ An error occurred.
- ‘b *baud*’ (Don’t use this packet; its behavior is not well-defined.) Change the serial line speed to *baud*.
JTC: When does the transport layer state change? When it’s received, or after the ACK is transmitted. In either case, there are problems if the command or the acknowledgment packet is dropped.
Stan: If people really wanted to add something like this, and get it working for the first time, they ought to modify ser-unix.c to send some kind of out-of-band message to a specially-setup stub and have the switch happen "in between" packets, so that from remote protocol’s point of view, nothing actually happened.
- ‘B *addr, mode*’
Set (*mode* is ‘S’) or clear (*mode* is ‘C’) a breakpoint at *addr*.
Don’t use this packet. Use the ‘Z’ and ‘z’ packets instead (see [\(undefined\) \[insert breakpoint or watchpoint packet\]](#), page [\(undefined\)](#)).
- ‘bc’ Backward continue. Execute the target system in reverse. No parameter. See [\(undefined\) \[Reverse Execution\]](#), page [\(undefined\)](#), for more information.

- Reply: See [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#), for the reply specifications.
- ‘bs’ Backward single step. Execute one instruction in reverse. No parameter. See [\(undefined\) \[Reverse Execution\]](#), page [\(undefined\)](#), for more information.
Reply: See [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#), for the reply specifications.
- ‘c [*addr*]
- Continue. *addr* is address to resume. If *addr* is omitted, resume at current address.
Reply: See [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#), for the reply specifications.
- ‘C *sig* [*;**addr*]
- Continue with signal *sig* (hex signal number). If ‘*;**addr*’ is omitted, resume at same address.
Reply: See [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#), for the reply specifications.
- ‘d’ Toggle debug flag.
Don’t use this packet; instead, define a general set packet (see [\(undefined\) \[General Query Packets\]](#), page [\(undefined\)](#)).
- ‘D’
- ‘D;*pid*’ The first form of the packet is used to detach GDB from the remote system. It is sent to the remote target before GDB disconnects via the `detach` command. The second form, including a process ID, is used when multiprocess protocol extensions are enabled (see [\(undefined\) \[multiprocess extensions\]](#), page [\(undefined\)](#)), to detach only a specific process. The *pid* is specified as a big-endian hex string.
Reply:
- ‘OK’ for success
- ‘E *NN*’ for an error
- ‘F *RC,EE,CF;XX*’
- A reply from GDB to an ‘F’ packet sent by the target. This is part of the File-I/O protocol extension. See [\(undefined\) \[File-I/O Remote Protocol Extension\]](#), page [\(undefined\)](#), for the specification.
- ‘g’ Read general registers.
Reply:
- ‘*XX...*’ Each byte of register data is described by two hex digits. The bytes with the register are transmitted in target byte order. The size of each register and their position within the ‘g’ packet are determined by the GDB internal `gdbarch` functions `DEPRECATED_REGISTER_RAW_SIZE` and `gdbarch_register_name`. The specification of several standard ‘g’ packets is specified below.
- ‘E *NN*’ for an error.

‘G *XX...*’ Write general registers. See [\(undefined\) \[read registers packet\]](#), page [\(undefined\)](#), for a description of the *XX...* data.

Reply:

‘OK’ for success

‘E *NN*’ for an error

‘H *c thread-id*’

Set thread for subsequent operations (‘m’, ‘M’, ‘g’, ‘G’, et.al.). *c* depends on the operation to be performed: it should be ‘c’ for step and continue operations, ‘g’ for other operations. The thread designator *thread-id* has the format and interpretation described in [\(undefined\) \[thread-id syntax\]](#), page [\(undefined\)](#).

Reply:

‘OK’ for success

‘E *NN*’ for an error

‘i [*addr* [,*nnn*]]’

Step the remote target by a single clock cycle. If ‘,*nnn*’ is present, cycle step *nnn* cycles. If *addr* is present, cycle step starting at that address.

‘I’ Signal, then cycle step. See [\(undefined\) \[step with signal packet\]](#), page [\(undefined\)](#). See [\(undefined\) \[cycle step packet\]](#), page [\(undefined\)](#).

‘k’ Kill request.

FIXME: *There is no description of how to operate when a specific thread context has been selected (i.e. does ‘k’ kill only that thread?).*

‘m *addr, length*’

Read *length* bytes of memory starting at address *addr*. Note that *addr* may not be aligned to any particular boundary.

The stub need not use any particular size or alignment when gathering data from memory for the response; even if *addr* is word-aligned and *length* is a multiple of the word size, the stub is free to use byte accesses, or not. For this reason, this packet may not be suitable for accessing memory-mapped I/O devices.

Reply:

‘*XX...*’ Memory contents; each byte is transmitted as a two-digit hexadecimal number. The reply may contain fewer bytes than requested if the server was able to read only part of the region of memory.

‘E *NN*’ *NN* is errno

‘M *addr, length:XX...*’

Write *length* bytes of memory starting at address *addr*. *XX...* is the data; each byte is transmitted as a two-digit hexadecimal number.

Reply:

‘OK’ for success

- ‘E *NN*’ for an error (this includes the case where only part of the data was written).
- ‘p *n*’ Read the value of register *n*; *n* is in hex. See [\(undefined\) \[read registers packet\], page \(undefined\)](#), for a description of how the returned register value is encoded.
Reply:
‘XX...’ the register’s value
‘E *NN*’ for an error
‘ ’ Indicating an unrecognized query.
- ‘P *n...=r...*’ Write register *n...* with value *r...*. The register number *n* is in hexadecimal, and *r...* contains two hex digits for each byte in the register (target byte order).
Reply:
‘OK’ for success
‘E *NN*’ for an error
- ‘q *name params...*’
‘Q *name params...*’
General query (‘q’) and set (‘Q’). These packets are described fully in [\(undefined\) \[General Query Packets\], page \(undefined\)](#).
- ‘r’ Reset the entire system.
Don’t use this packet; use the ‘R’ packet instead.
- ‘R *XX*’ Restart the program being debugged. *XX*, while needed, is ignored. This packet is only available in extended mode (see [\(undefined\) \[extended mode\], page \(undefined\)](#)).
The ‘R’ packet has no reply.
- ‘s [*addr*]’ Single step. *addr* is the address at which to resume. If *addr* is omitted, resume at same address.
Reply: See [\(undefined\) \[Stop Reply Packets\], page \(undefined\)](#), for the reply specifications.
- ‘S *sig[;addr]*’ Step with signal. This is analogous to the ‘C’ packet, but requests a single-step, rather than a normal resumption of execution.
Reply: See [\(undefined\) \[Stop Reply Packets\], page \(undefined\)](#), for the reply specifications.
- ‘t *addr:PP,MM*’ Search backwards starting at address *addr* for a match with pattern *PP* and mask *MM*. *PP* and *MM* are 4 bytes. *addr* must be at least 3 digits.
- ‘T *thread-id*’ Find out if the thread *thread-id* is alive. See [\(undefined\) \[thread-id syntax\], page \(undefined\)](#).
Reply:

- ‘OK’ thread is still alive
- ‘E *NN*’ thread is dead
- ‘v’ Packets starting with ‘v’ are identified by a multi-letter name, up to the first ‘;’ or ‘?’ (or the end of the packet).
- ‘vAttach;*pid*’
 - Attach to a new process with the specified process ID *pid*. The process ID is a hexadecimal integer identifying the process. In all-stop mode, all threads in the attached process are stopped; in non-stop mode, it may be attached without being stopped if that is supported by the target.
 - This packet is only available in extended mode (see [<undefined> \[extended mode\], page <undefined>](#)).
 - Reply:
 - ‘E *nn*’ for an error
 - ‘Any stop packet’
 - for success in all-stop mode (see [<undefined> \[Stop Reply Packets\], page <undefined>](#))
 - ‘OK’ for success in non-stop mode (see [<undefined> \[Remote Non-Stop\], page <undefined>](#))
- ‘vCont[;*action[:thread-id]]...*’
 - Resume the inferior, specifying different actions for each thread. If an action is specified with no *thread-id*, then it is applied to any threads that don’t have a specific action specified; if no default action is specified then other threads should remain stopped in all-stop mode and in their current state in non-stop mode. Specifying multiple default actions is an error; specifying no actions is also an error. Thread IDs are specified using the syntax described in [<undefined> \[thread-id syntax\], page <undefined>](#).
 - Currently supported actions are:
 - ‘c’ Continue.
 - ‘C *sig*’ Continue with signal *sig*. The signal *sig* should be two hex digits.
 - ‘s’ Step.
 - ‘S *sig*’ Step with signal *sig*. The signal *sig* should be two hex digits.
 - ‘t’ Stop.
 - The optional argument *addr* normally associated with the ‘c’, ‘C’, ‘s’, and ‘S’ packets is not supported in ‘vCont’.
 - The ‘t’ action is only relevant in non-stop mode (see [<undefined> \[Remote Non-Stop\], page <undefined>](#)) and may be ignored by the stub otherwise. A stop reply should be generated for any affected thread not already stopped. When a thread is stopped by means of a ‘t’ action, the corresponding stop reply should indicate that the thread has stopped with signal ‘0’, regardless of whether the target uses some other signal as an implementation detail.

Reply: See [\[Stop Reply Packets\]](#), page [\[undefined\]](#), for the reply specifications.

‘vCont?’ Request a list of actions supported by the ‘vCont’ packet.

Reply:

‘vCont[;action...]

The ‘vCont’ packet is supported. Each *action* is a supported command in the ‘vCont’ packet.

‘ The ‘vCont’ packet is not supported.

‘vFile:operation:parameter...’

Perform a file operation on the target system. For details, see [\[Host I/O Packets\]](#), page [\[undefined\]](#).

‘vFlashErase:addr,length’

Direct the stub to erase *length* bytes of flash starting at *addr*. The region may enclose any number of flash blocks, but its start and end must fall on block boundaries, as indicated by the flash block size appearing in the memory map (see [\[Memory Map Format\]](#), page [\[undefined\]](#)). GDB groups flash memory programming operations together, and sends a ‘vFlashDone’ request after each group; the stub is allowed to delay erase operation until the ‘vFlashDone’ packet is received.

The stub must support ‘vCont’ if it reports support for multiprocess extensions (see [\[multiprocess extensions\]](#), page [\[undefined\]](#)). Note that in this case ‘vCont’ actions can be specified to apply to all threads in a process by using the ‘*ppid*.-1’ form of the *thread-id*.

Reply:

‘OK’ for success

‘E *NN*’ for an error

‘vFlashWrite:addr:XX...’

Direct the stub to write data to flash address *addr*. The data is passed in binary form using the same encoding as for the ‘X’ packet (see [\[Binary Data\]](#), page [\[undefined\]](#)). The memory ranges specified by ‘vFlashWrite’ packets preceding a ‘vFlashDone’ packet must not overlap, and must appear in order of increasing addresses (although ‘vFlashErase’ packets for higher addresses may already have been received; the ordering is guaranteed only between ‘vFlashWrite’ packets). If a packet writes to an address that was neither erased by a preceding ‘vFlashErase’ packet nor by some other target-specific method, the results are unpredictable.

Reply:

‘OK’ for success

‘E.memtype’
for vFlashWrite addressing non-flash memory

‘E *NN*’ for an error

`'vFlashDone'`

Indicate to the stub that flash programming operation is finished. The stub is permitted to delay or batch the effects of a group of `'vFlashErase'` and `'vFlashWrite'` packets until a `'vFlashDone'` packet is received. The contents of the affected regions of flash memory are unpredictable until the `'vFlashDone'` request is completed.

`'vKill;pid'`

Kill the process with the specified process ID. *pid* is a hexadecimal integer identifying the process. This packet is used in preference to `'k'` when multiprocess protocol extensions are supported; see [\(undefined\) \[multiprocess extensions\]](#), page [\(undefined\)](#).

Reply:

`'E nn'` for an error

`'OK'` for success

`'vRun;filename[;argument]...'`

Run the program *filename*, passing it each *argument* on its command line. The file and arguments are hex-encoded strings. If *filename* is an empty string, the stub may use a default program (e.g. the last program run). The program is created in the stopped state.

This packet is only available in extended mode (see [\(undefined\) \[extended mode\]](#), page [\(undefined\)](#)).

Reply:

`'E nn'` for an error

`'Any stop packet'`

for success (see [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#))

`'vStopped'`

In non-stop mode (see [\(undefined\) \[Remote Non-Stop\]](#), page [\(undefined\)](#)), acknowledge a previous stop reply and prompt for the stub to report another one.

Reply:

`'Any stop packet'`

if there is another unreported stop event (see [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#))

`'OK'` if there are no unreported stop events

`'X addr,length:XX...'`

Write data to memory, where the data is transmitted in binary. *addr* is address, *length* is number of bytes, `'XX...'` is binary data (see [\(undefined\) \[Binary Data\]](#), page [\(undefined\)](#)).

Reply:

`'OK'` for success

`'E NN'` for an error

`'z type,addr,kind'`

`'Z type,addr,kind'`

Insert ('Z') or remove ('z') a type breakpoint or watchpoint starting at address *addr* of kind *kind*.

Each breakpoint and watchpoint packet *type* is documented separately.

Implementation notes: A remote target shall return an empty string for an unrecognized breakpoint or watchpoint packet type. A remote target shall support either both or neither of a given `'Ztype...'` and `'ztype...'` packet pair. To avoid potential problems with duplicate packets, the operations should be implemented in an idempotent way.

`'z0,addr,kind'`

`'Z0,addr,kind'`

Insert ('Z0') or remove ('z0') a memory breakpoint at address *addr* of type *kind*.

A memory breakpoint is implemented by replacing the instruction at *addr* with a software breakpoint or trap instruction. The *kind* is target-specific and typically indicates the size of the breakpoint in bytes that should be inserted. E.g., the ARM and MIPS can insert either a 2 or 4 byte breakpoint. Some architectures have additional meanings for *kind*; see [\(undefined\) \[Architecture-Specific Protocol Details\]](#), page [\(undefined\)](#).

Implementation note: It is possible for a target to copy or move code that contains memory breakpoints (e.g., when implementing overlays). The behavior of this packet, in the presence of such a target, is not defined.

Reply:

'OK'	success
'	not supported
'E <i>NN</i> '	for an error

`'z1,addr,kind'`

`'Z1,addr,kind'`

Insert ('Z1') or remove ('z1') a hardware breakpoint at address *addr*.

A hardware breakpoint is implemented using a mechanism that is not dependant on being able to modify the target's memory. *kind* has the same meaning as in 'Z0' packets.

Implementation note: A hardware breakpoint is not affected by code movement.

Reply:

'OK'	success
'	not supported
'E <i>NN</i> '	for an error

`'z2,addr,kind'`

`'Z2,addr,kind'`

Insert ('Z2') or remove ('z2') a write watchpoint at *addr*. *kind* is interpreted as the number of bytes to watch.

Reply:

‘OK’ success
 ‘’ not supported
 ‘E *NN*’ for an error

‘z3, *addr*, *kind*’

‘Z3, *addr*, *kind*’

Insert (‘Z3’) or remove (‘z3’) a read watchpoint at *addr*. *kind* is interpreted as the number of bytes to watch.

Reply:

‘OK’ success
 ‘’ not supported
 ‘E *NN*’ for an error

‘z4, *addr*, *kind*’

‘Z4, *addr*, *kind*’

Insert (‘Z4’) or remove (‘z4’) an access watchpoint at *addr*. *kind* is interpreted as the number of bytes to watch.

Reply:

‘OK’ success
 ‘’ not supported
 ‘E *NN*’ for an error

D.3 Stop Reply Packets

The ‘C’, ‘c’, ‘S’, ‘s’, ‘vCont’, ‘vAttach’, ‘vRun’, ‘vStopped’, and ‘?’ packets can receive any of the below as a reply. Except for ‘?’ and ‘vStopped’, that reply is only returned when the target halts. In the below the exact meaning of *signal number* is defined by the header ‘include/gdb/signals.h’ in the GDB source code.

As in the description of request packets, we include spaces in the reply templates for clarity; these are not part of the reply packet’s syntax. No GDB stop reply packet uses spaces to separate its components.

‘S *AA*’ The program received signal number *AA* (a two-digit hexadecimal number). This is equivalent to a ‘T’ response with no *n:r* pairs.

‘T *AA n1:r1;n2:r2;...*’

The program received signal number *AA* (a two-digit hexadecimal number). This is equivalent to an ‘S’ response, except that the ‘*n:r*’ pairs can carry values of important registers and other information directly in the stop reply packet, reducing round-trip latency. Single-step and breakpoint traps are reported this way. Each ‘*n:r*’ pair is interpreted as follows:

- If *n* is a hexadecimal number, it is a register number, and the corresponding *r* gives that register’s value. *r* is a series of bytes in target byte order, with each byte given by a two-digit hex number.

- If *n* is ‘thread’, then *r* is the *thread-id* of the stopped thread, as specified in [\(undefined\) \[thread-id syntax\]](#), page [\(undefined\)](#).
- If *n* is ‘core’, then *r* is the hexadecimal number of the core on which the stop event was detected.
- If *n* is a recognized *stop reason*, it describes a more specific event that stopped the target. The currently defined stop reasons are listed below. *aa* should be ‘05’, the trap signal. At most one stop reason should be present.
- Otherwise, GDB should ignore this ‘*n*:*r*’ pair and go on to the next; this allows us to extend the protocol in the future.

The currently defined stop reasons are:

- ‘watch’
‘rwatch’
‘awatch’ The packet indicates a watchpoint hit, and *r* is the data address, in hex.
- ‘library’ The packet indicates that the loaded libraries have changed. GDB should use ‘qXfer:libraries:read’ to fetch a new list of loaded libraries. *r* is ignored.
- ‘replaylog’
The packet indicates that the target cannot continue replaying logged execution events, because it has reached the end (or the beginning when executing backward) of the log. The value of *r* will be either ‘begin’ or ‘end’. See [\(undefined\) \[Reverse Execution\]](#), page [\(undefined\)](#), for more information.

‘W AA’

‘W AA ; process:pid’

The process exited, and *AA* is the exit status. This is only applicable to certain targets.

The second form of the response, including the process ID of the exited process, can be used only when GDB has reported support for multiprocess protocol extensions; see [\(undefined\) \[multiprocess extensions\]](#), page [\(undefined\)](#). The *pid* is formatted as a big-endian hex string.

‘X AA’

‘X AA ; process:pid’

The process terminated with signal *AA*.

The second form of the response, including the process ID of the terminated process, can be used only when GDB has reported support for multiprocess protocol extensions; see [\(undefined\) \[multiprocess extensions\]](#), page [\(undefined\)](#). The *pid* is formatted as a big-endian hex string.

‘O XX...’ ‘XX...’ is hex encoding of ASCII data, to be written as the program’s console output. This can happen at any time while the program is running and the debugger should continue to wait for ‘W’, ‘T’, etc. This reply is not permitted in non-stop mode.

`'F call-id,parameter...'`

call-id is the identifier which says which host system call should be called. This is just the name of the function. Translation into the correct system call is only applicable as it's defined in GDB. See [\[File-I/O Remote Protocol Extension\]](#), page [\(undefined\)](#), for a list of implemented system calls.

`'parameter...'` is a list of parameters as defined for this very system call.

The target replies with this packet when it expects GDB to call a host system call on behalf of the target. GDB replies with an appropriate 'F' packet and keeps up waiting for the next reply packet from the target. The latest 'C', 'c', 'S' or 's' action is expected to be continued. See [\[File-I/O Remote Protocol Extension\]](#), page [\(undefined\)](#), for more details.

D.4 General Query Packets

Packets starting with 'q' are *general query packets*; packets starting with 'Q' are *general set packets*. General query and set packets are a semi-unified form for retrieving and sending information to and from the stub.

The initial letter of a query or set packet is followed by a name indicating what sort of thing the packet applies to. For example, GDB may use a 'qSymbol' packet to exchange symbol definitions with the stub. These packet names follow some conventions:

- The name must not contain commas, colons or semicolons.
- Most GDB query and set packets have a leading upper case letter.
- The names of custom vendor packets should use a company prefix, in lower case, followed by a period. For example, packets designed at the Acme Corporation might begin with 'qacme.foo' (for querying foos) or 'Qacme.bar' (for setting bars).

The name of a query or set packet should be separated from any parameters by a ':'; the parameters themselves should be separated by ',' or ';' . Stubs must be careful to match the full packet name, and check for a separator or the end of the packet, in case two packet names share a common prefix. New packets should not begin with 'qC', 'qP', or 'qL'¹.

Like the descriptions of the other packets, each description here has a template showing the packet's overall syntax, followed by an explanation of the packet's meaning. We include spaces in some of the templates for clarity; these are not part of the packet's syntax. No GDB packet uses spaces to separate its components.

Here are the currently defined query and set packets:

`'QAllow:op:val...'`

Specify which operations GDB expects to request of the target, as a semicolon-separated list of operation name and value pairs. Possible values for *op* include 'WriteReg', 'WriteMem', 'InsertBreak', 'InsertTrace', 'InsertFastTrace', and 'Stop'. *val* is either 0, indicating that GDB will not request the operation, or 1, indicating that it may. (The target can then use this to set up its

¹ The 'qP' and 'qL' packets predate these conventions, and have arguments without any terminator for the packet name; we suspect they are in widespread use in places that are difficult to upgrade. The 'qC' packet has no arguments, but some existing stubs (e.g. RedBoot) are known to not check for the end of the packet.

own internals optimally, for instance if the debugger never expects to insert breakpoints, it may not need to install its own trap handler.)

‘qC’

Return the current thread ID.

Reply:

‘qC *thread-id*’

Where *thread-id* is a thread ID as documented in [\(undefined\) \[thread-id syntax\], page \(undefined\)](#).

‘(anything else)’

Any other reply implies the old thread ID.

‘qCRC: *addr, length*’

Compute the CRC checksum of a block of memory using CRC-32 defined in IEEE 802.3. The CRC is computed byte at a time, taking the most significant bit of each byte first. The initial pattern code 0xffffffff is used to ensure leading zeros affect the CRC.

Note: This is the same CRC used in validating separate debug files (see [\(undefined\) \[Debugging Information in Separate Files\], page \(undefined\)](#)). However the algorithm is slightly different. When validating separate debug files, the CRC is computed taking the *least* significant bit of each byte first, and the final result is inverted to detect trailing zeros.

Reply:

‘E *MM*’ An error (such as memory fault)

‘C *crc32*’ The specified memory region’s checksum is *crc32*.

‘qfThreadInfo’

‘qsThreadInfo’

Obtain a list of all active thread IDs from the target (OS). Since there may be too many active threads to fit into one reply packet, this query works iteratively: it may require more than one query/reply sequence to obtain the entire list of threads. The first query of the sequence will be the ‘qfThreadInfo’ query; subsequent queries in the sequence will be the ‘qsThreadInfo’ query.

NOTE: This packet replaces the ‘qL’ query (see below).

Reply:

‘m *thread-id*’

A single thread ID

‘m *thread-id, thread-id...*’

a comma-separated list of thread IDs

‘l’

(lower case letter ‘L’) denotes end of list.

In response to each query, the target will reply with a list of one or more thread IDs, separated by commas. GDB will respond to each reply with a request for more thread ids (using the ‘qs’ form of the query), until the target responds with ‘l’ (lower-case ell, for *last*). Refer to [\(undefined\) \[thread-id syntax\], page \(undefined\)](#), for the format of the *thread-id* fields.

`'qGetTLSAddr:thread-id,offset,lm'`

Fetch the address associated with thread local storage specified by *thread-id*, *offset*, and *lm*.

thread-id is the thread ID associated with the thread for which to fetch the TLS address. See [\(undefined\) \[thread-id syntax\]](#), page [\(undefined\)](#).

offset is the (big endian, hex encoded) offset associated with the thread local variable. (This offset is obtained from the debug information associated with the variable.)

lm is the (big endian, hex encoded) OS/ABI-specific encoding of the the load module associated with the thread local storage. For example, a GNU/Linux system will pass the link map address of the shared object associated with the thread local storage under consideration. Other operating environments may choose to represent the load module differently, so the precise meaning of this parameter will vary.

Reply:

`'XX...'` Hex encoded (big endian) bytes representing the address of the thread local storage requested.

`'E nn'` An error occurred. *nn* are hex digits.

`''` An empty reply indicates that `'qGetTLSAddr'` is not supported by the stub.

`'qGetTIBAddr:thread-id'`

Fetch address of the Windows OS specific Thread Information Block.

thread-id is the thread ID associated with the thread.

Reply:

`'XX...'` Hex encoded (big endian) bytes representing the linear address of the thread information block.

`'E nn'` An error occurred. This means that either the thread was not found, or the address could not be retrieved.

`''` An empty reply indicates that `'qGetTIBAddr'` is not supported by the stub.

`'qL startflag threadcount nextthread'`

Obtain thread information from RTOS. Where: *startflag* (one hex digit) is one to indicate the first query and zero to indicate a subsequent query; *threadcount* (two hex digits) is the maximum number of threads the response packet can contain; and *nextthread* (eight hex digits), for subsequent queries (*startflag* is zero), is returned in the response as *argthread*.

Don't use this packet; use the `'qfThreadInfo'` query instead (see above).

Reply:

`'qM count done argthread thread...'`

Where: *count* (two hex digits) is the number of threads being returned; *done* (one hex digit) is zero to indicate more threads

and one indicates no further threads; *argthreadid* (eight hex digits) is *nextthread* from the request packet; *thread...* is a sequence of thread IDs from the target. *threadid* (eight hex digits). See `remote.c:parse_threadlist_response()`.

‘qOffsets’

Get section offsets that the target used when relocating the downloaded image.

Reply:

‘Text=xxx;Data=yyy[;Bss=zzz]’

Relocate the **Text** section by *xxx* from its original address. Relocate the **Data** section by *yyy* from its original address. If the object file format provides segment information (e.g. ELF ‘PT_LOAD’ program headers), GDB will relocate entire segments by the supplied offsets.

Note: while a Bss offset may be included in the response, GDB ignores this and instead applies the Data offset to the Bss section.

‘TextSeg=xxx[;DataSeg=yyy]’

Relocate the first segment of the object file, which conventionally contains program code, to a starting address of *xxx*. If ‘DataSeg’ is specified, relocate the second segment, which conventionally contains modifiable data, to a starting address of *yyy*. GDB will report an error if the object file does not contain segment information, or does not contain at least as many segments as mentioned in the reply. Extra segments are kept at fixed offsets relative to the last relocated segment.

‘qP mode thread-id’

Returns information on *thread-id*. Where: *mode* is a hex encoded 32 bit mode; *thread-id* is a thread ID (see [\(undefined\) \[thread-id syntax\], page \(undefined\)](#)).

Don’t use this packet; use the ‘qThreadExtraInfo’ query instead (see below).

Reply: see `remote.c:remote_unpack_thread_info_response()`.

‘QNonStop:1’

‘QNonStop:0’

Enter non-stop (‘QNonStop:1’) or all-stop (‘QNonStop:0’) mode. See [\(undefined\) \[Remote Non-Stop\], page \(undefined\)](#), for more information.

Reply:

‘OK’ The request succeeded.

‘E nn’ An error occurred. *nn* are hex digits.

‘’ An empty reply indicates that ‘QNonStop’ is not supported by the stub.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)). Use of this packet is controlled by the `set non-stop` command; see [\(undefined\) \[Non-Stop Mode\], page \(undefined\)](#).

‘QPassSignals: *signal* [*;signal*]. . .’

Each listed *signal* should be passed directly to the inferior process. Signals are numbered identically to continue packets and stop replies (see [\(undefined\) \[Stop Reply Packets\]](#), page [\(undefined\)](#)). Each *signal* list item should be strictly greater than the previous item. These signals do not need to stop the inferior, or be reported to GDB. All other signals should be reported to GDB. Multiple ‘QPassSignals’ packets do not combine; any earlier ‘QPassSignals’ list is completely replaced by the new list. This packet improves performance when using ‘handle *signal* nostop noprint pass’.

Reply:

‘OK’ The request succeeded.

‘E *nn*’ An error occurred. *nn* are hex digits.

‘’ An empty reply indicates that ‘QPassSignals’ is not supported by the stub.

Use of this packet is controlled by the `set remote pass-signals` command (see [\(undefined\) \[Remote Configuration\]](#), page [\(undefined\)](#)). This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [\(undefined\) \[qSupported\]](#), page [\(undefined\)](#)).

‘qRcmd, *command*’

command (hex encoded) is passed to the local interpreter for execution. Invalid commands should be reported using the output string. Before the final result packet, the target may also respond with a number of intermediate ‘Ooutput’ console output packets. *Implementors should note that providing access to a stubs’s interpreter may have security implications.*

Reply:

‘OK’ A command response with no output.

‘OUTPUT’ A command response with the hex encoded output string *OUTPUT*.

‘E *NN*’ Indicate a badly formed request.

‘’ An empty reply indicates that ‘qRcmd’ is not recognized.

(Note that the qRcmd packet’s name is separated from the command by a ‘,’ , not a ‘:’, contrary to the naming conventions above. Please don’t use this packet as a model for new packets.)

‘qSearch:memory: *address* ; *length* ; *search-pattern*’

Search *length* bytes at *address* for *search-pattern*. *address* and *length* are encoded in hex. *search-pattern* is a sequence of bytes, hex encoded.

Reply:

‘0’ The pattern was not found.

‘1, *address*’ The pattern was found at *address*.

‘E *NN*’ A badly formed request or an error was encountered while searching memory.

‘ ’ An empty reply indicates that ‘qSearch:memory’ is not recognized.

‘QStartNoAckMode’

Request that the remote stub disable the normal ‘+’/‘-’ protocol acknowledgments (see [<undefined> \[Packet Acknowledgment\]](#), page [<undefined>](#)).

Reply:

‘OK’ The stub has switched to no-acknowledgment mode. GDB acknowledges this response, but neither the stub nor GDB shall send or expect further ‘+’/‘-’ acknowledgments in the current connection.

‘ ’ An empty reply indicates that the stub does not support no-acknowledgment mode.

‘qSupported [*:gdbfeature* [*;*gdbfeature**]. . .]’

Tell the remote stub about features supported by GDB, and query the stub for features it supports. This packet allows GDB and the remote stub to take advantage of each others’ features. ‘qSupported’ also consolidates multiple feature probes at startup, to improve GDB performance—a single larger packet performs better than multiple smaller probe packets on high-latency links. Some features may enable behavior which must not be on by default, e.g. because it would confuse older clients or stubs. Other features may describe packets which could be automatically probed for, but are not. These features must be reported before GDB will use them. This “default unsupported” behavior is not appropriate for all packets, but it helps to keep the initial connection time under control with new versions of GDB which support increasing numbers of packets.

Reply:

‘*stubfeature* [*;*stubfeature**]. . . ’

The stub supports or does not support each returned *stubfeature*, depending on the form of each *stubfeature* (see below for the possible forms).

‘ ’ An empty reply indicates that ‘qSupported’ is not recognized, or that no features needed to be reported to GDB.

The allowed forms for each feature (either a *gdbfeature* in the ‘qSupported’ packet, or a *stubfeature* in the response) are:

‘*name=value*’

The remote protocol feature *name* is supported, and associated with the specified *value*. The format of *value* depends on the feature, but it must not include a semicolon.

‘*name+*’

The remote protocol feature *name* is supported, and does not need an associated value.

‘*name-*’

The remote protocol feature *name* is not supported.

‘*name?*’ The remote protocol feature *name* may be supported, and GDB should auto-detect support in some other way when it is needed. This form will not be used for *gdbfeature* notifications, but may be used for *stubfeature* responses.

Whenever the stub receives a ‘qSupported’ request, the supplied set of GDB features should override any previous request. This allows GDB to put the stub in a known state, even if the stub had previously been communicating with a different version of GDB.

The following values of *gdbfeature* (for the packet sent by GDB) are defined:

‘multiprocess’

This feature indicates whether GDB supports multiprocess extensions to the remote protocol. GDB does not use such extensions unless the stub also reports that it supports them by including ‘multiprocess+’ in its ‘qSupported’ reply. See [\[multiprocess extensions\]](#), page [\[undefined\]](#), for details.

‘xmlRegisters’

This feature indicates that GDB supports the XML target description. If the stub sees ‘xmlRegisters=’ with target specific strings separated by a comma, it will report register description.

‘qRelocInsn’

This feature indicates whether GDB supports the ‘qRelocInsn’ packet (see [\[Relocate instruction reply packet\]](#), page [\[undefined\]](#)).

Stubs should ignore any unknown values for *gdbfeature*. Any GDB which sends a ‘qSupported’ packet supports receiving packets of unlimited length (earlier versions of GDB may reject overly long responses). Additional values for *gdbfeature* may be defined in the future to let the stub take advantage of new features in GDB, e.g. incompatible improvements in the remote protocol—the ‘multiprocess’ feature is an example of such a feature. The stub’s reply should be independent of the *gdbfeature* entries sent by GDB; first GDB describes all the features it supports, and then the stub replies with all the features it supports. Similarly, GDB will silently ignore unrecognized stub feature responses, as long as each response uses one of the standard forms.

Some features are flags. A stub which supports a flag feature should respond with a ‘+’ form response. Other features require values, and the stub should respond with an ‘=’ form response.

Each feature has a default value, which GDB will use if ‘qSupported’ is not available or if the feature is not mentioned in the ‘qSupported’ response. The default values are fixed; a stub is free to omit any feature responses that match the defaults.

Not all features can be probed, but for those which can, the probing mechanism is useful: in some cases, a stub’s internal architecture may not allow the protocol layer to know some information about the underlying target in advance. This is especially common in stubs which may be configured for multiple targets.

These are the currently defined stub features and their properties:

Feature Name	Value Required	Default	Probe Allowed
'PacketSize'	Yes	'-'	No
'qXfer:auxv:read'	No	'-'	Yes
'qXfer:features:read'	No	'-'	Yes
'qXfer:libraries:read'	No	'-'	Yes
'qXfer:memory-map:read'	No	'-'	Yes
'qXfer:sdata:read'	No	'-'	Yes
'qXfer:spu:read'	No	'-'	Yes
'qXfer:spu:write'	No	'-'	Yes
'qXfer:signinfo:read'	No	'-'	Yes
'qXfer:signinfo:write'	No	'-'	Yes
'qXfer:threads:read'	No	'-'	Yes
'QNonStop'	No	'-'	Yes
'QPassSignals'	No	'-'	Yes
'QStartNoAckMode'	No	'-'	Yes
'multiprocess'	No	'-'	No
'ConditionalTracepoints'	No	'-'	No
'ReverseContinue'	No	'-'	No
'ReverseStep'	No	'-'	No
'TracepointSource'	No	'-'	No
'QAllow'	No	'-'	No

These are the currently defined stub features, in more detail:

`'PacketSize=bytes'`

The remote stub can accept packets up to at least *bytes* in length. GDB will send packets up to this size for bulk transfers, and will never send larger packets. This is a limit on the data characters in the packet, including the frame and checksum. There is no trailing NUL byte in a remote protocol packet; if the stub stores packets in a NUL-terminated format, it should allow an extra byte in its buffer for the NUL. If this stub feature is not supported, GDB guesses based on the size of the 'g' packet response.

`'qXfer:auxv:read'`

The remote stub understands the 'qXfer:auxv:read' packet (see [\(undefined\) \[qXfer auxiliary vector read\]](#), page [\(undefined\)](#)).

`'qXfer:features:read'`

The remote stub understands the 'qXfer:features:read' packet (see [\(undefined\) \[qXfer target description read\]](#), page [\(undefined\)](#)).

`'qXfer:libraries:read'`

The remote stub understands the 'qXfer:libraries:read' packet (see [\(undefined\) \[qXfer library list read\]](#), page [\(undefined\)](#)).

`'qXfer:memory-map:read'`

The remote stub understands the 'qXfer:memory-map:read' packet (see [\(undefined\) \[qXfer memory map read\]](#), page [\(undefined\)](#)).

`'qXfer:sdata:read'`

The remote stub understands the 'qXfer:sdata:read' packet (see [\(undefined\) \[qXfer sdata read\]](#), page [\(undefined\)](#)).

`'qXfer:spu:read'`

The remote stub understands the 'qXfer:spu:read' packet (see [\(undefined\) \[qXfer spu read\]](#), page [\(undefined\)](#)).

`'qXfer:spu:write'`

The remote stub understands the 'qXfer:spu:write' packet (see [\(undefined\) \[qXfer spu write\]](#), page [\(undefined\)](#)).

`'qXfer:signinfo:read'`

The remote stub understands the 'qXfer:signinfo:read' packet (see [\(undefined\) \[qXfer signinfo read\]](#), page [\(undefined\)](#)).

`'qXfer:signinfo:write'`

The remote stub understands the 'qXfer:signinfo:write' packet (see [\(undefined\) \[qXfer signinfo write\]](#), page [\(undefined\)](#)).

`'qXfer:threads:read'`

The remote stub understands the 'qXfer:threads:read' packet (see [\(undefined\) \[qXfer threads read\]](#), page [\(undefined\)](#)).

`'QNonStop'`

The remote stub understands the 'QNonStop' packet (see [\(undefined\) \[QNonStop\]](#), page [\(undefined\)](#)).

`'QPassSignals'`

The remote stub understands the `'QPassSignals'` packet (see [\(undefined\) \[QPassSignals\], page \(undefined\)](#)).

`'QStartNoAckMode'`

The remote stub understands the `'QStartNoAckMode'` packet and prefers to operate in no-acknowledgment mode. See [\(undefined\) \[Packet Acknowledgment\], page \(undefined\)](#).

`'multiprocess'`

The remote stub understands the multiprocess extensions to the remote protocol syntax. The multiprocess extensions affect the syntax of thread IDs in both packets and replies (see [\(undefined\) \[thread-id syntax\], page \(undefined\)](#)), and add process IDs to the `'D'` packet and `'W'` and `'X'` replies. Note that reporting this feature indicates support for the syntactic extensions only, not that the stub necessarily supports debugging of more than one process at a time. The stub must not use multiprocess extensions in packet replies unless GDB has also indicated it supports them in its `'qSupported'` request.

`'qXfer:osdata:read'`

The remote stub understands the `'qXfer:osdata:read'` packet ((see [\(undefined\) \[qXfer osdata read\], page \(undefined\)](#))).

`'ConditionalTracepoints'`

The remote stub accepts and implements conditional expressions defined for tracepoints (see [\(undefined\) \[Tracepoint Conditions\], page \(undefined\)](#)).

`'ReverseContinue'`

The remote stub accepts and implements the reverse continue packet (see [\(undefined\) \[bc\], page \(undefined\)](#)).

`'ReverseStep'`

The remote stub accepts and implements the reverse step packet (see [\(undefined\) \[bs\], page \(undefined\)](#)).

`'TracepointSource'`

The remote stub understands the `'QTDPsrc'` packet that supplies the source form of tracepoint definitions.

`'QAllow'` The remote stub understands the `'QAllow'` packet.

`'StaticTracepoint'`

The remote stub supports static tracepoints.

`'qSymbol::'`

Notify the target that GDB is prepared to serve symbol lookup requests. Accept requests from the target for the values of symbols.

Reply:

`'OK'` The target does not need to look up any (more) symbols.

`'qSymbol:sym_name'`

The target requests the value of symbol *sym_name* (hex encoded). GDB may provide the value by using the `'qSymbol:sym_value:sym_name'` message, described below.

`'qSymbol:sym_value:sym_name'`

Set the value of *sym_name* to *sym_value*.

sym_name (hex encoded) is the name of a symbol whose value the target has previously requested.

sym_value (hex) is the value for symbol *sym_name*. If GDB cannot supply a value for *sym_name*, then this field will be empty.

Reply:

`'OK'` The target does not need to look up any (more) symbols.

`'qSymbol:sym_name'`

The target requests the value of a new symbol *sym_name* (hex encoded). GDB will continue to supply the values of symbols (if available), until the target ceases to request them.

`'qTBuffer'`

`'QTBuffer'`

`'QTDisconnected'`

`'QTDP'`

`'QTDPsrc'`

`'QTDV'`

`'qTfP'`

`'qTfV'`

`'QTFrame'` See [\(undefined\) \[Tracepoint Packets\], page \(undefined\)](#).

`'qThreadExtraInfo,thread-id'`

Obtain a printable string description of a thread's attributes from the target OS. *thread-id* is a thread ID; see [\(undefined\) \[thread-id syntax\], page \(undefined\)](#). This string may contain anything that the target OS thinks is interesting for GDB to tell the user about the thread. The string is displayed in GDB's `info threads` display. Some examples of possible thread extra info strings are `'Runnable'`, or `'Blocked on Mutex'`.

Reply:

`'XX...'` Where `'XX...'` is a hex encoding of ASCII data, comprising the printable string containing the extra information about the thread's attributes.

(Note that the `qThreadExtraInfo` packet's name is separated from the command by a `','`, not a `':'`, contrary to the naming conventions above. Please don't use this packet as a model for new packets.)

`'QTSave'`

`'qTsP'`

‘qTsV’
 ‘QTStart’
 ‘QTStop’
 ‘QTinit’
 ‘QTro’
 ‘QTstatus’
 ‘qTV’
 ‘qTfSTM’
 ‘qTsSTM’
 ‘qTSTMat’ See [\(undefined\)](#) [Tracepoint Packets], page [\(undefined\)](#).

‘qXfer:object:read:annex:offset,length’

Read uninterpreted bytes from the target’s special data area identified by the keyword *object*. Request *length* bytes starting at *offset* bytes into the data. The content and encoding of *annex* is specific to *object*; it can supply additional details about what data to access.

Here are the specific requests of this form defined so far. All ‘qXfer:object:read:...’ requests use the same reply formats, listed below.

‘qXfer:auxv:read::offset,length’

Access the target’s *auxiliary vector*. See [\(undefined\)](#) [OS Information], page [\(undefined\)](#). Note *annex* must be empty.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [\(undefined\)](#) [qSupported], page [\(undefined\)](#)).

‘qXfer:features:read:annex:offset,length’

Access the *target description*. See [\(undefined\)](#) [Target Descriptions], page [\(undefined\)](#). The annex specifies which XML document to access. The main description is always loaded from the ‘target.xml’ annex.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [\(undefined\)](#) [qSupported], page [\(undefined\)](#)).

‘qXfer:libraries:read:annex:offset,length’

Access the target’s list of loaded libraries. See [\(undefined\)](#) [Library List Format], page [\(undefined\)](#). The annex part of the generic ‘qXfer’ packet must be empty (see [\(undefined\)](#) [qXfer read], page [\(undefined\)](#)).

Targets which maintain a list of libraries in the program’s memory do not need to implement this packet; it is designed for platforms where the operating system manages the list of loaded libraries.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [\(undefined\)](#) [qSupported], page [\(undefined\)](#)).

`'qXfer:memory-map:read::offset,length'`

Access the target's *memory-map*. See [\(undefined\) \[Memory Map Format\], page \(undefined\)](#). The annex part of the generic `'qXfer'` packet must be empty (see [\(undefined\) \[qXfer read\], page \(undefined\)](#)).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `'qSupported'` response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

`'qXfer:sdata:read::offset,length'`

Read contents of the extra collected static tracepoint marker information. The annex part of the generic `'qXfer'` packet must be empty (see [\(undefined\) \[qXfer read\], page \(undefined\)](#)). See [\(undefined\) \[Tracepoint Action Lists\], page \(undefined\)](#).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `'qSupported'` response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

`'qXfer:siginfo:read::offset,length'`

Read contents of the extra signal information on the target system. The annex part of the generic `'qXfer'` packet must be empty (see [\(undefined\) \[qXfer read\], page \(undefined\)](#)).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `'qSupported'` response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

`'qXfer:spu:read:annex:offset,length'`

Read contents of an `spufs` file on the target system. The annex specifies which file to read; it must be of the form `'id/name'`, where `id` specifies an SPU context ID in the target process, and `name` identifies the `spufs` file in that context to be accessed.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `'qSupported'` response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

`'qXfer:threads:read::offset,length'`

Access the list of threads on target. See [\(undefined\) \[Thread List Format\], page \(undefined\)](#). The annex part of the generic `'qXfer'` packet must be empty (see [\(undefined\) \[qXfer read\], page \(undefined\)](#)).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `'qSupported'` response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

`'qXfer:osdata:read::offset,length'`

Access the target's *operating system information*. See [\(undefined\) \[Operating System Information\], page \(undefined\)](#).

Reply:

- 'm *data*' Data *data* (see [\(undefined\) \[Binary Data\], page \(undefined\)](#)) has been read from the target. There may be more data at a higher address (although it is permitted to return 'm' even for the last valid block of data, as long as at least one byte of data was read). *data* may have fewer bytes than the *length* in the request.
- 'l *data*' Data *data* (see [\(undefined\) \[Binary Data\], page \(undefined\)](#)) has been read from the target. There is no more data to be read. *data* may have fewer bytes than the *length* in the request.
- 'l' The *offset* in the request is at the end of the data. There is no more data to be read.
- 'E00' The request was malformed, or *annex* was invalid.
- 'E *nn*' The offset was invalid, or there was an error encountered reading the data. *nn* is a hex-encoded `errno` value.
- ' ' An empty reply indicates the *object* string was not recognized by the stub, or that the object does not support reading.

'qXfer:object:write:annex:offset:data...'

Write uninterpreted bytes into the target's special data area identified by the keyword *object*, starting at *offset* bytes into the data. *data...* is the binary-encoded data (see [\(undefined\) \[Binary Data\], page \(undefined\)](#)) to be written. The content and encoding of *annex* is specific to *object*; it can supply additional details about what data to access.

Here are the specific requests of this form defined so far. All 'qXfer:object:write:...' requests use the same reply formats, listed below.

'qXfer:signfo:write::offset:data...'

Write *data* to the extra signal information on the target system. The annex part of the generic 'qXfer' packet must be empty (see [\(undefined\) \[qXfer write\], page \(undefined\)](#)).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate 'qSupported' response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

'qXfer:spu:write:annex:offset:data...'

Write *data* to an `spufs` file on the target system. The annex specifies which file to write; it must be of the form '*id/name*', where *id* specifies an SPU context ID in the target process, and *name* identifies the `spufs` file in that context to be accessed.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate 'qSupported' response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

Reply:

- '*nn*' *nn* (hex encoded) is the number of bytes written. This may be fewer bytes than supplied in the request.
- 'E00' The request was malformed, or *annex* was invalid.

‘E *nn*’ The offset was invalid, or there was an error encountered writing the data. *nn* is a hex-encoded `errno` value.

‘’ An empty reply indicates the *object* string was not recognized by the stub, or that the object does not support writing.

‘qXfer:object:operation:...’

Requests of this form may be added in the future. When a stub does not recognize the *object* keyword, or its support for *object* does not recognize the *operation* keyword, the stub must respond with an empty packet.

‘qAttached:pid’

Return an indication of whether the remote server attached to an existing process or created a new process. When the multiprocess protocol extensions are supported (see [\(undefined\) \[multiprocess extensions\], page \(undefined\)](#)), *pid* is an integer in hexadecimal format identifying the target process. Otherwise, GDB will omit the *pid* field and the query packet will be simplified as ‘qAttached’.

This query is used, for example, to know whether the remote process should be detached or killed when a GDB session is ended with the `quit` command.

Reply:

‘1’ The remote server attached to an existing process.

‘0’ The remote server created a new process.

‘E *NN*’ A badly formed request or an error was encountered.

D.5 Architecture-Specific Protocol Details

This section describes how the remote protocol is applied to specific target architectures. Also see [\(undefined\) \[Standard Target Features\], page \(undefined\)](#), for details of XML target descriptions for each architecture.

D.5.1 ARM

D.5.1.1 Breakpoint Kinds

These breakpoint kinds are defined for the ‘Z0’ and ‘Z1’ packets.

- 2 16-bit Thumb mode breakpoint.
- 3 32-bit Thumb mode (Thumb-2) breakpoint.
- 4 32-bit ARM mode breakpoint.

D.5.2 MIPS

D.5.2.1 Register Packet Format

The following `g/G` packets have previously been defined. In the below, some thirty-two bit registers are transferred as sixty-four bits. Those registers should be zero/sign extended (which?) to fill the space allocated. Register bytes are transferred in target byte order. The two nibbles within a register byte are transferred most-significant - least-significant.

MIPS32

All registers are transferred as thirty-two bit quantities in the order: 32 general-purpose; sr; lo; hi; bad; cause; pc; 32 floating-point registers; fsr; fir; fp.

MIPS64

All registers are transferred as sixty-four bit quantities (including thirty-two bit registers such as `sr`). The ordering is the same as MIPS32.

D.6 Tracepoint Packets

Here we describe the packets GDB uses to implement tracepoints (see [\(undefined\)](#) [Tracepoints], page [\(undefined\)](#)).

`'QTDP:n:addr:ena:step:pass[:Fflen][:Xlen,bytes][-]'`

Create a new tracepoint, number *n*, at *addr*. If *ena* is 'E', then the tracepoint is enabled; if it is 'D', then the tracepoint is disabled. *step* is the tracepoint's step count, and *pass* is its pass count. If an 'F' is present, then the tracepoint is to be a fast tracepoint, and the *flen* is the number of bytes that the target should copy elsewhere to make room for the tracepoint. If an 'X' is present, it introduces a tracepoint condition, which consists of a hexadecimal length, followed by a comma and hex-encoded bytes, in a manner similar to action encodings as described below. If the trailing '-' is present, further 'QTDP' packets will follow to specify this tracepoint's actions.

Replies:

'OK' The packet was understood and carried out.

'qRelocInsn'

See [\(undefined\)](#) [Relocate instruction reply packet], page [\(undefined\)](#).

" The packet was not recognized.

`'QTDP:-n:addr:[S]action...[-]'`

Define actions to be taken when a tracepoint is hit. *n* and *addr* must be the same as in the initial 'QTDP' packet for this tracepoint. This packet may only be sent immediately after another 'QTDP' packet that ended with a '-'. If the trailing '-' is present, further 'QTDP' packets will follow, specifying more actions for this tracepoint.

In the series of action packets for a given tracepoint, at most one can have an 'S' before its first *action*. If such a packet is sent, it and the following packets define "while-stepping" actions. Any prior packets define ordinary actions — that is, those taken when the tracepoint is first hit. If no action packet has an 'S', then all the packets in the series specify ordinary tracepoint actions.

The '*action...*' portion of the packet is a series of actions, concatenated without separators. Each action has one of the following forms:

'R *mask*' Collect the registers whose bits are set in *mask*. *mask* is a hexadecimal number whose *i*'th bit is set if register number *i* should be collected. (The least significant bit is numbered zero.) Note that

mask may be any number of digits long; it may not fit in a 32-bit word.

‘M *basereg*, *offset*, *len*’

Collect *len* bytes of memory starting at the address in register number *basereg*, plus *offset*. If *basereg* is ‘-1’, then the range has a fixed address: *offset* is the address of the lowest byte to collect. The *basereg*, *offset*, and *len* parameters are all unsigned hexadecimal values (the ‘-1’ value for *basereg* is a special case).

‘X *len*, *expr*’

Evaluate *expr*, whose length is *len*, and collect memory as it directs. *expr* is an agent expression, as described in [\(undefined\)](#) [Agent Expressions], page [\(undefined\)](#). Each byte of the expression is encoded as a two-digit hex number in the packet; *len* is the number of bytes in the expression (and thus one-half the number of hex digits in the packet).

Any number of actions may be packed together in a single ‘QTDP’ packet, as long as the packet does not exceed the maximum packet length (400 bytes, for many stubs). There may be only one ‘R’ action per tracepoint, and it must precede any ‘M’ or ‘X’ actions. Any registers referred to by ‘M’ and ‘X’ actions must be collected by a preceding ‘R’ action. (The “while-stepping” actions are treated as if they were attached to a separate tracepoint, as far as these restrictions are concerned.)

Replies:

‘OK’ The packet was understood and carried out.

‘qRelocInsn’

See [\(undefined\)](#) [Relocate instruction reply packet], page [\(undefined\)](#).

‘’ The packet was not recognized.

‘QTDPsrc:n:addr:type:start:slen:bytes’

Specify a source string of tracepoint *n* at address *addr*. This is useful to get accurate reproduction of the tracepoints originally downloaded at the beginning of the trace run. *type* is the name of the tracepoint part, such as ‘cond’ for the tracepoint’s conditional expression (see below for a list of types), while *bytes* is the string, encoded in hexadecimal.

start is the offset of the *bytes* within the overall source string, while *slen* is the total length of the source string. This is intended for handling source strings that are longer than will fit in a single packet.

The available string types are ‘at’ for the location, ‘cond’ for the conditional, and ‘cmd’ for an action command. GDB sends a separate packet for each command in the action list, in the same order in which the commands are stored in the list.

The target does not need to do anything with source strings except report them back as part of the replies to the ‘qTfP’/‘qTsP’ query packets.

Although this packet is optional, and GDB will only send it if the target replies with ‘TracepointSource’ See [\(undefined\) \[General Query Packets\]](#), page [\(undefined\)](#), it makes both disconnected tracing and trace files much easier to use. Otherwise the user must be careful that the tracepoints in effect while looking at trace frames are identical to the ones in effect during the trace run; even a small discrepancy could cause ‘tdump’ not to work, or a particular trace frame not be found.

‘QTDV:*n*:*value*’

Create a new trace state variable, number *n*, with an initial value of *value*, which is a 64-bit signed integer. Both *n* and *value* are encoded as hexadecimal values. GDB has the option of not using this packet for initial values of zero; the target should simply create the trace state variables as they are mentioned in expressions.

‘QTFrame:*n*’

Select the *n*’th tracepoint frame from the buffer, and use the register and memory contents recorded there to answer subsequent request packets from GDB.

A successful reply from the stub indicates that the stub has found the requested frame. The response is a series of parts, concatenated without separators, describing the frame we selected. Each part has one of the following forms:

‘F *f*’ The selected frame is number *n* in the trace frame buffer; *f* is a hexadecimal number. If *f* is ‘-1’, then there was no frame matching the criteria in the request packet.

‘T *t*’ The selected trace frame records a hit of tracepoint number *t*; *t* is a hexadecimal number.

‘QTFrame:pc:*addr*’

Like ‘QTFrame:*n*’, but select the first tracepoint frame after the currently selected frame whose PC is *addr*; *addr* is a hexadecimal number.

‘QTFrame:tdp:*t*’

Like ‘QTFrame:*n*’, but select the first tracepoint frame after the currently selected frame that is a hit of tracepoint *t*; *t* is a hexadecimal number.

‘QTFrame:range:*start*:*end*’

Like ‘QTFrame:*n*’, but select the first tracepoint frame after the currently selected frame whose PC is between *start* (inclusive) and *end* (inclusive); *start* and *end* are hexadecimal numbers.

‘QTFrame:outside:*start*:*end*’

Like ‘QTFrame:range:*start*:*end*’, but select the first frame *outside* the given range of addresses (exclusive).

‘QTStart’ Begin the tracepoint experiment. Begin collecting data from tracepoint hits in the trace frame buffer. This packet supports the ‘qRelocInsn’ reply (see [\(undefined\) \[Relocate instruction reply packet\]](#), page [\(undefined\)](#)).

‘QTStop’ End the tracepoint experiment. Stop collecting trace frames.

‘QTInit’ Clear the table of tracepoints, and empty the trace frame buffer.

‘QTro:*start1,end1:start2,end2:...*’

Establish the given ranges of memory as “transparent”. The stub will answer requests for these ranges from memory’s current contents, if they were not collected as part of the tracepoint hit.

GDB uses this to mark read-only regions of memory, like those containing program code. Since these areas never change, they should still have the same contents they did when the tracepoint was hit, so there’s no reason for the stub to refuse to provide their contents.

‘QTDisconnected:*value*’

Set the choice to what to do with the tracing run when GDB disconnects from the target. A *value* of 1 directs the target to continue the tracing run, while 0 tells the target to stop tracing if GDB is no longer in the picture.

‘qTStatus’

Ask the stub if there is a trace experiment running right now.

The reply has the form:

‘Trunning[;*field*]...’

running is a single digit 1 if the trace is presently running, or 0 if not. It is followed by semicolon-separated optional fields that an agent may use to report additional status.

If the trace is not running, the agent may report any of several explanations as one of the optional fields:

‘tnotrun:0’

No trace has been run yet.

‘tstop:0’ The trace was stopped by a user-originated stop command.

‘tfull:0’ The trace stopped because the trace buffer filled up.

‘tdisconnected:0’

The trace stopped because GDB disconnected from the target.

‘tpasscount:*tpnum*’

The trace stopped because tracepoint *tpnum* exceeded its pass count.

‘terror:*text:tpnum*’

The trace stopped because tracepoint *tpnum* had an error. The string *text* is available to describe the nature of the error (for instance, a divide by zero in the condition expression). *text* is hex encoded.

‘tunknown:0’

The trace stopped for some other reason.

Additional optional fields supply statistical and other information. Although not required, they are extremely useful for users monitoring the progress of a trace run. If a trace has stopped, and these numbers are reported, they must reflect the state of the just-stopped trace.

- ‘**tframes:n**’
The number of trace frames in the buffer.
- ‘**tcreated:n**’
The total number of trace frames created during the run. This may be larger than the trace frame count, if the buffer is circular.
- ‘**tsize:n**’ The total size of the trace buffer, in bytes.
- ‘**tfree:n**’ The number of bytes still unused in the buffer.
- ‘**circular:n**’
The value of the circular trace buffer flag. 1 means that the trace buffer is circular and old trace frames will be discarded if necessary to make room, 0 means that the trace buffer is linear and may fill up.
- ‘**disconn:n**’
The value of the disconnected tracing flag. 1 means that tracing will continue after GDB disconnects, 0 means that the trace run will stop.
- ‘**qTV:var**’ Ask the stub for the value of the trace state variable number *var*.
Replies:
- ‘**Vvalue**’ The value of the variable is *value*. This will be the current value of the variable if the user is examining a running target, or a saved value if the variable was collected in the trace frame that the user is looking at. Note that multiple requests may result in different reply values, such as when requesting values while the program is running.
- ‘**U**’ The value of the variable is unknown. This would occur, for example, if the user is examining a trace frame in which the requested variable was not collected.
- ‘**qTfP**’
‘**qTsP**’ These packets request data about tracepoints that are being used by the target. GDB sends **qTfP** to get the first piece of data, and multiple **qTsP** to get additional pieces. Replies to these packets generally take the form of the **QTDP** packets that define tracepoints. (FIXME add detailed syntax)
- ‘**qTfV**’
‘**qTsV**’ These packets request data about trace state variables that are on the target. GDB sends **qTfV** to get the first vari of data, and multiple **qTsV** to get additional variables. Replies to these packets follow the syntax of the **QTDV** packets that define trace state variables.
- ‘**qTfSTM**’
‘**qTsSTM**’ These packets request data about static tracepoint markers that exist in the target program. GDB sends **qTfSTM** to get the first piece of data, and multiple **qTsSTM** to get additional pieces. Replies to these packets take the following form:

Reply:

`'m address:id:extra'`

A single marker

`'m address:id:extra,address:id:extra...'`

a comma-separated list of markers

`'l'` (lower case letter 'L') denotes end of list.

`'E nn'` An error occurred. *nn* are hex digits.

`''` An empty reply indicates that the request is not supported by the stub.

address is encoded in hex. *id* and *extra* are strings encoded in hex.

In response to each query, the target will reply with a list of one or more markers, separated by commas. GDB will respond to each reply with a request for more markers (using the `'qs'` form of the query), until the target responds with `'l'` (lower-case ell, for *last*).

`'qTSTMat:address'`

This packets requests data about static tracepoint markers in the target program at *address*. Replies to this packet follow the syntax of the `'qTfSTM'` and `qTsSTM` packets that list static tracepoint markers.

`'QTSave:filename'`

This packet directs the target to save trace data to the file name *filename* in the target's filesystem. *filename* is encoded as a hex string; the interpretation of the file name (relative vs absolute, wild cards, etc) is up to the target.

`'qTBuffer:offset,len'`

Return up to *len* bytes of the current contents of trace buffer, starting at *offset*. The trace buffer is treated as if it were a contiguous collection of traceframes, as per the trace file format. The reply consists as many hex-encoded bytes as the target can deliver in a packet; it is not an error to return fewer than were asked for. A reply consisting of just `1` indicates that no bytes are available.

`'qTBuffer:circular:value'`

This packet directs the target to use a circular trace buffer if *value* is 1, or a linear buffer if the value is 0.

D.6.1 Relocate instruction reply packet

When installing fast tracepoints in memory, the target may need to relocate the instruction currently at the tracepoint address to a different address in memory. For most instructions, a simple copy is enough, but, for example, call instructions that implicitly push the return address on the stack, and relative branches or other PC-relative instructions require offset adjustment, so that the effect of executing the instruction at a different address is the same as if it had executed in the original location.

In response to several of the tracepoint packets, the target may also respond with a number of intermediate `'qRelocInsn'` request packets before the final result packet, to have GDB handle this relocation operation. If a packet supports this mechanism, its documentation

will explicitly say so. See for example the above descriptions for the ‘QTStart’ and ‘QTDP’ packets. The format of the request is:

‘qRelocInsn: *from*; *to*’

This requests GDB to copy instruction at address *from* to address *to*, possibly adjusted so that executing the instruction at *to* has the same effect as executing it at *from*. GDB writes the adjusted instruction to target memory starting at *to*.

Replies:

‘qRelocInsn: *adjusted_size*’

Informs the stub the relocation is complete. *adjusted_size* is the length in bytes of resulting relocated instruction sequence.

‘E *NN*’ A badly formed request was detected, or an error was encountered while relocating the instruction.

D.7 Host I/O Packets

The *Host I/O* packets allow GDB to perform I/O operations on the far side of a remote link. For example, Host I/O is used to upload and download files to a remote target with its own filesystem. Host I/O uses the same constant values and data structure layout as the target-initiated File-I/O protocol. However, the Host I/O packets are structured differently. The target-initiated protocol relies on target memory to store parameters and buffers. Host I/O requests are initiated by GDB, and the target’s memory is not involved. See [\[File-I/O Remote Protocol Extension\]](#), page [\[undefined\]](#), for more details on the target-initiated protocol.

The Host I/O request packets all encode a single operation along with its arguments. They have this format:

‘vFile:operation: *parameter*...’

operation is the name of the particular request; the target should compare the entire packet name up to the second colon when checking for a supported operation. The format of *parameter* depends on the operation. Numbers are always passed in hexadecimal. Negative numbers have an explicit minus sign (i.e. two’s complement is not used). Strings (e.g. filenames) are encoded as a series of hexadecimal bytes. The last argument to a system call may be a buffer of escaped binary data (see [\[Binary Data\]](#), page [\[undefined\]](#)).

The valid responses to Host I/O packets are:

‘F *result* [, *errno*] [; *attachment*]’

result is the integer value returned by this operation, usually non-negative for success and -1 for errors. If an error has occurred, *errno* will be included in the result. *errno* will have a value defined by the File-I/O protocol (see [\[Errno Values\]](#), page [\[undefined\]](#)). For operations which return data, *attachment* supplies the data as a binary buffer. Binary buffers in response packets are escaped in the normal way (see [\[Binary Data\]](#), page [\[undefined\]](#)). See the individual packet documentation for the interpretation of *result* and *attachment*.

“ An empty response indicates that this operation is not recognized.

These are the supported Host I/O operations:

‘vFile:open: *pathname*, *flags*, *mode*’

Open a file at *pathname* and return a file descriptor for it, or return -1 if an error occurs. *pathname* is a string, *flags* is an integer indicating a mask of open flags (see [<undefined> \[Open Flags\], page <undefined>](#)), and *mode* is an integer indicating a mask of mode bits to use if the file is created (see [<undefined> \[mode_t Values\], page <undefined>](#)). See [<undefined> \[open\], page <undefined>](#), for details of the open flags and mode values.

‘vFile:close: *fd*’

Close the open file corresponding to *fd* and return 0, or -1 if an error occurs.

‘vFile:pread: *fd*, *count*, *offset*’

Read data from the open file corresponding to *fd*. Up to *count* bytes will be read from the file, starting at *offset* relative to the start of the file. The target may read fewer bytes; common reasons include packet size limits and an end-of-file condition. The number of bytes read is returned. Zero should only be returned for a successful read at the end of the file, or if *count* was zero.

The data read should be returned as a binary attachment on success. If zero bytes were read, the response should include an empty binary attachment (i.e. a trailing semicolon). The return value is the number of target bytes read; the binary attachment may be longer if some characters were escaped.

‘vFile:pwrite: *fd*, *offset*, *data*’

Write *data* (a binary buffer) to the open file corresponding to *fd*. Start the write at *offset* from the start of the file. Unlike many `write` system calls, there is no separate *count* argument; the length of *data* in the packet is used. ‘vFile:write’ returns the number of bytes written, which may be shorter than the length of *data*, or -1 if an error occurred.

‘vFile:unlink: *pathname*’

Delete the file at *pathname* on the target. Return 0, or -1 if an error occurs. *pathname* is a string.

D.8 Interrupts

When a program on the remote target is running, GDB may attempt to interrupt it by sending a ‘Ctrl-C’, `BREAK` or a `BREAK` followed by `g`, control of which is specified via GDB’s ‘interrupt-sequence’.

The precise meaning of `BREAK` is defined by the transport mechanism and may, in fact, be undefined. GDB does not currently define a `BREAK` mechanism for any of the network interfaces except for TCP, in which case GDB sends the `telnet` `BREAK` sequence.

‘Ctrl-C’, on the other hand, is defined and implemented for all transport mechanisms. It is represented by sending the single byte `0x03` without any of the usual packet overhead described in the Overview section (see [<undefined> \[Overview\], page <undefined>](#)). When a `0x03` byte is transmitted as part of a packet, it is considered to be packet data and does *not*

represent an interrupt. E.g., an ‘X’ packet (see [\[X packet\]](#), page [\[undefined\]](#)), used for binary downloads, may include an unescaped 0x03 as part of its packet.

BREAK followed by `g` is also known as Magic SysRq `g`. When Linux kernel receives this sequence from serial port, it stops execution and connects to `gdb`.

Stubs are not required to recognize these interrupt mechanisms and the precise meaning associated with receipt of the interrupt is implementation defined. If the target supports debugging of multiple threads and/or processes, it should attempt to interrupt all currently-executing threads and processes. If the stub is successful at interrupting the running program, it should send one of the stop reply packets (see [\[Stop Reply Packets\]](#), page [\[undefined\]](#)) to GDB as a result of successfully stopping the program in all-stop mode, and a stop reply for each stopped thread in non-stop mode. Interrupts received while the program is stopped are discarded.

D.9 Notification Packets

The GDB remote serial protocol includes *notifications*, packets that require no acknowledgment. Both the GDB and the stub may send notifications (although the only notifications defined at present are sent by the stub). Notifications carry information without incurring the round-trip latency of an acknowledgment, and so are useful for low-impact communications where occasional packet loss is not a problem.

A notification packet has the form ‘% *data* # *checksum*’, where *data* is the content of the notification, and *checksum* is a checksum of *data*, computed and formatted as for ordinary GDB packets. A notification’s *data* never contains ‘\$’, ‘%’ or ‘#’ characters. Upon receiving a notification, the recipient sends no ‘+’ or ‘-’ to acknowledge the notification’s receipt or to report its corruption.

Every notification’s *data* begins with a name, which contains no colon characters, followed by a colon character.

Recipients should silently ignore corrupted notifications and notifications they do not understand. Recipients should restart timeout periods on receipt of a well-formed notification, whether or not they understand it.

Senders should only send the notifications described here when this protocol description specifies that they are permitted. In the future, we may extend the protocol to permit existing notifications in new contexts; this rule helps older senders avoid confusing newer recipients.

(Older versions of GDB ignore bytes received until they see the ‘\$’ byte that begins an ordinary packet, so new stubs may transmit notifications without fear of confusing older clients. There are no notifications defined for GDB to send at the moment, but we assume that most older stubs would ignore them, as well.)

The following notification packets from the stub to GDB are defined:

‘Stop: *reply*’

Report an asynchronous stop event in non-stop mode. The *reply* has the form of a stop reply, as described in [\[Stop Reply Packets\]](#), page [\[undefined\]](#). Refer to [\[Remote Non-Stop\]](#), page [\[undefined\]](#), for information on how these notifications are acknowledged by GDB.

D.10 Remote Protocol Support for Non-Stop Mode

GDB's remote protocol supports non-stop debugging of multi-threaded programs, as described in [\(undefined\) \[Non-Stop Mode\], page \(undefined\)](#). If the stub supports non-stop mode, it should report that to GDB by including 'QNonStop+' in its 'qSupported' response (see [\(undefined\) \[qSupported\], page \(undefined\)](#)).

GDB typically sends a 'QNonStop' packet only when establishing a new connection with the stub. Entering non-stop mode does not alter the state of any currently-running threads, but targets must stop all threads in any already-attached processes when entering all-stop mode. GDB uses the '?' packet as necessary to probe the target state after a mode change.

In non-stop mode, when an attached process encounters an event that would otherwise be reported with a stop reply, it uses the asynchronous notification mechanism (see [\(undefined\) \[Notification Packets\], page \(undefined\)](#)) to inform GDB. In contrast to all-stop mode, where all threads in all processes are stopped when a stop reply is sent, in non-stop mode only the thread reporting the stop event is stopped. That is, when reporting a 'S' or 'T' response to indicate completion of a step operation, hitting a breakpoint, or a fault, only the affected thread is stopped; any other still-running threads continue to run. When reporting a 'W' or 'X' response, all running threads belonging to other attached processes continue to run.

Only one stop reply notification at a time may be pending; if additional stop events occur before GDB has acknowledged the previous notification, they must be queued by the stub for later synchronous transmission in response to 'vStopped' packets from GDB. Because the notification mechanism is unreliable, the stub is permitted to resend a stop reply notification if it believes GDB may not have received it. GDB ignores additional stop reply notifications received before it has finished processing a previous notification and the stub has completed sending any queued stop events.

Otherwise, GDB must be prepared to receive a stop reply notification at any time. Specifically, they may appear when GDB is not otherwise reading input from the stub, or when GDB is expecting to read a normal synchronous response or a '+'/'-' acknowledgment to a packet it has sent. Notification packets are distinct from any other communication from the stub so there is no ambiguity.

After receiving a stop reply notification, GDB shall acknowledge it by sending a 'vStopped' packet (see [\(undefined\) \[vStopped packet\], page \(undefined\)](#)) as a regular, synchronous request to the stub. Such acknowledgment is not required to happen immediately, as GDB is permitted to send other, unrelated packets to the stub first, which the stub should process normally.

Upon receiving a 'vStopped' packet, if the stub has other queued stop events to report to GDB, it shall respond by sending a normal stop reply response. GDB shall then send another 'vStopped' packet to solicit further responses; again, it is permitted to send other, unrelated packets as well which the stub should process normally.

If the stub receives a 'vStopped' packet and there are no additional stop events to report, the stub shall return an 'OK' response. At this point, if further stop events occur, the stub shall send a new stop reply notification, GDB shall accept the notification, and the process shall be repeated.

In non-stop mode, the target shall respond to the '?' packet as follows. First, any incomplete stop reply notification/'vStopped' sequence in progress is abandoned. The target

must begin a new sequence reporting stop events for all stopped threads, whether or not it has previously reported those events to GDB. The first stop reply is sent as a synchronous reply to the ‘?’ packet, and subsequent stop replies are sent as responses to ‘vStopped’ packets using the mechanism described above. The target must not send asynchronous stop reply notifications until the sequence is complete. If all threads are running when the target receives the ‘?’ packet, or if the target is not attached to any process, it shall respond ‘OK’.

D.11 Packet Acknowledgment

By default, when either the host or the target machine receives a packet, the first response expected is an acknowledgment: either ‘+’ (to indicate the package was received correctly) or ‘-’ (to request retransmission). This mechanism allows the GDB remote protocol to operate over unreliable transport mechanisms, such as a serial line.

In cases where the transport mechanism is itself reliable (such as a pipe or TCP connection), the ‘+’/‘-’ acknowledgments are redundant. It may be desirable to disable them in that case to reduce communication overhead, or for other reasons. This can be accomplished by means of the ‘QStartNoAckMode’ packet; see [\(undefined\) \[QStartNoAckMode\]](#), page [\(undefined\)](#).

When in no-acknowledgment mode, neither the stub nor GDB shall send or expect ‘+’/‘-’ protocol acknowledgments. The packet and response format still includes the normal checksum, as described in [\(undefined\) \[Overview\]](#), page [\(undefined\)](#), but the checksum may be ignored by the receiver.

If the stub supports ‘QStartNoAckMode’ and prefers to operate in no-acknowledgment mode, it should report that to GDB by including ‘QStartNoAckMode+’ in its response to ‘qSupported’; see [\(undefined\) \[qSupported\]](#), page [\(undefined\)](#). If GDB also supports ‘QStartNoAckMode’ and it has not been disabled via the `set remote noack-packet off` command (see [\(undefined\) \[Remote Configuration\]](#), page [\(undefined\)](#)), GDB may then send a ‘QStartNoAckMode’ packet to the stub. Only then may the stub actually turn off packet acknowledgments. GDB sends a final ‘+’ acknowledgment of the stub’s ‘OK’ response, which can be safely ignored by the stub.

Note that `set remote noack-packet` command only affects negotiation between GDB and the stub when subsequent connections are made; it does not affect the protocol acknowledgment state for any current connection. Since ‘+’/‘-’ acknowledgments are enabled by default when a new connection is established, there is also no protocol request to re-enable the acknowledgments for the current connection, once disabled.

D.12 Examples

Example sequence of a target being re-started. Notice how the restart does not get any direct output:

```
-> R00
<- +
target restarts
-> ?
<- +
<- T001:1234123412341234
-> +
```

Example sequence of a target being stepped by a single instruction:

```

-> G1445...
<- +
-> s
<- +
time passes
<- T001:1234123412341234
-> +
-> g
<- +
<- 1455...
-> +

```

D.13 File-I/O Remote Protocol Extension

D.13.1 File-I/O Overview

The *File I/O remote protocol extension* (short: File-I/O) allows the target to use the host's file system and console I/O to perform various system calls. System calls on the target system are translated into a remote protocol packet to the host system, which then performs the needed actions and returns a response packet to the target system. This simulates file system operations even on targets that lack file systems.

The protocol is defined to be independent of both the host and target systems. It uses its own internal representation of datatypes and values. Both GDB and the target's GDB stub are responsible for translating the system-dependent value representations into the internal protocol representations when data is transmitted.

The communication is synchronous. A system call is possible only when GDB is waiting for a response from the 'C', 'c', 'S' or 's' packets. While GDB handles the request for a system call, the target is stopped to allow deterministic access to the target's memory. Therefore File-I/O is not interruptible by target signals. On the other hand, it is possible to interrupt File-I/O by a user interrupt ('Ctrl-C') within GDB.

The target's request to perform a host system call does not finish the latest 'C', 'c', 'S' or 's' action. That means, after finishing the system call, the target returns to continuing the previous activity (continue, step). No additional continue or step request from GDB is required.

```

(gdb) continue
<- target requests 'system call X'
target is stopped, GDB executes system call
-> GDB returns result
... target continues, GDB returns to wait for the target
<- target hits breakpoint and sends a Txx packet

```

The protocol only supports I/O on the console and to regular files on the host file system. Character or block special devices, pipes, named pipes, sockets or any other communication method on the host system are not supported by this protocol.

File I/O is not supported in non-stop mode.

D.13.2 Protocol Basics

The File-I/O protocol uses the F packet as the request as well as reply packet. Since a File-I/O system call can only occur when GDB is waiting for a response from the continuing or stepping target, the File-I/O request is a reply that GDB has to expect as a result of a

previous ‘C’, ‘c’, ‘S’ or ‘s’ packet. This F packet contains all information needed to allow GDB to call the appropriate host system call:

- A unique identifier for the requested system call.
- All parameters to the system call. Pointers are given as addresses in the target memory address space. Pointers to strings are given as pointer/length pair. Numerical values are given as they are. Numerical control flags are given in a protocol-specific representation.

At this point, GDB has to perform the following actions.

- If the parameters include pointer values to data needed as input to a system call, GDB requests this data from the target with a standard m packet request. This additional communication has to be expected by the target implementation and is handled as any other m packet.
- GDB translates all value from protocol representation to host representation as needed. Datatypes are coerced into the host types.
- GDB calls the system call.
- It then coerces datatypes back to protocol representation.
- If the system call is expected to return data in buffer space specified by pointer parameters to the call, the data is transmitted to the target using a M or X packet. This packet has to be expected by the target implementation and is handled as any other M or X packet.

Eventually GDB replies with another F packet which contains all necessary information for the target to continue. This at least contains

- Return value.
- `errno`, if has been changed by the system call.
- “Ctrl-C” flag.

After having done the needed type and value coercion, the target continues the latest continue or step action.

D.13.3 The F Request Packet

The F request packet has the following format:

`'Fcall-id,parameter...'`

call-id is the identifier to indicate the host system call to be called. This is just the name of the function.

parameter... are the parameters to the system call. Parameters are hexadecimal integer values, either the actual values in case of scalar datatypes, pointers to target buffer space in case of compound datatypes and unspecified memory areas, or pointer/length pairs in case of string parameters. These are appended to the *call-id* as a comma-delimited list. All values are transmitted in ASCII string representation, pointer/length pairs separated by a slash.

D.13.4 The F Reply Packet

The F reply packet has the following format:

‘*Fretcode,errno,Ctrl-C flag;call-specific attachment*’

retcode is the return code of the system call as hexadecimal value.

errno is the `errno` set by the call, in protocol-specific representation. This parameter can be omitted if the call was successful.

Ctrl-C flag is only sent if the user requested a break. In this case, *errno* must be sent as well, even if the call was successful. The *Ctrl-C flag* itself consists of the character ‘C’:

F0,0,C

or, if the call was interrupted before the host call has been performed:

F-1,4,C

assuming 4 is the protocol-specific representation of `EINTR`.

D.13.5 The ‘Ctrl-C’ Message

If the ‘Ctrl-C’ flag is set in the GDB reply packet (see [⟨undefined⟩ \[The F Reply Packet\]](#), page [⟨undefined⟩](#)), the target should behave as if it had gotten a break message. The meaning for the target is “system call interrupted by `SIGINT`”. Consequentially, the target should actually stop (as with a break message) and return to GDB with a T02 packet.

It’s important for the target to know in which state the system call was interrupted. There are two possible cases:

- The system call hasn’t been performed on the host yet.
- The system call on the host has been finished.

These two states can be distinguished by the target by the value of the returned `errno`. If it’s the protocol representation of `EINTR`, the system call hasn’t been performed. This is equivalent to the `EINTR` handling on POSIX systems. In any other case, the target may presume that the system call has been finished — successfully or not — and should behave as if the break message arrived right after the system call.

GDB must behave reliably. If the system call has not been called yet, GDB may send the F reply immediately, setting `EINTR` as `errno` in the packet. If the system call on the host has been finished before the user requests a break, the full action must be finished by GDB. This requires sending M or X packets as necessary. The F packet may only be sent when either nothing has happened or the full action has been completed.

D.13.6 Console I/O

By default and if not explicitly closed by the target system, the file descriptors 0, 1 and 2 are connected to the GDB console. Output on the GDB console is handled as any other file output operation (`write(1, ...)` or `write(2, ...)`). Console input is handled by GDB so that after the target read request from file descriptor 0 all following typing is buffered until either one of the following conditions is met:

- The user types `Ctrl-c`. The behaviour is as explained above, and the `read` system call is treated as finished.
- The user presses RET. This is treated as end of input with a trailing newline.
- The user types `Ctrl-d`. This is treated as end of input. No trailing character (neither newline nor ‘Ctrl-D’) is appended to the input.

If the user has typed more characters than fit in the buffer given to the `read` call, the trailing characters are buffered in GDB until either another `read(0, ...)` is requested by the target, or debugging is stopped at the user's request.

D.13.7 List of Supported Calls

open

Synopsis:

```
int open(const char *pathname, int flags);
int open(const char *pathname, int flags, mode_t mode);
```

Request: `'Fopen, pathptr/len, flags, mode'`

flags is the bitwise OR of the following values:

- `O_CREAT` If the file does not exist it will be created. The host rules apply as far as file ownership and time stamps are concerned.
- `O_EXCL` When used with `O_CREAT`, if the file already exists it is an error and `open()` fails.
- `O_TRUNC` If the file already exists and the open mode allows writing (`O_RDWR` or `O_WRONLY` is given) it will be truncated to zero length.
- `O_APPEND` The file is opened in append mode.
- `O_RDONLY` The file is opened for reading only.
- `O_WRONLY` The file is opened for writing only.
- `O_RDWR` The file is opened for reading and writing.

Other bits are silently ignored.

mode is the bitwise OR of the following values:

- `S_IRUSR` User has read permission.
- `S_IWUSR` User has write permission.
- `S_IRGRP` Group has read permission.
- `S_IWGRP` Group has write permission.
- `S_IROTH` Others have read permission.
- `S_IWOTH` Others have write permission.

Other bits are silently ignored.

Return value:

`open` returns the new file descriptor or -1 if an error occurred.

Errors:

- `EEXIST` *pathname* already exists and `O_CREAT` and `O_EXCL` were used.
- `EISDIR` *pathname* refers to a directory.
- `EACCES` The requested access is not allowed.

ENAMETOOLONG	<i>pathname</i> was too long.
ENOENT	A directory component in <i>pathname</i> does not exist.
ENODEV	<i>pathname</i> refers to a device, pipe, named pipe or socket.
EROFS	<i>pathname</i> refers to a file on a read-only filesystem and write access was requested.
EFAULT	<i>pathname</i> is an invalid pointer value.
ENOSPC	No space on device to create the file.
EMFILE	The process already has the maximum number of files open.
ENFILE	The limit on the total number of files open on the system has been reached.
EINTR	The call was interrupted by the user.

close

Synopsis:

```
int close(int fd);
```

Request: ‘Fclose, *fd*’

Return value:

close returns zero on success, or -1 if an error occurred.

Errors:

EBADF	<i>fd</i> isn't a valid open file descriptor.
EINTR	The call was interrupted by the user.

read

Synopsis:

```
int read(int fd, void *buf, unsigned int count);
```

Request: ‘Fread, *fd*, *bufptr*, *count*’

Return value:

On success, the number of bytes read is returned. Zero indicates end of file. If count is zero, read returns zero as well. On error, -1 is returned.

Errors:

EBADF	<i>fd</i> is not a valid file descriptor or is not open for reading.
EFAULT	<i>bufptr</i> is an invalid pointer value.
EINTR	The call was interrupted by the user.

write

Synopsis:

```
int write(int fd, const void *buf, unsigned int count);
```

Request: `'Fwrite,fd,bufptr,count'`

Return value:

On success, the number of bytes written are returned. Zero indicates nothing was written. On error, -1 is returned.

Errors:

EBADF	<i>fd</i> is not a valid file descriptor or is not open for writing.
EFAULT	<i>bufptr</i> is an invalid pointer value.
EFBIG	An attempt was made to write a file that exceeds the host-specific maximum file size allowed.
ENOSPC	No space on device to write the data.
EINTR	The call was interrupted by the user.

lseek

Synopsis:

```
long lseek (int fd, long offset, int flag);
```

Request: `'Flseek,fd,offset,flag'`

flag is one of:

SEEK_SET	The offset is set to <i>offset</i> bytes.
SEEK_CUR	The offset is set to its current location plus <i>offset</i> bytes.
SEEK_END	The offset is set to the size of the file plus <i>offset</i> bytes.

Return value:

On success, the resulting unsigned offset in bytes from the beginning of the file is returned. Otherwise, a value of -1 is returned.

Errors:

EBADF	<i>fd</i> is not a valid open file descriptor.
ESPIPE	<i>fd</i> is associated with the GDB console.
EINVAL	<i>flag</i> is not a proper value.
EINTR	The call was interrupted by the user.

rename

Synopsis:

```
int rename(const char *oldpath, const char *newpath);
```

Request: `'Frename,oldpathptr/len,newpathptr/len'`

Return value:

On success, zero is returned. On error, -1 is returned.

Errors:

EISDIR	<i>newpath</i> is an existing directory, but <i>oldpath</i> is not a directory.
EEXIST	<i>newpath</i> is a non-empty directory.
EBUSY	<i>oldpath</i> or <i>newpath</i> is a directory that is in use by some process.
EINVAL	An attempt was made to make a directory a subdirectory of itself.
ENOTDIR	A component used as a directory in <i>oldpath</i> or <i>newpath</i> is not a directory. Or <i>oldpath</i> is a directory and <i>newpath</i> exists but is not a directory.
EFAULT	<i>oldpathptr</i> or <i>newpathptr</i> are invalid pointer values.
EACCES	No access to the file or the path of the file.
ENAMETOOLONG	<i>oldpath</i> or <i>newpath</i> was too long.
ENOENT	A directory component in <i>oldpath</i> or <i>newpath</i> does not exist.
EROFS	The file is on a read-only filesystem.
ENOSPC	The device containing the file has no room for the new directory entry.
EINTR	The call was interrupted by the user.

unlink

Synopsis:

```
int unlink(const char *pathname);
```

Request: ‘Funlink,*pathnameptr/len*’

Return value:

On success, zero is returned. On error, -1 is returned.

Errors:

EACCES	No access to the file or the path of the file.
EPERM	The system does not allow unlinking of directories.
EBUSY	The file <i>pathname</i> cannot be unlinked because it's being used by another process.
EFAULT	<i>pathnameptr</i> is an invalid pointer value.
ENAMETOOLONG	<i>pathname</i> was too long.
ENOENT	A directory component in <i>pathname</i> does not exist.
ENOTDIR	A component of the path is not a directory.
EROFS	The file is on a read-only filesystem.
EINTR	The call was interrupted by the user.

stat/fstat

Synopsis:

```
int stat(const char *pathname, struct stat *buf);
int fstat(int fd, struct stat *buf);
```

Request: ‘Fstat, *pathnameptr/len, bufptr*’
‘Ffstat, *fd, bufptr*’

Return value:

On success, zero is returned. On error, -1 is returned.

Errors:

EBADF *fd* is not a valid open file.

ENOENT A directory component in *pathname* does not exist or the path is an empty string.

ENOTDIR A component of the path is not a directory.

EFAULT *pathnameptr* is an invalid pointer value.

EACCES No access to the file or the path of the file.

ENAMETOOLONG
 pathname was too long.

EINTR The call was interrupted by the user.

gettimeofday

Synopsis:

```
int gettimeofday(struct timeval *tv, void *tz);
```

Request: ‘Fgettimeofday, *tvptr, tzptr*’

Return value:

On success, 0 is returned, -1 otherwise.

Errors:

EINVAL *tz* is a non-NULL pointer.

EFAULT *tvptr* and/or *tzptr* is an invalid pointer value.

isatty

Synopsis:

```
int isatty(int fd);
```

Request: ‘Fisatty, *fd*’

Return value:

Returns 1 if *fd* refers to the GDB console, 0 otherwise.

Errors:

EINTR The call was interrupted by the user.

Note that the `isatty` call is treated as a special case: it returns 1 to the target if the file descriptor is attached to the GDB console, 0 otherwise. Implementing through system calls would require implementing `ioctl` and would be more complex than needed.

system

Synopsis:

```
int system(const char *command);
```

Request: `'Fsystem,commandptr/len'`

Return value:

If *len* is zero, the return value indicates whether a shell is available. A zero return value indicates a shell is not available. For non-zero *len*, the value returned is -1 on error and the return status of the command otherwise. Only the exit status of the command is returned, which is extracted from the host's `system` return value by calling `WEXITSTATUS(retval)`. In case `'/bin/sh'` could not be executed, 127 is returned.

Errors:

EINTR The call was interrupted by the user.

GDB takes over the full task of calling the necessary host calls to perform the `system` call. The return value of `system` on the host is simplified before it's returned to the target. Any termination signal information from the child process is discarded, and the return value consists entirely of the exit status of the called command.

Due to security concerns, the `system` call is by default refused by GDB. The user has to allow this call explicitly with the `set remote system-call-allowed 1` command.

`set remote system-call-allowed`

Control whether to allow the `system` calls in the File I/O protocol for the remote target. The default is zero (disabled).

`show remote system-call-allowed`

Show whether the `system` calls are allowed in the File I/O protocol.

D.13.8 Protocol-specific Representation of Datatypes

Integral Datatypes

The integral datatypes used in the system calls are `int`, `unsigned int`, `long`, `unsigned long`, `mode_t`, and `time_t`.

`int`, `unsigned int`, `mode_t` and `time_t` are implemented as 32 bit values in this protocol.

`long` and `unsigned long` are implemented as 64 bit types.

See [\(undefined\) \[Limits\], page \(undefined\)](#), for corresponding MIN and MAX values (similar to those in `'limits.h'`) to allow range checking on host and target.

`time_t` datatypes are defined as seconds since the Epoch.

All integral datatypes transferred as part of a memory read or write of a structured datatype e.g. a `struct stat` have to be given in big endian byte order.

Pointer Values

Pointers to target data are transmitted as they are. An exception is made for pointers to buffers for which the length isn't transmitted as part of the function call, namely strings. Strings are transmitted as a pointer/length pair, both as hex values, e.g.

1aaf/12

which is a pointer to data of length 18 bytes at position 0x1aaf. The length is defined as the full string length in bytes, including the trailing null byte. For example, the string "hello world" at address 0x123456 is transmitted as

123456/d

Memory Transfer

Structured data which is transferred using a memory read or write (for example, a `struct stat`) is expected to be in a protocol-specific format with all scalar multibyte datatypes being big endian. Translation to this representation needs to be done both by the target before the F packet is sent, and by GDB before it transfers memory to the target. Transferred pointers to structured data should point to the already-coerced data at any time.

struct stat

The buffer of type `struct stat` used by the target and GDB is defined as follows:

```
struct stat {
    unsigned int  st_dev;      /* device */
    unsigned int  st_ino;     /* inode */
    mode_t       st_mode;     /* protection */
    unsigned int  st_nlink;   /* number of hard links */
    unsigned int  st_uid;     /* user ID of owner */
    unsigned int  st_gid;     /* group ID of owner */
    unsigned int  st_rdev;    /* device type (if inode device) */
    unsigned long st_size;    /* total size, in bytes */
    unsigned long st_blksize; /* blocksize for filesystem I/O */
    unsigned long st_blocks;  /* number of blocks allocated */
    time_t       st_atime;    /* time of last access */
    time_t       st_mtime;    /* time of last modification */
    time_t       st_ctime;    /* time of last change */
};
```

The integral datatypes conform to the definitions given in the appropriate section (see [\(undefined\) \[Integral Datatypes\], page \(undefined\)](#), for details) so this structure is of size 64 bytes.

The values of several fields have a restricted meaning and/or range of values.

<code>st_dev</code>	A value of 0 represents a file, 1 the console.
<code>st_ino</code>	No valid meaning for the target. Transmitted unchanged.
<code>st_mode</code>	Valid mode bits are described in (undefined) [Constants], page (undefined) . Any other bits have currently no meaning for the target.
<code>st_uid</code>	
<code>st_gid</code>	
<code>st_rdev</code>	No valid meaning for the target. Transmitted unchanged.
<code>st_atime</code>	
<code>st_mtime</code>	
<code>st_ctime</code>	These values have a host and file system dependent accuracy. Especially on Windows hosts, the file system may not support exact timing values.

The target gets a `struct stat` of the above representation and is responsible for coercing it to the target representation before continuing.

Note that due to size differences between the host, target, and protocol representations of `struct stat` members, these members could eventually get truncated on the target.

struct timeval

The buffer of type `struct timeval` used by the File-I/O protocol is defined as follows:

```
struct timeval {
    time_t tv_sec; /* second */
    long   tv_usec; /* microsecond */
};
```

The integral datatypes conform to the definitions given in the appropriate section (see [\(undefined\) \[Integral Datatypes\], page \(undefined\)](#), for details) so this structure is of size 8 bytes.

D.13.9 Constants

The following values are used for the constants inside of the protocol. GDB and target are responsible for translating these values before and after the call as needed.

Open Flags

All values are given in hexadecimal representation.

<code>O_RDONLY</code>	<code>0x0</code>
<code>O_WRONLY</code>	<code>0x1</code>
<code>O_RDWR</code>	<code>0x2</code>
<code>O_APPEND</code>	<code>0x8</code>
<code>O_CREAT</code>	<code>0x200</code>
<code>O_TRUNC</code>	<code>0x400</code>
<code>O_EXCL</code>	<code>0x800</code>

mode_t Values

All values are given in octal representation.

<code>S_IFREG</code>	<code>0100000</code>
<code>S_IFDIR</code>	<code>0400000</code>
<code>S_IRUSR</code>	<code>0400</code>
<code>S_IWUSR</code>	<code>0200</code>
<code>S_IXUSR</code>	<code>0100</code>
<code>S_IRGRP</code>	<code>040</code>
<code>S_IWGRP</code>	<code>020</code>
<code>S_IXGRP</code>	<code>010</code>
<code>S_IROTH</code>	<code>04</code>
<code>S_IWOTH</code>	<code>02</code>
<code>S_IXOTH</code>	<code>01</code>

Errno Values

All values are given in decimal representation.

<code>EPERM</code>	<code>1</code>
<code>ENOENT</code>	<code>2</code>
<code>EINTR</code>	<code>4</code>
<code>EBADF</code>	<code>9</code>
<code>EACCES</code>	<code>13</code>

EFAULT	14
EBUSY	16
EEXIST	17
ENODEV	19
ENOTDIR	20
EISDIR	21
EINVAL	22
ENFILE	23
EMFILE	24
EFBIG	27
ENOSPC	28
ESPIPE	29
EROFS	30
ENAMETOOLONG	91
EUNKNOWN	9999

EUNKNOWN is used as a fallback error value if a host system returns any error value not in the list of supported error numbers.

Lseek Flags

SEEK_SET	0
SEEK_CUR	1
SEEK_END	2

Limits

All values are given in decimal representation.

INT_MIN	-2147483648
INT_MAX	2147483647
UINT_MAX	4294967295
LONG_MIN	-9223372036854775808
LONG_MAX	9223372036854775807
ULONG_MAX	18446744073709551615

D.13.10 File-I/O Examples

Example sequence of a write call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be written:

```
<- Fwrite,3,1234,6
request memory read from target
-> m1234,6
<- XXXXXX
return "6 bytes written"
-> F6
```

Example sequence of a read call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be read:

```
<- Fread,3,1234,6
request memory write to target
-> X1234,6:XXXXXX
return "6 bytes read"
-> F6
```

Example sequence of a read call, call fails on the host due to invalid file descriptor (EBADF):

```
<- Fread,3,1234,6
-> F-1,9
```

Example sequence of a read call, user presses *Ctrl-c* before syscall on host is called:

```
<- Fread,3,1234,6
-> F-1,4,C
<- T02
```

Example sequence of a read call, user presses *Ctrl-c* after syscall on host is called:

```
<- Fread,3,1234,6
-> X1234,6:XXXXXX
<- T02
```

D.14 Library List Format

On some platforms, a dynamic loader (e.g. ‘*ld.so*’) runs in the same process as your application to manage libraries. In this case, GDB can use the loader’s symbol table and normal memory operations to maintain a list of shared libraries. On other platforms, the operating system manages loaded libraries. GDB can not retrieve the list of currently loaded libraries through memory operations, so it uses the ‘*qXfer:libraries:read*’ packet (see [\(undefined\) \[qXfer library list read\], page \(undefined\)](#)) instead. The remote stub queries the target’s operating system and reports which libraries are loaded.

The ‘*qXfer:libraries:read*’ packet returns an XML document which lists loaded libraries and their offsets. Each library has an associated name and one or more segment or section base addresses, which report where the library was loaded in memory.

For the common case of libraries that are fully linked binaries, the library should have a list of segments. If the target supports dynamic linking of a relocatable object file, its library XML element should instead include a list of allocated sections. The segment or section bases are start addresses, not relocation offsets; they do not depend on the library’s link-time base addresses.

GDB must be linked with the Expat library to support XML library lists. See [\(undefined\) \[Expat\], page \(undefined\)](#).

A simple memory map, with one loaded library relocated by a single offset, looks like this:

```
<library-list>
  <library name="/lib/libc.so.6">
    <segment address="0x10000000"/>
  </library>
</library-list>
```

Another simple memory map, with one loaded library with three allocated sections (.text, .data, .bss), looks like this:

```
<library-list>
  <library name="sharedlib.o">
    <section address="0x10000000"/>
    <section address="0x20000000"/>
    <section address="0x30000000"/>
  </library>
</library-list>
```

The format of a library list is described by this DTD:

```
<!-- library-list: Root element with versioning -->
<!ELEMENT library-list (library)*>
<!ATTLIST library-list version CDATA #FIXED "1.0">
<!ELEMENT library (segment*, section*)>
```

```

<!ATTLIST library      name      CDATA      #REQUIRED>
<!ELEMENT segment     EMPTY>
<!ATTLIST segment     address  CDATA      #REQUIRED>
<!ELEMENT section     EMPTY>
<!ATTLIST section     address  CDATA      #REQUIRED>

```

In addition, segments and section descriptors cannot be mixed within a single library element, and you must supply at least one segment or section for each library.

D.15 Memory Map Format

To be able to write into flash memory, GDB needs to obtain a memory map from the target. This section describes the format of the memory map.

The memory map is obtained using the ‘qXfer:memory-map:read’ (see [\(undefined\) \[qXfer memory map read\], page \(undefined\)](#)) packet and is an XML document that lists memory regions.

GDB must be linked with the Expat library to support XML memory maps. See [\(undefined\) \[Expat\], page \(undefined\)](#).

The top-level structure of the document is shown below:

```

<?xml version="1.0"?>
<!DOCTYPE memory-map
    PUBLIC "-//IDN gnu.org//DTD GDB Memory Map V1.0//EN"
    "http://sourceware.org/gdb/gdb-memory-map.dtd">
<memory-map>
  region...
</memory-map>

```

Each region can be either:

- A region of RAM starting at *addr* and extending for *length* bytes from there:


```
<memory type="ram" start="addr" length="length"/>
```
- A region of read-only memory:


```
<memory type="rom" start="addr" length="length"/>
```
- A region of flash memory, with erasure blocks *blocksize* bytes in length:


```
<memory type="flash" start="addr" length="length">
  <property name="blocksize">blocksize</property>
</memory>
```

Regions must not overlap. GDB assumes that areas of memory not covered by the memory map are RAM, and uses the ordinary ‘M’ and ‘X’ packets to write to addresses in such ranges.

The formal DTD for memory map format is given below:

```

<!-- ..... -->
<!-- Memory Map XML DTD ..... -->
<!-- File: memory-map.dtd ..... -->
<!-- ..... -->
<!-- memory-map.dtd -->
<!-- memory-map: Root element with versioning -->
<!ELEMENT memory-map (memory | property)>
<!ATTLIST memory-map  version CDATA      #FIXED  "1.0.0">
<!ELEMENT memory (property)>
<!-- memory: Specifies a memory region,
    and its type, or device. -->
<!ATTLIST memory      type      CDATA      #REQUIRED
                start    CDATA      #REQUIRED

```

```

                length CDATA #REQUIRED
                device CDATA #IMPLIED>
<!-- property: Generic attribute tag -->
<!ELEMENT property (#PCDATA | property)*>
<!ATTLIST property      name      CDATA      #REQUIRED>

```

D.16 Thread List Format

To efficiently update the list of threads and their attributes, GDB issues the ‘qXfer:threads:read’ packet (see [\[qXfer threads read\]](#), page [\[undefined\]](#)) and obtains the XML document with the following structure:

```

<?xml version="1.0"?>
<threads>
  <thread id="id" core="0">
    ... description ...
  </thread>
</threads>

```

Each ‘thread’ element must have the ‘id’ attribute that identifies the thread (see [\[undefined\]](#) [\[thread-id syntax\]](#), page [\[undefined\]](#)). The ‘core’ attribute, if present, specifies which processor core the thread was last executing on. The content of the of ‘thread’ element is interpreted as human-readable auxiliary information.

Appendix E The GDB Agent Expression Mechanism

In some applications, it is not feasible for the debugger to interrupt the program's execution long enough for the developer to learn anything helpful about its behavior. If the program's correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to fail, even when the code itself is correct. It is useful to be able to observe the program's behavior without interrupting it.

Using GDB's `trace` and `collect` commands, the user can specify locations in the program, and arbitrary expressions to evaluate when those locations are reached. Later, using the `tfind` command, she can examine the values those expressions had when the program hit the trace points. The expressions may also denote objects in memory — structures or arrays, for example — whose values GDB should record; while visiting a particular tracepoint, the user may inspect those objects as if they were in memory at that moment. However, because GDB records these values without interacting with the user, it can do so quickly and unobtrusively, hopefully not disturbing the program's behavior.

When GDB is debugging a remote target, the GDB *agent* code running on the target computes the values of the expressions itself. To avoid having a full symbolic expression evaluator on the agent, GDB translates expressions in the source language into a simpler bytecode language, and then sends the bytecode to the agent; the agent then executes the bytecode, and records the values for GDB to retrieve later.

The bytecode language is simple; there are forty-odd opcodes, the bulk of which are the usual vocabulary of C operands (addition, subtraction, shifts, and so on) and various sizes of literals and memory reference operations. The bytecode interpreter operates strictly on machine-level values — various sizes of integers and floating point numbers — and requires no information about types or symbols; thus, the interpreter's internal data structures are simple, and each bytecode requires only a few native machine instructions to implement it. The interpreter is small, and strict limits on the memory and time required to evaluate an expression are easy to determine, making it suitable for use by the debugging agent in real-time applications.

E.1 General Bytecode Design

The agent represents bytecode expressions as an array of bytes. Each instruction is one byte long (thus the term *bytecode*). Some instructions are followed by operand bytes; for example, the `goto` instruction is followed by a destination for the jump.

The bytecode interpreter is a stack-based machine; most instructions pop their operands off the stack, perform some operation, and push the result back on the stack for the next instruction to consume. Each element of the stack may contain either an integer or a floating point value; these values are as many bits wide as the largest integer that can be directly manipulated in the source language. Stack elements carry no record of their type; bytecode could push a value as an integer, then pop it as a floating point value. However, GDB will not generate code which does this. In C, one might define the type of a stack element as follows:

```
union agent_val {
    LONGEST l;
    DOUBLEST d;
```

```
};
```

where `LONGEST` and `DOUBLEST` are `typedef` names for the largest integer and floating point types on the machine.

By the time the bytecode interpreter reaches the end of the expression, the value of the expression should be the only value left on the stack. For tracing applications, `trace` bytecodes in the expression will have recorded the necessary data, and the value on the stack may be discarded. For other applications, like conditional breakpoints, the value may be useful.

Separate from the stack, the interpreter has two registers:

```
pc          The address of the next bytecode to execute.
start       The address of the start of the bytecode expression, necessary for interpreting
            the goto and if_goto instructions.
```

Neither of these registers is directly visible to the bytecode language itself, but they are useful for defining the meanings of the bytecode operations.

There are no instructions to perform side effects on the running program, or call the program's functions; we assume that these expressions are only used for unobtrusive debugging, not for patching the running code.

Most bytecode instructions do not distinguish between the various sizes of values, and operate on full-width values; the upper bits of the values are simply ignored, since they do not usually make a difference to the value computed. The exceptions to this rule are:

memory reference instructions (`refn`)

There are distinct instructions to fetch different word sizes from memory. Once on the stack, however, the values are treated as full-size integers. They may need to be sign-extended; the `ext` instruction exists for this purpose.

the sign-extension instruction (`ext n`)

These clearly need to know which portion of their operand is to be extended to occupy the full length of the word.

If the interpreter is unable to evaluate an expression completely for some reason (a memory location is inaccessible, or a divisor is zero, for example), we say that interpretation "terminates with an error". This means that the problem is reported back to the interpreter's caller in some helpful way. In general, code using agent expressions should assume that they may attempt to divide by zero, fetch arbitrary memory locations, and misbehave in other ways.

Even complicated C expressions compile to a few bytecode instructions; for example, the expression `x + y * z` would typically produce code like the following, assuming that `x` and `y` live in registers, and `z` is a global variable holding a 32-bit `int`:

```
reg 1
reg 2
const32 address of z
ref32
ext 32
mul
add
```

end

In detail, these mean:

- reg 1** Push the value of register 1 (presumably holding *x*) onto the stack.
- reg 2** Push the value of register 2 (holding *y*).
- const32 address of z**
 Push the address of *z* onto the stack.
- ref32** Fetch a 32-bit word from the address at the top of the stack; replace the address on the stack with the value. Thus, we replace the address of *z* with *z*'s value.
- ext 32** Sign-extend the value on the top of the stack from 32 bits to full length. This is necessary because *z* is a signed integer.
- mul** Pop the top two numbers on the stack, multiply them, and push their product. Now the top of the stack contains the value of the expression $y * z$.
- add** Pop the top two numbers, add them, and push the sum. Now the top of the stack contains the value of $x + y * z$.
- end** Stop executing; the value left on the stack top is the value to be recorded.

E.2 Bytecode Descriptions

Each bytecode description has the following form:

add (0x02): $a\ b \Rightarrow a+b$

Pop the top two stack items, *a* and *b*, as integers; push their sum, as an integer.

In this example, **add** is the name of the bytecode, and (0x02) is the one-byte value used to encode the bytecode, in hexadecimal. The phrase “ $a\ b \Rightarrow a+b$ ” shows the stack before and after the bytecode executes. Beforehand, the stack must contain at least two values, *a* and *b*; since the top of the stack is to the right, *b* is on the top of the stack, and *a* is underneath it. After execution, the bytecode will have popped *a* and *b* from the stack, and replaced them with a single value, $a+b$. There may be other values on the stack below those shown, but the bytecode affects only those shown.

Here is another example:

const8 (0x22) n: $\Rightarrow n$

Push the 8-bit integer constant *n* on the stack, without sign extension.

In this example, the bytecode **const8** takes an operand *n* directly from the bytecode stream; the operand follows the **const8** bytecode itself. We write any such operands immediately after the name of the bytecode, before the colon, and describe the exact encoding of the operand in the bytecode stream in the body of the bytecode description.

For the **const8** bytecode, there are no stack items given before the \Rightarrow ; this simply means that the bytecode consumes no values from the stack. If a bytecode consumes no values, or produces no values, the list on either side of the \Rightarrow may be empty.

If a value is written as *a*, *b*, or *n*, then the bytecode treats it as an integer. If a value is written as *addr*, then the bytecode treats it as an address.

We do not fully describe the floating point operations here; although this design can be extended in a clean way to handle floating point values, they are not of immediate interest to the customer, so we avoid describing them, to save time.

`float (0x01):` \Rightarrow

Prefix for floating-point bytecodes. Not implemented yet.

`add (0x02):` $a\ b \Rightarrow a+b$

Pop two integers from the stack, and push their sum, as an integer.

`sub (0x03):` $a\ b \Rightarrow a-b$

Pop two integers from the stack, subtract the top value from the next-to-top value, and push the difference.

`mul (0x04):` $a\ b \Rightarrow a*b$

Pop two integers from the stack, multiply them, and push the product on the stack. Note that, when one multiplies two n -bit numbers yielding another n -bit number, it is irrelevant whether the numbers are signed or not; the results are the same.

`div_signed (0x05):` $a\ b \Rightarrow a/b$

Pop two signed integers from the stack; divide the next-to-top value by the top value, and push the quotient. If the divisor is zero, terminate with an error.

`div_unsigned (0x06):` $a\ b \Rightarrow a/b$

Pop two unsigned integers from the stack; divide the next-to-top value by the top value, and push the quotient. If the divisor is zero, terminate with an error.

`rem_signed (0x07):` $a\ b \Rightarrow a \text{ modulo } b$

Pop two signed integers from the stack; divide the next-to-top value by the top value, and push the remainder. If the divisor is zero, terminate with an error.

`rem_unsigned (0x08):` $a\ b \Rightarrow a \text{ modulo } b$

Pop two unsigned integers from the stack; divide the next-to-top value by the top value, and push the remainder. If the divisor is zero, terminate with an error.

`lsh (0x09):` $a\ b \Rightarrow a \ll b$

Pop two integers from the stack; let a be the next-to-top value, and b be the top value. Shift a left by b bits, and push the result.

`rsh_signed (0x0a):` $a\ b \Rightarrow (\text{signed})a \gg b$

Pop two integers from the stack; let a be the next-to-top value, and b be the top value. Shift a right by b bits, inserting copies of the top bit at the high end, and push the result.

`rsh_unsigned (0x0b):` $a\ b \Rightarrow a \gg b$

Pop two integers from the stack; let a be the next-to-top value, and b be the top value. Shift a right by b bits, inserting zero bits at the high end, and push the result.

`log_not (0x0e):` $a \Rightarrow !a$

Pop an integer from the stack; if it is zero, push the value one; otherwise, push the value zero.

bit_and (0x0f): $a\ b \Rightarrow a\&b$

Pop two integers from the stack, and push their bitwise **and**.

bit_or (0x10): $a\ b \Rightarrow a\|b$

Pop two integers from the stack, and push their bitwise **or**.

bit_xor (0x11): $a\ b \Rightarrow a\^b$

Pop two integers from the stack, and push their bitwise exclusive-**or**.

bit_not (0x12): $a \Rightarrow \sim a$

Pop an integer from the stack, and push its bitwise complement.

equal (0x13): $a\ b \Rightarrow a=b$

Pop two integers from the stack; if they are equal, push the value one; otherwise, push the value zero.

less_signed (0x14): $a\ b \Rightarrow a<b$

Pop two signed integers from the stack; if the next-to-top value is less than the top value, push the value one; otherwise, push the value zero.

less_unsigned (0x15): $a\ b \Rightarrow a<b$

Pop two unsigned integers from the stack; if the next-to-top value is less than the top value, push the value one; otherwise, push the value zero.

ext (0x16) n : $a \Rightarrow a$, sign-extended from n bits

Pop an unsigned value from the stack; treating it as an n -bit twos-complement value, extend it to full length. This means that all bits to the left of bit $n-1$ (where the least significant bit is bit 0) are set to the value of bit $n-1$. Note that n may be larger than or equal to the width of the stack elements of the bytecode engine; in this case, the bytecode should have no effect.

The number of source bits to preserve, n , is encoded as a single byte unsigned integer following the **ext** bytecode.

zero_ext (0x2a) n : $a \Rightarrow a$, zero-extended from n bits

Pop an unsigned value from the stack; zero all but the bottom n bits. This means that all bits to the left of bit $n-1$ (where the least significant bit is bit 0) are set to the value of bit $n-1$.

The number of source bits to preserve, n , is encoded as a single byte unsigned integer following the **zero_ext** bytecode.

ref8 (0x17): $addr \Rightarrow a$

ref16 (0x18): $addr \Rightarrow a$

ref32 (0x19): $addr \Rightarrow a$

ref64 (0x1a): $addr \Rightarrow a$

Pop an address $addr$ from the stack. For bytecode **refn**, fetch an n -bit value from $addr$, using the natural target endianness. Push the fetched value as an unsigned integer.

Note that $addr$ may not be aligned in any particular way; the **refn** bytecodes should operate correctly for any address.

If attempting to access memory at $addr$ would cause a processor exception of some sort, terminate with an error.

`ref_float (0x1b): addr ⇒ d`
`ref_double (0x1c): addr ⇒ d`
`ref_long_double (0x1d): addr ⇒ d`
`l_to_d (0x1e): a ⇒ d`
`d_to_l (0x1f): d ⇒ a`

Not implemented yet.

`dup (0x28): a => a a`
 Push another copy of the stack's top element.

`swap (0x2b): a b => b a`
 Exchange the top two items on the stack.

`pop (0x29): a =>`
 Discard the top value on the stack.

`if_goto (0x20) offset: a ⇒`
 Pop an integer off the stack; if it is non-zero, branch to the given offset in the bytecode string. Otherwise, continue to the next instruction in the bytecode stream. In other words, if *a* is non-zero, set the pc register to `start + offset`. Thus, an offset of zero denotes the beginning of the expression.

The *offset* is stored as a sixteen-bit unsigned value, stored immediately following the `if_goto` bytecode. It is always stored most significant byte first, regardless of the target's normal endianness. The offset is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the offset one byte at a time.

`goto (0x21) offset: ⇒`
 Branch unconditionally to *offset*; in other words, set the pc register to `start + offset`.

The offset is stored in the same way as for the `if_goto` bytecode.

`const8 (0x22) n: ⇒ n`
`const16 (0x23) n: ⇒ n`
`const32 (0x24) n: ⇒ n`
`const64 (0x25) n: ⇒ n`

Push the integer constant *n* on the stack, without sign extension. To produce a small negative value, push a small twos-complement value, and then sign-extend it using the `ext` bytecode.

The constant *n* is stored in the appropriate number of bytes following the `constb` bytecode. The constant *n* is always stored most significant byte first, regardless of the target's normal endianness. The constant is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch *n* one byte at a time.

`reg (0x26) n: ⇒ a`
 Push the value of register number *n*, without sign extension. The registers are numbered following GDB's conventions.

The register number n is encoded as a 16-bit unsigned integer immediately following the `reg` bytecode. It is always stored most significant byte first, regardless of the target's normal endianness. The register number is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the register number one byte at a time.

`getv (0x2c) n : $\Rightarrow v$`

Push the value of trace state variable number n , without sign extension.

The variable number n is encoded as a 16-bit unsigned integer immediately following the `getv` bytecode. It is always stored most significant byte first, regardless of the target's normal endianness. The variable number is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the register number one byte at a time.

`setv (0x2d) n : $\Rightarrow v$`

Set trace state variable number n to the value found on the top of the stack. The stack is unchanged, so that the value is readily available if the assignment is part of a larger expression. The handling of n is as described for `getv`.

`trace (0x0c): $addr$ $size$ \Rightarrow`

Record the contents of the $size$ bytes at $addr$ in a trace buffer, for later retrieval by GDB.

`trace_quick (0x0d) $size$: $addr$ $\Rightarrow addr$`

Record the contents of the $size$ bytes at $addr$ in a trace buffer, for later retrieval by GDB. $size$ is a single byte unsigned integer following the `trace` opcode.

This bytecode is equivalent to the sequence `dup const8 $size$ trace`, but we provide it anyway to save space in bytecode strings.

`trace16 (0x30) $size$: $addr$ $\Rightarrow addr$`

Identical to `trace_quick`, except that $size$ is a 16-bit big-endian unsigned integer, not a single byte. This should probably have been named `trace_quick16`, for consistency.

`tracev (0x2e) n : $\Rightarrow a$`

Record the value of trace state variable number n in the trace buffer. The handling of n is as described for `getv`.

`end (0x27): \Rightarrow`

Stop executing bytecode; the result should be the top element of the stack. If the purpose of the expression was to compute an lvalue or a range of memory, then the next-to-top of the stack is the lvalue's address, and the top of the stack is the lvalue's size, in bytes.

E.3 Using Agent Expressions

Agent expressions can be used in several different ways by GDB, and the debugger can generate different bytecode sequences as appropriate.

One possibility is to do expression evaluation on the target rather than the host, such as for the conditional of a conditional tracepoint. In such a case, GDB compiles the source expression into a bytecode sequence that simply gets values from registers or memory, does arithmetic, and returns a result.

Another way to use agent expressions is for tracepoint data collection. GDB generates a different bytecode sequence for collection; in addition to bytecodes that do the calculation, GDB adds `trace` bytecodes to save the pieces of memory that were used.

- The user selects trace points in the program's code at which GDB should collect data.
- The user specifies expressions to evaluate at each trace point. These expressions may denote objects in memory, in which case those objects' contents are recorded as the program runs, or computed values, in which case the values themselves are recorded.
- GDB transmits the tracepoints and their associated expressions to the GDB agent, running on the debugging target.
- The agent arranges to be notified when a trace point is hit.
- When execution on the target reaches a trace point, the agent evaluates the expressions associated with that trace point, and records the resulting values and memory ranges.
- Later, when the user selects a given trace event and inspects the objects and expression values recorded, GDB talks to the agent to retrieve recorded data as necessary to meet the user's requests. If the user asks to see an object whose contents have not been recorded, GDB reports an error.

E.4 Varying Target Capabilities

Some targets don't support floating-point, and some would rather not have to deal with `long long` operations. Also, different targets will have different stack sizes, and different bytecode buffer lengths.

Thus, GDB needs a way to ask the target about itself. We haven't worked out the details yet, but in general, GDB should be able to send the target a packet asking it to describe itself. The reply should be a packet whose length is explicit, so we can add new information to the packet in future revisions of the agent, without confusing old versions of GDB, and it should contain a version number. It should contain at least the following information:

- whether floating point is supported
- whether `long long` is supported
- maximum acceptable size of bytecode stack
- maximum acceptable length of bytecode expressions
- which registers are actually available for collection
- whether the target supports disabled tracepoints

E.5 Rationale

Some of the design decisions apparent above are arguable.

What about stack overflow/underflow?

GDB should be able to query the target to discover its stack size. Given that information, GDB can determine at translation time whether a given expression

will overflow the stack. But this spec isn't about what kinds of error-checking GDB ought to do.

Why are you doing everything in LONGEST?

Speed isn't important, but agent code size is; using LONGEST brings in a bunch of support code to do things like division, etc. So this is a serious concern.

First, note that you don't need different bytecodes for different operand sizes. You can generate code without *knowing* how big the stack elements actually are on the target. If the target only supports 32-bit ints, and you don't send any 64-bit bytecodes, everything just works. The observation here is that the MIPS and the Alpha have only fixed-size registers, and you can still get C's semantics even though most instructions only operate on full-sized words. You just need to make sure everything is properly sign-extended at the right times. So there is no need for 32- and 64-bit variants of the bytecodes. Just implement everything using the largest size you support.

GDB should certainly check to see what sizes the target supports, so the user can get an error earlier, rather than later. But this information is not necessary for correctness.

Why don't you have > or <= operators?

I want to keep the interpreter small, and we don't need them. We can combine the `less_` opcodes with `log_not`, and swap the order of the operands, yielding all four asymmetrical comparison operators. For example, `(x <= y)` is `!(x > y)`, which is `!(y < x)`.

Why do you have `log_not`?

Why do you have `ext`?

Why do you have `zero_ext`?

These are all easily synthesized from other instructions, but I expect them to be used frequently, and they're simple, so I include them to keep bytecode strings short.

`log_not` is equivalent to `const8 0 equal`; it's used in half the relational operators.

`ext n` is equivalent to `const8 s-n lsh const8 s-n rsh_signed`, where `s` is the size of the stack elements; it follows `refm` and `reg` bytecodes when the value should be signed. See the next bulleted item.

`zero_ext n` is equivalent to `constm mask log_and`; it's used whenever we push the value of a register, because we can't assume the upper bits of the register aren't garbage.

Why not have sign-extending variants of the `ref` operators?

Because that would double the number of `ref` operators, and we need the `ext` bytecode anyway for accessing bitfields.

Why not have constant-address variants of the `ref` operators?

Because that would double the number of `ref` operators again, and `const32 address ref32` is only one byte longer.

Why do the `refn` operators have to support unaligned fetches?

GDB will generate bytecode that fetches multi-byte values at unaligned addresses whenever the executable's debugging information tells it to. Furthermore, GDB does not know the value the pointer will have when GDB generates the bytecode, so it cannot determine whether a particular fetch will be aligned or not.

In particular, structure bitfields may be several bytes long, but follow no alignment rules; members of packed structures are not necessarily aligned either.

In general, there are many cases where unaligned references occur in correct C code, either at the programmer's explicit request, or at the compiler's discretion. Thus, it is simpler to make the GDB agent bytecodes work correctly in all circumstances than to make GDB guess in each case whether the compiler did the usual thing.

Why are there no side-effecting operators?

Because our current client doesn't want them? That's a cheap answer. I think the real answer is that I'm afraid of implementing function calls. We should re-visit this issue after the present contract is delivered.

Why aren't the `goto ops` PC-relative?

The interpreter has the base address around anyway for PC bounds checking, and it seemed simpler.

Why is there only one offset size for the `goto ops`?

Offsets are currently sixteen bits. I'm not happy with this situation either:

Suppose we have multiple branch ops with different offset sizes. As I generate code left-to-right, all my jumps are forward jumps (there are no loops in expressions), so I never know the target when I emit the jump opcode. Thus, I have to either always assume the largest offset size, or do jump relaxation on the code after I generate it, which seems like a big waste of time.

I can imagine a reasonable expression being longer than 256 bytes. I can't imagine one being longer than 64k. Thus, we need 16-bit offsets. This kind of reasoning is so bogus, but relaxation is pathetic.

The other approach would be to generate code right-to-left. Then I'd always know my offset size. That might be fun.

Where is the function call bytecode?

When we add side-effects, we should add this.

Why does the `reg` bytecode take a 16-bit register number?

Intel's IA-64 architecture has 128 general-purpose registers, and 128 floating-point registers, and I'm sure it has some random control registers.

Why do we need `trace` and `trace_quick`?

Because GDB needs to record all the memory contents and registers an expression touches. If the user wants to evaluate an expression `x->y->z`, the agent must record the values of `x` and `x->y` as well as the value of `x->y->z`.

Don't the trace bytecodes make the interpreter less general?

They do mean that the interpreter contains special-purpose code, but that doesn't mean the interpreter can only be used for that purpose. If an expression doesn't use the `trace` bytecodes, they don't get in its way.

Why doesn't `trace_quick` consume its arguments the way everything else does?

In general, you do want your operators to consume their arguments; it's consistent, and generally reduces the amount of stack rearrangement necessary. However, `trace_quick` is a kludge to save space; it only exists so we needn't write `dup const8 SIZE trace` before every memory reference. Therefore, it's okay for it not to consume its arguments; it's meant for a specific context in which we know exactly what it should do with the stack. If we're going to have a kludge, it should be an effective kludge.

Why does `trace16` exist?

That opcode was added by the customer that contracted Cygnus for the data tracing work. I personally think it is unnecessary; objects that large will be quite rare, so it is okay to use `dup const16 size trace` in those cases.

Whatever we decide to do with `trace16`, we should at least leave opcode 0x30 reserved, to remain compatible with the customer who added it.

Appendix F Trace File Format

The trace file comes in three parts: a header, a textual description section, and a trace frame section with binary data.

The header has the form `\x7fTRACE0\n`. The first byte is `0x7f` so as to indicate that the file contains binary data, while the `0` is a version number that may have different values in the future.

The description section consists of multiple lines of ASCII text separated by newline characters (`0xa`). The lines may include a variety of optional descriptive or context-setting information, such as tracepoint definitions or register set size. GDB will ignore any line that it does not recognize. An empty line marks the end of this section.

The trace frame section consists of a number of consecutive frames. Each frame begins with a two-byte tracepoint number, followed by a four-byte size giving the amount of data in the frame. The data in the frame consists of a number of blocks, each introduced by a character indicating its type (at least register, memory, and trace state variable). The data in this section is raw binary, not a hexadecimal or other encoding; its endianness matches the target's endianness.

R *bytes* Register block. The number and ordering of bytes matches that of a **g** packet in the remote protocol. Note that these are the actual bytes, in target order and GDB register order, not a hexadecimal encoding.

M *address length bytes...* Memory block. This is a contiguous block of memory, at the 8-byte address *address*, with a 2-byte length *length*, followed by *length* bytes.

V *number value* Trace state variable block. This records the 8-byte signed value *value* of trace state variable numbered *number*.

Future enhancements of the trace file format may include additional types of blocks.

Appendix G Target Descriptions

Warning: target descriptions are still under active development, and the contents and format may change between GDB releases. The format is expected to stabilize in the future.

One of the challenges of using GDB to debug embedded systems is that there are so many minor variants of each processor architecture in use. It is common practice for vendors to start with a standard processor core — ARM, PowerPC, or MIPS, for example — and then make changes to adapt it to a particular market niche. Some architectures have hundreds of variants, available from dozens of vendors. This leads to a number of problems:

- With so many different customized processors, it is difficult for the GDB maintainers to keep up with the changes.
- Since individual variants may have short lifetimes or limited audiences, it may not be worthwhile to carry information about every variant in the GDB source tree.
- When GDB does support the architecture of the embedded system at hand, the task of finding the correct architecture name to give the `set architecture` command can be error-prone.

To address these problems, the GDB remote protocol allows a target system to not only identify itself to GDB, but to actually describe its own features. This lets GDB support processor variants it has never seen before — to the extent that the descriptions are accurate, and that GDB understands them.

GDB must be linked with the Expat library to support XML target descriptions. See [\(undefined\) \[Expat\], page \(undefined\)](#).

G.1 Retrieving Descriptions

Target descriptions can be read from the target automatically, or specified by the user manually. The default behavior is to read the description from the target. GDB retrieves it via the remote protocol using ‘qXfer’ requests (see [\(undefined\) \[General Query Packets\], page \(undefined\)](#)). The *annex* in the ‘qXfer’ packet will be ‘target.xml’. The contents of the ‘target.xml’ annex are an XML document, of the form described in [\(undefined\) \[Target Description Format\], page \(undefined\)](#).

Alternatively, you can specify a file to read for the target description. If a file is set, the target will not be queried. The commands to specify a file are:

```
set tdesc filename path
```

Read the target description from *path*.

```
unset tdesc filename
```

Do not read the XML target description from a file. GDB will use the description supplied by the current target.

```
show tdesc filename
```

Show the filename to read for a target description, if any.

G.2 Target Description Format

A target description annex is an **XML** document which complies with the Document Type Definition provided in the GDB sources in ‘`gdb/features/gdb-target.dtd`’. This means you can use generally available tools like `xmllint` to check that your feature descriptions are well-formed and valid. However, to help people unfamiliar with XML write descriptions for their targets, we also describe the grammar here.

Target descriptions can identify the architecture of the remote target and (for some architectures) provide information about custom register sets. They can also identify the OS ABI of the remote target. GDB can use this information to autoconfigure for your target, or to warn you if you connect to an unsupported target.

Here is a simple target description:

```
<target version="1.0">
  <architecture>i386:x86-64</architecture>
</target>
```

This minimal description only says that the target uses the x86-64 architecture.

A target description has the following overall form, with [] marking optional elements and . . . marking repeatable elements. The elements are explained further below.

```
<?xml version="1.0"?>
<!DOCTYPE target SYSTEM "gdb-target.dtd">
<target version="1.0">
  [architecture]
  [osabi]
  [compatible]
  [feature...]
</target>
```

The description is generally insensitive to whitespace and line breaks, under the usual common-sense rules. The XML version declaration and document type declaration can generally be omitted (GDB does not require them), but specifying them may be useful for XML validation tools. The ‘`version`’ attribute for ‘`<target>`’ may also be omitted, but we recommend including it; if future versions of GDB use an incompatible revision of ‘`gdb-target.dtd`’, they will detect and report the version mismatch.

G.2.1 Inclusion

It can sometimes be valuable to split a target description up into several different annexes, either for organizational purposes, or to share files between different possible target descriptions. You can divide a description into multiple files by replacing any element of the target description with an inclusion directive of the form:

```
<xi:include href="document"/>
```

When GDB encounters an element of this form, it will retrieve the named XML *document*, and replace the inclusion directive with the contents of that document. If the current description was read using ‘`qXfer`’, then so will be the included document; *document* will be interpreted as the name of an annex. If the current description was read from a file, GDB will look for *document* as a file in the same directory where it found the original description.

G.2.2 Architecture

An ‘`<architecture>`’ element has this form:

```
<architecture>arch</architecture>
```

arch is one of the architectures from the set accepted by `set architecture` (see [\(undefined\) \[Specifying a Debugging Target\]](#), page [\(undefined\)](#)).

G.2.3 OS ABI

This optional field was introduced in GDB version 7.0. Previous versions of GDB ignore it.

An ‘<osabi>’ element has this form:

```
<osabi>abi-name</osabi>
```

abi-name is an OS ABI name from the same selection accepted by `set osabi` (see [\(undefined\) \[Configuring the Current ABI\]](#), page [\(undefined\)](#)).

G.2.4 Compatible Architecture

This optional field was introduced in GDB version 7.0. Previous versions of GDB ignore it.

A ‘<compatible>’ element has this form:

```
<compatible>arch</compatible>
```

arch is one of the architectures from the set accepted by `set architecture` (see [\(undefined\) \[Specifying a Debugging Target\]](#), page [\(undefined\)](#)).

A ‘<compatible>’ element is used to specify that the target is able to run binaries in some other than the main target architecture given by the ‘<architecture>’ element. For example, on the Cell Broadband Engine, the main architecture is `powerpc:common` or `powerpc:common64`, but the system is able to run binaries in the `spu` architecture as well. The way to describe this capability with ‘<compatible>’ is as follows:

```
<architecture>powerpc:common</architecture>
<compatible>spu</compatible>
```

G.2.5 Features

Each ‘<feature>’ describes some logical portion of the target system. Features are currently used to describe available CPU registers and the types of their contents. A ‘<feature>’ element has this form:

```
<feature name="name">
  [type...]
  reg...
</feature>
```

Each feature’s name should be unique within the description. The name of a feature does not matter unless GDB has some special knowledge of the contents of that feature; if it does, the feature should have its standard name. See [\(undefined\) \[Standard Target Features\]](#), page [\(undefined\)](#).

G.2.6 Types

Any register’s value is a collection of bits which GDB must interpret. The default interpretation is a two’s complement integer, but other types can be requested by name in the register description. Some predefined types are provided by GDB (see [\(undefined\) \[Predefined Target Types\]](#), page [\(undefined\)](#)), and the description can define additional composite types.

Each type element must have an ‘id’ attribute, which gives a unique (within the containing ‘<feature>’) name to the type. Types must be defined before they are used.

Some targets offer vector registers, which can be treated as arrays of scalar elements. These types are written as ‘<vector>’ elements, specifying the array element type, *type*, and the number of elements, *count*:

```
<vector id="id" type="type" count="count"/>
```

If a register’s value is usefully viewed in multiple ways, define it with a union type containing the useful representations. The ‘<union>’ element contains one or more ‘<field>’ elements, each of which has a *name* and a *type*:

```
<union id="id">
  <field name="name" type="type"/>
  ...
</union>
```

If a register’s value is composed from several separate values, define it with a structure type. There are two forms of the ‘<struct>’ element; a ‘<struct>’ element must either contain only bitfields or contain no bitfields. If the structure contains only bitfields, its total size in bytes must be specified, each bitfield must have an explicit start and end, and bitfields are automatically assigned an integer type. The field’s *start* should be less than or equal to its *end*, and zero represents the least significant bit.

```
<struct id="id" size="size">
  <field name="name" start="start" end="end"/>
  ...
</struct>
```

If the structure contains no bitfields, then each field has an explicit type, and no implicit padding is added.

```
<struct id="id">
  <field name="name" type="type"/>
  ...
</struct>
```

If a register’s value is a series of single-bit flags, define it with a flags type. The ‘<flags>’ element has an explicit *size* and contains one or more ‘<field>’ elements. Each field has a *name*, a *start*, and an *end*. Only single-bit flags are supported.

```
<flags id="id" size="size">
  <field name="name" start="start" end="end"/>
  ...
</flags>
```

G.2.7 Registers

Each register is represented as an element with this form:

```
<reg name="name"
  bitsize="size"
  [regnum="num"]
  [save-restore="save-restore"]
  [type="type"]
  [group="group"]/>
```

The components are as follows:

- name* The register’s name; it must be unique within the target description.
- bitsize* The register’s size, in bits.
- regnum* The register’s number. If omitted, a register’s number is one greater than that of the previous register (either in the current feature or in a preceding

feature); the first register in the target description defaults to zero. This register number is used to read or write the register; e.g. it is used in the remote `p` and `P` packets, and registers appear in the `g` and `G` packets in order of increasing register number.

save-restore

Whether the register should be preserved across inferior function calls; this must be either **yes** or **no**. The default is **yes**, which is appropriate for most registers except for some system control registers; this is not related to the target's ABI.

type

The type of the register. *type* may be a predefined type, a type defined in the current feature, or one of the special types `int` and `float`. `int` is an integer type of the correct size for *bitsize*, and `float` is a floating point type (in the architecture's normal floating point format) of the correct size for *bitsize*. The default is `int`.

group

The register group to which this register belongs. *group* must be either **general**, **float**, or **vector**. If no *group* is specified, GDB will not display the register in `info registers`.

G.3 Predefined Target Types

Type definitions in the self-description can build up composite types from basic building blocks, but can not define fundamental types. Instead, standard identifiers are provided by GDB for the fundamental types. The currently supported types are:

`int8`

`int16`

`int32`

`int64`

`int128` Signed integer types holding the specified number of bits.

`uint8`

`uint16`

`uint32`

`uint64`

`uint128` Unsigned integer types holding the specified number of bits.

`code_ptr`

`data_ptr` Pointers to unspecified code and data. The program counter and any dedicated return address register may be marked as code pointers; printing a code pointer converts it into a symbolic address. The stack pointer and any dedicated address registers may be marked as data pointers.

`ieee_single`

Single precision IEEE floating point.

`ieee_double`

Double precision IEEE floating point.

`arm_fpa_ext`

The 12-byte extended precision format used by ARM FPA registers.

`i387_ext` The 10-byte extended precision format used by x87 registers.

`i386_eflags`
32bit EFLAGS register used by x86.

`i386_mxcsr`
32bit MXCSR register used by x86.

G.4 Standard Target Features

A target description must contain either no registers or all the target's registers. If the description contains no registers, then GDB will assume a default register layout, selected based on the architecture. If the description contains any registers, the default layout will not be used; the standard registers must be described in the target description, in such a way that GDB can recognize them.

This is accomplished by giving specific names to feature elements which contain standard registers. GDB will look for features with those names and verify that they contain the expected registers; if any known feature is missing required registers, or if any required feature is missing, GDB will reject the target description. You can add additional registers to any of the standard features — GDB will display them just as if they were added to an unrecognized feature.

This section lists the known features and their expected contents. Sample XML documents for these features are included in the GDB source tree, in the directory `'gdb/features'`.

Names recognized by GDB should include the name of the company or organization which selected the name, and the overall architecture to which the feature applies; so e.g. the feature containing ARM core registers is named `'org.gnu.gdb.arm.core'`.

The names of registers are not case sensitive for the purpose of recognizing standard features, but GDB will only display registers using the capitalization used in the description.

G.4.1 ARM Features

The `'org.gnu.gdb.arm.core'` feature is required for ARM targets. It should contain registers `'r0'` through `'r13'`, `'sp'`, `'lr'`, `'pc'`, and `'cpsr'`.

The `'org.gnu.gdb.arm.fpa'` feature is optional. If present, it should contain registers `'f0'` through `'f7'` and `'fps'`.

The `'org.gnu.gdb.xscale.iwmmxt'` feature is optional. If present, it should contain at least registers `'wR0'` through `'wR15'` and `'wCGR0'` through `'wCGR3'`. The `'wCID'`, `'wCon'`, `'wCSSF'`, and `'wCASF'` registers are optional.

The `'org.gnu.gdb.arm.vfp'` feature is optional. If present, it should contain at least registers `'d0'` through `'d15'`. If they are present, `'d16'` through `'d31'` should also be included. GDB will synthesize the single-precision registers from halves of the double-precision registers.

The `'org.gnu.gdb.arm.neon'` feature is optional. It does not need to contain registers; it instructs GDB to display the VFP double-precision registers as vectors and to synthesize the quad-precision registers from pairs of double-precision registers. If this feature is present, `'org.gnu.gdb.arm.vfp'` must also be present and include 32 double-precision registers.

G.4.2 i386 Features

The `org.gnu.gdb.i386.core` feature is required for i386/amd64 targets. It should describe the following registers:

- ‘`eax`’ through ‘`edi`’ plus ‘`eip`’ for i386
- ‘`rax`’ through ‘`r15`’ plus ‘`rip`’ for amd64
- ‘`eflags`’, ‘`cs`’, ‘`ss`’, ‘`ds`’, ‘`es`’, ‘`fs`’, ‘`gs`’
- ‘`st0`’ through ‘`st7`’
- ‘`fctrl`’, ‘`fstat`’, ‘`ftag`’, ‘`fiseg`’, ‘`fioff`’, ‘`foseg`’, ‘`fooff`’ and ‘`fop`’

The register sets may be different, depending on the target.

The `org.gnu.gdb.i386.sse` feature is optional. It should describe registers:

- ‘`xmm0`’ through ‘`xmm7`’ for i386
- ‘`xmm0`’ through ‘`xmm15`’ for amd64
- ‘`mxcsr`’

The `org.gnu.gdb.i386.avx` feature is optional and requires the `org.gnu.gdb.i386.sse` feature. It should describe the upper 128 bits of YMM registers:

- ‘`ymm0h`’ through ‘`ymm7h`’ for i386
- ‘`ymm0h`’ through ‘`ymm15h`’ for amd64
-

The `org.gnu.gdb.i386.linux` feature is optional. It should describe a single register, ‘`orig_eax`’.

G.4.3 MIPS Features

The `org.gnu.gdb.mips.cpu` feature is required for MIPS targets. It should contain registers ‘`r0`’ through ‘`r31`’, ‘`lo`’, ‘`hi`’, and ‘`pc`’. They may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.cp0` feature is also required. It should contain at least the ‘`status`’, ‘`badvaddr`’, and ‘`cause`’ registers. They may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.fpu` feature is currently required, though it may be optional in a future version of GDB. It should contain registers ‘`f0`’ through ‘`f31`’, ‘`fcsr`’, and ‘`fir`’. They may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.linux` feature is optional. It should contain a single register, ‘`restart`’, which is used by the Linux kernel to control restartable syscalls.

G.4.4 M68K Features

- ‘`org.gnu.gdb.m68k.core`’
- ‘`org.gnu.gdb.coldfire.core`’
- ‘`org.gnu.gdb.fido.core`’

One of those features must be always present. The feature that is present determines which flavor of m68k is used. The feature that is present should contain registers ‘`d0`’ through ‘`d7`’, ‘`a0`’ through ‘`a5`’, ‘`fp`’, ‘`sp`’, ‘`ps`’ and ‘`pc`’.

`'org.gnu.gdb.coldfire.fp'`

This feature is optional. If present, it should contain registers `'fp0'` through `'fp7'`, `'fpcontrol'`, `'fpstatus'` and `'fpiaaddr'`.

G.4.5 PowerPC Features

The `'org.gnu.gdb.power.core'` feature is required for PowerPC targets. It should contain registers `'r0'` through `'r31'`, `'pc'`, `'msr'`, `'cr'`, `'lr'`, `'ctr'`, and `'xer'`. They may be 32-bit or 64-bit depending on the target.

The `'org.gnu.gdb.power.fpu'` feature is optional. It should contain registers `'f0'` through `'f31'` and `'fpscr'`.

The `'org.gnu.gdb.power.altivec'` feature is optional. It should contain registers `'vr0'` through `'vr31'`, `'vscr'`, and `'vrsave'`.

The `'org.gnu.gdb.power.vsx'` feature is optional. It should contain registers `'vs0h'` through `'vs31h'`. GDB will combine these registers with the floating point registers (`'f0'` through `'f31'`) and the altivec registers (`'vr0'` through `'vr31'`) to present the 128-bit wide registers `'vs0'` through `'vs63'`, the set of vector registers for POWER7.

The `'org.gnu.gdb.power.spe'` feature is optional. It should contain registers `'ev0h'` through `'ev31h'`, `'acc'`, and `'spefscr'`. SPE targets should provide 32-bit registers in `'org.gnu.gdb.power.core'` and provide the upper halves in `'ev0h'` through `'ev31h'`. GDB will combine these to present registers `'ev0'` through `'ev31'` to the user.

Appendix H Operating System Information

Users of GDB often wish to obtain information about the state of the operating system running on the target—for example the list of processes, or the list of open files. This section describes the mechanism that makes it possible. This mechanism is similar to the target features mechanism (see [\[Target Descriptions\]](#), page [\(undefined\)](#)), but focuses on a different aspect of target.

Operating system information is retrieved from the target via the remote protocol, using ‘qXfer’ requests (see [\[qXfer osdata read\]](#), page [\(undefined\)](#)). The object name in the request should be ‘osdata’, and the *annex* identifies the data to be fetched.

H.1 Process list

When requesting the process list, the *annex* field in the ‘qXfer’ request should be ‘processes’. The returned data is an XML document. The formal syntax of this document is defined in ‘gdb/features/osdata.dtd’.

An example document is:

```
<?xml version="1.0"?>
<!DOCTYPE target SYSTEM "osdata.dtd">
<osdata type="processes">
  <item>
    <column name="pid">1</column>
    <column name="user">root</column>
    <column name="command">/sbin/init</column>
    <column name="cores">1,2,3</column>
  </item>
</osdata>
```

Each item should include a column whose name is ‘pid’. The value of that column should identify the process on the target. The ‘user’ and ‘command’ columns are optional, and will be displayed by GDB. The ‘cores’ column, if present, should contain a comma-separated list of cores that this process is running on. Target may provide additional columns, which GDB currently ignores.

Appendix I GNU GENERAL PUBLIC LICENSE

Version 3, 29 June 2007

Copyright © 2007 Free Software Foundation, Inc. <http://fsf.org/>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The GNU General Public License is a free, copyleft license for software and other kinds of works.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program—to make sure it remains free software for all its users. We, the Free Software Foundation, use the GNU General Public License for most of our software; it applies also to any other work released this way by its authors. You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for them if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs, and that you know you can do these things.

To protect your rights, we need to prevent others from denying you these rights or asking you to surrender the rights. Therefore, you have certain responsibilities if you distribute copies of the software, or if you modify it: responsibilities to respect the freedom of others.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must pass on to the recipients the same freedoms that you received. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

Developers that use the GNU GPL protect your rights with two steps: (1) assert copyright on the software, and (2) offer you this License giving you legal permission to copy, distribute and/or modify it.

For the developers' and authors' protection, the GPL clearly explains that there is no warranty for this free software. For both users' and authors' sake, the GPL requires that modified versions be marked as changed, so that their problems will not be attributed erroneously to authors of previous versions.

Some devices are designed to deny users access to install or run modified versions of the software inside them, although the manufacturer can do so. This is fundamentally incompatible with the aim of protecting users' freedom to change the software. The systematic pattern of such abuse occurs in the area of products for individuals to use, which is precisely where it is most unacceptable. Therefore, we have designed this version of the GPL to prohibit the practice for those products. If such problems arise substantially in other domains, we stand ready to extend this provision to those domains in future versions of the GPL, as needed to protect the freedom of users.

Finally, every program is threatened constantly by software patents. States should not allow patents to restrict development and use of software on general-purpose computers, but in those that do, we wish to avoid the special danger that patents applied to a free program could make it effectively proprietary. To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS

0. Definitions.

“This License” refers to version 3 of the GNU General Public License.

“Copyright” also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

“The Program” refers to any copyrightable work licensed under this License. Each licensee is addressed as “you”. “Licensees” and “recipients” may be individuals or organizations.

To “modify” a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a “modified version” of the earlier work or a work “based on” the earlier work.

A “covered work” means either the unmodified Program or a work based on the Program.

To “propagate” a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

To “convey” a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

An interactive user interface displays “Appropriate Legal Notices” to the extent that it includes a convenient and prominently visible feature that (1) displays an appropriate copyright notice, and (2) tells the user that there is no warranty for the work (except to the extent that warranties are provided), that licensees may convey the work under this License, and how to view a copy of this License. If the interface presents a list of user commands or options, such as a menu, a prominent item in the list meets this criterion.

1. Source Code.

The “source code” for a work means the preferred form of the work for making modifications to it. “Object code” means any non-source form of a work.

A “Standard Interface” means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The “System Libraries” of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A “Major Component”, in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The “Corresponding Source” for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work’s System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

The Corresponding Source for a work in source code form is that same work.

2. Basic Permissions.

All rights granted under this License are granted for the term of copyright on the Program, and are irrevocable provided the stated conditions are met. This License explicitly affirms your unlimited permission to run the unmodified Program. The output from running a covered work is covered by this License only if the output, given its content, constitutes a covered work. This License acknowledges your rights of fair use or other equivalent, as provided by copyright law.

You may make, run and propagate covered works that you do not convey, without conditions so long as your license otherwise remains in force. You may convey covered works to others for the sole purpose of having them make modifications exclusively for you, or provide you with facilities for running those works, provided that you comply with the terms of this License in conveying all material for which you do not control copyright. Those thus making or running the covered works for you must do so exclusively on your behalf, under your direction and control, on terms that prohibit them from making any copies of your copyrighted material outside their relationship with you.

Conveying under any other circumstances is permitted solely under the conditions stated below. Sublicensing is not allowed; section 10 makes it unnecessary.

3. Protecting Users’ Legal Rights From Anti-Circumvention Law.

No covered work shall be deemed part of an effective technological measure under any applicable law fulfilling obligations under article 11 of the WIPO copyright treaty adopted on 20 December 1996, or similar laws prohibiting or restricting circumvention of such measures.

When you convey a covered work, you waive any legal power to forbid circumvention of technological measures to the extent such circumvention is effected by exercising rights under this License with respect to the covered work, and you disclaim any intention to limit operation or modification of the work as a means of enforcing, against the work's users, your or third parties' legal rights to forbid circumvention of technological measures.

4. Conveying Verbatim Copies.

You may convey verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice; keep intact all notices stating that this License and any non-permissive terms added in accord with section 7 apply to the code; keep intact all notices of the absence of any warranty; and give all recipients a copy of this License along with the Program.

You may charge any price or no price for each copy that you convey, and you may offer support or warranty protection for a fee.

5. Conveying Modified Source Versions.

You may convey a work based on the Program, or the modifications to produce it from the Program, in the form of source code under the terms of section 4, provided that you also meet all of these conditions:

- a. The work must carry prominent notices stating that you modified it, and giving a relevant date.
- b. The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to "keep intact all notices".
- c. You must license the entire work, as a whole, under this License to anyone who comes into possession of a copy. This License will therefore apply, along with any applicable section 7 additional terms, to the whole of the work, and all its parts, regardless of how they are packaged. This License gives no permission to license the work in any other way, but it does not invalidate such permission if you have separately received it.
- d. If the work has interactive user interfaces, each must display Appropriate Legal Notices; however, if the Program has interactive interfaces that do not display Appropriate Legal Notices, your work need not make them do so.

A compilation of a covered work with other separate and independent works, which are not by their nature extensions of the covered work, and which are not combined with it such as to form a larger program, in or on a volume of a storage or distribution medium, is called an "aggregate" if the compilation and its resulting copyright are not used to limit the access or legal rights of the compilation's users beyond what the individual works permit. Inclusion of a covered work in an aggregate does not cause this License to apply to the other parts of the aggregate.

6. Conveying Non-Source Forms.

You may convey a covered work in object code form under the terms of sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:

- a. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.
- b. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.
- c. Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.
- d. Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.
- e. Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A “User Product” is either (1) a “consumer product”, which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, “normally used” refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless of whether the product has substantial commercial, industrial or non-consumer uses, unless such uses represent the only significant mode of use of the product.

“Installation Information” for a User Product means any methods, procedures, authorization keys, or other information required to install and execute modified versions of a covered work in that User Product from a modified version of its Corresponding Source.

The information must suffice to ensure that the continued functioning of the modified object code is in no case prevented or interfered with solely because modification has been made.

If you convey an object code work under this section in, or with, or specifically for use in, a User Product, and the conveying occurs as part of a transaction in which the right of possession and use of the User Product is transferred to the recipient in perpetuity or for a fixed term (regardless of how the transaction is characterized), the Corresponding Source conveyed under this section must be accompanied by the Installation Information. But this requirement does not apply if neither you nor any third party retains the ability to install modified object code on the User Product (for example, the work has been installed in ROM).

The requirement to provide Installation Information does not include a requirement to continue to provide support service, warranty, or updates for a work that has been modified or installed by the recipient, or for the User Product in which it has been modified or installed. Access to a network may be denied when the modification itself materially and adversely affects the operation of the network or violates the rules and protocols for communication across the network.

Corresponding Source conveyed, and Installation Information provided, in accord with this section must be in a format that is publicly documented (and with an implementation available to the public in source code form), and must require no special password or key for unpacking, reading or copying.

7. Additional Terms.

“Additional permissions” are terms that supplement the terms of this License by making exceptions from one or more of its conditions. Additional permissions that are applicable to the entire Program shall be treated as though they were included in this License, to the extent that they are valid under applicable law. If additional permissions apply only to part of the Program, that part may be used separately under those permissions, but the entire Program remains governed by this License without regard to the additional permissions.

When you convey a copy of a covered work, you may at your option remove any additional permissions from that copy, or from any part of it. (Additional permissions may be written to require their own removal in certain cases when you modify the work.) You may place additional permissions on material, added by you to a covered work, for which you have or can give appropriate copyright permission.

Notwithstanding any other provision of this License, for material you add to a covered work, you may (if authorized by the copyright holders of that material) supplement the terms of this License with terms:

- a. Disclaiming warranty or limiting liability differently from the terms of sections 15 and 16 of this License; or
- b. Requiring preservation of specified reasonable legal notices or author attributions in that material or in the Appropriate Legal Notices displayed by works containing it; or
- c. Prohibiting misrepresentation of the origin of that material, or requiring that modified versions of such material be marked in reasonable ways as different from the original version; or

- d. Limiting the use for publicity purposes of names of licensors or authors of the material; or
- e. Declining to grant rights under trademark law for use of some trade names, trademarks, or service marks; or
- f. Requiring indemnification of licensors and authors of that material by anyone who conveys the material (or modified versions of it) with contractual assumptions of liability to the recipient, for any liability that these contractual assumptions directly impose on those licensors and authors.

All other non-permissive additional terms are considered “further restrictions” within the meaning of section 10. If the Program as you received it, or any part of it, contains a notice stating that it is governed by this License along with a term that is a further restriction, you may remove that term. If a license document contains a further restriction but permits relicensing or conveying under this License, you may add to a covered work material governed by the terms of that license document, provided that the further restriction does not survive such relicensing or conveying.

If you add terms to a covered work in accord with this section, you must place, in the relevant source files, a statement of the additional terms that apply to those files, or a notice indicating where to find the applicable terms.

Additional terms, permissive or non-permissive, may be stated in the form of a separately written license, or stated as exceptions; the above requirements apply either way.

8. Termination.

You may not propagate or modify a covered work except as expressly provided under this License. Any attempt otherwise to propagate or modify it is void, and will automatically terminate your rights under this License (including any patent licenses granted under the third paragraph of section 11).

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, you do not qualify to receive new licenses for the same material under section 10.

9. Acceptance Not Required for Having Copies.

You are not required to accept this License in order to receive or run a copy of the Program. Ancillary propagation of a covered work occurring solely as a consequence of using peer-to-peer transmission to receive a copy likewise does not require acceptance.

However, nothing other than this License grants you permission to propagate or modify any covered work. These actions infringe copyright if you do not accept this License. Therefore, by modifying or propagating a covered work, you indicate your acceptance of this License to do so.

10. Automatic Licensing of Downstream Recipients.

Each time you convey a covered work, the recipient automatically receives a license from the original licensors, to run, modify and propagate that work, subject to this License. You are not responsible for enforcing compliance by third parties with this License.

An “entity transaction” is a transaction transferring control of an organization, or substantially all assets of one, or subdividing an organization, or merging organizations. If propagation of a covered work results from an entity transaction, each party to that transaction who receives a copy of the work also receives whatever licenses to the work the party’s predecessor in interest had or could give under the previous paragraph, plus a right to possession of the Corresponding Source of the work from the predecessor in interest, if the predecessor has it or can get it with reasonable efforts.

You may not impose any further restrictions on the exercise of the rights granted or affirmed under this License. For example, you may not impose a license fee, royalty, or other charge for exercise of rights granted under this License, and you may not initiate litigation (including a cross-claim or counterclaim in a lawsuit) alleging that any patent claim is infringed by making, using, selling, offering for sale, or importing the Program or any portion of it.

11. Patents.

A “contributor” is a copyright holder who authorizes use under this License of the Program or a work on which the Program is based. The work thus licensed is called the contributor’s “contributor version”.

A contributor’s “essential patent claims” are all patent claims owned or controlled by the contributor, whether already acquired or hereafter acquired, that would be infringed by some manner, permitted by this License, of making, using, or selling its contributor version, but do not include claims that would be infringed only as a consequence of further modification of the contributor version. For purposes of this definition, “control” includes the right to grant patent sublicenses in a manner consistent with the requirements of this License.

Each contributor grants you a non-exclusive, worldwide, royalty-free patent license under the contributor’s essential patent claims, to make, use, sell, offer for sale, import and otherwise run, modify and propagate the contents of its contributor version.

In the following three paragraphs, a “patent license” is any express agreement or commitment, however denominated, not to enforce a patent (such as an express permission to practice a patent or covenant not to sue for patent infringement). To “grant” such a patent license to a party means to make such an agreement or commitment not to enforce a patent against the party.

If you convey a covered work, knowingly relying on a patent license, and the Corresponding Source of the work is not available for anyone to copy, free of charge and under the terms of this License, through a publicly available network server or other readily accessible means, then you must either (1) cause the Corresponding Source to be so

available, or (2) arrange to deprive yourself of the benefit of the patent license for this particular work, or (3) arrange, in a manner consistent with the requirements of this License, to extend the patent license to downstream recipients. “Knowingly relying” means you have actual knowledge that, but for the patent license, your conveying the covered work in a country, or your recipient’s use of the covered work in a country, would infringe one or more identifiable patents in that country that you have reason to believe are valid.

If, pursuant to or in connection with a single transaction or arrangement, you convey, or propagate by procuring conveyance of, a covered work, and grant a patent license to some of the parties receiving the covered work authorizing them to use, propagate, modify or convey a specific copy of the covered work, then the patent license you grant is automatically extended to all recipients of the covered work and works based on it.

A patent license is “discriminatory” if it does not include within the scope of its coverage, prohibits the exercise of, or is conditioned on the non-exercise of one or more of the rights that are specifically granted under this License. You may not convey a covered work if you are a party to an arrangement with a third party that is in the business of distributing software, under which you make payment to the third party based on the extent of your activity of conveying the work, and under which the third party grants, to any of the parties who would receive the covered work from you, a discriminatory patent license (a) in connection with copies of the covered work conveyed by you (or copies made from those copies), or (b) primarily for and in connection with specific products or compilations that contain the covered work, unless you entered into that arrangement, or that patent license was granted, prior to 28 March 2007.

Nothing in this License shall be construed as excluding or limiting any implied license or other defenses to infringement that may otherwise be available to you under applicable patent law.

12. No Surrender of Others’ Freedom.

If conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot convey a covered work so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not convey it at all. For example, if you agree to terms that obligate you to collect a royalty for further conveying from those to whom you convey the Program, the only way you could satisfy both those terms and this License would be to refrain entirely from conveying the Program.

13. Use with the GNU Affero General Public License.

Notwithstanding any other provision of this License, you have permission to link or combine any covered work with a work licensed under version 3 of the GNU Affero General Public License into a single combined work, and to convey the resulting work. The terms of this License will continue to apply to the part which is the covered work, but the special requirements of the GNU Affero General Public License, section 13, concerning interaction through a network will apply to the combination as such.

14. Revised Versions of this License.

The Free Software Foundation may publish revised and/or new versions of the GNU General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies that a certain numbered version of the GNU General Public License “or any later version” applies to it, you have the option of following the terms and conditions either of that numbered version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of the GNU General Public License, you may choose any version ever published by the Free Software Foundation.

If the Program specifies that a proxy can decide which future versions of the GNU General Public License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Program.

Later license versions may give you additional or different permissions. However, no additional obligations are imposed on any author or copyright holder as a result of your choosing to follow a later version.

15. Disclaimer of Warranty.

THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

16. Limitation of Liability.

IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MODIFIES AND/OR CONVEYS THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

17. Interpretation of Sections 15 and 16.

If the disclaimer of warranty and limitation of liability provided above cannot be given local legal effect according to their terms, reviewing courts shall apply local law that most closely approximates an absolute waiver of all civil liability in connection with the Program, unless a warranty or assumption of liability accompanies a copy of the Program in return for a fee.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively state the exclusion of warranty; and each file should have at least the “copyright” line and a pointer to where the full notice is found.

```
one line to give the program's name and a brief idea of what it does.
Copyright (C) year name of author
```

```
This program is free software: you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation, either version 3 of the License, or (at
your option) any later version.
```

```
This program is distributed in the hope that it will be useful, but
WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU
General Public License for more details.
```

```
You should have received a copy of the GNU General Public License
along with this program. If not, see http://www.gnu.org/licenses/.
```

Also add information on how to contact you by electronic and paper mail.

If the program does terminal interaction, make it output a short notice like this when it starts in an interactive mode:

```
program Copyright (C) year name of author
This program comes with ABSOLUTELY NO WARRANTY; for details type 'show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type 'show c' for details.
```

The hypothetical commands ‘show w’ and ‘show c’ should show the appropriate parts of the General Public License. Of course, your program’s commands might be different; for a GUI interface, you would use an “about box”.

You should also get your employer (if you work as a programmer) or school, if any, to sign a “copyright disclaimer” for the program, if necessary. For more information on this, and how to apply and follow the GNU GPL, see <http://www.gnu.org/licenses/>.

The GNU General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Lesser General Public License instead of this License. But first, please read <http://www.gnu.org/philosophy/why-not-lgpl.html>.

Appendix J GNU Free Documentation License

Version 1.3, 3 November 2008

Copyright © 2000, 2001, 2002, 2007, 2008 Free Software Foundation, Inc.

<http://fsf.org/>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document *free* in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or non-commercially. Secondly, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of “copyleft”, which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released

under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The “Cover Texts” are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A “Transparent” copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not “Transparent” is called “Opaque”.

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The “Title Page” means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, “Title Page” means the text near the most prominent appearance of the work’s title, preceding the beginning of the body of the text.

The “publisher” means any person or entity that distributes copies of the Document to the public.

A section “Entitled XYZ” means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve the Title” of such a section when you modify the Document means that it remains a section “Entitled XYZ” according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any,

- be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
- B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.
 - C. State on the Title page the name of the publisher of the Modified Version, as the publisher.
 - D. Preserve all the copyright notices of the Document.
 - E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
 - F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
 - G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
 - H. Include an unaltered copy of this License.
 - I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.
 - J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
 - K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
 - L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.
 - M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.
 - N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.
 - O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their

titles to the list of Invariant Sections in the Modified Version’s license notice. These titles must be distinct from any other section titles.

You may add a section Entitled “Endorsements”, provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled “History” in the various original documents, forming one section Entitled “History”; likewise combine any sections Entitled “Acknowledgements”, and any sections Entitled “Dedications”. You must delete all sections Entitled “Endorsements.”

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an “aggregate” if the copyright resulting from the compilation is not used to limit the legal rights of the compilation’s users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document’s Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled “Acknowledgements”, “Dedications”, or “History”, the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See <http://www.gnu.org/copyleft/>.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

11. RELICENSING

“Massive Multiauthor Collaboration Site” (or “MMC Site”) means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A “Massive Multiauthor Collaboration” (or “MMC”) contained in the site means any set of copyrightable works thus published on the MMC site.

“CC-BY-SA” means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

“Incorporate” means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is “eligible for relicensing” if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

```
Copyright (C)  year  your name.  
Permission is granted to copy, distribute and/or modify this document  
under the terms of the GNU Free Documentation License, Version 1.3  
or any later version published by the Free Software Foundation;  
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover  
Texts. A copy of the license is included in the section entitled ‘‘GNU  
Free Documentation License’’.
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with...Texts.” line with this:

```
with the Invariant Sections being list their titles, with  
the Front-Cover Texts being list, and with the Back-Cover Texts  
being list.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

Index

(Index is nonexistent)

The body of this manual is set in
cmr10 at 10.95pt,
with headings in **cmb10 at 10.95pt**
and examples in **cmtt10 at 10.95pt**.
cmti10 at 10.95pt,
cmb10 at 10.95pt, and
cmsl10 at 10.95pt
are used for emphasis.