GDB's Obsolete Annotations

Edition 1.0
July 2003

Free Software Foundation

Copyright © 1994-2016 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 no Invariant Sections, with no Front-Cover Texts, and with no Back-Cover Texts. A copy of the license is included in the section entitled “GNU Free Documentation License”.

Table of Contents

1 What is an Annotation? 1

2 Limitations of the Annotation Interface 1

2.1 Dependant on CLI output 1
2.2 Scalability 2
2.3 Correctness 2
2.4 Reliability 2
2.5 Maintainability 2

3 Migrating to GDB/MI 2

4 The Server Prefix 2

5 Values 3

6 Frames 4

7 Displays 5

8 Annotation for GDB Input 6

9 Errors 7

10 Information on Breakpoints 7

11 Invalidation Notices 8

12 Running the Program 8

13 Displaying Source 9

14 Multi-threaded Applications 9

Appendix A GNU Free Documentation License 9

1 What is an Annotation?

To produce obsolete level two annotations, start GDB with the `--annotate=2` option.

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.

A simple example of starting up GDB with annotations is:

```
$ gdb --annotate=2
GNU GDB 5.0
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 "sparc-sun-sunos4.1.3"

^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.

2 Limitations of the Annotation Interface

The level two annotations mechanism is known to have a number of technical and architectural limitations. As a consequence, in 2001, with the release of GDB 5.1 and the addition of GDB/MI, the annotation interface was marked as deprecated.

This chapter discusses the known problems.

2.1 Dependant on CLI output

The annotation interface works by interspersing markups with GDB normal command-line interpreter output. Unfortunately, this makes the annotation client dependant on not just the annotations, but also the CLI output. This is because the client is forced to assume that specific GDB commands provide specific information. Any change to GDB's CLI output modifies or removes that information and, consequently, likely breaks the client.

Since the GDB/MI output is independent of the CLI, it does not have this problem.

2.2 Scalability

The annotation interface relies on value annotations (see Chapter 5 [Value Annotations], page 3) and the display mechanism as a way of obtaining up-to-date value information. These mechanisms are not scalable.

In a graphical environment, where many values can be displayed simultaneously, a serious performance problem occurs when the client tries to first extract from GDB, and then re-display, all those values. The client should instead only request and update the values that changed.

The GDB/MI Variable Objects provide just that mechanism.

2.3 Correctness

The annotation interface assumes that a variable's value can only be changed when the target is running. This assumption is not correct. A single assignment to a single variable can result in the entire target, and all displayed values, needing an update.

The GDB/MI Variable Objects include a mechanism for efficiently reporting such changes.

2.4 Reliability

The GDB/MI interface includes a dedicated test directory (`gdb/gdb.mi`), and any addition or fix to GDB/MI must include testsuite changes.

2.5 Maintainability

The annotation mechanism was implemented by interspersing CLI print statements with various annotations. As a consequence, any CLI output change can alter the annotation output.

Since the GDB/MI output is independent of the CLI, and the GDB/MI is increasingly implemented independent of the CLI code, its long term maintenance is much easier.

3 Migrating to GDB/MI

By using the '`interp mi`' command, it is possible for annotation clients to invoke GDB/MI commands, and hence access the GDB/MI. By doing this, existing annotation clients have a migration path from this obsolete interface to GDB/MI.

4 The Server Prefix

To issue a command to GDB without affecting certain aspects of the state which is seen by users, prefix it with '`server `'. 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.

5 Values

Value Annotations have been removed. GDB/MI *instead provides Variable Objects.*

When a value is printed in various contexts, GDB uses annotations to delimit the value from the surrounding text.

If a value is printed using `print` and added to the value history, the annotation looks like

```
^Z^Zvalue-history-begin history-number value-flags
history-string
^Z^Zvalue-history-value
the-value
^Z^Zvalue-history-end
```

where *history-number* is the number it is getting in the value history, *history-string* is a string, such as '`$5 = `', which introduces the value to the user, *the-value* is the output corresponding to the value itself, and *value-flags* is '`*`' for a value which can be dereferenced and '`-`' for a value which cannot.

If the value is not added to the value history (it is an invalid float or it is printed with the `output` command), the annotation is similar:

```
^Z^Zvalue-begin value-flags
the-value
^Z^Zvalue-end
```

When GDB prints an argument to a function (for example, in the output from the `backtrace` command), it annotates it as follows:

```
^Z^Zarg-begin
argument-name
^Z^Zarg-name-end
separator-string
^Z^Zarg-value value-flags
the-value
^Z^Zarg-end
```

where *argument-name* is the name of the argument, *separator-string* is text which separates the name from the value for the user's benefit (such as '`=`'), and *value-flags* and *the-value* have the same meanings as in a `value-history-begin` annotation.

When printing a structure, GDB annotates it as follows:

```
^Z^Zfield-begin value-flags
field-name
^Z^Zfield-name-end
separator-string
^Z^Zfield-value
the-value
^Z^Zfield-end
```

where *field-name* is the name of the field, *separator-string* is text which separates the name from the value for the user's benefit (such as '`=`'), and *value-flags* and *the-value* have the same meanings as in a `value-history-begin` annotation.

When printing an array, GDB annotates it as follows:

```
^Z^Zarray-section-begin array-index value-flags
```

where *array-index* is the index of the first element being annotated and *value-flags* has the same meaning as in a `value-history-begin` annotation. This is followed by any number of elements, where is element can be either a single element:

```
',' whitespace          ; omitted for the first element
the-value
^Z^Zelt
```

or a repeated element

```
',' whitespace          ; omitted for the first element
the-value
^Z^Zelt-rep number-of-repetitions
repetition-string
^Z^Zelt-rep-end
```

In both cases, *the-value* is the output for the value of the element and *whitespace* can contain spaces, tabs, and newlines. In the repeated case, *number-of-repetitions* is the number of consecutive array elements which contain that value, and *repetition-string* is a string which is designed to convey to the user that repetition is being depicted.

Once all the array elements have been output, the array annotation is ended with

```
^Z^Zarray-section-end
```

6 Frames

Value Annotations have been removed. GDB/MI *instead provides a number of frame commands.*

Frame annotations are no longer available. The GDB/MI *provides '*`-stack-list-arguments`*', '*`-stack-list-locals`*', and '*`-stack-list-frames`*' commands.*

Whenever GDB prints a frame, it annotates it. For example, this applies to frames printed when GDB stops, output from commands such as `backtrace` or `up`, etc.

The frame annotation begins with

```
^Z^Zframe-begin level address
level-string
```

where *level* is the number of the frame (0 is the innermost frame, and other frames have positive numbers), *address* is the address of the code executing in that frame, and *level-string* is a string designed to convey the level to the user. *address* is in the form '`0x`' followed by one or more lowercase hex digits (note that this does not depend on the language). The frame ends with

```
^Z^Zframe-end
```

Between these annotations is the main body of the frame, which can consist of

- ```
  ^Z^Zfunction-call
  function-call-string
  ```

  where *function-call-string* is text designed to convey to the user that this frame is associated with a function call made by GDB to a function in the program being debugged.

- ```
  ^Z^Zsignal-handler-caller
  signal-handler-caller-string
  ```

  where *signal-handler-caller-string* is text designed to convey to the user that this frame is associated with whatever mechanism is used by this operating system to call a signal handler (it is the frame which calls the signal handler, not the frame for the signal handler itself).

- A normal frame.

  This can optionally (depending on whether this is thought of as interesting information for the user to see) begin with

  ```
  ^Z^Zframe-address
  address
  ^Z^Zframe-address-end
  separator-string
  ```

  where *address* is the address executing in the frame (the same address as in the `frame-begin` annotation, but printed in a form which is intended for user consumption—in particular, the syntax varies depending on the language), and *separator-string* is a string intended to separate this address from what follows for the user's benefit.

  Then comes

  ```
  ^Z^Zframe-function-name
  function-name
  ^Z^Zframe-args
  arguments
  ```

  where *function-name* is the name of the function executing in the frame, or '`??`' if not known, and *arguments* are the arguments to the frame, with parentheses around them (each argument is annotated individually as well, see Chapter 5 [Value Annotations], page 3).

  If source information is available, a reference to it is then printed:

  ```
  ^Z^Zframe-source-begin
  source-intro-string
  ^Z^Zframe-source-file
  filename
  ^Z^Zframe-source-file-end
  :
  ^Z^Zframe-source-line
  line-number
  ^Z^Zframe-source-end
  ```

  where *source-intro-string* separates for the user's benefit the reference from the text which precedes it, *filename* is the name of the source file, and *line-number* is the line number within that file (the first line is line 1).

  If GDB prints some information about where the frame is from (which library, which load segment, etc.; currently only done on the RS/6000), it is annotated with

  ```
  ^Z^Zframe-where
  information
  ```

  Then, if source is to actually be displayed for this frame (for example, this is not true for output from the `backtrace` command), then a `source` annotation (see Chapter 13 [Source Annotations], page 9) is displayed. Unlike most annotations, this is output instead of the normal text which would be output, not in addition.

7 Displays

Display Annotations have been removed. GDB/MI *instead provides Variable Objects.*

When GDB is told to display something using the `display` command, the results of the display are annotated:

```
^Z^Zdisplay-begin
number
^Z^Zdisplay-number-end
number-separator
^Z^Zdisplay-format
format
^Z^Zdisplay-expression
expression
^Z^Zdisplay-expression-end
expression-separator
^Z^Zdisplay-value
value
^Z^Zdisplay-end
```

where *number* is the number of the display, *number-separator* is intended to separate the number from what follows for the user, *format* includes information such as the size, format, or other information about how the value is being displayed, *expression* is the expression being displayed, *expression-separator* is intended to separate the expression from the text that follows for the user, and *value* is the actual value being displayed.

8 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.

9 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.

10 Information on Breakpoints

Breakpoint Annotations have been removed. GDB/MI *instead provides breakpoint commands.*

The output from the `info breakpoints` command is annotated as follows:

```
^Z^Zbreakpoints-headers
header-entry
^Z^Zbreakpoints-table
```

where *header-entry* has the same syntax as an entry (see below) but instead of containing data, it contains strings which are intended to convey the meaning of each field to the user. This is followed by any number of entries. If a field does not apply for this entry, it is omitted. Fields may contain trailing whitespace. Each entry consists of:

```
^Z^Zrecord
^Z^Zfield 0
number
^Z^Zfield 1
type
^Z^Zfield 2
disposition
^Z^Zfield 3
enable
^Z^Zfield 4
address
^Z^Zfield 5
what
^Z^Zfield 6
frame
^Z^Zfield 7
condition
^Z^Zfield 8
ignore-count
^Z^Zfield 9
commands
```

Note that *address* is intended for user consumption—the syntax varies depending on the language.

The output ends with

```
^Z^Zbreakpoints-table-end
```

11 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.

12 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*.

13 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).

14 Multi-threaded Applications

The following annotations report thread related changes of state.

`^Z^Znew-thread`
: This annotation is issued once for each thread that is created apart from the main thread, which is not reported.

`^Z^Zthread-changed`
: The selected thread has changed. This may occur at the request of the user with the `thread` command, or as a result of execution, e.g., another thread hits a breakpoint.

Appendix A 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. Secondarily, 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.