GNU Direvent

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Short Contents

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1 Introduction

GNU `direvent` monitors events in file system directories. For each event that occurs in a set of pre-configured directories, the program calls an external program associated with it, supplying it the information about the event and the location within the file system where it took place.

GNU `direvent` provides an easy way to configure your system to react immediately if certain files undergo changes. This may be helpful, for example, to track changes in important configuration files.

Interfaces for tracking changes to file systems are highly system-specific. GNU `direvent` aims to provide a uniform and system-independent command-level interface. As of version 5.1 `direvent` works with modern Linux kernels (since v. 2.6.13) and BSD systems (FreeBSD, NetBSD, OpenBSD, Darwin).

2 Overview

GNU `direvent` monitors a set of directories on the file system and reacts when a file system event occurs in any of them. Directories and events to monitor are specified in the configuration file. When an event occurs, the program reacts by invoking an external command configured for that event.

File system events can be divided into two major groups. The *system-dependent events* are specific for each particular kernel interface. In the contrast, *generic events* don't depend on the underlying system. They provide a higher level of abstraction and make it possible to port GNU `direvent` configurations between various systems and architectures.

The generic events are:

create A file was created.

delete A file was deleted;

write A file was written to;

attrib File attributes have changed. This includes changes in the file ownership, mode, link count, etc.

A *watcher* is a configuration entity that associates a set of directories with a set of events and instructs `direvent` to run a specified external command when any of these events occur in any of these directories. This external command (called a *handler*) can obtain information about the event that triggered it from the environment variables, or from its command line.

Watchers are defined in the configuration file, which `direvent` reads at startup. This file has a simple and easy to use syntax.

Three types of comments are allowed: inline comments, that begin with a '`#`' or '`//`' and extend to the end of line, and multi-line comments, which comprise everything enclosed between '`/*`' and '`*/`'. Comments and empty lines are ignored. Whitespace characters are ignored as well, except as they serve to separate tokens.

A token is a string of consecutive characters from the following classes: alphanumeric characters, underscores, dots, asteriscs, slashes, semicolons, commercial at's, and dashes.

Any other sequence of characters must be enclosed in double quotation marks in order to represent a single token.

Adjacent quoted strings are concatenated.

A configuration statement consists of a keyword and value separated by any amount of whitespace and is terminated with a semicolon. A block statement is a collection of statements enclosed in curly braces.

The following block statement declares a watcher:

```
watcher {
    path pathname [recursive [level]];
    file pattern-list;
    event  event-list;
    command command-line;
    user name;
    timeout number;
    environ env-spec;
    option string-list;
}
```

Each `watcher` statement instructs `direvent` to monitor events listed in *event-list* occurring in the directories specified by *pathname*s in `path` statements (any number of `path` statements can be given). When any such event is detected, the supplied *command-line* will be executed.

Each directory defined with the `recursive` keyword will be watched recursively. This means that for each subdirectory created in it, `direvent` will install a watcher similar to that of its parent directory. Optional *level* statement can be used to set up a cut-off nesting level, beyond which the recursive operation is disabled.

The rest of statements are optional. The `file` statement instructs GNU `direvent` to react only if the event concerned the file whose name matches one of the patterns given in its argument. The `user` statement can be used to execute the *command-line* as the user *name* (provided, of course, that `direvent` is started with root privileges). The `timeout` specifies the maximum amount of time (in seconds) the command is allowed to run. It defaults to 5. The `environ` statement modifies the command environment. Finally, the `option` statement supplies additional options. It can be used, for example, to divert the command's output to syslog.

3 Quick Start

Let's suppose you have a directory where users can upload their files and you want these files to be processed right after upload, in real time. Let this directory be `/home/ftp/incoming` and the program to process the upload be `/usr/bin/upload`. Let's also suppose that this program expects name of the uploaded file as its argument.

To make `direvent` handle this task, you would need to create a watcher for the upload directory which would handle the '`create`' event:

```
watcher {
    path /home/ftp/incoming;
    event create;
    # more statements follow...
```

On this event, the watcher is to invoke `/usr/bin/upload` with the name of the created file as an argument. To make it possible, the `direvent` configuration file provides *macro variables*, which can be used in the `command` argument at configuration time and which are expanded to the actual values before the command is executed. Macro variables are referred to using the same syntax as shell variables: a dollar sign followed by the variable name, optionally enclosed in curly braces. The '`file`' variable is expanded to the name of the file for which the event is reported. This name is relative to the current working directory which, by the time the handler is executed, is set to the directory where the event occurred. Thus, the handler can be configured as:

```
    command "/usr/bin/upload $file";
```

To summarize, the watcher declaration is:

```
watcher {
    path /home/ftp/incoming;
    event create;
    command "/usr/bin/upload $file";
}
```

Before invoking the handler, the following operations are performed:

1. The current working directory is set to the directory where the event occurred.
2. If the `environ` statement is present in the watcher, the environment is modified according to its rules. (see [environ], page 15)
3. The standard input is closed.
4. If the '`stdout`' option is supplied, the standard output is captured and redirected to the syslog. Otherwise it is closed.
5. If the '`stderr`' option is supplied, the standard error is captured and redirected to the syslog. Otherwise it is closed.
6. File descriptors above 2 are closed.

7. Macro variables are expanded. See Section 5.2 [macro expansion], page 12.
8. If the '`shell`' option is set, the handler is invoked via the shell, as `/bin/sh -c "`*`command`*`"`.

   Otherwise, word splitting is performed on the resulting command line. The first word is treated as the pathname of the program, which is then invoked via the `execve` system call.

4 Invocation

The invocation syntax is:

```
direvent [options] [config]
```

where *options* are command line options discussed below and optional *config* supplies the configuration file to use instead of the default `/etc/direvent.conf`.

The options are:

`-d`
`--debug` Increase debug level.

`-F` *name*
`--facility=`*name*
Set syslog facility.

`-f`
`--foreground`
Remain in foreground.

`-I` *dir*
`--include=`*dir*
Add *dir* to the beginning of the include search path (see [include search path], page 8).

`-l` *prio* While connected to a terminal, `direvent` outputs its diagnostics messages to stderr and, if configured, to syslog. This option limits the amount of information output to the standard error. The *prio* argument is one of the following priorities (in order of increasing severity): '`debug`', '`info`', '`notice`', '`warning`', '`err`', '`crit`', '`alert`', '`emerg`'. When this option is given, only messages with the priority level equal to or greater than *prio* will be duplicated on the standard error.

`-P` *file*
`--pidfile=`*file*
Upon successful startup store the PID of the daemon process in *file*.

`-T` *command*
`--self-test=`*command*
Run in *self-test mode*. In this mode, `direvent` starts external command supplied as the argument to this option and continues running until the command exits. If *command* terminates normally, `direvent` exits with the code returned by it. If *command* terminates on signal, `direvent` exits with code '`0`' if this signal was `SIGHUP`, and with code '`2`' otherwise.

The *command* can include any command line options or arguments, provided that it is properly quoted. It is invoked as

`/bin/sh -c` *command* in the environment of the parent `direvent` process.

This mode is used in `direvent` test suite. The idea is to configure the handler (see [handler], page 2) so that it sends `SIGHUP` to *command* before exiting. To this effect, the special macro variable `$self_test_pid` is defined (see Section 5.2 [macro expansion], page 12) to the PID of the running *command* process. For example, consider configuration file `test.conf`, which contains the following:

```
watcher {
    path /tmp;
    command "/bin/kill -HUP $self_test_pid";
}
```

Then, the following command can be used to check whether `direvent` correctly reacts on file creation in the watched directory:

```
$ direvent --foreground \
    --self-test 'touch /tmp/file && /usr/bin/sleep 20 && exit
    test.conf
```

The command will return '`0`' if the handler was invoked, and '`1`' if it was not.

`-t`
`--lint` Check configuration file for errors and exit.

`-u` *name*
`--user=`*name*
Run as this user. This option overrides the `user` configuration statement (see Section 5.3 [general settings], page 12).

The following options are *informative*. They cause the program to display the requested piece of information and terminate:

`-H`
`--config-help`
Show configuration file summary.

`-h`
`--help` Give a short usage summary.

`--usage` Display available command line options.

`-V`
`--version`
Print program version.

5 Configuration

5.1 Configuration Syntax

The configuration file consists of statements and comments.

There are three classes of lexical tokens: keywords, values, and separators. Blanks, tabs, newlines and comments, collectively called *white space* are ignored except as they serve to separate tokens. Some white space is required to separate otherwise adjacent keywords and values.

5.1.1 Comments

Comments may appear anywhere where white space may appear in the configuration file. There are two kinds of comments: single-line and multi-line comments. *Single-line* comments start with '`#`' or '`//`' and continue to the end of the line:

```
# This is a comment
// This too is a comment
```

Multi-line or *C-style* comments start with the two characters '`/*`' (slash, star) and continue until the first occurrence of '`*/`' (star, slash).

Multi-line comments cannot be nested. However, single-line comments may well appear within multi-line ones.

5.1.2 Pragmatic Comments

Pragmatic comments are similar to usual single-line comments, except that they cause some changes in the way the configuration is parsed. Pragmatic comments begin with a '`#`' sign and end with the next physical newline character.

`#include <`*file*`>`
`#include "`*file*`"`

Include the contents of the file *file*. If *file* is an absolute file name, the named file is included. An error message will be issued if it does not exist.

If *file* contains wildcard characters ('`*`', '`[`', '`]`' or '`?`'), it is interpreted as a shell globbing pattern and all files matching that pattern are included, in lexicographical order. If no matching files are found, the directive is replaced with an empty line.

Otherwise, the form with angle brackets searches for file in the *include search path*, while the second one looks for it in the current working directory first, and, if not found there, in the include search path. If the file is not found, an error message will be issued.

Include search path is formed by two directory sets: the user-defined search path, as defined by eventual `-I` (see [include option], page 6) command line options, and the standard include

search path, defined at compile time. The latter can be inspected using the `--help` option.

The order of directories is as follows. First, `direvent` scans any directories given with `-I` options, in the same order as given on the command line. If *file* is not found in any of them, the standard include search path is scanned. It is defined at the compile time and by default consists of two directories:

- *prefix*`/share/direvent/5.1/include`
- *prefix*`/share/direvent/include`

where *prefix* is the installation prefix. The default can be changed when configuring the package. To inspect the actual standard include search path at the runtime, run `direvent --help`, and look for the string '`Include search path:`' in its output.

`#include_once <`*file*`>`
`#include_once` *file*
Same as `#include`, except that, if the *file* has already been included, it will not be included again.

`#line` *num*
`#line` *num* `"`*file*`"`
This line causes the parser to believe, for purposes of error diagnostics, that the line number of the next source line is given by *num* and the current input file is named by *file*. If the latter is absent, the remembered file name does not change.

`#` *num* `"`*file*`"`
This is a special form of `#line` statement, understood for compatibility with the C preprocessor.

5.1.3 Statements

A *simple statement* consists of a keyword and value separated by any amount of whitespace. Simple statement is terminated with a semicolon ('`;`').

The following is a simple statement:

```
standalone yes;
pidfile /var/run/direvent.pid;
```

A *keyword* begins with a letter and may contain letters, decimal digits, underscores ('`_`') and dashes ('`-`'). Examples of keywords are: '`expression`', '`output-file`'.

A *value* can be one of the following:

number — A number is a sequence of decimal digits.

boolean — A boolean value is one of the following: '`yes`', '`true`', '`t`' or '`1`', meaning *true*, and '`no`', '`false`', '`nil`', '`0`' meaning *false*.

unquoted string
: An unquoted string may contain letters, digits, and any of the following characters: '`_`', '`-`', '`.`', '`/`', '`@`', '`*`', '`:`'.

quoted string
: A quoted string is any sequence of characters enclosed in double-quotes ('`"`'). A backslash appearing within a quoted string introduces an *escape sequence*, which is replaced with a single character according to the following rules:

Sequence	Replaced with
\a	Audible bell character (ASCII 7)
\b	Backspace character (ASCII 8)
\f	Form-feed character (ASCII 12)
\n	Newline character (ASCII 10)
\r	Carriage return character (ASCII 13)
\t	Horizontal tabulation character (ASCII 9)
\v	Vertical tabulation character (ASCII 11)
\\	A single backslash ('\')
\"	A double-quote.

Table 5.1: Backslash escapes

In addition, the sequence '`\`*`newline`*' is removed from the string. This allows to split long strings over several physical lines, e.g.:

```
"a long string may be\
 split over several lines"
```

If the character following a backslash is not one of those specified above, the backslash is ignored and a warning is issued.

Two or more adjacent quoted strings are concatenated, which gives another way to split long strings over several lines to improve readability. The following fragment produces the same result as the example above:

```
"a long string may be"
" split over several lines"
```

Here-document
: A *here-document* is a special construct that allows to introduce strings of text containing embedded newlines.

  The `<<`*`word`* construct instructs the parser to read all the following lines up to the line containing only *word*, with possible trailing blanks. Any lines thus read are concatenated together into a single string. For example:

```
<<EOT
A multiline
string
EOT
```

The body of a here-document is interpreted the same way as a double-quoted string, unless *word* is preceded by a backslash (e.g. '`<<\EOT`') or enclosed in double-quotes, in which case the text is read as is, without interpretation of escape sequences.

If *word* is prefixed with `-` (a dash), then all leading tab characters are stripped from input lines and the line containing *word*. Furthermore, if `-` is followed by a single space, all leading whitespace is stripped from them. This allows to indent here-documents in a natural fashion. For example:

```
<<- TEXT
    The leading whitespace will be
    ignored when reading these lines.
TEXT
```

It is important that the terminating delimiter be the only token on its line. The only exception to this rule is allowed if a here-document appears as the last element of a statement. In this case a semicolon can be placed on the same line with its terminating delimiter, as in:

```
help-text <<-EOT
        A sample help text.
EOT;
```

list

A *list* is a comma-separated list of values. Lists are enclosed in parentheses. The following example shows a statement whose value is a list of strings:

```
option (stdout,stderr);
```

In any case where a list is appropriate, a single value is allowed without being a member of a list: it is equivalent to a list with a single member. This means that, e.g.

```
option wait;
```

is equivalent to

```
option (wait);
```

A *block statement* introduces a logical group of statements. It consists of a keyword, followed by an optional value, and a sequence of statements enclosed in curly braces, as shown in the example below:

```
syslog {
  facility local0;
  tag "direvent";
}
```

The closing curly brace may be followed by a semicolon, although this is not required.

5.2 Macro Expansion

Arguments of some statements undergo macro expansion before use. During the macro expansion any occurrence of '`$name`' is replaced by the value of the macro variable *name*. Variable names follow the usual convention: they begin with a letter and contain letters, digits and underscores. Curly braces around the *name* are optional. They are required only if the macro reference is followed by a character that is not to be interpreted as part of its name, as in '`${command}string`'.

The following macros are defined:

file
: Name of the file that triggered the event.

genev_code
: Generic (system-independent) event code. It is a bitwise OR of the event codes represented as a decimal number.

genev_name
: Generic event name. If several generic events are reported simultaneously, the value of this variable is a list of event names separated by space characters. Each name corresponds to a bit in '`$genev_code`'.

self_test_pid
: The PID of the external command started with the `--self-test` option (see [self-test mode], page 6). If `direvent` is started without this option, this variable is not defined.

sysev_code
: A system-dependent event code. It is a bitwise OR of the event codes represented as a decimal number.

sysev_name
: A system-dependent event name. If several events are reported, the value of this variable is a list of event names separated by space characters. Each name corresponds to a bit in '`sysev_code`'. See Chapter 6 [System dependencies], page 18, for a list of system-dependent event names.

5.3 General Settings

`user` *`name`* [Config]
: Sets the user to run as. The *name* argument must be a name of an existing user.

`foreground` *`bool`* [Config]
: Run in foreground.

`pidfile` *`file`* [Config]
: Upon successful startup store the PID of the daemon process in *file*.

`debug` *number* [Config]
Set debug level. Valid *number* values are '`0`' (no debug) to '`3`' (maximum verbosity).

5.4 Syslog

While connected to the terminal, `direvent` outputs its diagnostics and debugging messages to the standard error. After disconnecting from the controlling terminal it closes the first three file descriptors and directs all its output to the syslog. When running in foreground mode, its messages are sent both to the standard error and to the syslog.

The following configuration statement controls the syslog output:

```
syslog {
    facility string;
    tag string;
    print-priority bool;
}
```

The statements are:

`facility` *string* [Config]
Set syslog facility. The argument is one of the following: '`user`', '`daemon`', '`auth`' or '`authpriv`', '`mail`', '`cron`', '`local0`' through '`local7`' (case-insensitive), or a facility number.

`tag` *string* [Config]
Tag syslog messages with '`string`'. Normally the messages are tagged with the program name.

`print-priority` *'bool'* [Config]
Prefix each message with its priority.

An example `syslog` statement:

```
syslog {
    facility local0;
    print-priority yes;
}
```

5.5 Watcher

The '`watcher`' statement configures a single event watcher. A watcher can control several events in multiple pathnames. Any number of `watcher` statements is allowed in the configuration file, each one of them declaring a separate watcher.

```
watcher {
    path pathname [recursive [level]];
    file regexp-list;
    event event-list;
    command command-line;
    user name;
    timeout number;
    environ env-spec;
    option string-list;
}
```

The statements within a `watcher` block are:

`path` *`pathname`* [*recursive* [*`number`*]] [Config]

Defines a pathname to watch. The *pathname* argument must be the name of an existing directory in the file system. The watcher will watch events occurring for all files within that directory. If the optional `recursive` clause is specified, this directory will be watched recursively, i.e. when any subdirectory is created in it, `direvent` will set up a watcher for files in this subdirectory. This new watcher will be an exact copy of the parent watcher, excepting for the pathnames. The optional *number* parameter defines a cut-off nesting level for recursive watching. If supplied, the recursive behaviour will apply only to the directories that are nested below that level.

Any number of `path` statements can appear in a `watcher` block. At least one `path` must be defined.

`file` *`regexp-list`* [Config]

Selects which files are eligible for monitoring. The argument is a list of globbing patterns (in the sense of see Section "fnmatch" in *fnmatch(3)*) or extended regular expressions (see Section "Extended regular expressions" in *GNU sed*) one of which must match the file name in order for the watcher to act on it. A '`!`' in front of a pattern or regular expression indicates negation. Such construct matches if the file name doesn't match the pattern. Regular expressions must be surrounded by a pair of slashes, optionally followed by the following flags:

b Use basic regular expressions.

i Enable case-insensitive matching.

For example:

```
file ("*.cfg", "/.*\\.jpg/i");
```

In this statement, the first string ('`*.cfg`') is treated as a shell globbing pattern. The second one is a case-sensitive extended regular expression.

`event` *`string-list`* [Config]

Configures the filesystem events to watch for in the directories declared by the `path` statements. The argument is a list of event names. Both

generic and system-dependent event namess are allowed. Multiple `event` statements accumulate.

A missing `event` statement means "watch all events".

For example:

```
event (open,delete);
```

`command` *string* [Config]

Defines a command to execute on event. The *string* is a command line just as you would type it in `sh`. It may contain macro variables (see Section 5.2 [macro expansion], page 12), which will be expanded prior to execution.

For example:

```
command "/bin/prog -event $genev_name -file $file";
```

By default, the command is executed directly via `execve` system call. If '`shell`' option is set, the command is executed via `/bin/sh`.

See [handler environment], page 4, for a detailed discussion of how the command is executed.

`user` *string* [Config]

Run command as this user.

`timeout` *number* [Config]

Terminate the command if it runs longer than *number* seconds. The default is 5 seconds.

`option` *string-list* [Config]

A list of additional options. The following options are defined:

shell — Invoke the handler command as `/bin/sh -c "`*command*`"`.

wait — Wait for the program to terminate before handling next event from the event queue. Normally the program runs asynchronously.

stdout — Capture the standard output of the command and redirect it to the syslog with the '`LOG_INFO`' priority.

stderr — Capture the standard error of the command and redirect it to the syslog with the '`LOG_ERR`' priority.

`environ` *env-spec* [Config]

Modify command environment. By default the command inherits the environment of `direvent` augmented with the following variables:

`DIREVENT_SYSEV_CODE`
: The system-dependent event code (see [$sysev_code], page 12).

`DIREVENT_SYSEV_NAME`
: The system-dependent event name or names (see [$sysev_name], page 12).

`DIREVENT_GENEV_CODE`
: The generic event code (see [$genev_code], page 12).

`DIREVENT_GENEV_NAME`
: The generic event name or names (see [$genev_name], page 12).

`DIREVENT_FILE`
: The name of the affected file relative to the current working directory (see [$file], page 12).

The `environ` statement allows for trimming the environment. Its argument is a list of environment modification directives. Before applying, each directive undergoes macro expansion (see Section 5.2 [macro expansion], page 12). The following directives are available:

'`-`' (a single dash)
: Clear the inherited environment, but retain the variables added by `direvent` itself. The removed environment variables can be selectively restored using the directives discussed below.

  If used, this must be the first directive in the list.

'`--`' (double-dash)
: Clear the entire environment, including the variables added by `direvent`.

  If used, this must be the first directive in the list.

-name
: Unset the variable *name*.

-name=val
: Unset the environment variable *name* only if its value is *val*.

name
: Restore the environment variable *name*. This directive is useful after '`-`' or '`--`' to retain some variables from the environment.

name=value
: Define environment variable *name* to have given *value*.

name+=value
: Retain variable *name* and append *value* to its existing value. If no such variable is present in the environment, it is created and *value* is assigned to it. However, if *value* begins with a punctuation character, this character is removed from it before the assignment. This is convenient for using this construct with environment variables like `PATH`, e.g.:

  ```
  PATH+=:/sbin
  ```

  In this example, if `PATH` exists, '`:/sbin`' will be appended to it. Otherwise, it will be created and '`/sbin`' will be assigned to it.

name=+*value*
: Retain variable *name* and prepend *value* to its existing value. If no such variable is present in the environment, it is created and *value* is assigned to it. However, if *value* ends with a punctuation character, this character is removed from it before assignment.

6 System Dependencies

`Direvent` relies on the event monitoring API provided by the kernel.

6.1 GNU/Linux systems.

On GNU/Linux the program uses `inotify`. See Section "monitoring file system events" in *inotify(7) man page*.

The maximum number of watches a user process can have is controlled by the '`fs.inotify.max_user_watches`' system variable. Normally it is set to 8192, which is quite enough for most purposes. However, if you monitor a big number or directories and/or are using recursive watchers, you may need to increase this number. In that case, use `sysctl` (see Section "configure kernel parameters at runtime" in *sysctl(8) man page*) to raise the limit, e.g.:

```
sysctl -w fs.inotify.max_user_watches=16384
```

Most GNU/Linux distributions provide the file `/etc/sysctl.conf` which can be used to set this variable on startup.

The following system-dependent events are defined on systems that use `inotify`:

ACCESS A file was accessed.

ATTRIB A file's metadata changed.

CLOSE_WRITE
: A writable file was closed.

CLOSE_NOWRITE
: An unwritable file closed.

CREATE A file was created.

DELETE A file was deleted.

MODIFY A file was modified.

MOVED_FROM
: A file was moved into a monitored directory.

MOVED_TO
: A file was moved out from a monitored directory.

OPEN A file was opened.

6.2 BSD systems

When compiled on BSD systems (including Darwin), `direvent` uses `kqueue` (see Section "kernel event notification mechanism" in *kqueue(2) man page*).

This interface needs an open file handle for each file in a monitored directory, which means that the number of watchers is limited by the maximum

number of open files. Use '`ulimit -n` *NUM*' in order to raise it to a higher number.

Since it operates on files, `kqueue` does not provide direct support for the '`create`' generic event. `Direvent` works over this disadvantage by keeping track of the contents of each monitored directory and rescanning it each time a '`WRITE`' system event is reported for it. It then generates the '`open`' event for each file that appeared after the last scan. Such a rescan can consume considerable time if a directory has a very large number of files in it.

The following system-dependent events are available:

DELETE The `unlink()` system call was called on the monitored file.

WRITE A write occurred on the file.

EXTEND The file was extended.

ATTRIB The file attributes have changed.

LINK The link count on the file changed.

RENAME The file was renamed.

REVOKE Access to the file was revoked via `revoke()` (see Section "revoke file access" in *revoke(2) man page*) or the underlying file system was unmounted.

6.3 Darwin (Mac OS X)

Essentially the same as BSD. The main difference compared to Linux and BSD is that on Darwin the watchers are set after disconnecting from the controlling terminal, because Darwin lacks the `rfork` call and the event queue cannot be inherited by the child process.

7 How to Report a Bug

Please, report bugs and suggestions to bug-direvent@gnu.org.ua.

You hit a bug if at least one of the conditions below is met:

- `direvent` terminates on signal 11 (SIGSEGV) or 6 (SIGABRT).
- The program fails to do its job as described in this manual.

If you think you've found a bug, please be sure to include maximum information available to reliably reproduce it, or at least to analyze it. The information needed is:

- Version of the package you are using.
- Command line options and configuration file.
- Conditions under which the bug appears.

Any errors, typos or omissions found in this manual also qualify as bugs. Please report them, if you happen to find any.

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Version 1.2, November 2002

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