powerd++

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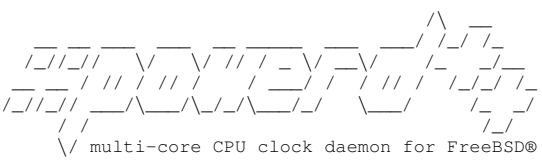


The powerd++ daemon is a drop-in replacement for FreeBSD's native powerd(8). It monitors the system load and adjusts the CPU clock accordingly, avoiding some of the pitfalls of powerd.

What Pitfalls?

At the time powerd++ was first created (February 2016), powerd exhibited some unhealthy behaviours on multi-core machines.

In order to make sure that single core loads do not suffer from the use of powerd it was designed to use the sum load of all cores as the current load rating. A side effect of this is that it causes powerd to never clock down on systems with even moderate numbers of cores. E.g. on a quad-core system with hyper threading a background load of 12.5% per core suffices to score a 100% load rating.

The more cores are added, the worse it gets. Even on a dual core machine (with HT) having a browser and an e-mail client open, suffices to keep the load rating above 100% for most of the time, even without user activity. Thus powerd never does its job of saving energy by reducing the clock frequency.

Advantages of powerd++

The powerd++ implementation addresses this issue and more:

- powerd++ groups cores with a common clock frequency together and handles each group's load and target frequency separately. I.e. the moment FreeBSD starts offering individual clock settings on the CPU, core or thread level, powerd++ already supports it.
- powerd++ takes the highest load within a group of cores to rate the load. This approach responds well to single core loads as well as evenly distributed loads.
- powerd++ sets the clock frequency according to a load target, i.e. it jumps right to the clock rate it will stay in if the load does not change.
- powerd++ supports taking the average load over more than two samples, this makes it more robust against small load spikes, but sacrifices less responsiveness than just increasing the polling interval would. Because only the oldest and the newest sample are required for calculating the average, this approach does not even cause additional runtime cost!
- powerd++ parses command line arguments as floating point numbers, allowing expressive commands like `powerd++ --batt 1.2ghz`.

Building

Download the repository and run `make`:

```
> make
c++ -O2 -pipe  -std=c++11 -Wall -Werror -pedantic -c src/powerd++.cpp -o powerd++.o
c++ -O2 -pipe  -std=c++11 -Wall -Werror -pedantic powerd++.o -lutil -o powerd++
c++ -O2 -pipe  -std=c++11 -Wall -Werror -pedantic -c src/loadrec.cpp -o loadrec.o
c++ -O2 -pipe  -std=c++11 -Wall -Werror -pedantic loadrec.o -o loadrec
c++ -O2 -pipe  -std=c++11 -Wall -Werror -pedantic -fPIC -c src/loadplay.cpp -o loadplay.o
c++ -O2 -pipe  -std=c++11 -Wall -Werror -pedantic loadplay.o -lpthread -shared -o libloadplay.so
```

Documentation

The manual pages can be read with the following commands:

```
> man ./powerd++.8 ./loadrec.1 ./loadplay.1
```

Tooling

In addition to the `powerd++` daemon this repository also comes with the tools `loadrec` and `loadplay`. They can be used to record loads and test both `powerd` and `powerd++` under reproducible load conditions.

This is great for tuning, testing, bug reports and creating fancy plots.

FAQ

- **Why C++?** The `powerd++` code is not object oriented, but it uses some *C++∗ and ∗C++11* features to avoid common pitfalls of writing *C* code. E.g. there is a small *RAII* wrapper around the pidfile facilities (`pidfile_open()`, `pidfile_write()`, `pidfile_remove()`), turning the use of pidfiles into a fire and forget affair. Templated wrappers around calls like `sysctl()` use array references to infer buffer sizes at compile time, taking the burden of safely passing these buffer sizes on to the command away from the programmer. The `std::unique_ptr<>` template obsoletes memory cleanup code, providing the liberty of using exceptions without worrying about memory leaks.
- **Why does powerd++ show a high load when top shows a high idle time?** By default `top` shows the load percentage over all cores/threads, `powerd++` uses the load of a single core/thread (the one with the highest load). This keeps `powerd++` from starving single threaded processes, because they only have a small impact on overall load. An effect that increases with the number of cores/threads. E.g. 80% load on a quad core CPU with hyper threading only has an overall load impact of 10%. Use `top -P` to monitor idle times per core/thread.

LICENSE

For those who care about this stuff, this project is available under the ISC license.

2 LICENSE

3 loadplay(1)

Manual page for loadplay(1).

```
loadplay(1)             FreeBSD General Commands Manual             loadplay(1)

NAME
     loadplay --- CPU load player

SYNOPSIS
     loadplay -h
     loadplay [ -i file] [ -o file] command ...

DESCRIPTION
    The  loadplay command replays a load recording created with loadrec(1).
    The  command can either be powerd(8) or powerd++(8), compatibility with
    other tools has not been tested.

   OPTIONS
    The following options are supported:

     -h,  --help
            Show usage and exit.

     -i,  --input  file
            Read load recording from  file instead of  stdin.

     -o,  --output  file
            Output statistics to  file instead of  stdout.

USAGE NOTES
    The  loadplay command is a shell script that injects  libloadplay.so into
     command.  This library simulates the load from the input and outputs load
    statistics.  If  command generates output on  stdout, it will be mixed into
    the load statistics. So powerd(8) should be run without the  -v flag and
    powerd++(8) without the  -f flag.
```

OUTPUT

The first line of output contains column headings, columns are separated by a single space.

The Following columns are present, columns containing **d** occur for each core simulated:

time[s]
The simulation progress in seconds.

cpu.d.freq[MHz]
The current clock speed rating.

cpu.d.recload
The load as recorded, a value in the range [0, 1.0].

cpu.d.load
The load under the current clock speed. This value may go above 1.0, because the current speed rating may be too low to consume the load. In this case the unconsumed load (i.e. everything above 1.0) spills over to the next simulation frame.

max(freqs)[MHz]
The highest clock speed in the output line.

sum(recloads)
The sum of recorded loads in in the output line, a value in the range [0, ncpu].

max(recloads)
The highest recorded load in this output line, a value in the range [0, 1.0].

sum(loads)
The sum of loads according to the current clock speed in the output line.

max(loads)
The highest load according to the current clock speed in the output line.

SAMPLING

There is one sample for each recorded line. The duration of each frame depends on the recording, which defaults to 25 ms. At this sample rate loads are dominated by noise, so a gliding average should be applied to any load columns for further use, such as plotting. Note that the **max()** columns must be recreated in this case.

IMPLEMENTATION

The injected *libloadplay.so* works by intercepting system function calls and substituting the host environment with the recording. To achieve this the following function calls are intercepted:

- sysctl(3), sysctlnametomib(3), sysctlbyname(3)
- daemon(3)
- geteuid(2)
- pidfile_open(3), pidfile_write, pidfile_close(3), pidfile_remove(3), pidfile_fileno(3)

INITIALISATION

The **sysctl** family of functions is backed by a table that is initialised from the header of the load recording. If the heading is incomplete the setup routines print a message on *stderr*. All the following intercepted function calls will return failure, ensuring that the hijacked process is unable to operate and terminates.

Like powerd++(8) and loadrec(1) **loadplay** is core agnostic. Meaning that any core may have a **.freq** and **.freq_levels** sysctl handle. Due to this flexibility load recordings may in part or wholly be fabricated to test artificial loads or systems and features that do not yet exist. E.g. it is possible to offer a **.freq** handle for each core or fabricate new **.freq_levels**.

SIMULATION

If setup succeeds a simulation thread is started that reads the remaining input lines, simulates the load and updates the **kern.cp_times** entry in the thread safe sysctl table. For each frame a line of output with load statistics is produced.

Interaction with the hijacked process happens solely through the sysctl table. The simulation reads the recorded loads and the current core frequencies to update **kern.cp_times**. The hijacked process reads this data and adjusts the clock frequencies, which in turn affects the next frame.

FINALISATION

After reading the last line of input the simulation thread sends a **SIGINT** to the process to cause it to terminate.

FILES

%PREFIX%%/lib/libloadplay.so A library injected into *command* via the LD_PRELOAD environment variable.

SEE ALSO

loadrec(1), powerd(8), powerd++(8), rtld(1), signal(3)

AUTHORS

Implementation and manual by Dominic Fandrey kami@freebsd.org

FreeBSD 11.0 19 October, 2016 FreeBSD 11.0

4 loadrec(1)

Manual page for `loadrec(1)`.

```
loadrec(1)              FreeBSD General Commands Manual             loadrec(1)
```

NAME

loadrec --- CPU load recorder

SYNOPSIS

loadrec -h
loadrec [**-v**] [**-d** *ival*] [**-p** *ival*] [**-o** *file*]

DESCRIPTION

The **loadrec** command performs a recording of the current load. The purpose is to reproduce this load to test different powerd(8) and powerd++(8) configurations under identical load conditions using loadplay(1).

ARGUMENTS

The following argument types can be given:

ival A time interval can be given in seconds or milliseconds.
s, ms
An interval without a unit is treated as milliseconds.

file A file name.

OPTIONS

The following options are supported:

-h, --help
Show usage and exit.

-v, --verbose
Be verbose and produce initial diagnostics on *stderr*.

-d, --duration *ival*
The duration of the recording session, defaults to 30 seconds.

-p, --poll *ival*
The polling interval to take load samples at, defaults to 25 milliseconds.

-o, --output *file*
The output file to write the load to.

USAGE NOTES

To create reproducible results stop any running CPU clock daemons like powerd(8) or powerd++(8). And set a fixed CPU frequency below the threshold at which the turbo mode is activated. E.g. an **Intel(R) Core(TM) i7-4500U CPU** supports the following frequency settings:

```
> sysctl dev.cpu.0.freq_levels
dev.cpu.0.freq_levels: 2401/15000 2400/15000 2300/14088 2200/13340 2000/11888 1900/11184 1800/10495 1700/9680
```

Supposedly the first mode, which is off by 1 MHz, invokes the turbo mode. However all modes down to 1800 MHz actually invoke the turbo mode for this model. The only way to determine this is by benchmarking the steppings to find out that there is a huge performance step between 1700 and 1800 MHz and that all the modes above 1700 MHz show the exact same performance (given similar thermal conditions).

So in order to produce a usable measurement for this CPU the clock needs to be set to 1700 MHz or lower (higher is better to be able to record a wider range of loads):

```
# service powerd++ stop
Stopping powerdxx.
Waiting for PIDS: 63574.
# sysctl dev.cpu.0.freq=1700
dev.cpu.0.freq: 2401 -> 1700
```

Run **loadrec** for a brief time to test it:

```
> loadrec -d.25s
hw.machine=amd64
hw.model=Intel(R) Core(TM) i7-4500U CPU @ 1.80GHz
hw.ncpu=4
hw.acpi.acline=1
dev.cpu.0.freq=1700
dev.cpu.0.freq_levels=2401/15000 2400/15000 2300/14088 2200/13340 2000/11888 1900/11184 1800/10495 1700/9680 1
0 1658618 4728 563004 146277 7197047 1900009 5683 552503 10915 7100524 1849422 5838 528699 25364 7160311 18830
25 0 0 0 0 3 0 0 1 0 2 1 0 0 0 2 0 0 0 0 3
25 0 0 0 0 3 0 0 2 0 1 0 0 0 0 3 0 0 0 0 3
25 0 0 0 0 4 1 0 2 0 1 0 0 0 0 4 0 0 0 0 2
25 0 0 1 1 1 0 0 1 0 2 0 0 0 0 3 1 0 0 0 4
25 0 0 0 0 3 0 0 0 0 2 0 0 0 0 3 1 0 0 0 2
25 0 0 0 0 3 2 0 0 0 1 0 0 0 0 3 0 0 0 0 3
25 0 0 1 0 2 1 0 1 0 2 0 0 0 0 3 0 0 0 1 2
25 0 0 0 0 3 0 0 0 0 3 0 0 0 0 3 0 0 0 0 3
25 0 0 2 0 2 0 0 1 0 3 0 0 0 0 3 0 0 0 0 3
25 1 0 2 0 0 1 0 0 0 2 1 0 0 0 3 0 0 0 0 4
```

Printing the load creates significant load itself, so for the actual measurement the output should be written to a file. Create your workload and start your measurement:

```
> loadrec -o video-session.load
```

On the example setup **loadrec** produces a load of 0.001 (i.e. 0.1%), so its effect on the measurement is negligible.

SEE ALSO

cpufreq(4), loadplay(1), powerd(8), powerd++(8), sysctl(8)

AUTHORS

Implementation and manual by Dominic Fandrey kami@freebsd.org

5 powerd++(8)

Manual page for powerd++(8).

powerd++(8) FreeBSD System Manager's Manual powerd++(8)

NAME

powerd++ --- CPU clock speed daemon

SYNOPSIS

powerd++ -h
powerd++ [**-vf**] [**-a** *mode*] [**-b** *mode*] [**-n** *mode*] [**-m** *freq*] [**-M** *freq*] [**-p** *ival*] [**-s** *cnt*] [**-P** *file*]

DESCRIPTION

The **powerd++** daemon monitors the system load and adjusts the CPU clock speed accordingly. It is a drop-in replacement for powerd(8) and supports two modes of operation, a load feedback control loop or fixed frequency operation.

ARGUMENTS

The following argument types can be given:

mode The mode is either a *load* target or a fixed *freq*. The powerd(8) modes are interpreted as follows:

maximum, max
: Use the highest clock frequency.

minimum, min
: Use the lowest clock frequency.

adaptive, adp
: A target load of 0.5 (50%).

hiadaptive, hadp
: A target load of 0.375 (37.5%).

If a scalar number is given, it is interpreted as a load.

load A load is either a fraction in the range [0.0, 1.0] or a percentage in the range [0%, 100%].

freq A clock frequency consists of a number and a frequency unit.

Hz, KHz, MHz, GHz, THz

The unit is not case sensitive, if omitted MHz are assumed for compatibility with powerd(8).

ival A time interval can be given in seconds or milliseconds.

s, ms

An interval without a unit is treated as milliseconds.

cnt A positive integer.

file A file name.

OPTIONS
The following options are supported:

-h, --help
Show usage and exit

-v, --verbose
Be verbose and produce initial diagnostics on *stderr*.

-f, --foreground
Stay in foreground, produce an event log on *stdout*.

-a, --ac *mode*
Mode to use while the AC power line is connected (default hadp).

-b, --batt *mode*
Mode to use while battery powered (default adp).

-n, --unknown *mode*
Mode to use while the power line state is unknown (default hadp).

-m, --min *freq*
The lowest CPU clock frequency to use (default 0Hz).

-M, --max *freq*
The highest CPU clock frequency to use (default 1THz).

--min-ac *freq*
The lowest CPU clock frequency to use on AC power.

--max-ac *freq*
The highest CPU clock frequency to use on AC power.

--min-batt *freq*
The lowest CPU clock frequency to use on battery power.

--max-batt *freq*
The highest CPU clock frequency to use on battery power.

-p, --poll *ival*
The polling interval that is used to take load samples and update the CPU clock (default 0.5s).

-s, --samples *cnt*
The number of load samples to use to calculate the current load. The default is 4.

-P, --pid *file*
Use an alternative pidfile, the default is */var/run/powerd.pid*. The default ensures that powerd(8) and **powerd++** are not run simultaneously.

-i, -r *load*
Legacy arguments from powerd(8) not applicable to **powerd++** and thus ignored.

SERVICE

The **powerd++** daemon can be run as an rc(8) service. Add the following line to rc.conf(5):

```
powerdxx_enable="YES"
```

Command line arguments can be set via *powerdxx_flags*.

TOOLS

The loadrec(1) and loadplay(1) tools offer the possibility to record system loads and replay them.

IMPLEMENTATION NOTES

This section describes the operation of **powerd++**.

Both powerd(8) and **powerd++** have in common, that they work by polling kern.cp_times via sysctl(3), which is an array of the accumulated loads of every core. By subtracting the last cp_times sample the loads over the polling interval can be determined. This information is used to set a new CPU clock frequency by updating dev.cpu.0.freq.

Initialisation

After parsing command line arguments **powerd++** assigns a clock frequency controller to every core. I.e. cores are grouped by a common dev.cpu.d.freq handle that controls the clock for all of them. Due to limitations of cpufreq(4) dev.cpu.0.freq is the controlling handle for all cores, even across multiple CPUs. However **powerd++** is not built with that assumption and per CPU, core or thread controls will work as soon as the hardware and kernel support them.

In the next initialisation stage the available frequencies for every core group are determined to set appropriate lower and upper boundaries. This is a purely cosmetic measure and used to avoid unnecessary frequency updates. The controlling algorithm does not require this information, so failure to do so will only be reported (non-fatally) in verbose mode.

Detaching From the Terminal

After the initialisation phase **powerd++** prepares to detach from the terminal. The first step is to acquire a lock on the pidfile. Afterwards all the frequencies are read and written as a last opportunity to fail. After detaching from the terminal the pidfile is written and the daemon goes into frequency controlling operation until killed by a signal.

Load Control Loop

The original powerd(8) uses a hysteresis to control the CPU frequency. I.e. it determines the load over all cores since taking the last sample (the summary load during the last polling interval) and uses a lower and an upper load boundary to decide whether it should update the frequency or not.

powerd++ has some core differences. It can take more than two samples (four by default), this makes it more robust against small spikes in load, while retaining much of its ability to quickly react to sudden surges in load. Changing the number of samples does not change the runtime cost of running **powerd++**.

Instead of taking the sum of all loads, the highest load within the core group is used to decide the next frequency target. Like with powerd(8) this means, that high load on a single core will cause an increase in the clock frequency. Unlike powerd(8) it also means that moderate load over all cores allows a decrease of the clock frequency.

The **powerd++** daemon steers the clock frequency to match a load target, e.g. if there was a 25% load on 2 GHz and the load target was 50%, the frequency would be set to 1 GHz.

Termination and Signals

The signals HUP and TERM cause an orderly shutdown of **powerd++**. An orderly shutdown means the pidfile is removed and the clock frequencies are restored to their original values.

FILES

/var/run/powerd.pid Common pidfile with powerd(8).
%PREFIX%%/etc/rc.d/powerdxx Service file, enable in rc.conf(5).

EXAMPLES

Run in foreground, minimum clock frequency 800 MHz:

```
powerd++ -fm800
```

Report configuration before detaching into the background:

```
powerd++ -v
```

Target 75% load on battery power and run at 2.4 GHz on AC power:

```
powerd++ -b .75 -a 2.4ghz
```

Target 25% load on AC power:

```
powerd++ -a 25%
```

Use the same load sampling powerd(8) does:

```
powerd++ -s2 -p.25s
```

DIAGNOSTICS

The **powerd++** daemon exits 0 on receiving an INT or TERM signal, and >0 if an error occurs.

COMPATIBILITY

So far **powerd++** requires ACPI to detect the current power line state.

SEE ALSO

cpufreq(4), powerd(8), loadrec(1), loadplay(1)

AUTHORS

Implementation and manual by Dominic Fandrey kami@freebsd.org

6 Namespace Index

6.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

7 Hierarchical Index

7.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

8 Class Index

8.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

9 File Index

9.1 File List

Here is a list of all documented files with brief descriptions:

10 Namespace Documentation

10.1 anonymous_namespace{loadplay.cpp} Namespace Reference

File local scope.

Classes

- class Callback

  Implements a recursion safe std::function wrapper.
- class Emulator

  Instances of this class represent an emulator session.
- class Hold

  Sets a referenced variable to a given value and restores it when going out of context.
- class Main

  Singleton class representing the main execution environment.
- struct mib_t

  Represents MIB, but wraps it to provide the necessary operators to use it as an std::map key.
- class Sysctls

  Singleton class representing the sysctl table for this library.
- class SysctlValue

  Instances of this class represents a specific sysctl value.

Functions

- template<size_t Size>
  int strcmp (char const ∗const s1, char const (&s2)[Size])

  Safe wrapper around strncmp, which automatically determines the buffer size of s2.
- std::regex operator"" _r (char const ∗const str, size_t const len)

  User defined literal for regular expressions.
- template<>
  std::string SysctlValue::get< std::string > () const

  Returns a copy of the value string.
- void warn (std::string const &msg)

  Print a warning.
- void fail (std::string const &msg)

  This prints an error message and sets sys_results to make the hijacked process fail.

Variables

- int sys_results = 0

  The success return value of intercepted functions.
- class anonymous_namespace{loadplay.cpp}::Sysctls sysctls

  Sole instance of Sysctls.
- class anonymous_namespace{loadplay.cpp}::Main main

  Sole instance of Main.
- bool sysctl_fallback = false

  Set to activate fallback to the original sysctl functions.

10.1.1 Detailed Description

File local scope.

10.1.2 Function Documentation

10.1.2.1 fail()

```
void anonymous_namespace{loadplay.cpp}::fail (
            std::string const & msg )  [inline]
```

This prints an error message and sets sys_results to make the hijacked process fail.

Parameters

msg	The error message

10.1.2.2 operator"""" _r()

```
std::regex anonymous_namespace{loadplay.cpp}::operator"" _r (
            char const *const str,
            size_t const len )  [inline]
```

User defined literal for regular expressions.

Parameters

str,len	The literal string and its length

Returns

A regular expression

10.1.2.3 strcmp()

```
template<size_t Size>
int anonymous_namespace{loadplay.cpp}::strcmp (
```

```
            char const *const s1,
            char const (&) s2[Size] )  [inline]
```

Safe wrapper around strncmp, which automatically determines the buffer size of s2.

Template Parameters

Size	The size of the buffer s2

Parameters

s1,s2	The strings to compare

Return values

0	Strings are equal
!0	Strings are not equal

10.1.2.4 SysctlValue::get< std::string >()

```
template<>
std::string anonymous_namespace{loadplay.cpp}::SysctlValue::get< std::string > ( ) const
```

Returns a copy of the value string.

Returns

The value

10.1.2.5 warn()

```
void anonymous_namespace{loadplay.cpp}::warn (
            std::string const & msg )  [inline]
```

Print a warning.

Parameters

msg	The warning message

10.1.3 Variable Documentation

10.1.3.1 main

```
class anonymous_namespace{loadplay.cpp}::Main anonymous_namespace{loadplay.cpp}::main
```

Sole instance of Main.

10.1.3.2 sysctls

`class anonymous_namespace{loadplay.cpp}::Sysctls anonymous_namespace{loadplay.cpp}::sysctls`

Sole instance of Sysctls.

10.2 anonymous_namespace{loadrec.cpp} Namespace Reference

File local scope.

Enumerations

- enum OE {
  OE::USAGE, OE::IVAL_DURATION, OE::IVAL_POLL, OE::FILE_OUTPUT,
  OE::FILE_PID, OE::FLAG_VERBOSE, OE::OPT_UNKNOWN, OE::OPT_NOOPT,
  OE::OPT_DASH, OE::OPT_LDASH, OE::OPT_DONE }

  An enum for command line parsing.

Functions

- void verbose (std::string const &msg)

  Outputs the given message on stderr if g.verbose is set.
- void init ()

  Set up output to the given file.
- void read_args (int const argc, char const *const argv[])

  Parse command line arguments.
- void print_sysctls ()

  Print the sysctls.
- void run ()

  Report the load frames.

Variables

- struct {
  bool **verbose** {false}
  Verbosity flag.
  ms **duration** {30000}
  Recording duration in ms.
  ms **interval** {25}
  Recording sample interval in ms.
  std::ofstream **outfile** {}
  The output file stream to use if an outfilename is provided on the CLI.
  std::ostream * **out** = &std::cout
  A pointer to the stream to use for output, either std::cout or outfile.
  char const * **outfilename** {nullptr}
  The user provided output file name.
  char const * **pidfilename** {POWERD_PIDFILE}
  The PID file location for clock frequency daemons.
  sys::ctl::SysctlOnce< coreid_t, 2 > const **ncpu** {1U, {CTL_HW, HW_NCPU}}
  The number of CPU cores/threads.
  } g

  The global state.
- char const *const USAGE = "[-hv] [-d ival] [-p ival] [-o file]"

  The short usage string.
- Option< OE > const OPTIONS [ ]

  Definitions of command line options.

10.2.1 Detailed Description

File local scope.

10.2.2 Enumeration Type Documentation

10.2.2.1 OE

```
enum anonymous_namespace{loadrec.cpp}::OE  [strong]
```

An enum for command line parsing.

Enumerator

USAGE	Print help.
IVAL_DURATION	Set the duration of the recording.
IVAL_POLL	Set polling interval.
FILE_OUTPUT	Set output file.
FILE_PID	Set PID file.
FLAG_VERBOSE	Verbose output on stderr.
OPT_UNKNOWN	Obligatory.
OPT_NOOPT	Obligatory.
OPT_DASH	Obligatory.
OPT_LDASH	Obligatory.
OPT_DONE	Obligatory.

10.2.3 Function Documentation

10.2.3.1 read_args()

```
void anonymous_namespace{loadrec.cpp}::read_args (
            int const argc,
            char const *const argv[] )
```

Parse command line arguments.

Parameters

argc,argv	The command line arguments

10.2.3.2 run()

```
void anonymous_namespace{loadrec.cpp}::run ( )
```

Report the load frames.

This prints the time in ms since the last frame and the cp_times growth as a space separated list.

10.2.3.3 verbose()

```
void anonymous_namespace{loadrec.cpp}::verbose (
            std::string const & msg )  [inline]
```

Outputs the given message on stderr if g.verbose is set.

Parameters

msg	The message to output

10.2.4 Variable Documentation

10.2.4.1 OPTIONS

```
Option<OE> const anonymous_namespace{loadrec.cpp}::OPTIONS[]
```

Initial value:

```
{
    {OE::USAGE,         'h', "help",     "",     "Show usage and exit"},
    {OE::FLAG_VERBOSE,  'v', "verbose",  "",     "Be verbose"},
    {OE::IVAL_DURATION, 'd', "duration", "ival", "The duration of the recording"},
    {OE::IVAL_POLL,     'p', "poll",     "ival", "The polling interval"},
    {OE::FILE_OUTPUT,   'o', "output",   "file", "Output to file"},
    {OE::FILE_PID,      'P', "pid",      "file", "PID file of the local clock frequency daemon"},
}
```

Definitions of command line options.

10.3 anonymous_namespace{powerd++.cpp} Namespace Reference

File local scope.

Classes

- struct anonymous_namespace{powerd++.cpp}.ADP

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MAX

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MIN

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}.FREQ_UNSET

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}.HADP

  Per AC line state settings. More...
- struct Core

  Contains the management information for a single CPU core. More...
- class FreqGuard

  A core frequency guard.

Enumerations

- enum AcLineState : unsigned int { AcLineState::BATTERY, AcLineState::ONLINE, AcLineState::UNKNOWN, AcLineState::LENGTH }

  The available AC line states.
- enum OE {
  OE::USAGE, OE::MODE_AC, OE::MODE_BATT, OE::FREQ_MIN,
  OE::FREQ_MAX, OE::FREQ_MIN_AC, OE::FREQ_MAX_AC, OE::FREQ_MIN_BATT,
  OE::FREQ_MAX_BATT, OE::MODE_UNKNOWN, OE::IVAL_POLL, OE::FILE_PID,
  OE::FLAG_VERBOSE, OE::FLAG_FOREGROUND, OE::CNT_SAMPLES, OE::IGNORE,
  OE::OPT_UNKNOWN, OE::OPT_NOOPT, OE::OPT_DASH, OE::OPT_LDASH,
  OE::OPT_DONE }

  An enum for command line parsing.

Functions

- void verbose (std::string const &msg)

  Outputs the given message on stderr if g.verbose is set.
- void sysctl_fail (sys::sc_error< sys::ctl::error > const err)

  Treat sysctl errors.
- void init ()

  Perform initial tasks.
- void update_loads ()

  Updates the cp_times ring buffer and computes the load average for each core.
- void update_group_loads ()

  Sets the load time of each clock controlling core to the maximum load in the group.
- void update_freq ()

  Update the CPU clocks depending on the AC line state and targets.
- void init_loads ()

  Fill the loads buffers with n samples.
- void set_mode (AcLineState const line, char const *const str)

  Sets a load target or fixed frequency for the given AC line state.
- void read_args (int const argc, char const *const argv[])

  Parse command line arguments.
- void show_settings ()

  Prints the configuration on stderr in verbose mode.
- void signal_recv (int signal)

  Sets g.signal, terminating the main loop.
- void run_daemon ()

  Daemonise and run the main loop.

Variables

- char const *const AcLineStateStr [] {"battery", "online", "unknown"}

  String descriptions for the AC line states.

- struct {
  volatile sig_atomic_t **signal** {0}
  The last signal received, used for terminating.
  size_t **samples** {4}
  The number of load samples to take.
  ms **interval** {500}
  The polling interval.
  size_t **sample** {0}
  The current sample.
  sys::ctl::SysctlOnce< coreid_t, 2 > const **ncpu** {1, {CTL_HW, HW_NCPU}}
  The number of CPU cores or threads.
  struct anonymous_namespace{powerd++.cpp}:: { ... } **FREQ_UNSET** [3]
  Per AC line state settings.
  struct anonymous_namespace{powerd++.cpp}:: { ... } **ADP** [3]
  struct anonymous_namespace{powerd++.cpp}:: { ... } **HADP** [3]
  struct anonymous_namespace{powerd++.cpp}:: { ... } **FREQ_DEFAULT_MIN** [3]
  struct anonymous_namespace{powerd++.cpp}:: { ... } **FREQ_DEFAULT_MAX** [3]
  sys::ctl::Sysctl< 3 > **acline_ctl**
  The hw.acpi.acline ctl.
  bool **verbose** {false}
  Verbose mode.
  bool **foreground** {false}
  Foreground mode.
  char const * **pidfilename** {POWERD_PIDFILE}
  Name of an alternative pidfile.
  sys::ctl::Sysctl< 2 > **cp_times_ctl** {}
  The kern.cp_times sysctl.
  std::unique_ptr< cptime_t[ ][CPUSTATES]> **cp_times**
  The kern.cp_times buffer for all cores.
  std::unique_ptr< Core[ ]> **cores**
  This buffer is to be allocated with ncpu instances of the Core struct to store the management information of every core.
  } g

  A collection of all the gloabl, mutable states.
- char const *const USAGE = "[-hvf] [-abn mode] [-mM freq] [-p ival] [-s cnt] [-P file]"
  The short usage string.
- Option< OE > const OPTIONS [ ]
  Definitions of command line options.

10.3.1 Detailed Description

File local scope.

10.3.2 Class Documentation

10.3.2.1 struct anonymous_namespace{powerd++.cpp}.ADP

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.

Class Members

mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩ _t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

10.3.2.2 struct anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MAX

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩ _t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

10.3.2.3 struct anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MIN

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩ _t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

10.3.2.4 struct anonymous_namespace{powerd++.cpp}.FREQ_UNSET

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩ _t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

10.3.2.5 struct anonymous_namespace{powerd++.cpp}.HADP

Per AC line state settings.

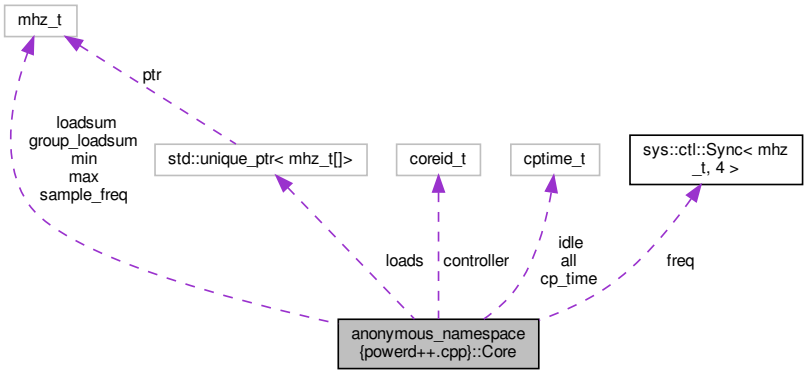
Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩ _t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

10.3.2.6 struct anonymous_namespace{powerd++.cpp}::Core

Contains the management information for a single CPU core.

Collaboration diagram for anonymous_namespace{powerd++.cpp}::Core:



Class Members

cptime_t	all	Count of all ticks.
coreid_t	controller	The core that controls the frequency for this core.
cptime_t const ∗	cp_time	A pointer to the kern.cp_times section for this core.
SysctlSync< mhz_t, 4 >	freq	The sysctl kern.cpu.N.freq, if present.
mhz_t	group_loadsum	For the controlling core this is set to the group loadsum. This is reset by update_loads() and set by update_group_loads().
cptime_t	idle	The idle ticks count.
unique_ptr< mhz_t[ ]>	loads	A ring buffer of load samples for this core. Each load sample is weighted with the core frequency at which it was taken. This is updated by update_loads().
mhz_t	loadsum	The sum of all load samples. This is updated by update_loads().

Class Members

mhz_t	max	The maximum core clock rate.
mhz_t	min	The minimum core clock rate.
mhz_t	sample_freq	The kern.cpu.N.freq value for the current load sample. This is updated by update_loads().

10.3.3 Enumeration Type Documentation

10.3.3.1 AcLineState

```
enum anonymous_namespace{powerd++.cpp}::AcLineState : unsigned int [strong]
```

The available AC line states.

Enumerator

BATTERY	Battery is power source.
ONLINE	External power source.
UNKNOWN	Unknown power source.
LENGTH	Enum length.

10.3.3.2 OE

```
enum anonymous_namespace{powerd++.cpp}::OE [strong]
```

An enum for command line parsing.

Enumerator

USAGE	Print help.
MODE_AC	Set AC power mode.
MODE_BATT	Set battery power mode.
FREQ_MIN	Set minimum clock frequency.
FREQ_MAX	Set maximum clock frequency.
FREQ_MIN_AC	Set minimum clock frequency on AC power.
FREQ_MAX_AC	Set maximum clock frequency on AC power.
FREQ_MIN_BATT	Set minimum clock frequency on battery power.
FREQ_MAX_BATT	Set maximum clock frequency on battery power.
MODE_UNKNOWN	Set unknown power source mode.
IVAL_POLL	Set polling interval.
FILE_PID	Set pidfile.
FLAG_VERBOSE	Activate verbose output on stderr.
FLAG_FOREGROUND	Stay in foreground, log events to stdout.
CNT_SAMPLES	Set number of load samples.
IGNORE	Legacy settings.
OPT_UNKNOWN	Obligatory.

Enumerator

OPT_NOOPT	Obligatory.
OPT_DASH	Obligatory.
OPT_LDASH	Obligatory.
OPT_DONE	Obligatory.

10.3.4 Function Documentation

10.3.4.1 init()

```
void anonymous_namespace{powerd++.cpp}::init ( )
```

Perform initial tasks.

- Get number of CPU cores/threads
- Determine the clock controlling core for each core
- Set the MIBs of hw.acpi.acline and kern.cp_times

10.3.4.2 init_loads()

```
void anonymous_namespace{powerd++.cpp}::init_loads ( )
```

Fill the loads buffers with n samples.

The samples are filled with the target load, this creates a bias to stay at the initial frequency until sufficient real measurements come in to flush these initial samples out.

10.3.4.3 read_args()

```
void anonymous_namespace{powerd++.cpp}::read_args (
            int const argc,
            char const *const argv[] )
```

Parse command line arguments.

Parameters

argc,argv	The command line arguments

10.3.4.4 set_mode()

```
void anonymous_namespace{powerd++.cpp}::set_mode (
            AcLineState const line,
            char const *const str )
```

Sets a load target or fixed frequency for the given AC line state.

The string must be in the following format:

```
mode_predefined = "minimum" | "min" | "maximum" | "max" |
                  "adaptive" | "adp" | "hiadptive" | "hadp";
mode =            mode_predefined | load | freq;
```

Scalar values are treated as loads.

The predefined values have the following meaning:

Symbol	Meaning
minimum	The minimum clock rate (default 0 MHz)
min	
maximum	The maximum clock rate (default 1000000 MHz)
max	
adaptive	A target load of 50%
adp	
hiadptive	A target load of 37.5%
hadp	

Parameters

line	The power line state to set the mode for
str	A mode string

10.3.4.5 signal_recv()

```
void anonymous_namespace{powerd++.cpp}::signal_recv (
             int signal )
```

Sets g.signal, terminating the main loop.

Parameters

signal	The signal number received

10.3.4.6 sysctl_fail()

```
void anonymous_namespace{powerd++.cpp}::sysctl_fail (
             sys::sc_error< sys::ctl::error > const err )  [inline]
```

Treat sysctl errors.

Fails appropriately for the given error.

Parameters

err	The errno value after calling sysctl

10.3.4.7 verbose()

```
void anonymous_namespace{powerd++.cpp}::verbose (
```

```
            std::string const & msg )  [inline]
```

Outputs the given message on stderr if g.verbose is set.

Parameters

msg	The message to output

10.3.5 Variable Documentation

10.3.5.1 g

```
struct { ...  } anonymous_namespace{powerd++.cpp}::g
```

A collection of all the gloabl, mutable states.

This is mostly for semantic clarity.

10.3.5.2 OPTIONS

```
Option<OE> const anonymous_namespace{powerd++.cpp}::OPTIONS[]
```

Initial value:

```
{
    {OE::USAGE,           'h', "help",       "",     "Show usage and exit"},
    {OE::FLAG_VERBOSE,    'v', "verbose",    "",     "Be verbose"},
    {OE::FLAG_FOREGROUND, 'f', "foreground", "",     "Stay in foreground"},
    {OE::MODE_AC,         'a', "ac",         "mode", "Select the mode while on AC power"},
    {OE::MODE_BATT,       'b', "batt",       "mode", "Select the mode while on battery power"},
    {OE::MODE_UNKNOWN,    'n', "unknown",    "mode", "Select the mode while power source is unknown"},
    {OE::FREQ_MIN,        'm', "min",        "freq", "The minimum CPU frequency"},
    {OE::FREQ_MAX,        'M', "max",        "freq", "The maximum CPU frequency"},
    {OE::FREQ_MIN_AC,      0 , "min-ac",     "freq", "The minimum CPU frequency on AC power"},
    {OE::FREQ_MAX_AC,      0 , "max-ac",     "freq", "The maximum CPU frequency on AC power"},
    {OE::FREQ_MIN_BATT,    0 , "min-batt",   "freq", "The minimum CPU frequency on battery power"},
    {OE::FREQ_MAX_BATT,    0 , "max-batt",   "freq", "The maximum CPU frequency on battery power"},
    {OE::IVAL_POLL,       'p', "poll",       "ival", "The polling interval"},
    {OE::CNT_SAMPLES,     's', "samples",    "cnt",  "The number of samples to use"},
    {OE::FILE_PID,        'P', "pid",        "file", "Alternative PID file"},
    {OE::IGNORE,          'i', "",           "load", "Ignored"},
    {OE::IGNORE,          'r', "",           "load", "Ignored"}
}
```

Definitions of command line options.

10.4 clas Namespace Reference

A collection of functions to process command line arguments.

Enumerations

- enum Unit : size_t {
  Unit::SCALAR, Unit::PERCENT, Unit::SECOND, Unit::MILLISECOND,
  Unit::HZ, Unit::KHZ, Unit::MHZ, Unit::GHZ,
  Unit::THZ, Unit::UNKNOWN }

  Command line argument units.

Functions

- Unit unit (std::string const &str)

  Determine the unit of a string encoded value.
- types::cptime_t load (char const *const str)

  Convert string to load in the range [0, 1024].
- types::mhz_t freq (char const *const str)

  Convert string to frequency in MHz.
- types::ms ival (char const *const str)

  Convert string to time interval in milliseconds.
- size_t samples (char const *const str)

  A string encoded number of samples.

Variables

- char const *const UnitStr [ ]

  The unit strings on the command line, for the respective Unit instances.

10.4.1 Detailed Description

A collection of functions to process command line arguments.

10.4.2 Enumeration Type Documentation

10.4.2.1 Unit

```
enum clas::Unit : size_t [strong]
```

Command line argument units.

These units are supported for command line arguments, for SCALAR arguments the behaviour of powerd is to be imitated.

Enumerator

SCALAR	Values without a unit.
PERCENT	%
SECOND	s
MILLISECOND	ms
HZ	hz
KHZ	khz
MHZ	mhz
GHZ	ghz
THZ	thz
UNKNOWN	Unknown unit.

10.4.3 Function Documentation

10.4.3.1 freq()

```
types::mhz_t clas::freq (
            char const *const str )
```

Convert string to frequency in MHz.

The given string must have the following format:

```
freq = <float>, [ "hz" | "khz" | "mhz" | "ghz" | "thz" ];
```

For compatibility with powerd MHz are assumed, if no unit string is given.

The resulting frequency must be in the range [0Hz, 1THz].

Parameters

str	A string encoded frequency

Returns

The frequency given by str

10.4.3.2 ival()

```
types::ms clas::ival (
            char const *const str )
```

Convert string to time interval in milliseconds.

The given string must have the following format:

```
ival = <float>, [ "s" | "ms" ];
```

For compatibility with powerd scalar values are assumed to represent milliseconds.

Parameters

str	A string encoded time interval

Returns

The interval in milliseconds

10.4.3.3 load()

```
types::cptime_t clas::load (
            char const *const str )
```

Convert string to load in the range [0, 1024].

The given string must have the following format:

```
load = <float>, [ "%" ];
```

The input value must be in the range [0.0, 1.0] or [0%, 100%].

Parameters

str	A string encoded load

Return values

[0,1024]	The load given by str
>	1024 The given string is not a load

10.4.3.4 samples()

```
size_t clas::samples (
            char const *const str )
```

A string encoded number of samples.

The string is expected to contain a scalar integer.

Parameters

str	The string containing the number of samples

Returns

The number of samples

10.4.3.5 unit()

```
Unit clas::unit (
            std::string const & str )
```

Determine the unit of a string encoded value.

Parameters

str	The string to determine the unit of

Returns

A unit

10.4.4 Variable Documentation

10.4.4.1 UnitStr

```
char const* const clas::UnitStr[]
```

Initial value:

```
{
    "", "%", "s", "ms", "hz", "khz", "mhz", "ghz", "thz"
}
```

The unit strings on the command line, for the respective Unit instances.

10.5 constants Namespace Reference

A collection of constants.

Variables

- char const *const CP_TIMES = "kern.cp_times"
  The MIB name for per-CPU time statistics.
- char const *const ACLINE = "hw.acpi.acline"
  The MIB name for the AC line state.
- char const *const FREQ = "dev.cpu.%d.freq"
  The MIB name for CPU frequencies.
- char const *const FREQ_LEVELS = "dev.cpu.%d.freq_levels"
  The MIB name for CPU frequency levels.
- types::mhz_t const FREQ_DEFAULT_MAX {1000000}
  Default maximum clock frequency value.
- types::mhz_t const FREQ_DEFAULT_MIN {0}
  Default minimum clock frequency value.
- types::mhz_t const FREQ_UNSET {1000001}
  Clock frequency representing an uninitialised value.
- char const *const POWERD_PIDFILE = "/var/run/powerd.pid"
  The default pidfile name of powerd.
- types::cptime_t const ADP {512}
  The load target for adaptive mode, equals 50% load.
- types::cptime_t const HADP {384}
  The load target for hiadaptive mode, equals 37.5% load.

10.5.1 Detailed Description

A collection of constants.

10.6 errors Namespace Reference

Common error handling types and functions.

Classes

- struct Exception

  Exceptions bundle an exit code, errno value and message. More...

Enumerations

- enum Exit : int {
  Exit::OK, Exit::ECLARG, Exit::EOUTOFRANGE, Exit::ELOAD,
  Exit::EFREQ, Exit::EMODE, Exit::EIVAL, Exit::ESAMPLES,
  Exit::ESYSCTL, Exit::ENOFREQ, Exit::ECONFLICT, Exit::EPID,
  Exit::EFORBIDDEN, Exit::EDAEMON, Exit::EWOPEN, Exit::ESIGNAL,
  Exit::LENGTH }

  Exit codes.

Functions

- void fail (Exit const exitcode, int const err, std::string const &msg)

  Throws an Exception instance with the given message.

Variables

- const char ∗const ExitStr [ ]

  Printable strings for exit codes.

10.6.1 Detailed Description

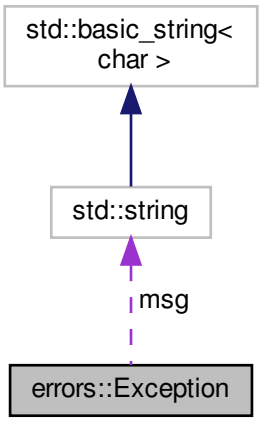
Common error handling types and functions.

10.6.2 Class Documentation

10.6.2.1 struct errors::Exception

Exceptions bundle an exit code, errno value and message.

Collaboration diagram for errors::Exception:



Class Members

int	err	The errno value at the time of creation.
Exit	exitcode	The code to exit with.
string	msg	An error message.

10.6.3 Enumeration Type Documentation

10.6.3.1 Exit

```
enum errors::Exit :  int  [strong]
```

Exit codes.

Enumerator

OK	Regular termination.
ECLARG	Unexpected command line argument.
EOUTOFRANGE	A user provided value is out of range.
ELOAD	The provided value is not a valid load.
EFREQ	The provided value is not a valid frequency.
EMODE	The provided value is not a valid mode.
EIVAL	The provided value is not a valid interval.
ESAMPLES	The provided value is not a valid sample count.
ESYSCTL	A sysctl operation failed.
ENOFREQ	System does not support changing core frequencies.
ECONFLICT	Another frequency daemon instance is running.
EPID	A pidfile could not be created.
EFORBIDDEN	Insufficient privileges to change sysctl.
EDAEMON	Unable to detach from terminal.
EWOPEN	Could not open file for writing.
ESIGNAL	Failed to install signal handler.
LENGTH	Enum length.

10.6.4 Function Documentation

10.6.4.1 fail()

```
void errors::fail (
            Exit const exitcode,
            int const err,
            std::string const & msg )  [inline]
```

Throws an Exception instance with the given message.

Parameters

exitcode	The exit code to return on termination
err	The errno value at the time the exception was created
msg	The message to show

10.6.5 Variable Documentation

10.6.5.1 ExitStr

```
const char* const errors::ExitStr[]
```

Initial value:

```
{
    "OK", "ECLARG", "EOUTOFRANGE", "ELOAD", "EFREQ", "EMODE", "EIVAL",
    "ESAMPLES", "ESYSCTL", "ENOFREQ", "ECONFLICT", "EPID", "EFORBIDDEN",
    "EDAEMON", "EWOPEN", "ESIGNAL"
}
```

Printable strings for exit codes.

10.7 fixme Namespace Reference

Workarounds for compiler/library bugs.

Functions

- template<typename T >
  std::string to_string (T const &op)

  G++ 5.3 does not believe in std::to_string().

10.7.1 Detailed Description

Workarounds for compiler/library bugs.

10.7.2 Function Documentation

10.7.2.1 to_string()

```
template<typename T >
std::string fixme::to_string (
            T const & op )  [inline]
```

G++ 5.3 does not believe in std::to_string().

Template Parameters

T	The argument type to convert

Parameters

op	The argument to convert

Returns

A string of the given argument

10.8 nih Namespace Reference

Not invented here namespace, for code that substitutes already commonly available functionality.

Classes

- struct enum_has_members

  Tests whether the given enum provides all the required definitions.
- struct Option

  Container for an option definition. More...
- class Options

  An instance of this class offers operators to retrieve command line options and arguments.

Typedefs

- template<class... >
  using void_t = void

  See std::void_t in C++17 <type_traits>.

Functions

- template<class Enum >
  size_t argCount (Option< Enum > const &def)

  Retrieves the count of arguments in an option definition.
- template<class Enum , size_t DefCount>
  constexpr Options< Enum, DefCount > make_Options (int const argc, char const *const argv[ ], char const *const usage, Option< Enum > const (&defs)[DefCount])

  Wrapper around the Options<> constructor, that uses function template matching to deduce template arguments.

10.8.1 Detailed Description

Not invented here namespace, for code that substitutes already commonly available functionality.

10.8.2 Class Documentation

10.8.2.1 struct nih::Option

template<class Enum>
struct nih::Option< Enum >

Container for an option definition.

Aliases can be defined by creating definitions with the same enumval member.

The lopt, args and usage members have to be 0 terminated, using string literals is safe.

Template Parameters

Enum	An enum or enum class representing the available options

Class Members

char const *	args	A comma separated list of arguments. Set to nullptr or "" if no argument is available.
Enum	enumval	The enum value to return for this option.
char const *	lopt	The long version of this option. Set to nullptr or "" if no long option is available.
char	sopt	The short version of this option. Set to 0 if no short option is available.
char const *	usage	A usage string.

10.8.3 Function Documentation

10.8.3.1 argCount()

```
template<class Enum >
size_t nih::argCount (
            Option< Enum > const & def )
```

Retrieves the count of arguments in an option definition.

Template Parameters

Enum	An enum or enum class representing the available options

Parameters

def	The option definition

Returns

The number of arguments specified in the given definition

10.8.3.2 make_Options()

```
template<class Enum , size_t DefCount>
constexpr Options<Enum, DefCount> nih::make_Options (
            int const argc,
            char const *const argv[],
            char const *const usage,
            Option< Enum > const (&) defs[DefCount] )
```

Wrapper around the Options<> constructor, that uses function template matching to deduce template arguments.

Template Parameters

Enum	An enum for all the available options
DefCount	The number of option definitions

Parameters

argc,argv	The command line arguments
usage	A usage string that is used in the header of the usage output
defs	An array of option definitions

10.9 sys Namespace Reference

Wrappers around native system interfaces.

Namespaces

- ctl

  This namespace contains safer c++ wrappers for the sysctl() interface.
- pid

  This namespace contains safer c++ wrappers for the pidfile_*() interface.
- sig

  This namespace provides c++ wrappers for signal(3).

Classes

- struct sc_error

  Can be thrown by syscall function wrappers if the function returned with an error.

10.9.1 Detailed Description

Wrappers around native system interfaces.

10.10 sys::ctl Namespace Reference

This namespace contains safer c++ wrappers for the sysctl() interface.

Classes

- struct error

  The domain error type. More...
- class Once

  A read once representation of a Sysctl.
- class Sync

  This is a wrapper around Sysctl that allows semantically transparent use of a sysctl.
- class Sysctl

  Represents a sysctl MIB address.

Typedefs

- typedef int mib_t

  Management Information Base identifier type (see sysctl(3)).
- template<typename T , size_t MibDepth>
  using SysctlSync = Sync< T, Sysctl< MibDepth >>

  A convenience alias around Sync.
- template<typename T , size_t MibDepth>
  using SysctlOnce = Once< T, Sysctl< MibDepth >>

  A convenience alias around Once.

Functions

- template<typename... Args>
  constexpr Sysctl< sizeof...(Args)> make_Sysctl (Args const ... args)

  Create a Sysctl instances.
- template<typename T , class SysctlT >
  constexpr Once< T, SysctlT > make_Once (T const &value, SysctlT const &sysctl) noexcept

  This creates a Once instance.

10.10.1 Detailed Description

This namespace contains safer c++ wrappers for the sysctl() interface.

The template class Sysctl represents a sysctl address and offers handles to retrieve or set the stored value.

The template class Sync represents a sysctl value that is read and written synchronously.

The template class Once represents a read once value.

10.10.2 Class Documentation

10.10.2.1 struct sys::ctl::error

The domain error type.

10.10.3 Typedef Documentation

10.10.3.1 SysctlOnce

```
template<typename T , size_t MibDepth>
using sys::ctl::SysctlOnce = typedef Once<T, Sysctl<MibDepth>>
```

A convenience alias around Once.

```
// Once<coreid_t, Sysctl<2>> ncpu{0, {CTL_HW, HW_NCPU}};
SysctlOnce<coreid_t, 2> ncpu{1, {CTL_HW, HW_NCPU}};
```

Template Parameters

T	The type to represent the sysctl as
MibDepth	The maximum allowed MIB depth

10.10.3.2 SysctlSync

```
template<typename T , size_t MibDepth>
using sys::ctl::SysctlSync = typedef Sync<T, Sysctl<MibDepth>>
```

A convenience alias around Sync.

```
// Sync<int, Sysctl<3>> sndUnit{{"hw.snd.default_unit"}};
SysctlSync<int, 3> sndUnit{{"hw.snd.default_unit"}};
if (sndUnit != 3) {    // read from sysctl
    sndUnit = 3;      // assign to sysctl
}
```

Template Parameters

T	The type to represent the sysctl as
MibDepth	The maximum allowed MIB depth

10.10.4 Function Documentation

10.10.4.1 make_Once()

```
template<typename T , class SysctlT >
constexpr Once<T, SysctlT> sys::ctl::make_Once (
            T const & value,
            SysctlT const & sysctl )  [noexcept]
```

This creates a Once instance.

This is intended for cases when a Once instance is created as a temporary to retrieve a value, using it's fallback to a default mechanism.

Template Parameters

T	The value type
SysctlT	The Sysctl type

Parameters

value	The default value to fall back to
sysctl	The sysctl to try and read from

10.10.4.2 make_Sysctl()

```
template<typename... Args>
constexpr Sysctl<sizeof...(Args)> sys::ctl::make_Sysctl (
            Args const ... args )
```

Create a Sysctl instances.

This is only compatible with creating sysctls from predefined MIBs.

Template Parameters

Args	List of argument types, should all be pid_t

Parameters

args	List of initialising arguments

Returns

A Sysctl instance with the depth matching the number of arguments

10.11 sys::pid Namespace Reference

This namespace contains safer c++ wrappers for the pidfile_∗() interface.

Classes

- struct error

  The domain error type. More...
- class Pidfile

  A wrapper around the pidfile_∗ family of commands implementing the RAII pattern.

10.11.1 Detailed Description

This namespace contains safer c++ wrappers for the pidfile_∗() interface.

The class Pidfile implements the RAII pattern for holding a pidfile.

10.11.2 Class Documentation

10.11.2.1 struct sys::pid::error

The domain error type.

10.12 sys::sig Namespace Reference

This namespace provides c++ wrappers for signal(3).

Classes

- struct error

  The domain error type. More...
- class Signal

  Sets up a given signal handler and restores the old handler when going out of scope.

Typedefs

- using sig_t = void(∗)(int)

  Convenience type for signal handlers.

10.12.1 Detailed Description

This namespace provides c++ wrappers for signal(3).

10.12.2 Class Documentation

10.12.2.1 struct sys::sig::error

The domain error type.

10.13 timing Namespace Reference

Namespace for time management related functionality.

Classes

- class Cycle

  Implements an interruptible cyclic sleeping functor.

10.13.1 Detailed Description

Namespace for time management related functionality.

10.14 types Namespace Reference

A collection of type aliases.

Typedefs

- typedef std::chrono::milliseconds ms

  Millisecond type for polling intervals.
- typedef int coreid_t

  Type for CPU core indexing.
- typedef unsigned long cptime_t

  Type for load counting.
- typedef unsigned int mhz_t

  Type for CPU frequencies in MHz.

10.14.1 Detailed Description

A collection of type aliases.

10.14.2 Typedef Documentation

10.14.2.1 cptime_t

```
typedef unsigned long types::cptime_t
```

Type for load counting.

According to src/sys/kern/kern_clock.c the type is `long` (an array of loads `long[CPUSTATES]` is defined). But in order to have defined wrapping characteristics `unsigned long` will be used here.

10.15 utility Namespace Reference

A collection of generally useful functions.

Namespaces

- literals

  Contains literals.

Classes

- class Formatter

  A formatting wrapper around string literals.

Functions

- template<typename T , size_t Count>
  constexpr size_t countof (T(&)[Count])

  Like sizeof(), but it returns the number of elements an array consists of instead of the number of bytes.
- template<typename... Args>
  void sprintf (Args...)

  This is a safeguard against accidentally using sprintf().
- template<size_t Size, typename... Args>
  int sprintf_safe (char(&dst)[Size], char const *const format, Args const ... args)

  A wrapper around snprintf() that automatically pulls in the destination buffer size.
- template<class ET , typename VT = typename std::underlying_type<ET>::type>
  constexpr VT to_value (ET const op)

  Casts an enum to its underlying value.

10.15.1 Detailed Description

A collection of generally useful functions.

10.15.2 Function Documentation

10.15.2.1 countof()

```
template<typename T , size_t Count>
constexpr size_t utility::countof (
            T(&) [Count] )
```

Like sizeof(), but it returns the number of elements an array consists of instead of the number of bytes.

Template Parameters

T,Count	The type and number of array elements

Returns

The number of array entries

10.15.2.2 sprintf()

```
template<typename...  Args>
void utility::sprintf (
            Args...    )
```

This is a safeguard against accidentally using sprintf().

Using it triggers a static_assert(), preventing compilation.

Template Parameters

Args	Catch all arguments

10.15.2.3 sprintf_safe()

```
template<size_t Size, typename...  Args>
int utility::sprintf_safe (
             char(&) dst[Size],
             char const *const format,
             Args const ...  args )  [inline]
```

A wrapper around snprintf() that automatically pulls in the destination buffer size.

Template Parameters

Size	The destination buffer size
Args	The types of the arguments

Parameters

dst	A reference to the destination buffer
format	A printf style formatting string
args	The printf arguments

Returns

The number of characters in the resulting string, regardless of the available space

10.15.2.4 to_value()

```
template<class ET , typename VT = typename std::underlying_type<ET>::type>
constexpr VT utility::to_value (
             ET const op )
```

Casts an enum to its underlying value.

Template Parameters

ET,VT	The enum and value type

Parameters

op	The operand to convert

Returns

The integer representation of the operand

10.16 utility::literals Namespace Reference

Contains literals.

Functions

- std::string operator"" _s (char const *const op, size_t const size)

  A string literal operator equivalent to the `operator "" s` literal provided by C++14 in <string>.
- constexpr Formatter< 16384 > operator"" _fmt (char const *const fmt, size_t const)

  Literal to convert a string literal to a Formatter instance.

10.16.1 Detailed Description

Contains literals.

10.16.2 Function Documentation

10.16.2.1 operator"""" _fmt()

```
constexpr Formatter<16384> utility::literals::operator"" _fmt (
            char const *const fmt,
            size_t const )
```

Literal to convert a string literal to a Formatter instance.

Parameters

fmt	A printf style format string
const	Unused

Returns

A Formatter instance

10.16.2.2 operator"""" _s()

```
std::string utility::literals::operator"" _s (
            char const *const op,
            size_t const size )  [inline]
```

A string literal operator equivalent to the `operator "" s` literal provided by C++14 in <string>.

Parameters

op	The raw string to turn into an std::string object
size	The size of the raw string

Returns

An std::string instance

11 Class Documentation

11.1 anonymous_namespace{loadplay.cpp}::Callback< FunctionArgs > Class Template Reference

Implements a recursion safe std::function wrapper.

Public Types

- typedef std::function< void(FunctionArgs...)> function_t
  The callback function type.

Public Member Functions

- Callback ()
  Default constructor, creates a non-callable handle.
- Callback (function_t const &callback)
  Construct from function.
- Callback (function_t &&callback)
  Construct from temporary function.
- void operator() (FunctionArgs... args)
  Forward call to callback functions.

Private Attributes

- function_t callback
  Storage for the callback function.
- bool called {false}
  Set if this handle is currently in use.

11.1.1 Detailed Description

template<typename... FunctionArgs>
class anonymous_namespace{loadplay.cpp}::Callback< FunctionArgs >

Implements a recursion safe std::function wrapper.

The purpose is to prevent recursive calls of a callback function handle, in cases when a callback function performs actions that cause a successive call of the callback function.

To avoid having to return a value when a successive function call occurs only functions returning void are valid callback functions.

This is not thread safe.

Template Parameters

FunctionArgs	The argument types of the callback function

11.1.2 Constructor & Destructor Documentation

11.1.2.1 Callback() [1/2]

```
template<typename... FunctionArgs>
anonymous_namespace{loadplay.cpp}::Callback< FunctionArgs >::Callback (
            function_t const & callback ) [inline]
```

Construct from function.

Parameters

callback	The callback function

11.1.2.2 Callback() [2/2]

```
template<typename... FunctionArgs>
anonymous_namespace{loadplay.cpp}::Callback< FunctionArgs >::Callback (
            function_t && callback ) [inline]
```

Construct from temporary function.

Parameters

callback	The callback function

11.1.3 Member Function Documentation

11.1.3.1 operator()()

```
template<typename... FunctionArgs>
void anonymous_namespace{loadplay.cpp}::Callback< FunctionArgs >::operator() (
            FunctionArgs... args ) [inline]
```

Forward call to callback functions.

Parameters

args	The arguments to the callback function

Exceptions

std::bad_function_call	In case this handler was default constructed or constructed from a nullptr

The documentation for this class was generated from the following file:

- loadplay.cpp

11.2 timing::Cycle Class Reference

Implements an interruptible cyclic sleeping functor.

`#include <Cycle.hpp>`

Public Member Functions

- bool operator() () const

  Completes an interrupted sleep cycle.
- template<class... DurTraits>
  bool operator() (std::chrono::duration< DurTraits... > const &cycleTime)

  Sleep for the time required to complete the given cycle time.

Private Types

- using clock = std::chrono::steady_clock

  Use steady_clock, avoid time jumps.
- using us = std::chrono::microseconds

  Shorthand for microseconds.

Private Attributes

- std::chrono::time_point< clock > clk = clock::now()

  The current time clock.

11.2.1 Detailed Description

Implements an interruptible cyclic sleeping functor.

Cyclic sleeping means that instead of having a fixed sleeping time, each sleep is timed to meet a fixed wakeup time. I.e. the waking rhythm does not drift with changing system loads.

The canonical way to do this in C++ is like this:

```
#include <chrono>
#include <thread>

int main() {
    std::chrono::milliseconds const ival{500};
    auto time = std::chrono::steady_clock::now();
    while (...something...) {
        std::this_thread::sleep_until(time += ival);
        ...do stuff...
    }
    return 0;
}
```

The issue is that you might want to install a signal handler to guarantee stack unwinding and sleep_until() will resume its wait after the signal handler completes.

The Cycle class offers you an interruptible sleep:

```
#include "Cycle.hpp"
#include <csignal>
...signal handlers...

int main() {
    std::chrono::milliseconds const ival{500};
    ...setup some signal handlers...
    timing::Cycle sleep;
    while (...something... && sleep(ival)) {
        ...do stuff...
    }
    return 0;
}
```

In the example the while loop is terminated if the `sleep()` is interrupted by a signal. Optionally the sleep cycle can be resumed:

```
timing::Cycle sleep;
while (...something...) {
    if (!sleep(ival)) {
        ...interrupted...
        while (!sleep());
    }
    ...do stuff...
}
```

Note there was a design decision between providing a cycle time to the constructor or providing it every cycle. The latter was chosen so the cycle time can be adjusted.

11.2.2 Member Function Documentation

11.2.2.1 operator()() [1/2]

```
bool timing::Cycle::operator() ( ) const  [inline]
```

Completes an interrupted sleep cycle.

I.e. if the last sleep cycle was 500 ms and the sleep was interrupted 300 ms into the cycle, this would sleep for the remaining 200 ms unless interrupted.

Return values

true	Sleep completed uninterrupted
false	Sleep was interrupted

11.2.2.2 operator()() [2/2]

```
template<class...  DurTraits>
bool timing::Cycle::operator() (
             std::chrono::duration< DurTraits...  > const & cycleTime )  [inline]
```

Sleep for the time required to complete the given cycle time.

I.e. if the time since the last sleep cycle was 12 ms and the given cycleTime was 500 ms, the actual sleeping time would be 488 ms.

Template Parameters

DurTraits	The traits of the duration type

Parameters

cycleTime	The duration of the cycle to complete

Return values

true	Command completed uninterrupted
false	Command was interrupted

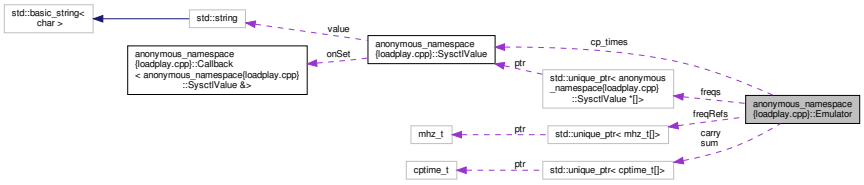
The documentation for this class was generated from the following file:

- Cycle.hpp

11.3 anonymous_namespace{loadplay.cpp}::Emulator Class Reference

Instances of this class represent an emulator session.

Collaboration diagram for anonymous_namespace{loadplay.cpp}::Emulator:



Public Member Functions

- Emulator (bool const &die)

  The constructor initialises all the members necessary for emulation.
- void operator() ()

  Performs load emulation and prints statistics std::cout.

Private Attributes

- bool const & die

  A reference to a bool that tells the emulator to die.
- int const ncpu = sysctls[{CTL_HW, HW_NCPU}].get<int>()

  The hw.ncpu value.
- std::unique_ptr< SysctlValue *[ ]> freqs {new SysctlValue *[ncpu]{}}

  Pointers to the dev.cpu.

- std::unique_ptr< mhz_t[ ]> freqRefs {new mhz_t[ncpu]{}}

  The reference frequencies the recording was based on.
- SysctlValue & cp_times = sysctls[sysctls.getMib(CP_TIMES)]

  The kern.cp_times sysctl handler.
- std::unique_ptr< cptime_t[ ]> sum {new cptime_t[CPUSTATES * ncpu]{}}

  The current kern.cp_times values.
- std::unique_ptr< cptime_t[ ]> carry {new cptime_t[ncpu]{}}

  The load points to carry over to the next frame.
- size_t const size = CPUSTATES * ncpu * sizeof(cptime_t)

  The size of the kern.cp_times buffer.

11.3.1 Detailed Description

Instances of this class represent an emulator session.

This should be run in its own thread and expects the sysctl table to be complete.

11.3.2 Constructor & Destructor Documentation

11.3.2.1 Emulator()

```
anonymous_namespace{loadplay.cpp}::Emulator::Emulator (
            bool const & die )  [inline]
```

The constructor initialises all the members necessary for emulation.

It also prints the column headers on stdout.

Exceptions

std::out_of_range	* In case one of the required sysctls is missing

Parameters

die	If the referenced bool is true, emulation is terminated prematurely

11.3.3 Member Function Documentation

11.3.3.1 operator()()

```
void anonymous_namespace{loadplay.cpp}::Emulator::operator() ( )  [inline]
```

Performs load emulation and prints statistics std::cout.

Reads std::cin to pull in load changes and updates the kern.cp_times sysctl to represent the current state.

When it runs out of load changes it terminates emulation and sends a SIGINT to the process.

11.3.4 Member Data Documentation

11.3.4.1 freqs

```
std::unique_ptr<SysctlValue * []> anonymous_namespace{loadplay.cpp}::Emulator::freqs {new
SysctlValue *[ncpu]{}}  [private]
```

Pointers to the dev.cpu.

d.freq handlers.

The documentation for this class was generated from the following file:

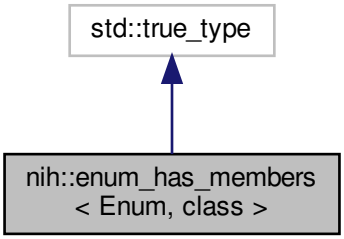
- loadplay.cpp

11.4 nih::enum_has_members< Enum, class > Struct Template Reference

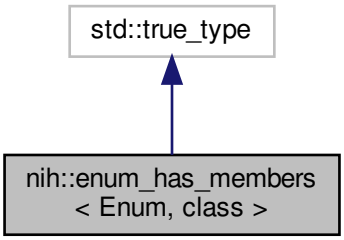
Tests whether the given enum provides all the required definitions.

```
#include <Options.hpp>
```

Inheritance diagram for nih::enum_has_members< Enum, class >:



Collaboration diagram for nih::enum_has_members< Enum, class >:



11.4.1 Detailed Description

template<class Enum, class = void>
struct nih::enum_has_members< Enum, class >

Tests whether the given enum provides all the required definitions.

The Options<> template expects the provided enum to provide the following members:

Member	Description
OPT_UNKNOWN	An undefined option (long or short) was encountered
OPT_NOOPT	The encountered command line argument is not an option
OPT_DASH	A single dash "-" was encountered
OPT_LDASH	Double dashes "--" were encountered
OPT_DONE	All command line arguments have been processed

Template Parameters

Enum	An enum or enum class representing the available options

The documentation for this struct was generated from the following file:

- Options.hpp

11.5 utility::Formatter< BufSize > Class Template Reference

A formatting wrapper around string literals.

`#include <utility.hpp>`

Public Member Functions

- constexpr Formatter (char const *const fmt)

  Construct from string literal.
- template<typename... ArgTs>
  std::string operator() (ArgTs const &... args) const

  Returns a formatted string.

Private Attributes

- char const *const fmt

  Pointer to the string literal.

11.5.1 Detailed Description

template<size_t BufSize>
class utility::Formatter< BufSize >

A formatting wrapper around string literals.

Overloads operator (), which treats the string as a printf formatting string, the arguments represent the data to format.

In combination with the literal _fmt, it can be used like this:

```
std::cout << "%-15.15s %#018p\n"_fmt("Address:", this);
```

Template Parameters

BufSize	The buffer size for formatting, resulting strings cannot grow beyond `BufSize - 1`

11.5.2 Member Function Documentation

11.5.2.1 operator()()

```
template<size_t BufSize>
template<typename...  ArgTs>
std::string utility::Formatter< BufSize >::operator() (
             ArgTs const &...  args ) const  [inline]
```

Returns a formatted string.

Template Parameters

ArgTs	Variadic argument types

Parameters

args	Variadic arguments

Returns

An std::string formatted according to fmt

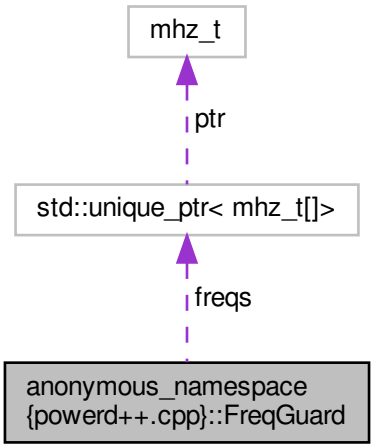
The documentation for this class was generated from the following file:

- utility.hpp

11.6 anonymous_namespace{powerd++.cpp}::FreqGuard Class Reference

A core frequency guard.

Collaboration diagram for anonymous_namespace{powerd++.cpp}::FreqGuard:



Public Member Functions

- FreqGuard ()
  Read and write all core frequencies, may throw.
- ~FreqGuard ()
  Restore all core frequencies.

Private Attributes

- std::unique_ptr< mhz_t[ ]> freqs
  The list of initial frequencies.

11.6.1 Detailed Description

A core frequency guard.

This uses the RAII pattern to achieve two things:

- Upon creation it reads and writes all controlling cores
- Upon destruction it sets all cores to the maximum frequencies

The documentation for this class was generated from the following file:

- powerd++.cpp

11.7 anonymous_namespace{loadplay.cpp}::Hold< T > Class Template Reference

Sets a referenced variable to a given value and restores it when going out of context.

Public Member Functions

- Hold (T &ref, T const value)

  The constructor sets the referenced varibale to the given value.
- ~Hold ()

  Restores the original value.

Private Attributes

- T const restore

  The original value.
- T & ref

  Reference to the variable.

11.7.1 Detailed Description

template<typename T>
class anonymous_namespace{loadplay.cpp}::Hold< T >

Sets a referenced variable to a given value and restores it when going out of context.

Template Parameters

T	The type of the value to hold

11.7.2 Constructor & Destructor Documentation

11.7.2.1 Hold()

```
template<typename T >
anonymous_namespace{loadplay.cpp}::Hold< T >::Hold (
            T & ref,
            T const value )  [inline]
```

The constructor sets the referenced varibale to the given value.

Parameters

ref	The variable to hold and restore
value	The value to set the variable to

11.7.3 Member Data Documentation

11.7.3.1 ref

```
template<typename T >
T& anonymous_namespace{loadplay.cpp}::Hold< T >::ref  [private]
```

Reference to the variable.

11.7.3.2 restore

```
template<typename T >
T const anonymous_namespace{loadplay.cpp}::Hold< T >::restore  [private]
```

The original value.

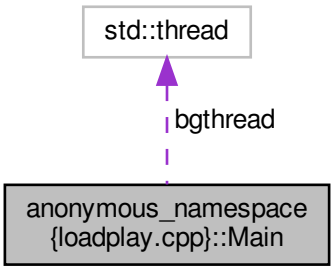
The documentation for this class was generated from the following file:

- loadplay.cpp

11.8 anonymous_namespace{loadplay.cpp}::Main Class Reference

Singleton class representing the main execution environment.

Collaboration diagram for anonymous_namespace{loadplay.cpp}::Main:



Public Member Functions

- Main ()

  The constructor starts up the emulation.
- ~Main ()

  Clean up the background emulation thread.

Private Attributes

- std::thread bgthread

  The background emulation thread.
- bool die {false}

  Used to request premature death from the emulation thread.

11.8.1 Detailed Description

Singleton class representing the main execution environment.

11.8.2 Constructor & Destructor Documentation

11.8.2.1 Main()

```
anonymous_namespace{loadplay.cpp}::Main::Main ( )  [inline]
```

The constructor starts up the emulation.

- Read the headers from std::cin and populate sysctls
- Ensure the existence of all required sysctls
- Spawn an Emulator instance in its own thread

The documentation for this class was generated from the following file:

- loadplay.cpp

11.9 anonymous_namespace{loadplay.cpp}::mib_t Struct Reference

Represents MIB, but wraps it to provide the necessary operators to use it as an std::map key.

Public Member Functions

- template<typename... Ints>
  constexpr mib_t (Ints const ... ints)

  Construct a mib with the given number of arguments.
- mib_t (int const *const mibs, u_int const len)

  Initialise from a pointer to an int array.
- bool operator== (mib_t const &op) const

  Equality operator required by std::map.
- bool operator< (mib_t const &op) const

  Less than operator required by std::map.
- operator int * ()

  Cast to `int *` for value access.
- operator int const * () const

  Cast to `int const *` for value access.

Public Attributes

- int mibs [CTL_MAXNAME]

  The mib values.

11.9.1 Detailed Description

Represents MIB, but wraps it to provide the necessary operators to use it as an std::map key.

11.9.2 Constructor & Destructor Documentation

11.9.2.1 mib_t() [1/2]

```
template<typename... Ints>
constexpr anonymous_namespace{loadplay.cpp}::mib_t::mib_t (
            Ints const ... ints ) [inline]
```

Construct a mib with the given number of arguments.

Template Parameters

Ints	A list of integer types

Parameters

ints	A list of integers to create a mib from

11.9.2.2 mib_t() [2/2]

```
anonymous_namespace{loadplay.cpp}::mib_t::mib_t (
            int const *const mibs,
            u_int const len ) [inline]
```

Initialise from a pointer to an int array.

Parameters

mibs,len	The array and its length

11.9.3 Member Function Documentation

11.9.3.1 operator int *()

```
anonymous_namespace{loadplay.cpp}::mib_t::operator int * ( ) [inline]
```

Cast to `int *` for value access.

Returns

A pointer to mibs

11.9.3.2 operator int const *()

```
anonymous_namespace{loadplay.cpp}::mib_t::operator int const * ( ) const  [inline]
```

Cast to `int const *` for value access.

Returns

A pointer to mibs

11.9.3.3 operator<()

```
bool anonymous_namespace{loadplay.cpp}::mib_t::operator< (
            mib_t const & op ) const  [inline]
```

Less than operator required by std::map.

Parameters

op	Another mib_t instance

Returns

Whether this mib is less than the given one

11.9.3.4 operator==()

```
bool anonymous_namespace{loadplay.cpp}::mib_t::operator== (
            mib_t const & op ) const  [inline]
```

Equality operator required by std::map.

Parameters

op	Another mib_t instance

Returns

Whether all values in this and the given mib are equal

The documentation for this struct was generated from the following file:

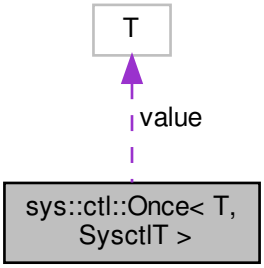
- loadplay.cpp

11.10 sys::ctl::Once< T, SysctlT > Class Template Reference

A read once representation of a Sysctl.

`#include <sysctl.hpp>`

Collaboration diagram for sys::ctl::Once< T, SysctlT >:



Public Member Functions

- Once (T const &value, SysctlT const &sysctl) noexcept
  The constructor tries to read and store the requested sysctl.
- operator T const & () const
  Return a const reference to the value.

Private Attributes

- T value
  The sysctl value read upon construction.

11.10.1 Detailed Description

template<typename T, class SysctlT>
class sys::ctl::Once< T, SysctlT >

A read once representation of a Sysctl.

This reads a sysctl once upon construction and always returns that value. It does not support assignment.

This class is intended for sysctls that are not expected to change, such as hw.ncpu. A special property of this class is that the constructor does not throw and takes a default value in case reading the sysctl fails.

```
// Read number of CPU cores, assume 1 on failure:
Once<coreid_t, Sysctl<2>> ncpu{1, {CTL_HW, HW_NCPU}};
// Equivalent:
int hw_ncpu;
try {
    Sysctl<2>{CTL_HW, HW_NCPU}.get(hw_ncpu);
} catch (sys::sc_error<error>) {
    hw_ncpu = 1;
}
```

Template Parameters

T	The type to represent the sysctl as
SysctlT	The Sysctl type

11.10.2 Constructor & Destructor Documentation

11.10.2.1 Once()

```
template<typename T, class SysctlT>
sys::ctl::Once< T, SysctlT >::Once (
            T const & value,
            SysctlT const & sysctl )  [inline], [noexcept]
```

The constructor tries to read and store the requested sysctl.

If reading the requested sysctl fails for any reason, the given value is stored instead.

Parameters

value	The fallback value
sysctl	The sysctl to represent

11.10.3 Member Function Documentation

11.10.3.1 operator T const &()

```
template<typename T, class SysctlT>
sys::ctl::Once< T, SysctlT >::operator T const & ( ) const  [inline]
```

Return a const reference to the value.

Returns

A const reference to the value

The documentation for this class was generated from the following file:

- sys/sysctl.hpp

11.11 nih::Options< Enum, DefCount > Class Template Reference

An instance of this class offers operators to retrieve command line options and arguments.

```
#include <Options.hpp>
```

Public Member Functions

- Options (int const argc, char const *const argv[], char const *const usage, Option< Enum > const (&defs)[DefCount])

  Construct an options functor.
- Enum operator() ()

  Returns the next option from the command line arguments.
- char const * operator[] (int const i) const

  Retrieve arguments to the current option.
- std::string usage () const

  Returns a string for usage output, created from the option definitions.

Private Member Functions

- Enum get (char const ch)

  Finds the short option matching the given character.
- Enum get (char const *const str)

  Finds the long option matching the given string.

Static Private Member Functions

- static char const * removePath (char const *const file)

  Returns a pointer to the file name portion of the given string.
- static bool match (char const *const lstr, char const *const rstr)

  Returns true if the given strings match.
- static bool bmatch (char const *const lstr, char const *const rstr)

  Returns true if one of the given strings matches the beginning of the other.

Private Attributes

- int const argc

  The number of command line arguments.
- char const *const *const argv

  The command line arguments.
- char const *const usageStr

  A string literal for the usage() output.
- Option< Enum > const (& defs)[DefCount]

  A reference to the option definitions.
- Option< Enum > const expose

  The option definition to use for special options that are exposed by the [] operator.
- int argi

  The index of the command line argument containing the current option.
- char const * argp

  Points to the current short option character.
- Option< Enum > const * current

  Points to the current option definition.

11.11.1 Detailed Description

template<class Enum, size_t DefCount>
class nih::Options< Enum, DefCount >

An instance of this class offers operators to retrieve command line options and arguments.

Instantiate with make_Options() to infer template parameters automatically.

Check the `operator ()` and `operator []` for use.

Template Parameters

Enum	An enum or enum class matching the requirements set by enum_has_members
DefCount	The number of option definitions

11.11.2 Constructor & Destructor Documentation

11.11.2.1 Options()

```
template<class Enum , size_t DefCount>
nih::Options< Enum, DefCount >::Options (
            int const argc,
            char const *const argv[],
            char const *const usage,
            Option< Enum > const (&) defs[DefCount] )  [inline]
```

Construct an options functor.

Parameters

argc,argv	The command line arguments
usage	A usage string following "usage: progname "
defs	An array of option definitions

11.11.3 Member Function Documentation

11.11.3.1 bmatch()

```
template<class Enum , size_t DefCount>
static bool nih::Options< Enum, DefCount >::bmatch (
            char const *const lstr,
            char const *const rstr )  [inline], [static], [private]
```

Returns true if one of the given strings matches the beginning of the other.

Parameters

lstr,rstr	Two 0 terminated strings

Return values

true	The shorter string matches the beginning of the other string
false	The strings do not match

11.11.3.2 get() [1/2]

```
template<class Enum , size_t DefCount>
```

```
Enum nih::Options< Enum, DefCount >::get (
            char const ch )  [inline], [private]
```

Finds the short option matching the given character.

Parameters

ch	The short option to find

Returns

The option or OPT_UNKNOWN

11.11.3.3 get() [2/2]

```
template<class Enum , size_t DefCount>
Enum nih::Options< Enum, DefCount >::get (
            char const *const str )  [inline], [private]
```

Finds the long option matching the given string.

Parameters

str	The long option to find

Returns

The option or OPT_UNKNOWN

11.11.3.4 match()

```
template<class Enum , size_t DefCount>
static bool nih::Options< Enum, DefCount >::match (
            char const *const lstr,
            char const *const rstr )  [inline], [static], [private]
```

Returns true if the given strings match.

Parameters

lstr,rstr	Two 0 terminated strings

Return values

true	The given strings match
false	The strings do not match

11.11.3.5 operator()()

```
template<class Enum , size_t DefCount>
```

```
Enum nih::Options< Enum, DefCount >::operator() ( )  [inline]
```

Returns the next option from the command line arguments.

Returns

An Enum member representing the current option

Return values

OPT_UNKNOWN	An option that was not in the list of option definitions was encountered
OPT_NOOPT	An argument that is not an option was encountered
OPT_DASH	A lone dash "-" was encountered
OPT_LDASH	A lone long dash "--" was encountered
OPT_DONE	All arguments have been processed

11.11.3.6 operator[]()

```
template<class Enum , size_t DefCount>
char const* nih::Options< Enum, DefCount >::operator[] (
             int const i ) const  [inline]
```

Retrieve arguments to the current option.

The string containing the current option is returned with i = 0, the arguments following the option with greater values of i.

When no more arguments are left the empty string is returned.

Parameters

i	The index of the argument to retrieve

Returns

The option or one of its arguments

11.11.3.7 removePath()

```
template<class Enum , size_t DefCount>
static char const* nih::Options< Enum, DefCount >::removePath (
             char const *const file )  [inline], [static], [private]
```

Returns a pointer to the file name portion of the given string.

Parameters

file	The string containing the path to the file

Returns

A pointer to the file name portion of the path

11.11.3.8 usage()

```
template<class Enum , size_t DefCount>
std::string nih::Options< Enum, DefCount >::usage ( ) const  [inline]
```

Returns a string for usage output, created from the option definitions.

Returns

A usage string for printing on the CLI

11.11.4 Member Data Documentation

11.11.4.1 expose

```
template<class Enum , size_t DefCount>
Option<Enum> const nih::Options< Enum, DefCount >::expose  [private]
```

Initial value:

```
{
        Enum::OPT_NOOPT, 0, nullptr, nullptr, nullptr
    }
```

The option definition to use for special options that are exposed by the [] operator.

The documentation for this class was generated from the following file:

- Options.hpp

11.12 sys::pid::Pidfile Class Reference

A wrapper around the pidfile_∗ family of commands implementing the RAII pattern.

```
#include <pidfile.hpp>
```

Public Member Functions

- Pidfile (char const ∗const pfname, mode_t const mode)
  Attempts to open the pidfile.
- ∼Pidfile ()
  Removes the pidfile.
- pid_t other ()
  Returns the PID of the other process holding the lock.
- void write ()
  Write PID to the file, should be called after daemon().

Private Attributes

- pid_t otherpid

  In case of failure to acquire the lock, the PID of the other process holding it is stored here.
- pidfh ∗ pfh

  Pointer to the pidfile state data structure.

11.12.1 Detailed Description

A wrapper around the pidfile_∗ family of commands implementing the RAII pattern.

11.12.2 Constructor & Destructor Documentation

11.12.2.1 Pidfile()

```
sys::pid::Pidfile::Pidfile (
            char const *const pfname,
            mode_t const mode )  [inline]
```

Attempts to open the pidfile.

Parameters

pfname,mode	Arguments to pidfile_open()

Exceptions

pid_t	Throws the PID of the other process already holding ∗ the requested pidfile
sys::sc_error<error>	Throws with the errno of pidfile_open()

11.12.3 Member Function Documentation

11.12.3.1 write()

```
void sys::pid::Pidfile::write ( )  [inline]
```

Write PID to the file, should be called after daemon().

Exceptions

sys::sc_error<error>	Throws with the errno of pidfile_write()

11.12.4 Member Data Documentation

11.12.4.1 pfh

```
pidfh* sys::pid::Pidfile::pfh  [private]
```

Pointer to the pidfile state data structure.

Thus is allocated by pidfile_open() and assumedly freed by pidfile_remove().

The documentation for this class was generated from the following file:

- sys/pidfile.hpp

11.13 sys::sc_error< Domain > Struct Template Reference

Can be thrown by syscall function wrappers if the function returned with an error.

```
#include <error.hpp>
```

Public Member Functions

- operator int () const
  Cast to integer.
- char const * c_str () const
  Return c style string.

Public Attributes

- int error
  The errno set by the native C function.

11.13.1 Detailed Description

template<class Domain>
struct sys::sc_error< Domain >

Can be thrown by syscall function wrappers if the function returned with an error.

This is its own type for easy catching, but implicitly casts to int for easy comparison.

Template Parameters

Domain	A type marking the domain the error comes from, e.g. sys::ctl::error

11.13.2 Member Function Documentation

11.13.2.1 c_str()

```
template<class Domain >
char const* sys::sc_error< Domain >::c_str ( ) const  [inline]
```

Return c style string.

Returns

A string representation of the error

11.13.2.2 operator int()

```
template<class Domain >
sys::sc_error< Domain >::operator int ( ) const  [inline]
```

Cast to integer.

Returns

The errno code

The documentation for this struct was generated from the following file:

- sys/error.hpp

11.14 sys::sig::Signal Class Reference

Sets up a given signal handler and restores the old handler when going out of scope.

`#include <signal.hpp>`

Public Member Functions

- Signal (int const sig, sig_t const handler)
  Sets up the given handler.
- ~Signal ()
  Restore previous signal handler.

Private Attributes

- int const sig
  The signal this handler is handling.
- sig_t const handler
  The previous signal handler.

11.14.1 Detailed Description

Sets up a given signal handler and restores the old handler when going out of scope.

11.14.2 Constructor & Destructor Documentation

11.14.2.1 Signal()

```
sys::sig::Signal::Signal (
            int const sig,
            sig_t const handler )  [inline]
```

Sets up the given handler.

Parameters

sig	The signal to set a handler for
handler	The signal handling function

Exceptions

sys::sc_error<error>	Throws with the errno of signal()

The documentation for this class was generated from the following file:

- sys/signal.hpp

11.15 sys::ctl::Sync< T, SysctlT > Class Template Reference

This is a wrapper around Sysctl that allows semantically transparent use of a sysctl.

`#include <sysctl.hpp>`

Public Member Functions

- constexpr Sync ()
  The default constructor.
- constexpr Sync (SysctlT const &sysctl) noexcept
  The constructor copies the given Sysctl instance.
- Sync & operator= (T const &value)
  Transparently assiges values of type T to the represented Sysctl instance.
- operator T () const
  Implicitly cast to the represented type.

Private Attributes

- SysctlT sysctl
  A sysctl to represent.

11.15.1 Detailed Description

template<typename T, class SysctlT>
class sys::ctl::Sync< T, SysctlT >

This is a wrapper around Sysctl that allows semantically transparent use of a sysctl.

```
Sync<int, Sysctl<3>> sndUnit{{"hw.snd.default_unit"}};
if (sndUnit != 3) {    // read from sysctl
    sndUnit = 3;      // assign to sysctl
}
```

Note that both assignment and read access (implemented through type casting to T) may throw an exception.

Template Parameters

T	The type to represent the sysctl as
SysctlT	The Sysctl type

11.15.2 Constructor & Destructor Documentation

11.15.2.1 Sync() [1/2]

```
template<typename T, class SysctlT>
constexpr sys::ctl::Sync< T, SysctlT >::Sync ( )  [inline]
```

The default constructor.

This is available to defer initialisation to a later moment. This might be useful when initialising global or static instances by a character string repesented name.

11.15.2.2 Sync() [2/2]

```
template<typename T, class SysctlT>
constexpr sys::ctl::Sync< T, SysctlT >::Sync (
            SysctlT const & sysctl )  [inline], [noexcept]
```

The constructor copies the given Sysctl instance.

Parameters

sysctl	The Sysctl instance to represent

11.15.3 Member Function Documentation

11.15.3.1 operator T()

```
template<typename T, class SysctlT>
sys::ctl::Sync< T, SysctlT >::operator T ( ) const  [inline]
```

Implicitly cast to the represented type.

Returns

Returns the value from the sysctl

11.15.3.2 operator=()

```
template<typename T, class SysctlT>
Sync& sys::ctl::Sync< T, SysctlT >::operator= (
            T const & value )  [inline]
```

Transparently assiges values of type T to the represented Sysctl instance.

Parameters

value	The value to assign

Returns

A self reference

The documentation for this class was generated from the following file:

- sys/sysctl.hpp

11.16 sys::ctl::Sysctl< MibDepth > Class Template Reference

Represents a sysctl MIB address.

`#include <sysctl.hpp>`

Public Member Functions

- constexpr Sysctl ()
  The default constructor.
- Sysctl (char const *const name)
  Initialise the MIB address from a character string.
- template<typename... Tail>
  constexpr Sysctl (mib_t const head, Tail const ... tail) noexcept
  Initialise the MIB address directly.
- void get (void *const buf, size_t const bufsize) const
  Update the given buffer with a value retrieved from the sysctl.
- template<typename T >
  void get (T &value) const
  Update the given value with a value retreived from the sysctl.
- template<typename T >
  std::unique_ptr< T[ ]> get () const
  Retrieve an array from the sysctl address.
- void set (void const *const buf, size_t const bufsize)
  Update the the sysctl value with the given buffer.
- template<typename T >
  void set (T const &value)
  Update the the sysctl value with the given value.

Private Attributes

- mib_t mib [MibDepth]
  Stores the MIB address.

11.16.1 Detailed Description

template<size_t MibDepth>
class sys::ctl::Sysctl< MibDepth >

Represents a sysctl MIB address.

It offers set() and get() methods to access these sysctls.

There are two ways of initialising a Sysctl instance, by symbolic name or by directly using the MIB address. The latter one only makes sense for sysctls with a fixed address, known at compile time, e.g. `Sysctl<2>{CTL_HW, HW_NCPU}` for "hw.ncpu". Check `/usr/include/sys/sysctl.h` for predefined MIBs.

For all other sysctls, symbolic names must be used. E.g. `Sysctl<4>{"dev.cpu.0.freq"}`. Creating a Sysctl from a symbolic name may throw.

A Sysctl instance created with the default constructor is unitialised, initialisation can be deferred to a later moment by using copy assignment. This can be used to create globals but construct them inline where exceptions can be handled.

Template Parameters

MibDepth	The MIB level, e.g. "hw.ncpu" is two levels deep

11.16.2 Constructor & Destructor Documentation

11.16.2.1 Sysctl() [1/3]

```
template<size_t MibDepth>
constexpr sys::ctl::Sysctl< MibDepth >::Sysctl ( )  [inline]
```

The default constructor.

This is available to defer initialisation to a later moment. This might be useful when initialising global or static instances by a character string repesented name.

11.16.2.2 Sysctl() [2/3]

```
template<size_t MibDepth>
sys::ctl::Sysctl< MibDepth >::Sysctl (
            char const *const name )  [inline]
```

Initialise the MIB address from a character string.

Parameters

name	The symbolic name of the sysctl

Exceptions

sys::sc_error<error>	May throw an exception if the addressed sysct does not exist or if the address is too long to store

11.16.2.3 Sysctl() [3/3]

```
template<size_t MibDepth>
template<typename... Tail>
constexpr sys::ctl::Sysctl< MibDepth >::Sysctl (
            mib_t const head,
            Tail const ... tail ) [inline], [noexcept]
```

Initialise the MIB address directly.

Some important sysctl values have a fixed address that can be initialised at compile time with a noexcept guarantee.

Spliting the MIB address into head and tail makes sure that `Sysctl(char *)` does not match the template and is instead implicitly cast to invoke `Sysctl(char const *)`.

Template Parameters

Tail	The types of the trailing MIB address values (must be mib_t)

Parameters

head,tail	The mib

11.16.3 Member Function Documentation

11.16.3.1 get() [1/3]

```
template<size_t MibDepth>
void sys::ctl::Sysctl< MibDepth >::get (
            void *const buf,
            size_t const bufsize ) const [inline]
```

Update the given buffer with a value retrieved from the sysctl.

Parameters

buf,bufsize	The target buffer and its size

Exceptions

sys::sc_error<error>	Throws if value retrieval fails or is incomplete, e.g. because the value does not fit into the target buffer

11.16.3.2 get() [2/3]

```
template<size_t MibDepth>
template<typename T >
void sys::ctl::Sysctl< MibDepth >::get (
            T & value ) const  [inline]
```

Update the given value with a value retreived from the sysctl.

Template Parameters

T	The type store the sysctl value in

Parameters

value	A reference to the target value

Exceptions

sys::sc_error<error>	Throws if value retrieval fails or is incomplete, e.g. because the value does not fit into the target type

11.16.3.3 get() [3/3]

```
template<size_t MibDepth>
template<typename T >
std::unique_ptr<T[]> sys::ctl::Sysctl< MibDepth >::get ( ) const  [inline]
```

Retrieve an array from the sysctl address.

This is useful to retrieve variable length sysctls, like characer strings.

Template Parameters

T	The type stored in the array

Returns

And array of T with the right length to store the whole sysctl value

Exceptions

sys::sc_error<error>	May throw if the size of the sysctl increases after the length was queried

11.16.3.4 set() [1/2]

```
template<size_t MibDepth>
void sys::ctl::Sysctl< MibDepth >::set (
```

```
            void const *const buf,
            size_t const bufsize )  [inline]
```

Update the the sysctl value with the given buffer.

Parameters

buf,bufsize	The source buffer

Exceptions

sys::sc_error<error>	If the source buffer cannot be stored in the sysctl

11.16.3.5 set() [2/2]

```
template<size_t MibDepth>
template<typename T >
void sys::ctl::Sysctl< MibDepth >::set (
            T const & value )  [inline]
```

Update the the sysctl value with the given value.

Template Parameters

T	The value type

Parameters

value	The value to set the sysctl to

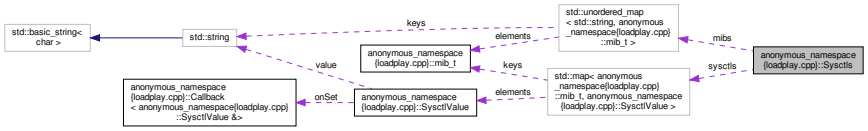
The documentation for this class was generated from the following file:

- sys/sysctl.hpp

11.17 anonymous_namespace{loadplay.cpp}::Sysctls Class Reference

Singleton class representing the sysctl table for this library.

Collaboration diagram for anonymous_namespace{loadplay.cpp}::Sysctls:



Public Member Functions

- void addValue (mib_t const &mib, std::string const &value)

  Add a value to the sysctls map.
- void addValue (std::string const &name, std::string const &value)

  Add a value to the sysctls map.
- mib_t const & getMib (std::string const &name) const

  Returns a mib for a given symbolic name.
- SysctlValue & operator[ ] (mib_t const &mib)

  Returns a reference to a sysctl value container.

Private Types

- typedef std::lock_guard< decltype(mtx)> lock_guard

  The appropriate lock guard type for mtx.

Private Attributes

- std::mutex mtx

  A simple mutex.
- std::unordered_map< std::string, mib_t > mibs

  Maps name → mib.
- std::map< mib_t, SysctlValue > sysctls

  Maps mib → (type, value).

11.17.1 Detailed Description

Singleton class representing the sysctl table for this library.

11.17.2 Member Function Documentation

11.17.2.1 addValue() [1/2]

```
void anonymous_namespace{loadplay.cpp}::Sysctls::addValue (
            mib_t const & mib,
            std::string const & value ) [inline]
```

Add a value to the sysctls map.

Parameters

mib	The mib to add the value for
value	The value to store

11.17.2.2 addValue() [2/2]

```
void anonymous_namespace{loadplay.cpp}::Sysctls::addValue (
```

```
            std::string const & name,
            std::string const & value )  [inline]
```

Add a value to the sysctls map.

Parameters

name	The symbolic name of the mib to add the value for
value	The value to store

11.17.2.3 getMib()

```
mib_t const& anonymous_namespace{loadplay.cpp}::Sysctls::getMib (
            std::string const & name ) const  [inline]
```

Returns a mib for a given symbolic name.

Parameters

name	The MIB name

Returns

The MIB

11.17.2.4 operator[]()

```
SysctlValue& anonymous_namespace{loadplay.cpp}::Sysctls::operator[] (
            mib_t const & mib )  [inline]
```

Returns a reference to a sysctl value container.

Parameters

mib	The MIB to return the reference for

Returns

A SysctlValue reference

11.17.3 Member Data Documentation

11.17.3.1 mibs

```
std::unordered_map<std::string, mib_t> anonymous_namespace{loadplay.cpp}::Sysctls::mibs  [private]
```

Initial value:

```
{
        {"hw.machine", {CTL_HW, HW_MACHINE}},
        {"hw.model",   {CTL_HW, HW_MODEL}},
        {"hw.ncpu",    {CTL_HW, HW_NCPU}},
        {ACLINE,       {1000}},
        {FREQ,         {1001}},
        {FREQ_LEVELS,  {1002}},
        {CP_TIMES,     {1003}}
    }
```

Maps name → mib.

11.17.3.2 sysctls

```
std::map<mib_t, SysctlValue> anonymous_namespace{loadplay.cpp}::Sysctls::sysctls  [private]
```

Initial value:

```
{
        {{CTL_HW, HW_MACHINE}, {CTLTYPE_STRING, "hw.machine"}},
        {{CTL_HW, HW_MODEL},   {CTLTYPE_STRING, "hw.model"}},
        {{CTL_HW, HW_NCPU},    {CTLTYPE_INT,    "0"}},
        {{1000},               {CTLTYPE_INT,    "2"}},
        {{1001},               {CTLTYPE_INT,    "0"}},
        {{1002},               {CTLTYPE_STRING, ""}},
        {{1003},               {CTLTYPE_LONG,   ""}}
    }
```

Maps mib → (type, value).

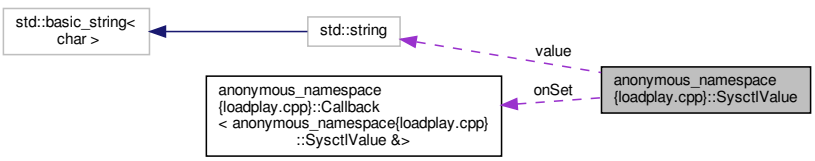
The documentation for this class was generated from the following file:

- loadplay.cpp

11.18 anonymous_namespace{loadplay.cpp}::SysctlValue Class Reference

Instances of this class represents a specific sysctl value.

Collaboration diagram for anonymous_namespace{loadplay.cpp}::SysctlValue:



Public Member Functions

- SysctlValue ()

  Default constructor.
- SysctlValue (SysctlValue const &copy)

  Copy constructor.
- SysctlValue (SysctlValue &&move)

  Move constructor.
- SysctlValue (unsigned int type, std::string const &value, callback_function const callback=nullptr)

  Construct from a type, value and optionally callback tuple.
- SysctlValue & operator= (SysctlValue const &copy)

  Copy assignment operator.
- SysctlValue & operator= (SysctlValue &&move)

  Move assignment operator.
- size_t size () const

  Returns the required storage size according to the CTLTYPE.
- template<typename T >
  int get (T *dst, size_t &size) const

  Copy a list of values into the given buffer.
- int get (char *dst, size_t &size) const

  Copy a C string into the given buffer.
- template<typename T >
  T get () const

  Returns a single value.
- int get (void *dst, size_t &size) const

  Copy a list of values into the given buffer.
- template<typename T >
  void set (T const *const newp, size_t newlen)

  Set this value to the values in the given buffer.
- int set (void const *const newp, size_t newlen)

  Set this value to the values in the given buffer.
- void set (std::string &&value)

  Move a string to the value.
- void set (std::string const &value)

  Copy a string to the value.
- template<typename T >
  void set (T const &value)

  Set the value.
- void registerOnSet (callback_function &&callback)

  Register a callback function.
- void registerOnSet (callback_function const &callback)

  Register a callback function.

Private Types

- typedef std::lock_guard< decltype(mtx)> lock_guard

  Lock guard type, fitting the mutex.

Private Attributes

- decltype(onSet) typedef ::function_t callback_function

  Callback function type.
- std::recursive_mutex mtx

  A stackable mutex.
- unsigned int type

  The sysctl type.
- std::string value

  The value of the sysctl.
- Callback< SysctlValue & > onSet

  Callback function handle.

11.18.1 Detailed Description

Instances of this class represents a specific sysctl value.

There should only be one instance of this class per MIB.

Instances are thread safe.

11.18.2 Constructor & Destructor Documentation

11.18.2.1 SysctlValue() [1/3]

```
anonymous_namespace{loadplay.cpp}::SysctlValue::SysctlValue (
            SysctlValue const & copy )  [inline]
```

Copy constructor.

Parameters

copy	The instance to copy

11.18.2.2 SysctlValue() [2/3]

```
anonymous_namespace{loadplay.cpp}::SysctlValue::SysctlValue (
            SysctlValue && move )  [inline]
```

Move constructor.

Parameters

move	The instance to move

11.18.2.3 SysctlValue() [3/3]

```
anonymous_namespace{loadplay.cpp}::SysctlValue::SysctlValue (
            unsigned int type,
```

```
            std::string const & value,
            callback_function const callback = nullptr )  [inline]
```

Construct from a type, value and optionally callback tuple.

Parameters

type	The CTLTYPE
value	A string representation of the value
callback	A callback function that is called for each set() call

11.18.3 Member Function Documentation

11.18.3.1 get() [1/4]

```
template<typename T >
int anonymous_namespace{loadplay.cpp}::SysctlValue::get (
            T * dst,
            size_t & size ) const  [inline]
```

Copy a list of values into the given buffer.

Template Parameters

T	The type of the values to extract

Parameters

dst,size	The destination buffer and size

Return values

0	On success
-1	On failure to fit all values into the taget buffer, also sets errno=ENOMEM

11.18.3.2 get() [2/4]

```
int anonymous_namespace{loadplay.cpp}::SysctlValue::get (
            char * dst,
            size_t & size ) const  [inline]
```

Copy a C string into the given buffer.

Parameters

dst,size	The destination buffer and size

Return values

0	On success
-1	On failure to fit all values into the taget buffer, also sets errno=ENOMEM

11.18.3.3 get() [3/4]

```
template<typename T >
T anonymous_namespace{loadplay.cpp}::SysctlValue::get ( ) const  [inline]
```

Returns a single value.

Template Parameters

T	The type of the value

Returns

The value

11.18.3.4 get() [4/4]

```
int anonymous_namespace{loadplay.cpp}::SysctlValue::get (
            void * dst,
            size_t & size ) const  [inline]
```

Copy a list of values into the given buffer.

Parameters

dst,size	The destination buffer and size

Return values

0	On success
-1	On failure to fit all values into the taget buffer, also sets errno=ENOMEM

11.18.3.5 operator=() [1/2]

```
SysctlValue& anonymous_namespace{loadplay.cpp}::SysctlValue::operator= (
            SysctlValue const & copy )  [inline]
```

Copy assignment operator.

Parameters

copy	The instance to copy

Returns

A self reference

11.18.3.6 operator=() [2/2]

```
SysctlValue& anonymous_namespace{loadplay.cpp}::SysctlValue::operator= (
            SysctlValue && move )  [inline]
```

Move assignment operator.

Parameters

move	The instance to move

Returns

A self reference

11.18.3.7 registerOnSet() [1/2]

```
void anonymous_namespace{loadplay.cpp}::SysctlValue::registerOnSet (
            callback_function && callback )  [inline]
```

Register a callback function.

Parameters

callback	The function to move to the callback handler

11.18.3.8 registerOnSet() [2/2]

```
void anonymous_namespace{loadplay.cpp}::SysctlValue::registerOnSet (
            callback_function const & callback )  [inline]
```

Register a callback function.

Parameters

callback	The function to copy to the callback handler

11.18.3.9 set() [1/5]

```
template<typename T >
void anonymous_namespace{loadplay.cpp}::SysctlValue::set (
            T const *const newp,
            size_t newlen )  [inline]
```

Set this value to the values in the given buffer.

Template Parameters

T	The type of the values

Parameters

newp,newlen	The source buffer and size

11.18.3.10 set() [2/5]

```
int anonymous_namespace{loadplay.cpp}::SysctlValue::set (
            void const *const newp,
            size_t newlen )  [inline]
```

Set this value to the values in the given buffer.

The buffer will be treated as an array of CTLTYPE values.

Parameters

newp,newlen	The source buffer and size

11.18.3.11 set() [3/5]

```
void anonymous_namespace{loadplay.cpp}::SysctlValue::set (
            std::string && value )  [inline]
```

Move a string to the value.

Parameters

value	The new value

11.18.3.12 set() [4/5]

```
void anonymous_namespace{loadplay.cpp}::SysctlValue::set (
            std::string const & value )  [inline]
```

Copy a string to the value.

Parameters

value	The new value

11.18.3.13 set() [5/5]

```
template<typename T >
void anonymous_namespace{loadplay.cpp}::SysctlValue::set (
            T const & value )  [inline]
```

Set the value.

Template Parameters

T	The value type

Parameters

value	The value to set

11.18.3.14 size()

```
size_t anonymous_namespace{loadplay.cpp}::SysctlValue::size ( ) const  [inline]
```

Returns the required storage size according to the CTLTYPE.

Returns

The required buffer size to hold the values.

Exceptions

int	Throws -1 if the current CTLTYPE is not implemented.

11.18.4 Member Data Documentation

11.18.4.1 mtx

```
std::recursive_mutex anonymous_namespace{loadplay.cpp}::SysctlValue::mtx  [mutable], [private]
```

A stackable mutex.

nice for exposing methods publicly and still let them allow accessing each other.

11.18.4.2 value

```
std::string anonymous_namespace{loadplay.cpp}::SysctlValue::value  [private]
```

The value of the sysctl.

This is stored as a string and converted to the appropriate type by the set() and get() methods.

The documentation for this class was generated from the following file:

- loadplay.cpp

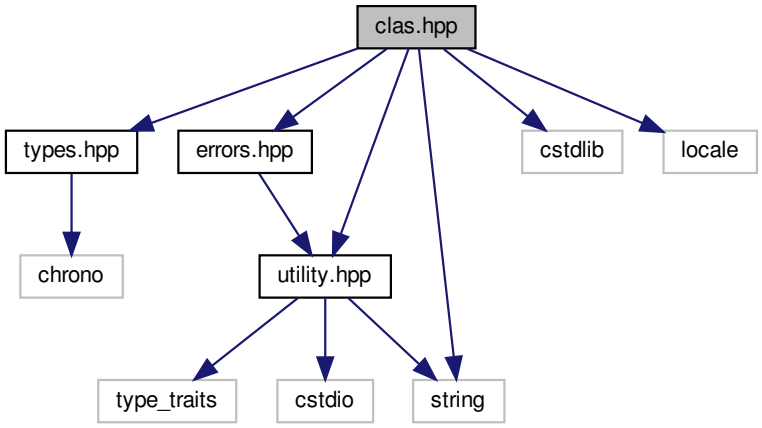
12 File Documentation

12.1 clas.hpp File Reference

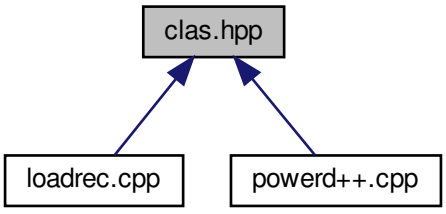
Implements functions to process command line arguments.

```
#include "types.hpp"
#include "errors.hpp"
#include "utility.hpp"
#include <cstdlib>
#include <string>
#include <locale>
```

Include dependency graph for clas.hpp:



This graph shows which files directly or indirectly include this file:



Namespaces

- clas

  A collection of functions to process command line arguments.

Enumerations

- enum clas::Unit : size_t {
  clas::Unit::SCALAR, clas::Unit::PERCENT, clas::Unit::SECOND, clas::Unit::MILLISECOND,
  clas::Unit::HZ, clas::Unit::KHZ, clas::Unit::MHZ, clas::Unit::GHZ,
  clas::Unit::THZ, clas::Unit::UNKNOWN }

  Command line argument units.

Functions

- Unit clas::unit (std::string const &str)

  Determine the unit of a string encoded value.
- types::cptime_t clas::load (char const ∗const str)

  Convert string to load in the range [0, 1024].
- types::mhz_t clas::freq (char const ∗const str)

  Convert string to frequency in MHz.
- types::ms clas::ival (char const ∗const str)

  Convert string to time interval in milliseconds.
- size_t clas::samples (char const ∗const str)

  A string encoded number of samples.

Variables

- char const ∗const clas::UnitStr [ ]

  The unit strings on the command line, for the respective Unit instances.

12.1.1 Detailed Description

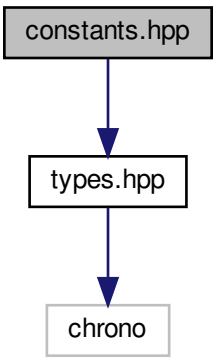
Implements functions to process command line arguments.

12.2 constants.hpp File Reference

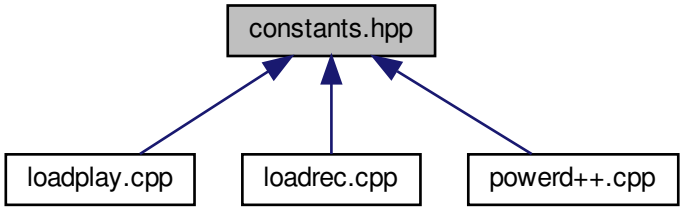
Defines a collection of constants.

```
#include "types.hpp"
```

Include dependency graph for constants.hpp:



This graph shows which files directly or indirectly include this file:



Namespaces

- constants

  A collection of constants.

Variables

- char const ∗const constants::CP_TIMES = "kern.cp_times"

  The MIB name for per-CPU time statistics.
- char const ∗const constants::ACLINE = "hw.acpi.acline"

  The MIB name for the AC line state.
- char const ∗const constants::FREQ = "dev.cpu.%d.freq"

  The MIB name for CPU frequencies.
- char const ∗const constants::FREQ_LEVELS = "dev.cpu.%d.freq_levels"

  The MIB name for CPU frequency levels.
- types::mhz_t const constants::FREQ_DEFAULT_MAX {1000000}

  Default maximum clock frequency value.
- types::mhz_t const constants::FREQ_DEFAULT_MIN {0}

  Default minimum clock frequency value.
- types::mhz_t const constants::FREQ_UNSET {1000001}

  Clock frequency representing an uninitialised value.
- char const ∗const constants::POWERD_PIDFILE = "/var/run/powerd.pid"

  The default pidfile name of powerd.
- types::cptime_t const constants::ADP {512}

  The load target for adaptive mode, equals 50% load.
- types::cptime_t const constants::HADP {384}

  The load target for hiadaptive mode, equals 37.5% load.

12.2.1 Detailed Description

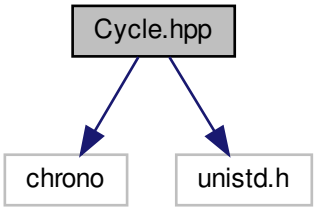
Defines a collection of constants.

12.3 Cycle.hpp File Reference

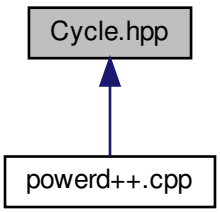
Implements timing::Cycle, a cyclic sleep functor.

```
#include <chrono>
#include <unistd.h>
```

Include dependency graph for Cycle.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- class timing::Cycle

  Implements an interruptible cyclic sleeping functor.

Namespaces

- timing

  Namespace for time management related functionality.

12.3.1 Detailed Description

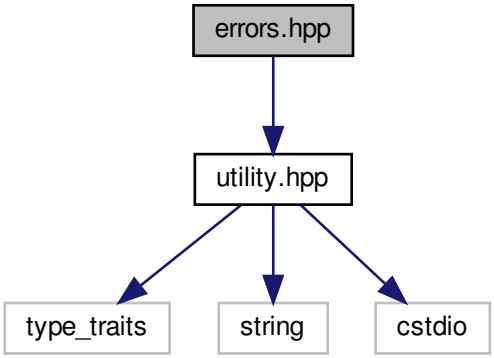
Implements timing::Cycle, a cyclic sleep functor.

12.4 errors.hpp File Reference

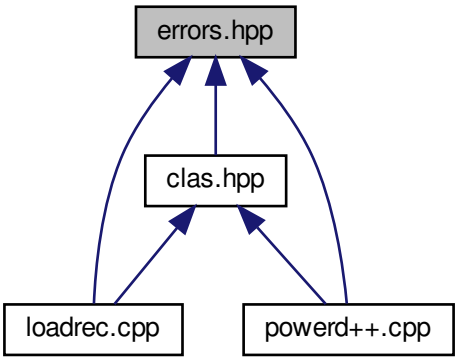
Common error handling code.

```
#include "utility.hpp"
```

Include dependency graph for errors.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct errors::Exception

  Exceptions bundle an exit code, errno value and message. More...

Namespaces

- errors

  Common error handling types and functions.

Enumerations

- enum errors::Exit : int {
  errors::Exit::OK, errors::Exit::ECLARG, errors::Exit::EOUTOFRANGE, errors::Exit::ELOAD,
  errors::Exit::EFREQ, errors::Exit::EMODE, errors::Exit::EIVAL, errors::Exit::ESAMPLES,
  errors::Exit::ESYSCTL, errors::Exit::ENOFREQ, errors::Exit::ECONFLICT, errors::Exit::EPID,
  errors::Exit::EFORBIDDEN, errors::Exit::EDAEMON, errors::Exit::EWOPEN, errors::Exit::ESIGNAL,
  errors::Exit::LENGTH }

  Exit codes.

Functions

- void errors::fail (Exit const exitcode, int const err, std::string const &msg)

  Throws an Exception instance with the given message.

Variables

- const char ∗const errors::ExitStr [ ]

  Printable strings for exit codes.

12.4.1 Detailed Description

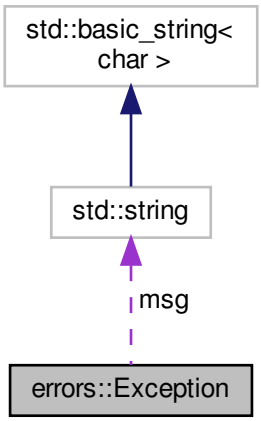
Common error handling code.

12.4.2 Class Documentation

12.4.2.1 struct errors::Exception

Exceptions bundle an exit code, errno value and message.

Collaboration diagram for errors::Exception:



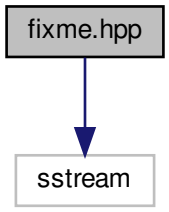
Class Members

int	err	The errno value at the time of creation.
Exit	exitcode	The code to exit with.
string	msg	An error message.

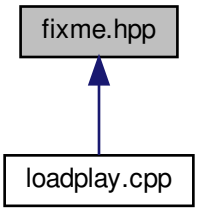
12.5 fixme.hpp File Reference

Implementations in the fixme namespace.

`#include <sstream>`
Include dependency graph for fixme.hpp:



This graph shows which files directly or indirectly include this file:



Namespaces

- fixme

  Workarounds for compiler/library bugs.

Functions

- template<typename T >
  std::string fixme::to_string (T const &op)

  G++ 5.3 does not believe in std::to_string().

12.5.1 Detailed Description

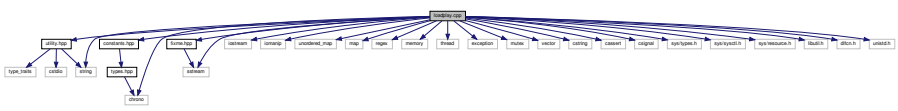
Implementations in the fixme namespace.

12.6 loadplay.cpp File Reference

Implements a library intended to be injected into a clock frequency deamon via LD_PRELOAD.

```
#include "utility.hpp"
#include "constants.hpp"
#include "fixme.hpp"
#include <iostream>
#include <iomanip>
#include <unordered_map>
#include <map>
#include <string>
#include <regex>
#include <sstream>
#include <memory>
#include <thread>
#include <exception>
#include <mutex>
#include <chrono>
#include <vector>
#include <cstring>
#include <cassert>
#include <csignal>
#include <sys/types.h>
#include <sys/sysctl.h>
#include <sys/resource.h>
#include <libutil.h>
#include <dlfcn.h>
#include <unistd.h>
```

Include dependency graph for loadplay.cpp:



Classes

- struct anonymous_namespace{loadplay.cpp}::mib_t

  Represents MIB, but wraps it to provide the necessary operators to use it as an std::map key.
- class anonymous_namespace{loadplay.cpp}::Callback< FunctionArgs >

Implements a recursion safe std::function wrapper.

- class anonymous_namespace{loadplay.cpp}::SysctlValue

  Instances of this class represents a specific sysctl value.
- class anonymous_namespace{loadplay.cpp}::Sysctls

  Singleton class representing the sysctl table for this library.
- class anonymous_namespace{loadplay.cpp}::Emulator

  Instances of this class represent an emulator session.
- class anonymous_namespace{loadplay.cpp}::Main

  Singleton class representing the main execution environment.
- class anonymous_namespace{loadplay.cpp}::Hold< T >

  Sets a referenced variable to a given value and restores it when going out of context.

Namespaces

- anonymous_namespace{loadplay.cpp}

  File local scope.

Functions

- template<size_t Size>
  int anonymous_namespace{loadplay.cpp}::strcmp (char const *const s1, char const (&s2)[Size])

  Safe wrapper around strncmp, which automatically determines the buffer size of s2.
- std::regex anonymous_namespace{loadplay.cpp}::operator"" _r (char const *const str, size_t const len)

  User defined literal for regular expressions.
- template<>
  std::string anonymous_namespace{loadplay.cpp}::SysctlValue::get< std::string > () const

  Returns a copy of the value string.
- void anonymous_namespace{loadplay.cpp}::warn (std::string const &msg)

  Print a warning.
- void anonymous_namespace{loadplay.cpp}::fail (std::string const &msg)

  This prints an error message and sets sys_results to make the hijacked process fail.
- int sysctl (const int *name, u_int namelen, void *oldp, size_t *oldlenp, const void *newp, size_t newlen)

  Functions to intercept.
- int sysctlnametomib (const char *name, int *mibp, size_t *sizep)

  Intercept calls to sysctlnametomib().
- int sysctlbyname (const char *name, void *oldp, size_t *oldlenp, const void *newp, size_t newlen)

  Intercept calls to sysctlbyname().
- int daemon (int, int)

  Intercept calls to daemon().
- uid_t geteuid (void)

  Intercept calls to geteuid().
- pidfh * pidfile_open (const char *, mode_t, pid_t *)

  Intercept calls to pidfile_open().
- int pidfile_write (pidfh *)

  Intercept calls to pidfile_write().
- int pidfile_close (pidfh *)

  Intercept calls to pidfile_close().
- int pidfile_remove (pidfh *)

  Intercept calls to pidfile_remove().
- int pidfile_fileno (pidfh const *)

  Intercept calls to pidfile_fileno().

Variables

- int anonymous_namespace{loadplay.cpp}::sys_results = 0

  The success return value of intercepted functions.
- class anonymous_namespace{loadplay.cpp}::Sysctls anonymous_namespace{loadplay.cpp}::sysctls

  Sole instance of Sysctls.
- class anonymous_namespace{loadplay.cpp}::Main anonymous_namespace{loadplay.cpp}::main

  Sole instance of Main.
- bool anonymous_namespace{loadplay.cpp}::sysctl_fallback = false

  Set to activate fallback to the original sysctl functions.

12.6.1 Detailed Description

Implements a library intended to be injected into a clock frequency deamon via LD_PRELOAD.

This library reads instructions from std::cin and outputs statistics about the hijacked process on std::cout.

12.6.2 Function Documentation

12.6.2.1 daemon()

```
int daemon (
            int ,
            int  )
```

Intercept calls to daemon().

Prevents process from separating from the controlling terminal.

Returns

The value of sys_results

12.6.2.2 geteuid()

```
uid_t geteuid (
            void  )
```

Intercept calls to geteuid().

Tells the asking process that it is running as root.

Returns

Always returns 0

12.6.2.3 pidfile_close()

```
int pidfile_close (
            pidfh *  )
```

Intercept calls to pidfile_close().

Returns

The value of sys_results

12.6.2.4 pidfile_fileno()

```
int pidfile_fileno (
            pidfh const *  )
```

Intercept calls to pidfile_fileno().

Returns

The value of sys_results

12.6.2.5 pidfile_open()

```
pidfh* pidfile_open (
            const char * ,
            mode_t ,
            pid_t *  )
```

Intercept calls to pidfile_open().

Prevents pidfile locking and creation by the hijacked process.

Returns

A dummy pointer

12.6.2.6 pidfile_remove()

```
int pidfile_remove (
            pidfh *  )
```

Intercept calls to pidfile_remove().

Returns

The value of sys_results

12.6.2.7 pidfile_write()

```
int pidfile_write (
            pidfh *  )
```

Intercept calls to pidfile_write().

Returns

The value of sys_results

12.6.2.8 sysctl()

```
int sysctl (
            const int * name,
            u_int namelen,
            void * oldp,
            size_t * oldlenp,
            const void * newp,
            size_t newlen )
```

Functions to intercept.

Intercept calls to sysctl().

Uses the local anonymous_namespace{loadplay::cpp}::sysctls store.

Falls back to the original if kern.usrstack is requested or sysctl_fallback is set.

The call may fail for 3 reasons:

1. The fail() function was called and sys_results was assigned -1
2. A target buffer was too small (errno == ENOMEM)
3. The given sysctl is not in the sysctls store (errno == ENOENT)

Parameters

name,namelen,oldp,oldlenp,newp,newlen	Please refer to sysctl(3)

Return values

0	The call succeeded
-1	The call failed

12.6.2.9 sysctlbyname()

```
int sysctlbyname (
            const char * name,
            void * oldp,
```

```
            size_t * oldlenp,
            const void * newp,
            size_t newlen )
```

Intercept calls to sysctlbyname().

Falls back on the original sysctlbyname() for the following names:

- vm.overcommit
- kern.smp.cpus

May fail for the same reasons as sysctl().

Parameters

name,oldp,oldlenp,newp,newlen	Please refer to sysctl(3)

Return values

0	The call succeeded
-1	The call failed

12.6.2.10 sysctlnametomib()

```
int sysctlnametomib (
            const char * name,
            int * mibp,
            size_t * sizep )
```

Intercept calls to sysctlnametomib().

Parameters

name,mibp,sizep	Please refer to sysctl(3)

Return values

0	The call succeeded
-1	The call failed

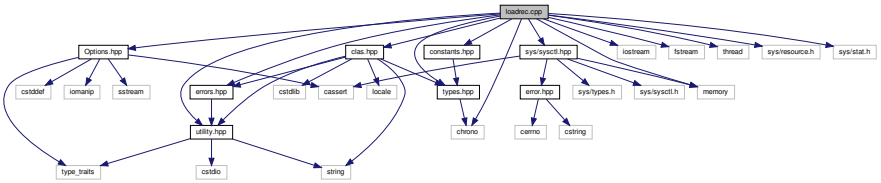
12.7 loadrec.cpp File Reference

Implements a load recorder, useful for simulating loads to test CPU clock daemons and settings.

```
#include "Options.hpp"
#include "types.hpp"
#include "constants.hpp"
#include "errors.hpp"
```

```
#include "utility.hpp"
#include "clas.hpp"
#include "sys/sysctl.hpp"
#include <iostream>
#include <fstream>
#include <chrono>
#include <thread>
#include <memory>
#include <sys/resource.h>
#include <sys/stat.h>
```

Include dependency graph for loadrec.cpp:



Namespaces

- anonymous_namespace{loadrec.cpp}

  File local scope.

Enumerations

- enum anonymous_namespace{loadrec.cpp}::OE { anonymous_namespace{loadrec.cpp}::OE::USAGE, anonymous_namespace{loadrec.cpp}::OE::IVAL_DURATION, anonymous_namespace{loadrec.cpp}::OE::IVAL_POLL, anonymous_namespace{loadrec.cpp}::OE::FILE_OUTPUT, anonymous_namespace{loadrec.cpp}::OE::FILE_PID, anonymous_namespace{loadrec.cpp}::OE::FLAG_VERBOSE, anonymous_namespace{loadrec.cpp}::OE::OPT_UNKNOWN, anonymous_namespace{loadrec.cpp}::OE::OPT_NOOPT, anonymous_namespace{loadrec.cpp}::OE::OPT_DASH, anonymous_namespace{loadrec.cpp}::OE::OPT_LDASH, anonymous_namespace{loadrec.cpp}::OE::OPT_DONE }

  An enum for command line parsing.

Functions

- void anonymous_namespace{loadrec.cpp}::verbose (std::string const &msg)

  Outputs the given message on stderr if g.verbose is set.
- void anonymous_namespace{loadrec.cpp}::init ()

  Set up output to the given file.
- void anonymous_namespace{loadrec.cpp}::read_args (int const argc, char const *const argv[])

  Parse command line arguments.
- void anonymous_namespace{loadrec.cpp}::print_sysctls ()

  Print the sysctls.
- void anonymous_namespace{loadrec.cpp}::run ()

  Report the load frames.
- int main (int argc, char *argv[])

  Main routine, setup and execute daemon, print errors.

Variables

- struct {
  bool **verbose** {false}
  Verbosity flag.
  ms **duration** {30000}
  Recording duration in ms.
  ms **interval** {25}
  Recording sample interval in ms.
  std::ofstream **outfile** {}
  The output file stream to use if an outfilename is provided on the CLI.
  std::ostream * **out** = &std::cout
  A pointer to the stream to use for output, either std::cout or outfile.
  char const * **outfilename** {nullptr}
  The user provided output file name.
  char const * **pidfilename** {POWERD_PIDFILE}
  The PID file location for clock frequency daemons.
  sys::ctl::SysctlOnce< coreid_t, 2 > const **ncpu** {1U, {CTL_HW, HW_NCPU}}
  The number of CPU cores/threads.
  } anonymous_namespace{loadrec.cpp}::g

  The global state.
- char const *const anonymous_namespace{loadrec.cpp}::USAGE = "[-hv] [-d ival] [-p ival] [-o file]"
  The short usage string.
- Option< OE > const anonymous_namespace{loadrec.cpp}::OPTIONS [ ]
  Definitions of command line options.

12.7.1 Detailed Description

Implements a load recorder, useful for simulating loads to test CPU clock daemons and settings.

12.7.2 Function Documentation

12.7.2.1 main()

```
int main (
            int argc,
            char * argv[] )
```

Main routine, setup and execute daemon, print errors.

Parameters

argc,argv	The command line arguments

Returns

An exit code

See also

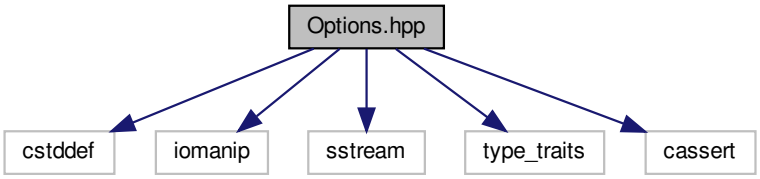
Exit

12.8 Options.hpp File Reference

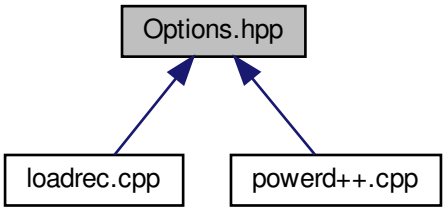
This file provides nih::Options<>, a substitute for `getopt(3)`.

```
#include <cstddef>
#include <iomanip>
#include <sstream>
#include <type_traits>
#include <cassert>
```

Include dependency graph for Options.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct nih::enum_has_members< Enum, class >

  Tests whether the given enum provides all the required definitions.
- struct nih::Option< Enum >

  Container for an option definition. More...
- class nih::Options< Enum, DefCount >

  An instance of this class offers operators to retrieve command line options and arguments.

Namespaces

- nih

  Not invented here namespace, for code that substitutes already commonly available functionality.

Typedefs

- template<class... >
  using nih::void_t = void

  See std::void_t in C++17 <type_traits>.

Functions

- template<class Enum >
  size_t nih::argCount (Option< Enum > const &def)

  Retrieves the count of arguments in an option definition.
- template<class Enum , size_t DefCount>
  constexpr Options< Enum, DefCount > nih::make_Options (int const argc, char const *const argv[], char const *const usage, Option< Enum > const (&defs)[DefCount])

  Wrapper around the Options<> constructor, that uses function template matching to deduce template arguments.

12.8.1 Detailed Description

This file provides nih::Options<>, a substitute for `getopt(3)`.

The `getopt(3)` interface takes the command line arguments as `char * const` instead of `char const *`. I.e. it reserves the right to mutate the provided arguments, which it actually does.

The nih::Options<> functor is not a drop in substitute, but tries to be easily adoptable and does not change the data given to it.

To use the options an enum or enum class is required, e.g.:

```
enum class MyOptions {
    USAGE, FILE_IN, FILE_OUT, FLAG_VERBOSE,
    OPT_UNKNOWN, OPT_NOOPT, OPT_DASH, OPT_LDASH, OPT_DONE
};
```

The options prefixed with `OPT_` are obligatory. Their meaning is documented in nih::enum_has_members<>. Their presence is validated at compile time.

The enum values are returned whe selecting the next option, in order to do that a usage string and a list of definitions are needed:

```
static char const * const USAGE = "[-hv] [-i file] [-o file] [command ...]";

static nih::Option<MyOptions> const OPTIONS[]{
    {MyOptions::USAGE,        'h', "help",    "",     "Show this help"},
    {MyOptions::USAGE,        0,   "usage",   "",     ""},
    {MyOptions::FILE_IN,      'i', "in",      "file", "Input file"},
    {MyOptions::FILE_OUT,     'o', "out",     "file", "Output file"},
    {MyOptions::FLAG_VERBOSE, 'v', "verbose", "",     "Verbose output"}
};
```

Every array entry defines an option consisting of the enum value that represents it, a short and a long version (either of which are optional) and a comma separated list of arguments. The final string appears in the usage() output. The details are documented by nih::Option<>.

Aliases are created by adding a definition that returns the same enum value.

For the short version it does not matter whether `-ifile` or `-i file` is provided, the long version must be `--in file`. Short options without arguments may be directly followed by another short option, e.g. `-vofile` is equivalent to `-v -o file`.

The option definitions should be passed to nih::make_Options() to create the functor:

```
#include <iostream>
...

int main(int argc, char * argv[]) {
    char const * infile = "-";
    char const * outfile = "-";
    bool verbose = false;

    auto getopt = nih::make_Options(argc, argv, USAGE, OPTIONS);
    while (true) switch (getopt()) { // get new option/argument
    case MyOptions::USAGE:
        std::cerr << getopt.usage(); // show usage
        return 0;
    case MyOptions::FILE_IN:
        infile = getopt[1]; // get first argument
        break;
    case MyOptions::FILE_OUT:
        outfile = getopt[1]; // get first argument
        break;
    case MyOptions::FLAG_VERBOSE:
        verbose = true;
        break;
    case MyOptions::OPT_UNKNOWN:
    case MyOptions::OPT_NOOPT:
    case MyOptions::OPT_DASH:
    case MyOptions::OPT_LDASH:
        std::cerr << "Unexpected command line argument: "
                  << getopt[0] << '\n'; // output option/argument
        return 1;
    case MyOptions::OPT_DONE:
        return do_something(infile, outfile, verbose);
    }
    return 0;
}
```

Every call of the functor moves on to the next option or argument. For non-option arguments it returns `OPT_NOOPT`.

The `getopt[1]` calls return the first argument following the option. It is possible to retrieve more arguments than were defined in the options definition. The `[]` opterator always returns a valid, termindated string (provided the command line arguments are valid, terminated strings). So it is always safe to dereference the pointer, even when reading beyond the end of command line arguments.

The `getopt[0]` calls return the command line argument that contains the selected option. So in the `FILE_IN` case it could be any of `-i`, `--in`, `-vi`, `-ifile` or `-vifile`. This is useful for the `OPT_UNKNOWN` and `OPT_NOOPT` cases. The `getopt[1]` call on the other hand would always return `file` regardless of argument chaining.

12.8.2 Class Documentation

12.8.2.1 struct nih::Option

template<class Enum>
struct nih::Option< Enum >

Container for an option definition.

Aliases can be defined by creating definitions with the same enumval member.

The lopt, args and usage members have to be 0 terminated, using string literals is safe.

Template Parameters

Enum	An enum or enum class representing the available options

Class Members

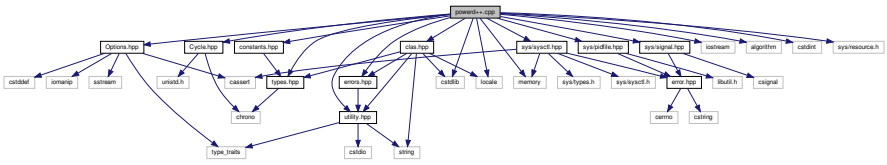
char const *	args	A comma separated list of arguments. Set to nullptr or "" if no argument is available.
Enum	enumval	The enum value to return for this option.
char const *	lopt	The long version of this option. Set to nullptr or "" if no long option is available.
char	sopt	The short version of this option. Set to 0 if no short option is available.
char const *	usage	A usage string.

12.9 powerd++.cpp File Reference

Implements powerd++ a drop in replacement for FreeBSD's powerd.

```
#include "Options.hpp"
#include "Cycle.hpp"
#include "types.hpp"
#include "constants.hpp"
#include "errors.hpp"
#include "clas.hpp"
#include "utility.hpp"
#include "sys/sysctl.hpp"
#include "sys/pidfile.hpp"
#include "sys/signal.hpp"
#include <iostream>
#include <locale>
#include <memory>
#include <algorithm>
#include <cstdlib>
#include <cstdint>
#include <sys/resource.h>
```

Include dependency graph for powerd++.cpp:



Classes

- struct anonymous_namespace{powerd++.cpp}::Core

  Contains the management information for a single CPU core. More...
- class anonymous_namespace{powerd++.cpp}::FreqGuard

  A core frequency guard.
- struct anonymous_namespace{powerd++.cpp}::anonymous_namespace{powerd++.cpp}.FREQ_UNSET

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}::anonymous_namespace{powerd++.cpp}.ADP

  Per AC line state settings. More...

- struct anonymous_namespace{powerd++.cpp}::anonymous_namespace{powerd++.cpp}.HADP

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}::anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MIN

  Per AC line state settings. More...
- struct anonymous_namespace{powerd++.cpp}::anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MAX

  Per AC line state settings. More...

Namespaces

- anonymous_namespace{powerd++.cpp}

  File local scope.

Enumerations

- enum anonymous_namespace{powerd++.cpp}::AcLineState : unsigned int { anonymous_namespace{powerd++.cpp}::AcLineState::BATTERY, anonymous_namespace{powerd++.cpp}::AcLineState::ONLINE, anonymous_namespace{powerd++.cpp}::AcLineState::UNKNOWN, anonymous_namespace{powerd++.cpp}::AcLineState::LENGTH }

  The available AC line states.
- enum anonymous_namespace{powerd++.cpp}::OE { anonymous_namespace{powerd++.cpp}::OE::USAGE, anonymous_namespace{powerd++.cpp}::OE::MODE_AC, anonymous_namespace{powerd++.cpp}::OE::MODE_BATT, anonymous_namespace{powerd++.cpp}::OE::FREQ_MIN, anonymous_namespace{powerd++.cpp}::OE::FREQ_MAX, anonymous_namespace{powerd++.cpp}::OE::FREQ_MIN_AC, anonymous_namespace{powerd++.cpp}::OE::FREQ_MAX_AC, anonymous_namespace{powerd++.cpp}::OE::FREQ_MIN_BATT, anonymous_namespace{powerd++.cpp}::OE::FREQ_MAX_BATT, anonymous_namespace{powerd++.cpp}::OE::MODE_UNKNOWN, anonymous_namespace{powerd++.cpp}::OE::IVAL_POLL, anonymous_namespace{powerd++.cpp}::OE::FILE_PID, anonymous_namespace{powerd++.cpp}::OE::FLAG_VERBOSE, anonymous_namespace{powerd++.cpp}::OE::FLAG_FOREGROUND, anonymous_namespace{powerd++.cpp}::OE::CNT_SAMPLES, anonymous_namespace{powerd++.cpp}::OE::IGNORE, anonymous_namespace{powerd++.cpp}::OE::OPT_UNKNOWN, anonymous_namespace{powerd++.cpp}::OE::OPT_NOOPT, anonymous_namespace{powerd++.cpp}::OE::OPT_DASH, anonymous_namespace{powerd++.cpp}::OE::OPT_LDASH, anonymous_namespace{powerd++.cpp}::OE::OPT_DONE }

  An enum for command line parsing.

Functions

- void anonymous_namespace{powerd++.cpp}::verbose (std::string const &msg)

  Outputs the given message on stderr if g.verbose is set.
- void anonymous_namespace{powerd++.cpp}::sysctl_fail (sys::sc_error< sys::ctl::error > const err)

  Treat sysctl errors.
- void anonymous_namespace{powerd++.cpp}::init ()

  Perform initial tasks.
- void anonymous_namespace{powerd++.cpp}::update_loads ()

  Updates the cp_times ring buffer and computes the load average for each core.
- void anonymous_namespace{powerd++.cpp}::update_group_loads ()

  Sets the load time of each clock controlling core to the maximum load in the group.

- void anonymous_namespace{powerd++.cpp}::update_freq ()

  Update the CPU clocks depending on the AC line state and targets.
- void anonymous_namespace{powerd++.cpp}::init_loads ()

  Fill the loads buffers with n samples.
- void anonymous_namespace{powerd++.cpp}::set_mode (AcLineState const line, char const *const str)

  Sets a load target or fixed frequency for the given AC line state.
- void anonymous_namespace{powerd++.cpp}::read_args (int const argc, char const *const argv[])

  Parse command line arguments.
- void anonymous_namespace{powerd++.cpp}::show_settings ()

  Prints the configuration on stderr in verbose mode.
- void anonymous_namespace{powerd++.cpp}::signal_recv (int signal)

  Sets g.signal, terminating the main loop.
- void anonymous_namespace{powerd++.cpp}::run_daemon ()

  Daemonise and run the main loop.
- int main (int argc, char *argv[])

  Main routine, setup and execute daemon, print errors.

Variables

- char const *const anonymous_namespace{powerd++.cpp}::AcLineStateStr [] {"battery", "online", "unknown"}

  String descriptions for the AC line states.
- struct {
  volatile sig_atomic_t **signal** {0}
  The last signal received, used for terminating.
  size_t **samples** {4}
  The number of load samples to take.
  ms **interval** {500}
  The polling interval.
  size_t **sample** {0}
  The current sample.
  sys::ctl::SysctlOnce< coreid_t, 2 > const **ncpu** {1, {CTL_HW, HW_NCPU}}
  The number of CPU cores or threads.
  struct anonymous_namespace{powerd++.cpp}:: { ... } **FREQ_UNSET** [3]
  Per AC line state settings.
  struct anonymous_namespace{powerd++.cpp}:: { ... } **ADP** [3]
  struct anonymous_namespace{powerd++.cpp}:: { ... } **HADP** [3]
  struct anonymous_namespace{powerd++.cpp}:: { ... } **FREQ_DEFAULT_MIN** [3]
  struct anonymous_namespace{powerd++.cpp}:: { ... } **FREQ_DEFAULT_MAX** [3]
  sys::ctl::Sysctl< 3 > **acline_ctl**
  The hw.acpi.acline ctl.
  bool **verbose** {false}
  Verbose mode.
  bool **foreground** {false}
  Foreground mode.
  char const * **pidfilename** {POWERD_PIDFILE}
  Name of an alternative pidfile.
  sys::ctl::Sysctl< 2 > **cp_times_ctl** {}
  The kern.cp_times sysctl.
  std::unique_ptr< cptime_t[][CPUSTATES]> **cp_times**
  The kern.cp_times buffer for all cores.
  std::unique_ptr< Core[]> **cores**
  This buffer is to be allocated with ncpu instances of the Core struct to store the management information of every core.
  } anonymous_namespace{powerd++.cpp}::g

A collection of all the gloabl, mutable states.

- char const ∗const anonymous_namespace{powerd++.cpp}::USAGE = "[-hvf] [-abn mode] [-mM freq] [-p ival] [-s cnt] [-P file]"

  The short usage string.

- Option< OE > const anonymous_namespace{powerd++.cpp}::OPTIONS [ ]

  Definitions of command line options.

12.9.1 Detailed Description

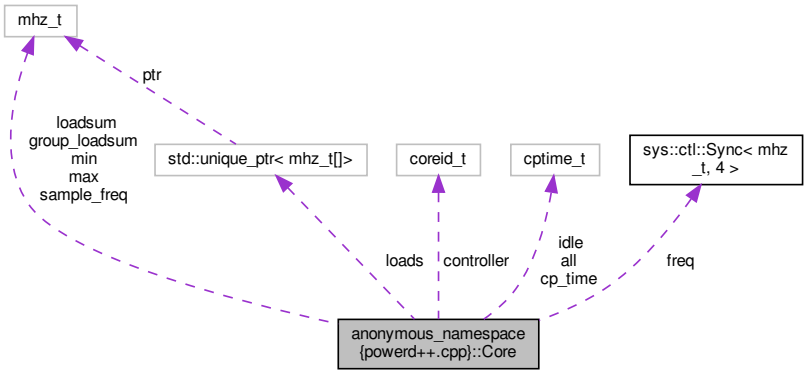
Implements powerd++ a drop in replacement for FreeBSD's powerd.

12.9.2 Class Documentation

12.9.2.1 struct anonymous_namespace{powerd++.cpp}::Core

Contains the management information for a single CPU core.

Collaboration diagram for anonymous_namespace{powerd++.cpp}::Core:



Class Members

cptime_t	all	Count of all ticks.
coreid_t	controller	The core that controls the frequency for this core.
cptime_t const ∗	cp_time	A pointer to the kern.cp_times section for this core.
SysctlSync< mhz_t, 4 >	freq	The sysctl kern.cpu.N.freq, if present.
mhz_t	group_loadsum	For the controlling core this is set to the group loadsum. This is reset by update_loads() and set by update_group_loads().
cptime_t	idle	The idle ticks count.
unique_ptr< mhz_t[ ]>	loads	A ring buffer of load samples for this core. Each load sample is weighted with the core frequency at which it was taken. This is updated by update_loads().

Class Members

mhz_t	loadsum	The sum of all load samples. This is updated by update_loads().
mhz_t	max	The maximum core clock rate.
mhz_t	min	The minimum core clock rate.
mhz_t	sample_freq	The kern.cpu.N.freq value for the current load sample. This is updated by update_loads().

12.9.2.2 struct anonymous_namespace{powerd++.cpp}.FREQ_UNSET

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩_t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

12.9.2.3 struct anonymous_namespace{powerd++.cpp}.ADP

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩_t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

12.9.2.4 struct anonymous_namespace{powerd++.cpp}.HADP

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩_t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

12.9.2.5 struct anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MIN

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩_t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

12.9.2.6 struct anonymous_namespace{powerd++.cpp}.FREQ_DEFAULT_MAX

Per AC line state settings.

Class Members

mhz_t	freq_max	Highest frequency to set in MHz.
mhz_t	freq_min	Lowest frequency to set in MHz.
mhz_t	target_freq	Fixed clock frequencies to use if the target load is set to 0.
cptime↩_t	target_load	Target load times [0, 1024]. The value 0 indicates the corresponding fixed frequency setting from target_freqs should be used.

12.9.3 Function Documentation

12.9.3.1 main()

```
int main (
            int argc,
            char * argv[] )
```

Main routine, setup and execute daemon, print errors.

Parameters

argc,argv	The command line arguments

Returns

An exit code

See also

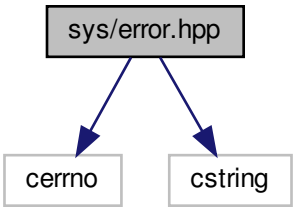
Exit

12.10 sys/error.hpp File Reference

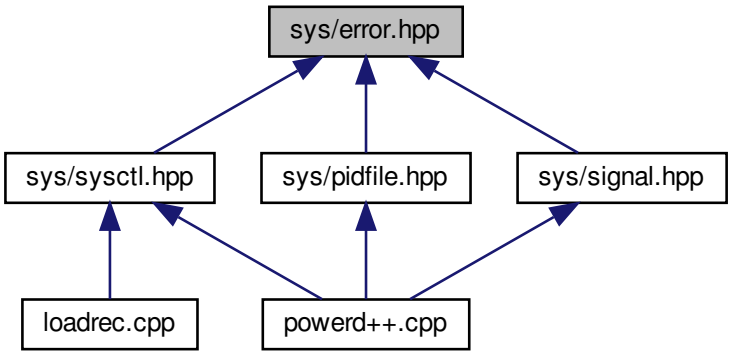
Provides system call error handling.

```
#include <cerrno>
#include <cstring>
```

Include dependency graph for error.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct sys::sc_error< Domain >

  Can be thrown by syscall function wrappers if the function returned with an error.

Namespaces

- sys

  Wrappers around native system interfaces.

12.10.1 Detailed Description

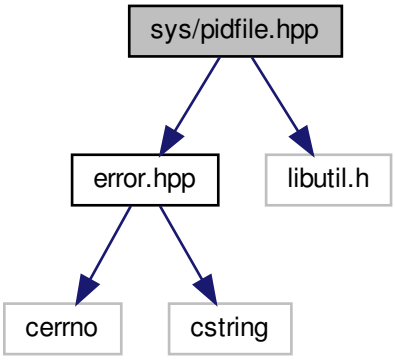
Provides system call error handling.

12.11 sys/pidfile.hpp File Reference

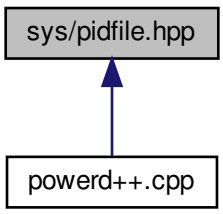
Implements safer c++ wrappers for the pidfile_∗() interface.

```
#include "error.hpp"
#include <libutil.h>
```

Include dependency graph for pidfile.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct sys::pid::error

  The domain error type. More...
- class sys::pid::Pidfile

  A wrapper around the pidfile_∗ family of commands implementing the RAII pattern.

Namespaces

- sys

  Wrappers around native system interfaces.
- sys::pid

  This namespace contains safer c++ wrappers for the pidfile_∗() interface.

12.11.1 Detailed Description

Implements safer c++ wrappers for the pidfile_∗() interface.

Requires linking with -lutil.

12.11.2 Class Documentation

12.11.2.1 struct sys::pid::error

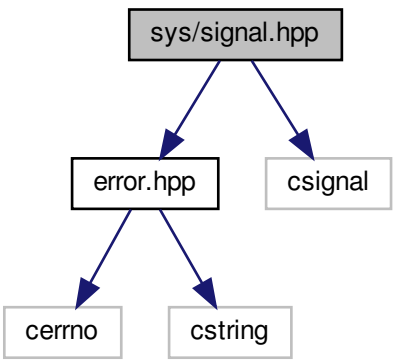
The domain error type.

12.12 sys/signal.hpp File Reference

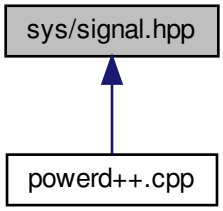
Implements a c++ wrapper for the signal(3) call.

```
#include "error.hpp"
#include <csignal>
```

Include dependency graph for signal.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct sys::sig::error

  The domain error type. More...
- class sys::sig::Signal

  Sets up a given signal handler and restores the old handler when going out of scope.

Namespaces

- sys

  Wrappers around native system interfaces.
- sys::sig

  This namespace provides c++ wrappers for signal(3).

Typedefs

- using sys::sig::sig_t = void(*)(int)

  Convenience type for signal handlers.

12.12.1 Detailed Description

Implements a c++ wrapper for the signal(3) call.

12.12.2 Class Documentation

12.12.2.1 struct sys::sig::error

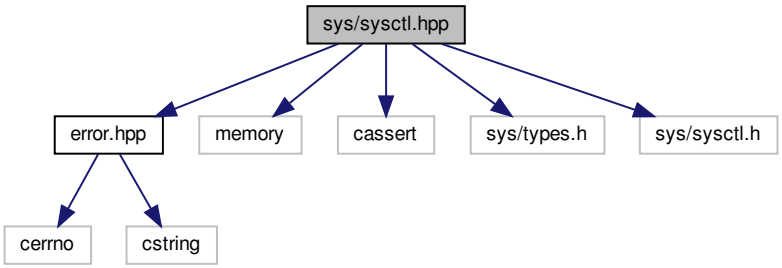
The domain error type.

12.13 sys/sysctl.hpp File Reference

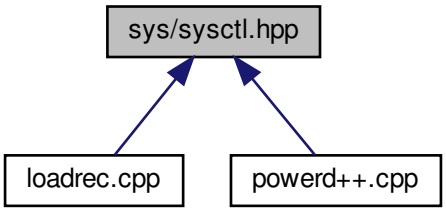
Implements safer c++ wrappers for the sysctl() interface.

```
#include "error.hpp"
#include <memory>
#include <cassert>
#include <sys/types.h>
#include <sys/sysctl.h>
```

Include dependency graph for sysctl.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- struct sys::ctl::error

  The domain error type. More...
- class sys::ctl::Sysctl< MibDepth >

  Represents a sysctl MIB address.
- class sys::ctl::Sync< T, SysctlT >

  This is a wrapper around Sysctl that allows semantically transparent use of a sysctl.
- class sys::ctl::Once< T, SysctlT >

  A read once representation of a Sysctl.

Namespaces

- sys

  Wrappers around native system interfaces.
- sys::ctl

  This namespace contains safer c++ wrappers for the sysctl() interface.

Typedefs

- typedef int sys::ctl::mib_t

  Management Information Base identifier type (see sysctl(3)).
- template<typename T , size_t MibDepth>
  using sys::ctl::SysctlSync = Sync< T, Sysctl< MibDepth >>

  A convenience alias around Sync.
- template<typename T , size_t MibDepth>
  using sys::ctl::SysctlOnce = Once< T, Sysctl< MibDepth >>

  A convenience alias around Once.

Functions

- template<typename... Args>
  constexpr Sysctl< sizeof...(Args)> sys::ctl::make_Sysctl (Args const ... args)

  Create a Sysctl instances.
- template<typename T , class SysctlT >
  constexpr Once< T, SysctlT > sys::ctl::make_Once (T const &value, SysctlT const &sysctl) noexcept

  This creates a Once instance.

12.13.1 Detailed Description

Implements safer c++ wrappers for the sysctl() interface.

12.13.2 Class Documentation

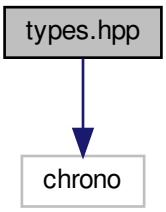
12.13.2.1 struct sys::ctl::error

The domain error type.

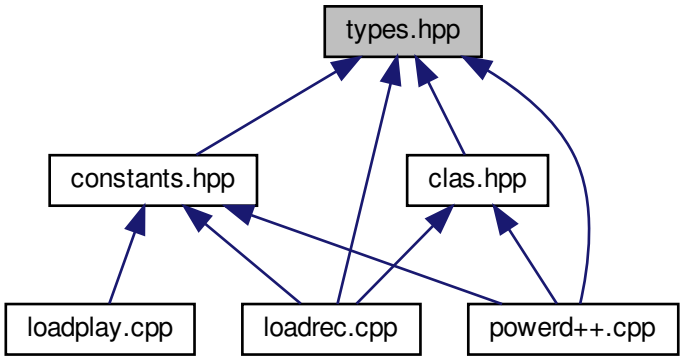
12.14 types.hpp File Reference

A collection of type aliases.

`#include <chrono>`
Include dependency graph for types.hpp:



This graph shows which files directly or indirectly include this file:



Namespaces

- types

  A collection of type aliases.

Typedefs

- typedef std::chrono::milliseconds types::ms

  Millisecond type for polling intervals.
- typedef int types::coreid_t

Type for CPU core indexing.

- typedef unsigned long types::cptime_t

  Type for load counting.

- typedef unsigned int types::mhz_t

  Type for CPU frequencies in MHz.

12.14.1 Detailed Description

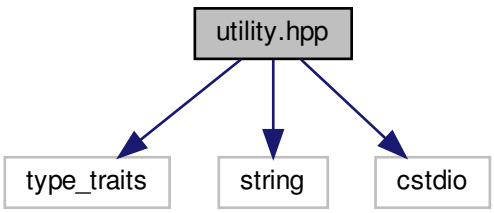
A collection of type aliases.

12.15 utility.hpp File Reference

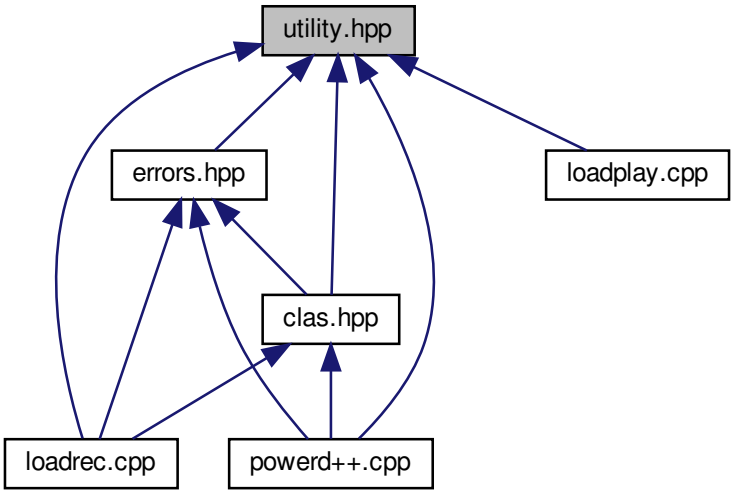
Implements generally useful functions.

```
#include <type_traits>
#include <string>
#include <cstdio>
```

Include dependency graph for utility.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- class utility::Formatter< BufSize >

  A formatting wrapper around string literals.

Namespaces

- utility

  A collection of generally useful functions.
- utility::literals

  Contains literals.

Functions

- template<typename T , size_t Count>
  constexpr size_t utility::countof (T(&)[Count])

  Like sizeof(), but it returns the number of elements an array consists of instead of the number of bytes.
- std::string utility::literals::operator"" _s (char const *const op, size_t const size)

  A string literal operator equivalent to the `operator "" s` literal provided by C++14 in <string>.
- template<typename... Args>
  void utility::sprintf (Args...)

  This is a safeguard against accidentally using sprintf().
- template<size_t Size, typename... Args>
  int utility::sprintf_safe (char(&dst)[Size], char const *const format, Args const ... args)

  A wrapper around snprintf() that automatically pulls in the destination buffer size.
- template<class ET , typename VT = typename std::underlying_type<ET>::type>
  constexpr VT utility::to_value (ET const op)

  Casts an enum to its underlying value.
- constexpr Formatter< 16384 > utility::literals::operator"" _fmt (char const *const fmt, size_t const)

  Literal to convert a string literal to a Formatter instance.

12.15.1 Detailed Description

Implements generally useful functions.

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