MonAMI v0.10 User Guide

Paul Millar

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Chapter 1. Introduction

This document describes how to configure and run MonAMI: a universal sensor infrastructure. Following the Unix philosophy, it aims to do a simple job well. That job is to move monitoring information from a service into a monitoring system. It does not attempt to store monitoring information or display (graphically) the data, as other systems exist that already do this. Rather, it aims to interface well with existing software.

To understand how MonAMI may be configured, a brief introduction to the underlying ideas of MonAMI must be given. This introduction chapter will give an overview of how MonAMI allows monitoring information to flow. This is important as later chapters (which describe specific aspects of MonAMI) may be confusing without a clear understanding of the “big picture.”

It is worth stressing at this stage that monitoring is a more involved process than merely periodically collecting data. Without a clear understanding of this, MonAMI may appear superfluous!

In essence, MonAMI allows the collection of information from one or more services. This information is then sent off, perhaps to some data storage or to be displayed within some monitoring software. This gathering of information can be triggered by MonAMI internally or from an external agent, depending on how MonAMI is configured.

1.1. MonAMI architecture

MonAMI has two parts: a core infrastructure and a set of plugins. *Plugins* do the more immediately useful activity, such as collecting information and sending the information somewhere. There are broadly two classes of plugins: monitoring plugins and reporting plugins.

Monitoring plugins can collect information from a specific source; for example, the MySQL plugin (described in Section 3.4.8, “MySQL”) can collect the current performance of a MySQL database. A configured monitoring plugin will act as a source of monitoring information.

Reporting plugins store gathered information or send it to some monitoring system. For example, the filelog plugin (described in Section 3.5.1, “filelog”) will store information as a single line within a log file, each line starting with the appropriate date/time stamp information. Another example is the Ganglia plugin (see Section 3.5.3, “Ganglia”), which sends network packets containing the information so that an existing Ganglia monitoring system can display the information. A configured reporting plugin will act as a sink of information.

A *target* is a configured instance of a plugin, one that is monitoring something specific or sending information to a specific information system. MonAMI can be configured so it has many MySQL targets, each monitoring target monitoring a different MySQL database server. Another example is when the filelog plugin is used to log data to different files. Although there is only ever one filelog plugin, there are many filelog targets, one per file.

MonAMI-core provides the infrastructure that allows gathered information (provided by monitoring plugins) to be sent to reporting plugins (which send the information off to where it is needed). MonAMI-core also handles internal bookkeeping and the functionality common between plugins, such as reading configuration files and caching results.

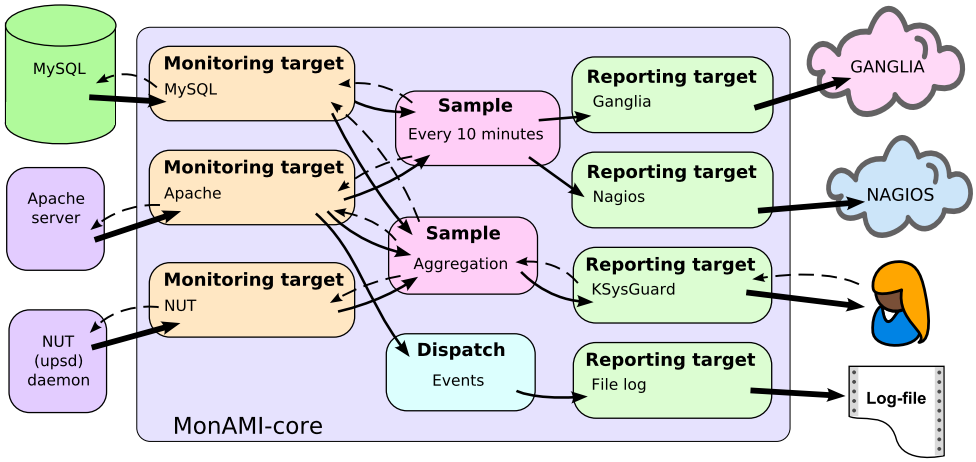


Figure 1.1. Illustration of MonAMI architecture

Several useful plugins (both monitoring and reporting) are included with the default distribution. However, MonAMI aims to be extensible. Writing a new monitoring plugin allows data to be sent to any of the existing reporting plugins; writing a new reporting plugin allows any of the MonAMI data to be sent to a new storage or monitoring system. Instructions on how to write new plugins are given in the developers guide (the file `README.developers`).

1.2. The three monitoring flows

A monitoring agent (such as MonAMI) is charged with the job of marshalling information from one or more systems (usually local to the agent) to some other system (often remote). Whether we are monitoring a database for performance problems, keeping a watchful eye on missing web pages or plotting a graph to see how many users are logged in over time, all monitoring activity can be understood as consisting of three abstract components: the *monitoring target*, the *monitoring agent* and the *information system*. In this context, the monitoring agent is MonAMI. The monitoring target might be a database, webserver or the operating system's current-user information. The information system might be a log file, web page or some distributed monitoring system, such as Ganglia (Section 3.5.3, “Ganglia”) or Nagios (Section 3.5.9, “Nagios”).

Unlike mechanical monitoring systems (see, for example, the Watt governor), computers work in discrete units of time. In a multitasking operating system any monitoring activity must be triggered by something outside the monitoring system. From the three components, we can describe three monitoring flows based on which component triggered the monitoring activity. If the information system triggered the monitoring activity, the monitoring is *on-demand*; monitoring that is triggered within the agent (i.e. triggered internally within MonAMI) is *internally-triggered*; if the service triggered the monitoring, due to some service-related activity, the monitoring is *event-based*.

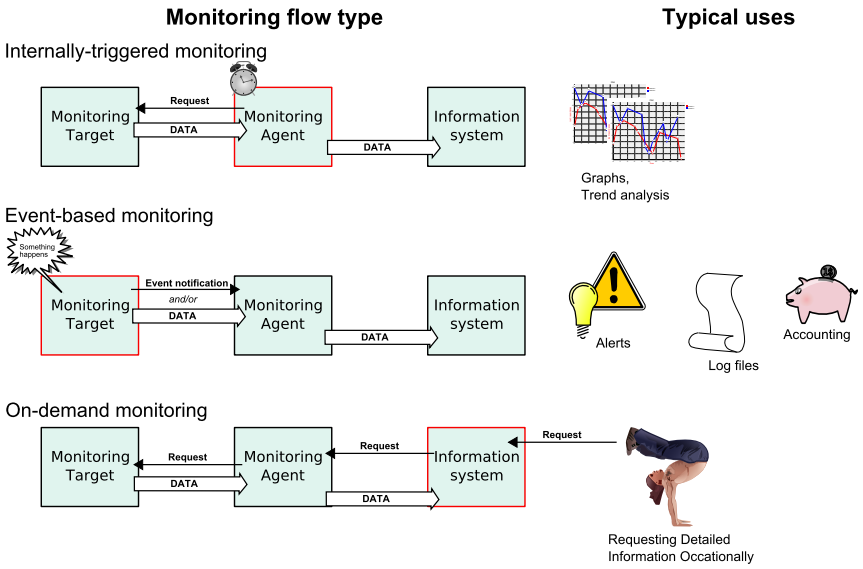


Figure 1.2. Illustration of the three data flows

Internally-triggered monitoring is perhaps the most common. An example of internally-triggered monitoring is periodically asking for (and recording somewhere) the current status of some service. We might ask an Apache web-server the current activity of its threads; we might ask a MySQL database how many times its query-cache has been useful. These questions can be asked at any time. Typically the values are queried at regular intervals and the results are plotted on a graph.

With *on-demand monitoring*, some external agent asks for data. An example of on-demand monitoring would be a web-page that returned the current status of a database: the information could be gathered only when queried by a user. The external agent can request information at any time, although in practice, requests are often periodic. A major benefit of on-demand monitoring flows is that it allows the monitoring requirements to vary dynamically as greater or lesser volume of information is requested. A potential problem with on-demand monitoring is with requests overloading the monitoring system. MonAMI provides some protection against this by allowing the enforcement of a caching policy (see Section 3.3.2, “The cache attribute”).

The third monitoring flow is *event-based monitoring*. Events are triggered by the monitoring target (e.g., the Apache server). The target (such as an Apache server) sends information voluntarily at an unpredictable time, usually due to something happening externally. Event monitoring flow is most often used to record that “something” has happened; for example that a web download has completed.

A plugin that supports event-based monitoring flow makes the events available in different *channels*. One can subscribe to one or more channels. Information from that channel is then sent to one or more reporting targets. For example, the Apache web-server monitoring plugin (see Section 3.4.2, “Apache”) can produce an event for each attempted `HTTP` transfer (whether successful or not) as the `access` channel, so subscribing to the *apache* target's `access` channel would provide information on all transfers. A subscription can be more more specific: the channel `access.4xx` provides information on only those transfers resulting in an error status-code, and subscribing to `access.4xx.404` will report on only missing page (status-code 404) events.

Explicit examples of each of the three event flows are given in Section 3.8, “Example configurations”. Although the examples rely on an understanding of the `monami.conf` format (which Chapter 3, *Configuring MonAMI* documents in detail), the examples (along with the accompanying notes) should be fairly obvious.

1.3. Datatrees

When monitoring something (a service, for example) it is rare that the current status is described by a single metric. Although you might only want a tiny subset of the available information, the current

status is usually described by a vast slew of data. We want a convenient concept that allows the data to be grouped together, allowing easy selection of the interesting subsets.

A *datatree* is a collection of related information. As the name suggests, the metrics are held in a tree structure, analogous to a filesystem. A datatree has branches (like “directories” or “folders”) each of which contains measurements (like files) and further branches. In general, branches are generic concepts and the data underneath the branches are measurements of the generic concept.

A typical datatree is represented below. Here, the `Threads` branch contains data related to the generic concept of threads, each of which might be undertaking one of several different activites. The data underneath the `Threads` branch (`waiting`, `starting`, etc.) are the number of threads in the respective state (“waiting for a connection”, “starting up”, etc..)

```
Apache
 |
 +--Workers
 |   |
 |   +--busy: 1
 |   |
 |   +--idle: 49
 |
 +--Threads
     |
     +--waiting: 49
     |
     +--starting: 0
     |
     +--reading: 0
     |
     +--replying: 1
     |
     +--keep-alive: 0
     |
     +--dns: 0
     |
     +--closing: 0
     |
     +--logging: 0
     |
     +--graceful exit: 0
     |
     +--idle: 0
     |
     +--unused: 0
```

Each item of data is usually referred to by its full path separated by periods (`.`), excluding the root node. For example, the number of Apache threads currently replying with requested information is `Threads.replying`. In the above example, `Threads.replying` has a value of `1`.

Each metric has multiple elements of metadata. They all have a name (e.g., `Threads.replying`), a value (`1` for `Threads.replying` in above example), a type (integer, floating-point number, string, etc...), a string describing in what units the measurement was taken (with numerical data and where appropriate) and some additional binary metadata such as whether the information is static, a counter or reflects current status.

Datatrees can be combined to form larger datatrees; or subtrees can be selected, limiting the information delivered. Details of how to do this are given in Section 3.6.1, “The read attribute”.

Chapter 2. Running MonAMI

In this section, the various modes of running MonAMI are discussed. In most production environments, MonAMI runs as a single detached process (a daemon), launched from the system start-up scripts (the *init* scripts), as described in Section 2.3, “Running in production environment”. Other modes of running *monamid*, such as testing a new configuration, are also discussed.

2.1. Options for *monamid*

The MonAMI application (*monamid*) accepts only a limited number of options as most of the behaviour is controlled by the configuration file (`/home/paul/monami-test-install/etc/monami.conf`). The format of this configuration file is described in a later section of this guide (Chapter 3, *Configuring MonAMI*).

The following options are available for the *monamid* application.

`monamid` [-f] [-h] [-v] [-V] [--pid-file *`file`*]

`-f` or `--no-daemon`	run in the foreground, i.e. do not detach from current terminal. Unless explicitly configured in `monami.conf`, logging output will be sent to `stdout` or `stderr`.
`-h` or `--help`	display a brief synopsis of available options.
`-v` or `--verbose`	show more of the logging information. MonAMI aims to be a quiet application. By default it will only report problems that are from extern resources or that are due to configuration that is inconsistent. With the `-v` option specified extra information is reported that, whilst not necessarily reporting an error, is indicative of potentially abnormal activity. This is often useful when MonAMI is not behaving as expected. This option can be repeated to include extra debugging information; information useful when tracking down programming problems within MonAMI.
`-V` or `--version`	display the version of MonAMI and exit.
`--pid-file` *`file`*	store the PID of *monamid* in *`file`*, creating *`file`* if it does not already exist.

2.2. Testing a configuration

Without the `-f` option, the MonAMI application (*monamid*) will assume it is running in a production environment and will detach itself from the terminal. The *init* scripts for starting MonAMI also make this assumption, and run *monamid* without the `-f` option.

When first using MonAMI, or when investigating a new configuration, it is often easier to understand any problems if the application does not detach from the terminal and continues to display output to the terminal. When experimenting, it is recommended to run MonAMI with the `-f` (foreground) and `-v` (verbose) command-line options. As with other command-line options these can be combined, so to test-run MonAMI, one can use the following: `/usr/bin/monamid -fv`.

2.3. Running in production environment

In normal operation, MonAMI will detach itself and run independently as a background task. Typically, one would want to run MonAMI automatically when a computer starts up. The de facto method of

achieving this is with *init* scripts. MonAMI includes a suitable script, which is stored in the `/home/paul/monami-test-install/etc/init.d` directory.

When installing MonAMI (either with the RPM package or manually with "make install") a suitable "init script" will be installed in the `/home/paul/monami-test-install/etc/init.d` directory. Once this is done, a further two steps are needed: to register the new init script with the system and "switch on" MonAMI. On RedHat-like machines, this is achieved with the following two commands:

```
chkconfig monami on
```

To manually start or stop MonAMI, one can use the init scripts, with either the `start` or `stop` option. You can either execute the script directly:

```
/etc/init.d/monami start
```

or using the "**service**" command.

```
service monami start
```

The complete list of arguments the init script accepts is:

`start` Unconditionally attempt to start *monamid*. If *monamid* is already running, this attempt will fail.

`stop` Unconditionally stops *monamid*. If the application is not already running, then this will (obviously) fail.

`reload` Signals MonAMI to reload its configuration. This will only happen if *monamid* is running: if the application is not running, this will fail. The reload is achieved *without* stopping and starting *monamid*.

`restart` Unconditionally stop and start MonAMI. If *monamid* was not running, an error is reported and the application is started.

`condrestart` If MonAMI is running, then stop *monamid* and restart it. If the application is not running, then no action is taken.

2.4. Running from within the CVS tree

Finally, as an aid to development work, one can run MonAMI from within the CVS tree.

With the configuration, if MonAMI fails to find the configuration file in the configured location (`/home/paul/monami-test-install/etc/monami.conf`), it will look for `monami.conf` within the current working directory.

For plugins, MonAMI will first look in the configured plugin directory (`/home/paul/monami-test-install/lib/monami`). If this directory does not exist, or contains no plugins, then the `plugin` directory within the current directory is examined. The `src/plugin` directory is where plugins are placed as they are built.

MonAMI will run within CVS provided that the "current working directory" is `src` and the CVS-configured MonAMI does not share the same prefix as an installed MonAMI instance. It is recommended not to run an installed MonAMI on a development machine and to use the `-f` command-line option when running *monamid* from the CVS directory tree.

Chapter 3. Configuring MonAMI

MonAMI looks for the configuration file `monami.conf`. It will first look for this file in the `/home/paul/monami-test-install/etc` directory. If `monami.conf` is not found there, the program will check the current directory. If the configuration file still cannot be found, MonAMI will exit with error code 1.

The configuration file can describe four things:

- configuration for MonAMI, independent of specific monitoring,
- which services need monitoring (the monitoring targets) and how to get that information,
- where information should be sent (the reporting targets),
- how data should flow from the monitoring targets to the reporting target.

As will be discussed later, it is possible to split parts of MonAMI configuration into different files. This allows a set of monitoring definitions to be stated independently of other monitoring activity, which may prove useful when MonAMI is satisfying multiple groups requiring monitoring of services.

3.1. Structure of a configuration file.

Comments can be included by starting a line with the hash (#) symbol. White space (consisting of space or tab characters) before the hash symbol is allowed in comment lines.

Each configuration file is split into multiple stanzas (or sections). Each stanza has a section title line followed by zero or more attribute lines.

A section title is a line containing a word in square brackets ("`[mysql]`" for example). The case used for the section title does not matter: "`[MySQL]`", "`[mysql]`" and "`[mySQL]`" can be used interchangeably.

All lines following a section title line until the next section title line (or the end of the file) must be either a blank line, a comment line or an attribute line. Attribute lines are keyword-value pairs separated by an equals symbol ("`=`"), for example:

```
name = myMonitor
```

White space at the start of the line, either side of the equals symbol and at the end of the line is ignored. Other white space, if significant, is preserved.

If a line ends with a back-slash symbol ("\") then that line and the one following it are combined into a single line. This can be repeated, allowing a single very long line to be broken into several shorter (and more manageable) lines; each of the shorter lines, except the last one, must end with a back-slash symbol.

Example configuration files are include in Section 3.8, “Example configurations”.

The following sections describe the different sections that may appear in a configuration file, along with the valid assignment lines that further refine MonAMI behaviour.

3.2. The `[monami]` stanza.

One one stanza entitled "`monami`" is allowed: subsequent `monami` stanzas will be silently ignored. The MonAMI section describes how MonAMI-core should run.

3.2.1. Logging Messages from MonAMI

MonAMI provides messages containing information about events that occur during runtime. The destination of these messages is controlled by a set of configuration parameters that all begin with "`log`".

Each message has a severity; the four severity levels are:

critical	no further execution is possible, MonAMI will stop immediately.
error	something went wrong. It is possible to continue running but with (potentially) reduced functionality. Errors might be rectified by altering MonAMI configuration.
info	a message that, whilst not indicating that there was an error, is part of a limited commentary that might be useful in deciphering apparently bizarre behaviour.
debug	a message that is useful in determining why some internal inconsistency has arisen. The information provided is tediously verbose and only likely of use when finding problems within the MonAMI program and plugins.

The destination of messages (and whether certain messages are ignored) can be configured on the command line, or within the `[monami]` section of the configuration file.

Normally, a user is only interested in "critical" and "error" messages. If MonAMI is not working correctly, then examining the messages with "info" severity might provide a clue. Supplying the `-v` command-line option tells MonAMI to return info messages.

If MonAMI is running as a normal process (using the `-f` option), then critical and error messages are sent to standard error (`stderr`) and other message severity levels are ignored. If MonAMI is running verbosely (using the `-v` option) then info messages are sent to standard output (`stdout`), if running more verbosely (with `-vv`) then the debug messages are also sent to `stdout`.

If MonAMI is running as a daemon (i.e. without the `-f` command-line option) then, by default, critical and error messages are sent to syslog (using the "daemon" facility), info is ignored (unless running with the verbose option: `-v`) and debug is ignored (unless running more verbosely: `-vv`). Any messages generated before MonAMI has detached itself are either sent to `stdout`, `stderr` or ignored.

Other destinations are defined as follows:

An absolute file location (i.e. beginning with "`/`")	This is treated as a file destination. The message is appended to the file, creating the file if necessary.
syslog	indicates the message should be sent to syslog daemon facility.
ignore	indicates the message should be ignored.
stderr	sends the message to standard-error output.
stdout	sends the message to standard output.

Some examples:

```
[monami]
  # ignore all but critical errors
  log          = ignore
  log_critical = syslog
```

```
[monami]
  # store critical and error messages in separate files
  log          = ignore
  log_critical = /var/log/monami/critical.log
```

```
  log_error    = /var/log/monami/error.log
```

3.2.2. Dropping `root` privileges

MonAMI needs no special privileges to run. In common with other applications, it is possible that some bug in MonAMI be exploitable and allow a local (or worse, remote) user to compromise the local system. To reduce the impact of this, it is common for an application to “drop” their elevated privileges (if running with any) soon after they start.

There are two options within the configuration file to control this: user and group. The user option tells MonAMI to switch its user-ID to that of the supplied user and to switch group-ID to the default group for that user. The group option overrides the user's default group, with MonAMI adopting the group-ID specified.

In the following example, the `[monami]` stanza tells MonAMI to drop `root` privileges and assume the identity of user `monami` and group `monitors`.

```
[monami]
  user  = monami
  group = monitors
```

3.2.3. Auxiliary configuration file directories

Often, a server may have multiple services running concurrently. Maintaining a monolithic configuration file containing the different monitoring requirements may be difficult as services are added or removed.

To get around this problem, MonAMI will load all the configuration files that end `.conf` within a named directory (`/home/paul/monami-test-install/etc/monami.d`). If a new service has been installed, additional monitoring can be indicated by copying a suitable file into the `/home/paul/monami-test-install/etc/monami.d` directory. When the service has been removed the corresponding file in `/home/paul/monami-test-install/etc/monami.d` can be deleted.

Auxiliary configuration directories are specified with the `config_dir` option. This option can occur multiple times in a `[monami]` stanza. For example:

```
[monami]
  config_dir = /etc/monami.d
```

3.2.4. Attributes

Summary of possible attributes within the `[monami]` stanza:

`log`, string, optional	change the default destination for all message severity levels. This overwrites the built-in default behaviour, but is overwritten by any severity-specific options.
`log_critical`, string, optional	change the destination for critical messages. This overwrites any other destination option for critical messages.
`log_error`, string, optional	change the destination for error messages. This overwrites any other destination option for error messages.
`log_info`, string, optional	change the destination for info messages. This overwrites any other destination option for info messages.

`log_debug`, string, optional	change the destination for debugging messages. This overwrites any other destination option for debug messages.
`user`, string, optional	The user-name or user-id of the account MonAMI should use. By default, MonAMI will also adopt the corresponding group ID.
`group`, string, optional	The group-name or group-id of the group MonAMI should use. This will override the group ID corresponding to the user option.
`config_dir`, string, optional	A directory that contains additional configuration files. Each file ending `.conf` is read and processed, but any `monami` stanzas are ignored. Its recommended that this directory be only readable by the user account that MonAMI will run under.

3.3. Features common across plugins

There are some features that are common to each of the plugins. Rather than repeat the same information under each plugin's description, the information is presented here.

3.3.1. The name attribute

Each distinct service has a separate stanza within the configuration file, using the plugin name. Considering the *apache* monitoring plugin (which monitors an Apache `HTTP` webserver) as an example, one can monitor multiple Apache webservers with several separate `[apache]` stanzas: one for each monitoring target. To illustrate this, the following configuration describes how to monitor an intranet web server and an external web server.

```
[apache]
 name = external-webserver
 host = www.example.org

[apache]
 name = internal-webserver
 host = www.intranet.example.org
```

Each target must have a unique name. It is possible to specify the name a target will adopt with the `name` attribute (as in the above example). If no `name` attribute is given, the target take the name of the plugin by default. However, since all names must be unique, only one target can adopt the default name: all subsequent targets (from this plugin) must have their name specified explicitly using the `name` attribute.

Although specifying a `name` is optional, it is often useful to set a name explicitly (preferably to something meaningful). Simple configuration files will work fine without explicitly specifying target names, whilst configuration files describing more complex monitoring requirements will likely fail unless they have explicitly named targets.

If there is an ambiguity (due to different targets having the same name) MonAMI will attempt to monitor as much as possible (to “degrade gracefully”) but some loss of functionality is inevitable.

3.3.2. The cache attribute

Acquiring the current status of a service will inevitably take resources (such as CPU time and perhaps disk space) away from the service. For some services this effort is minimal, for others it is more substantial. Whatever the burden, there will be some monitoring frequency above which monitoring will impact strongly on service provision.

To prevent overloading a service, the results from querying a service are stored within MonAMI for a period. If there is a subsequent request for the current state of the target within that period then the stored results are used rather than directly querying the underlying service: the results are cached.

The cache retention period is adjustable for each target and can be set with the `cache` attribute. The `cache` attribute value is the time for which data is retained, or (equivalently) the guaranteed minimum time between successive queries to the underlying service.

The value is specified using the standard time-interval notation: one or more numbers each followed by a single letter modifier. The modifiers are `s`, `m`, `h` and `d` for seconds, minutes, hours and days respectively. If a qualifier is omitted, seconds is assumed. The total cache retention period is the sum of the time. For example `5m 10s` is five minutes and ten seconds and is equivalent to specifying `310`.

In the following example configuration file, the MySQL queries are cached for a minute whilst the Apache queries are cached for 2 seconds:

```
[apache]
 host = www.example.org
 cache = 2

[mysql]
 host = mysql-serv.example.org
 user = monami
 password = monami-secret
 cache = 1m
```

If no cache retention period is specified, a default value of one second is used. Since MonAMI operates at the granularity of one second, there is apparently no effect on individual monitoring activity, yet we ensure that targets are queried no more often than once a second.

For many services, a one second cache retention time is too short and the cached data should be retained for longer; yet if the cache retention time is set for too long, transitory behaviour will not be detectable. A balance must be struck, which (most likely) will need some experimentation.

3.3.3. The map attribute

The `map` attribute describes how additional information is to be added to an incoming datatree. When a datatree is sent to a target that has one or more `map` attributes it is first processed to alter the incoming datatree. To the target, the additional metrics provided by `map` attributes are indistinguishable from those of the original datatree.

The `map` attribute values take the following form:

```
map = target metric : source
```

The value of *`target metric`* determines the name of the new metric and where it is to be stored. Any periods (`.`) within *`target metric`* will be interpreted as a path within the datatree. If the elements of the path do not exist, they are created as necessary, unless there is already a metric with the same name as a path element.

The *`source`* describes where the information for this new metric is to come from. The two possibilities are string-literals and specials.

String-literals are a string metric that never change: they have a fixed value independent of any monitoring activity. A string-literal starts and ends with a double-quote symbol (`"`) and can have any content in between. Since MonAMI aims at providing monitoring information, the use of string literals is discouraged.

A *special* is something that provides some very basic information about the computer: sufficiently basic that providing the information via a plugin is unnecessary. A special is represented by its name contained in angle-brackets (`<` and `>`). The following specials are available:

`FQDN` the Fully Qualified Domain Name of the machine. This is the full DNS name of the computer; for example, `www.example.org`.

The follow simple, stand-alone MonAMI configuration illustrates `map` attributes.

```
[null]

[sample]
 read = null
 write = snapshot
 interval = 1

[snapshot]
 filename = /tmp/monami-snapshot
 map = tests.string-literal.first : "this is a string-literal"
 map = tests.special.fqdn : <FQDN>
 map = tests.string-literal.second : "this is also a \
                  string-literal"
```

The *null* plugin (see Section 3.4.9, “null”) produces datatrees with no data. Without the `map` attributes, the snapshot would produce an empty file at `/tmp/monami-snapshot`. The `map` attributes add additional metrics to otherwise-empty datatrees. This is reflected in the contents of `/tmp/monami-snapshot`.

3.3.4. Estimating future data-gathering delays

The process of gathering monitoring data from a service is not instantaneous. In general, there will be a delay between MonAMI requesting the data and it receiving that data. The length of this delay may depend on several factors, but is likely to depend strongly on the software being monitored and how busy is the server.

Whenever MonAMI receives data, it makes a note of how long this data-gathering took. MonAMI uses this information to maintain an estimate for the time needed for the next request for data from this monitoring target.

This estimate is available to all plugins, but currently only two use it: ganglia and sample. The *ganglia* plugin passes this information on to Ganglia as the `dmax` value (see Section 3.5.3, “dmax”) and the *sample* plugin uses this information to achieve adaptive monitoring (see Section 3.6.4, “Adaptive monitoring”).

When maintaining an estimate of the next data-gathering delay, MonAMI takes a somewhat pessimistic view. It assumes that data-gathering will take as long as the longest observed delay, unless there is strong evidence that the situation has improved. If gathering data took longer than the current estimate, the estimate is increased correspondingly. If a service becomes sufficiently loaded (e.g., due to increase user activity) so that the observed data-gathering delay increases, MonAMI will adjust its estimate to match.

If data-gathering takes less time than the current estimated value, the current estimate is *not* automatically decreased. Instead, MonAMI waits to see if the lower value is reliable, and that the delay has stabilised at the lower value. Once it is reasonably sure of this, MonAMI will reduce its estimate for future data-gathering delays.

To determine when the delay has stabilised, MonAMI keeps a history of previous data-gathering delay values. The history is stored as several discrete *intervals*, each with the same minimum duration. By default, there are ten history intervals each with a one minute minimum duration, giving MonAMI a view of recent history going back at least ten minutes.

Each interval has only one associated value: the maximum observed delay during that interval. At all times, there is an interval called the *current interval*. Only the current interval is updated, the other intervals provide historical context. As data is gathered the maximum observed delay for the current interval is updated.

When the current interval has existed for more than the minimum duration (one minute, by default), all the intervals moved: the current history interval becomes the first non-current history interval, what was the first non-current interval becomes the second, and so on. The information in the last history interval is dropped and a new current interval is created. Future data-gathering delays are recorded in this new current interval until the minimum interval has elapsed and the intervals moved again.

MonAMI takes two statistical measures of the history intervals: the maximum value and the average absolute deviation (or average deviation for short). The maximum value is the proposed new value for the estimated delay, if it is lower, and the absolute deviation is used to determine if the change is significant.

Broadly speaking, the average deviation describes how settled the data stored in the historic intervals are over the recent history: a low number implies data-taking delays are more predictable, a high number indicates they are less predicable. MonAMI only reduces the estimate for future delays if the difference (between current estimate value and the maximum over all historic intervals) is significant. It is significant if the ratio between the proposed drop in delay and the average deviation exceeds a certain threshold value.

In summary, to reduce the estimate of future delays, the observed delay must be persistently low over the recorded history (minimum of 10 minutes, by default). If the delay is temporarily low, is decreasing over time or fluctuates, the estimate is not reduced.

There are two attributes that affect how MonAMI determines its estimate. The default values should be sufficient under most circumstances. Moreover, there are separate attributes for adjusting the behaviour both of adaptive monitoring (see Section 3.6.5, “Sample attributes”), and the `dmax` value of Ganglia (see Section 3.5.3, “Attributes”). Adjusting these attributes may be more appropriate.

Attributes

`md_intervals` integer, optional

the number of historic intervals to consider. The default is 10 and the value must be between 2 and 30. Increased number of intervals results in more stringent requirement needed before the estimate is reduced. It also increases the accuracy of the average deviation measurements.

Having a small number of intervals (less then 5, say) is not recommended as the statistics becomes less reliable.

A large number of intervals gives more reliable statistical results, but the system will take longer to react (to reduce the delay estimate) to changing situations. Perhaps this is most noticeable if there is a single data-gathering delay that is unusually long. If this happens, MonAMI will take at least the md_intervals times the minimum delay to reduce the delay estimate.

`md_duration` integer, optional

The minimum duration, in seconds, for an interval. The default is 60 seconds and the value must be between 1 second and 1200 seconds (20 minutes).

Each interval must have at least one data point: an observation of the data-gathering delay. To ensure this, the value of md_duration is implemented as a minimum duration and, in practise, the intervals can be longer. For example, with the default configuration (md_duration of one minute, md_intervals of 10) if only a single monitoring flow is established that gathers data from a monitoring target every 90 seconds, each interval will have a 90 second duration and complete history will be 15 minute.

3.4. Monitoring Plugins

This section describes the different services that can be monitored (for example, a MySQL database or an Apache webserver). It gives brief introductions to which services the plugins can monitor and how they can be configured. Wherever possible, sensible defaults are available so often little or no configuration is required for common deployment scenarios.

The available monitoring plugins depend on which plugins have been built and installed. If you have received this document as part of a binary distribution, it is possible that the distribution does not include all the plugins described here. It might also contain other plugins provided independently from the main MonAMI release.

3.4.1. AMGA

AMGA (ARDA Metadata Catalogue Project) is a metadata server provided by the ARDA/EGEE project as part of their gLite software releases. It provides additional metadata functionality by wrapping an underlying database storage. More information about *AMGA* is available from the *AMGA project page* [http://project-arda-dev.web.cern.ch/project-arda-dev/metadata/].

The *amga* monitoring plugin will monitor the server's database connection usage and the number of incoming connections. For both, the current value and configured maximum permitted are monitored.

Attributes

`host` string, optional	the host on which the *AMGA* server is running. The default value is `localhost`.
`port` integer, optional	the port on which the *AMGA* server listens. The default value is 8822.

3.4.2. Apache

The Apache HTTP (or web) server is perhaps the most well known project from the Apache Software Foundation. Since April 1996, the Netcraft web survey has shown it to be the most popular on the Internet. More details can be found at the *Apache home page* [http://httpd.apache.org/].

The *apache* plugin monitors the current status of an Apache HTTP server. It can also provide event-based monitoring, based on various log files.

The Apache server monitoring is achieved by downloading the server-status page (provided by the mod_status Apache plugin) and parsing the output. Usually, this option is available within the Apache configuration, but commented-out by default (depending on the distribution). The location of the Apache configuration is Apache-version and OS specific, but is usually found in either the `/etc/apache`, `/etc/apache2` or `/etc/httpd` directory. To enable the server-status page, uncomment the section or add lines within the apache configuration that look like:

```
<Location /server-status>
    SetHandler server-status
    Order deny,allow
    Deny from all
    Allow from .example.com
</Location>
```

Here `.example.com` is an illustration of how to limit access to this page. You should change this to either your DNS domain or explicitly to the machine on which you are to run MonAMI.

There is an ExtendedStatus option that configures Apache to include some additional information. This is controlled within the Apache configuration by lines similar to:

```
<IfModule mod_status.c>
  ExtendedStatus On
</IfModule>
```

Switching on the extended status should not greatly affect the server's load and provides some additional information. MonAMI can understand this extra information, so it is recommended to switch on this ExtendedStatus option.

Event-based monitoring

Event-based monitoring is made available by watching log files. Any time the Apache server writes to a watched log file, an event is generated. The plugin supports multiple event channels, allowing support for multi-homed servers that log events to different log files.

Event channels are specified by `log` attributes. This can be repeated to configure multiple event channels. Each `log` attribute has a corresponding value like:

name:*path*[*type*]

where:

name is an arbitrary name given to this channel. It cannot have a colon (`:`) and should not have a dot (`.`) but most names are valid.

path is the path to the file. Log rotations (where a log file is archived and a new one created) are supported.

type is either `combined`, or `error`.

The following example configures the `access` channel to read the log file `/var/log/apache2/access.log`, which is in the Apache standard “combined” format.

```
[apache]
 log = access: /var/log/apache2/access.log [combined]
```

Attributes

`host` string, optional	the hostname for webserver to monitor. The default value is `localhost`.
`port` integer, optional	the port on which the webserver listens. The default value is 80
`log` string, zero or more	specifies an event monitoring channel. Each `log` attribute has a value like: *name* : *path* [*type*]

3.4.3. dCache

dCache (see *dCache home page* [http://www.dcache.org]) is a system jointly developed by Deutsches Elektronen-Synchrotron (DESY) and Fermilab that aims to provide a mechanism for storing and retrieving huge amounts of data among a large number of heterogeneous server nodes, which can be of varying architectures (x86, ia32, ia64). It provides a single namespace view of all of the files that it manages and allows access to these files using a variety of protocols, including SRM, GridFTP, dCap and xroot. By connecting dCache to a tape storage backend, it becomes a hierarchical storage manager (HSM).

Authentication

The dCache monitoring plugin works by connecting to the underlying PostGreSQL database that dCache uses to store the current system state. To achieve this, MonAMI must have the credentials (a username and password) to log into the database and perform read queries.

If you do not already have a read-only account, you will need to create such an account. It is strongly recommended not to use an account with any write privileges as the password will be stored plain-text within the MonAMI configuration file (see Section 4.2.2, “Passwords being stored insecurely”).

To configure PostGreSQL, SQL commands need to be sent to the database server. To achieve this, you will need to use the **psql** command, connecting to the dcache database. On many systems you must log in as the database user “postgres”, which often has no password when connecting from the same machine on which database server is running. A suitable command is:

```
psql -U postgres -d dcache
```

The following SQL commands will create an account *monami* with password *monami-secret* that has read-only access to the tables that MonAMI will read.

Important

Please ensure you change the example password (*monami-secret*).

```
CREATE USER monami;
ALTER USER monami PASSWORD 'monami-secret';

GRANT SELECT ON TABLE copyfilerequests_b TO monami;
GRANT SELECT ON TABLE getfilerequests_b TO monami;
GRANT SELECT ON TABLE putfilerequests_b TO monami;
```

If you intend to monitor the database remotely, you may need to add an extra entry in PostGreSQL's remote access file: `pg_hba.conf`. With some distribution, this file is located in the directory `/var/lib/pgsql/data`.

Currently, the information gathered is limited to the rate of SRM GET, PUT and COPY requests received. This information is gathered from the copyfilerequests_b, getfilerequests_b and putfilerequests_b tables. Future versions of MonAMI may read other tables, so requiring additional `GRANT` statements.

Attributes

`host` string, optional	the host on which the PostGreSQL database is running. The default is `localhost`.
`ipaddr` string, optional	the IP address of the host on which the database is running. This is useful when the host is on multiple IP subnets and a specific one must be used. The default is to look up the IP address from the host.
`port` integer, optional	the `TCP` port to use when connecting to the database. The default is port 5432 (the standard PostGreSQL port).
`user` string, optional	the username to use when connecting to the database. The default is the username of the system account MonAMI is running under. When running as a daemon from a standard RPM-based installation, the default user will be `monami`.
`password` string, optional	the password to use when authenticating. The default is to attempt password-less login to the database.

3.4.4. Disk Pool Manager (DPM)

Disk Pool Manager (DPM) is a service that implements the SRM protocol (mainly for remote access) and rfio protocol (for site-local access). It is an easy-to-deploy solution that can support multiple disk servers but has no support for tape/mass-storage systems. More information on DPM can be found at the *DPM home page* [https://twiki.cern.ch/twiki/bin/view/LCG/DataManagementDocumentation].

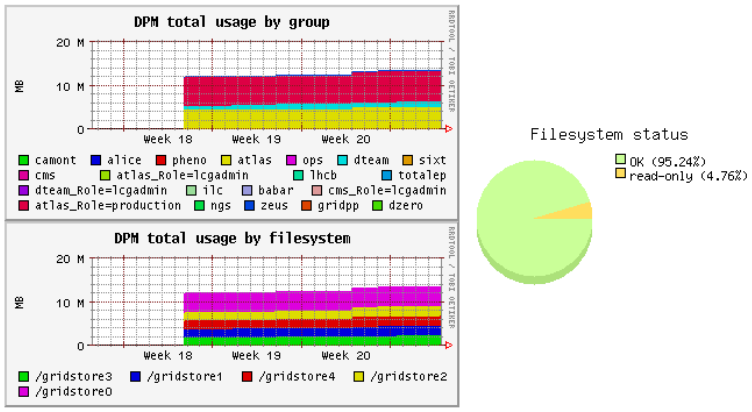


Figure 3.1. Data from DPM displayed within Ganglia.

The *dpm* plugin connects to the MySQL server DPM uses. By querying this database, information is extracted such as the status of the filesystems and the used and available space. The space statistics are available as a summary, and broken down for each group, and for each filesystem. The daemon activity on the head node can also be monitored.

Authentication

This plugin requires read-only privileges for the database DPM uses. The following set of SQL statements creates login credentials with username of *`monamiuser`* and password of *`monamipass`* suitable for local access:

```
GRANT SELECT ON cns_db.* TO 'monamiuser'@'localhost'
                IDENTIFIED BY 'monamipass';
GRANT SELECT ON dpm_db.* TO 'monamiuser'@'localhost'
                IDENTIFIED BY 'monamipass';
```

If MonAMI is to monitor the MySQL database remotely, the following SQL can be used to create login credentials

```
GRANT SELECT ON cns_db.* TO 'monamiuser'@'%'
                IDENTIFIED BY 'monamipass';
GRANT SELECT ON dpm_db.* TO 'monamiuser'@'%'
                IDENTIFIED BY 'monamipass';
```

If local and remote access to the MonAMI database is needed all four above SQL commands should be combined.

Attributes

`host` string, optional	the host on which the MySQL server is running. Default is `localhost`.
`user` string, required	the username with which to log into the server.
`password` string, required	the password with which to log into the server.

3.4.5. Filesystem

The *filesystem* plugin monitors generic (i.e., non-filesystem specific) features of a mounted filesystem. It reports both capacity and “file” statistics. The “file” statistics correspond to inode usage for filesystems that use inodes (such as ext2).

Note

With both reported resources (blocks and files), there are similar-sounding metrics: “free” and “available”. “free” refers to total resource potentially available and “available” refers to the resource available to general (non-root) users.

The difference between the two comes about because it is common to reserve some capacity for the root user. This allows core system services to continue when a partition is full: normal users cannot create files but root (and processes running as root) can.

Attributes

`location` string, required — the absolute path to any file on the filesystem.

3.4.6. GridFTP

The Globus Alliance distribute a modified version of the WU-FTP client that has been patched to allow GSI-based authentication and multiple streams. This is often referred to as “GridFTP”.

Various grid components use GridFTP as an underlying transfer mechanism. Often, these have the same log-file format for recording transfers, so parsing this log-file is a common requirement.

The *gridftp* plugin monitors GridFTP log files, providing an event for each transfer. This is under the `transfers` channel.

Attributes

`filename` string, required — the absolute path to the GridFTP log file.

3.4.7. Maui

On their website, Cluster Resources describe Maui as “an advanced batch scheduler with a large feature set well suited for high performance computing (HPC) platforms”. Within a cluster it is used to decide which job (of many that are available) should be run next. Maui provides sophisticated scheduling features such as advanced fair-share definitions and “allocation bank”. More details are available within the *Maui homepage* [http://www.clusterresources.com/pages/products/maui-cluster-scheduler.php].

Access control

The MonAMI *maui* plugin will need sufficient access rights to query the Maui server. If MonAMI is running on the same machine as the Maui server, (most likely) no additional host will be needed. If MonAMI is running on a remote machine, then access-right must be granted for that machine. Append the remote host's hostname to the space-separated `ADMINHOST` list.

The plugin will also need to use a valid username. By default it will use the name of the user it is running as (`monami`), but the plugin can use an alternative username (see the `user` attribute). To add an additional username, append the username to the space-separated `ADMIN3` list.

The following example configuration shows how to configure Maui to allow monitoring from host *`monami.example.org`* as user *`monami`*.

```
SERVERHOST              maui-server.example.org
ADMIN1                  root
ADMIN3                  monami
ADMINHOST               maui-server.example.org  monami.example.org
RMCFG[base]             TYPE=PBS
SERVERPORT              40559
SERVERMODE              NORMAL
```

Password

The Maui authenticates by the client and server keeping a shared secret: a password. Currently this password must be integer number. Unfortunately, the password is decided as part of the Maui build process. If one is not explicitly specified, a random number is selected as the password. The password is then embedded within the Maui client programs and used when they communicate with the Maui server. Currently, it is not possible to configure the Maui server to use an alternative password without rebuilding the Maui client and servers.

To communicate with the Maui server the *maui* plugin must know the password. Unfortunately, as the password is only stored within the executables, it is difficult to discover. The *maui* plugin has heuristics that allow it to scan a Maui client program and, in most cases, discover the password. This requires a Maui client program to be present on whichever computer MonAMI is running. If the Maui client is in a non-standard location, its absolute path can be specified with the `exec` attribute.

If the password is known (for example, its value was specified when compiling Maui) then it can be specified using the `password` attribute. Specifying the `password` attribute will stop MonAMI from scanning Maui client programs.

Once the password is known, it can be stored in the MonAMI configuration using the `password` attribute. This removes the need for a Maui client program. However, should the Maui binaries change (for example, upgrading an installed Maui package), it is likely that the password will also change. This would stop the MonAMI plugin from working until the new password was supplied.

The recommended deployment strategy is to install MonAMI on the Maui server and allow the *maui* plugin to scan the Maui client programs for the required password.

Time synchronisation

When communicating between the *maui* and Maui server, both parties want to know that the messages are really from the other party. The shared-secret is one part of this process, another is to check the time within the message. This is to prevent a malicious third-party from sending messages that have already been sent: a “replay attack”.

To prevent these replay attacks, the clocks on the Maui server and the server MonAMI is running must agree. If both machines are well configured, their clocks will agree with ~10 millisecond difference. Since the network may introduce a slight delay, some tolerance is needed.

The *maui* plugin requires an agreement of one second by default. This should be easy to satisfied with modern networks. If, for whatever reason, this is not possible the tolerance can be make more lax by specifying the `max_time_delta` attribute.

Note

Should there be a systematic error between the clocks on two servers, effort should be made in synchronosing those clocks. Increasing the `max_time_delta` makes MonAMI more vulnerable to replay attacks.

Attributes

`host` string, optional	the hostname of the Maui server. If not specified, `localhost` will be used.
`port` integer, optional	the `TCP` port to which the plugin with connect. If not specified, the default value is 40559.
`user` string, optional	the user name to present to the Maui server when communicating. The default value is the name of the account under which MonAMI is running.

`max_time_delta` integer, optional	the maximum allowed time difference, in seconds, between the server and client. The default value is one second.
`password` integer, optional	the shared-secret between this plugin and the Maui server. The default policy is to attempt to discover the password automatically. Specifying the password will prevent attempts at discovering it automatically.
`timeout` string, optional	the time MonAMI should wait for a reply. The string is in time-interval format (e.g., "`5m 10s`" is five minutes and ten seconds; "`310`" would be equivalent). The default behaviour is to wait indefinitely.
`exec` string, optional	the absolute path to the **mclient** (or similar) Maui client program. If the plugin was unsuccessful scanning the program given by `exec` it will also try standard locations.

3.4.8. MySQL

This plugin monitors the performance of a MySQL database. MySQL is a commonly used Free (GPLed) database. The parent company (MySQL AB) describe it as "the world's most popular open source database". For more information, please see the *MySQL home page* [http://www.mysql.com/]

The statistics monitored are taken from the status variables. They are acquired by executing the MySQL SQL `SHOW STATUS;`. The raw variables are described in the MySQL manual, section 5.2.5: *Status Variables* [http://dev.mysql.com/doc/refman/5.0/en/server-status-variables.html].

Note

The metrics names provided by MySQL are in a flat namespace. These names are *not* used by MonAMI; instead, the metrics are mapped into a tree structure, allowing more easy navigation of, and section from, the available metrics.

Privileges

To function, this plugin requires an account to access the database. Please note: this database account requires no database access privileges, only that the username and password will allow MonAMI to connect to the MySQL database. For security considerations, you should *not* employ login credentials used elsewhere (and never `root` or similar power-user). The following is a suitable SQL statement for creating a username and password of *`monami`* and *`monamipass`*.

```
CREATE USER 'monami'@'localhost' IDENTIFIED BY "monamipass";
```

Sharing login credentials is not recommended. If you decide to share credentials make sure the MonAMI configuration file is readable only by the `monami` user (see Section 3.2.2, "Dropping `root` privileges").

Note

In addition to monitoring a MySQL database, the *mysql* plugin can also store information MonAMI has gathered within MySQL. This is described in Section 3.5.8, "MySQL".

Attributes

`user` string, required	the username with which to log into the server.
`password` string, required	the password with which to log into the server
`host` string, optional	the host on which the MySQL server is running. If no host is specified, the default `localhost` is used.

3.4.9. null

The *null* plugin is perhaps the simplest to understand. As a monitoring plugin, it providing an empty datatree when requested for data. The main use for *null* as a monitoring target is to demonstrating aspects of MonAMI without the distraction of real-life effects from other monitoring plugins.

The *null* plugin will supply an empty datatree. In conjunction with a reporting plugin (e.g., the *snapshot*), this can be used to demonstrate the `map` attribute for adding static content. This attribute is described in Section 3.3.3, “The map attribute”.

Delays

Another use for a *null* target is to investigate the effect of a service taking a variable length of time to respond with monitoring data. This is emulated by specifying a delay file. If the `delayfile` attribute is set, then the corresponding file is read. It should contain a single integer number. This number dictates how long (in seconds) a *null* target should wait when requested for data. The file can be changed at any time and the change will affect the next time the *null* target is read from. This is particularly useful for demonstrating how MonAMI estimates future delays (see Section 3.3.4, “Estimating future data-gathering delays”) and undertakes adaptive monitoring (see Section 3.6.4, “Adaptive monitoring”).

The following example will demonstrate this usage:

```
[null]
 delayfile=/tmp/monami-delay

[sample]
 read = null
 write = null
 interval = 1s
```

Then, by changing the number stored in `/tmp/monami-delay`, the delay can be adjusted dynamically. To set the delay to three seconds, do:

```
$ echo 3 > /tmp/monami-delay
```

To remove the delay, simply set the delay to zero:

```
$ echo 0 > /tmp/monami-delay
```

Attributes

`delayfile` string, optional — the filename of the delay file, the contents of which is parsed as an integer number. This number is the number of seconds the *null* target will delay when replying with an empty datatree.

3.4.10. NUT

Network UPS Tools (NUT) provides a standard method through which an Uninterruptable Power Supply (UPS) can be monitored. Part of this framework allows for signalling, so that machines can undergo a controlled shutdown in the event of a power failure. Further details of NUT are available from the *NUT home page* [http://www.networkupstools.org/].

The MonAMI *nut* plugin connects to the NUT data aggregator daemon (`upsd`) and queries the status of all known, attached UPS devices. The `ups.conf` file must be configured for available hardware and the startup scripts must be configured to start the required UPS-specific monitoring daemons.

By default, `localhost` will be allowed access to the `upsd` daemon but access for external hosts must be added explicitly in the `upsd.conf` file. See the NUT documentation on how best to achieve this.

Attributes

`host` string, optional	the host on which the NUT `upsd` daemon is running. The default value is `localhost`.
`port` integer, optional	the port on which the NUT `upsd` daemon listens. The default value is 3493.

3.4.11. Process

The *process* plugin monitors Unix processes. It can count the number of processes that match search criteria and can give detailed information on a specific process.

The information *process* gives should not be confused with any process, memory or thread statistics other monitoring plugins provide. Some services report their current thread, process or memory usage, which may duplicate some of the information this plugin reports (see, for example, Section 3.4.2, “Apache” and Section 3.4.8, “MySQL”). However, *process* reports information from the kernel and should work with any application.

The *process* plugin has two main types of monitors: counting processes and detailed information about a single process. A single *process* target can be configured to do any number of either type of monitoring and the results are combined in the resulting datatree.

Counting processes

To count the number of processes, a `count` attribute must be specified. In its simplest form, the `count` attribute value is simply the name of the process to count. The following example reports the number of `imapd` processes that are currently in existance.

```
[process]
 count = imapd
```

The format of the `count` attribute allows for more sophisticated queries of form: *`reported name`* `:` *`proc name`* `[`*`cond1, cond2, ...`*`]`

All of the parts are optional: the part upto and including the colon (*`reported name`* `:`), the part after the colon but before the square brackets (*`proc name`*) and the part in square brackets (`[`*`cond1, cond2, ...`*`]`) can be omitted, but at least one of the first two parts must be specified. The examples below may help clarify this!

To be included in the count, a process' name must match the *`proc name`* (if specified). The statistics will be reported as *`reported name`*. If no reporting name is specified, then *`proc name`* will be used.

The part in square brackets, if present, specifies some additional constraints. The comma-separated list of key, value pairs define additional predicates; for example, `[uid=root, state=R]` means only processes that are running as `root` and are in state running will be counted. The valid conditions are:

`uid =` *`uid`*	to be considered, the process must be running with a user ID of *`uid`*. The value may be the numerical uid or the username.
`gid =` *`gid`*	the process must be running with a group ID of *`gid`*. The value may be the numerical gid or the group name.
`state =` *`statelist`*	the process must have one of the states listed in *`statelist`*. Each acceptable process state is represented by a single capital letter and they are concatinated together. Valid process states letters are:

`R` process is running (or ready to be run),

`S` sleeping, awaiting some external event,

`D` in uninterruptable sleep (typically waiting for disk IO to complete),

`T` stopped (due to being traced),

`W` paging,

`X` dead,

`Z` defunct (or "zombie" state).

The following example illustrates `count` used to count the number of processes. The different attributes show how the different criteria are represented.

```
[process]
 count = imapd ❶
 count = io_imapd    : imapd [state=D] ❷
 count = all_java    : java ❸
 count = tomcat_java : java  [uid=tomcat5] ❹
 count = zombies     :       [state=Z] ❺
 count = tcat_z      : java  [uid=tomcat4, state=Z] ❻
 count = run_as_root :       [uid=0] ❼
```

❶ Count the number of `imapd` processes.

❷ Count the number of `imapd` processes that are in “uninterruptable sleep” state: stopped whilst waiting for block I/O (e.g. disk I/O).

❸ Count the number of **java** processes that are running. Store the number as a metric called `all_java`.

❹ Count the number of **java** processes that are running as user `tomcat5`. Store the number as a metric called `tomcat_java`.

❺ Count the total number of zombie processes. Store the number as a metric called `zombies`.

❻ Count the number of zombie **tomcat** processes. Store the number as a metric called `tcat_z`.

❼ Count the number of processes running as `root`. Store the number as a metric called `run_as_root`.

Detailed information

The `watch` attribute specifies a process to monitor in detail. The process to watch is identified using the same format as with `count` statements; however, the expectation is that only a single process will match the criteria.

If there is more than one process matching the search criteria then one is chosen and that process is reported. In principle, the selected process might change from one time to the next, which would lead to confusing results. In practise, the process with the lowest pid is chosen, so is both likely to be the oldest process and unlikely to change over time. However, this behaviour is not guaranteed.

Much information is gathered with a `watch` attribute. This information is documented in the `stat` and `status` sections of the proc(5) manual page. Some of the more useful entries are copied below:

pid — the process ID the the process being monitored.

ppid — the process ID of the parent process.

state — a single character, with the same semantics as the different process states listed above.

minflt — number of minor memory page faults (no disk swap activity was required).

majflt — number of major memory page faults (those requiring disk swap activity).

utime — number of jiffies[1] of time spent with this process scheduled in user-mode.

stime — number of jiffies[1] of time spent with this process scheduled in kernel-mode.

threads — number of threads in use by this process.

Note

An accurate value is provided by the 2.6-series kernels. Under 2.4-series kernel with LinuxThreads, heuristics are used to derive a value. This value should be correct under most circumstances, but it may be confused if multiple instances of the same multi-threaded process is running concurrently.

vsize — virtual memory size: total memory used by the process.

rss — Resident Set Size: number of pages of physical memory a process is using (less 3 for administrative bookkeeping).

Attributes

`count` string, optional — either the name of the process(es) to count, or the conditions processes must satisfy to be included in the count. This attribute may be repeated for multiple process counting.

`count` attributes have the form: *`reported name`* : *`proc name`* [*`cond1, cond2, ...`*]

`watch` string, optional — either the name of the process to obtain detailed information, or the conditions a process must satisfy to be watched. This attribute may be repeated to obtain detailed information about multiple processes.

`watch` attributes have the form: *`reported name`* : *`proc name`* [*`cond1, cond2, ...`*]

3.4.12. Stocks

The *stocks* plugin uses one of the web-services provided by *XMethods* [http://www.xmethods.com/] to obtain a near real-time quote (delayed by 20 minutes) for one or more stocks on the United States Stock market. Further details of this service are available from the *Stocks service summary page* [http://www.xmethods.com/ve2/ViewListing.po?key=uuid:889A05A5-5C03-AD9B-D456-0E54A527EDEE].

In addition to providing financial information, *stocks* is a pedagogical example that demonstrates the use of SOAP within MonAMI.

Caution

The authors of MonAMI expressly disclaim the accuracy, adequacy, or completeness of any data and shall not be liable for any errors, omissions or other defects in, delays or interruptions in such data, or for any actions taken in reliance thereon.

Please do not send too many requests. A request every couple of minutes should be sufficient.

Attributes

`symbols` string, required — a comma- (or space-) separated list of ticker symbols to monitor. For example, GOOG is the symbol for Google Inc. and RHT is the symbol for RedHat Inc.

3.4.13. TCP

The *tcp* monitoring plugin provides information about the number of `TCP` sockets in a particular state. Here, a socket is either a `TCP` connection to some machine or the ability to receive a particular connection (i.e., that the local machine is "listening" for incoming connections).

A *tcp* monitoring target takes an arbitrary number of `count` attributes. The value of a `count` attributes describes how to report the number of matching sockets and the criteria for including a socket within that count. These attributes take values like: *`name`* `[`*`cond1, cond2, ...`*`]`, where *`name`* is the name used to report the number of matching `TCP` sockets. The conditions (*`cond1`*, *`cond2`*, etc.) are comma-separated keyword-value pairs (e.g., `state=ESTABLISHED`). A socket must match all conditions to be included in the count.

The condition keywords may be any of the following:

`local_addr` The local `IP` address to which the socket is bound. This may be useful on multi-homed machines for sockets bound to a single interface.

`remote_addr` The remote `IP` address of the socket, if connected.

`local_port` The port on the local machine. This can be the numerical value or a common name for the port, as defined in `/etc/service`.

`remote_port` The port on the remote machine, if connected. This can be the numerical value or a common name for the port.

`port` A socket's local or remote port must match. This can be the numerical value or a common name for the port.

`state` The current state of the socket. Each local socket will be in one of a number of states and changes state during the lifetime of a connection. All the states listed below are valid and may occur naturally on a working system; however, under normal circumstances some states are transitory: one would not expect a socket to stay in a transitory state for long. A large and/or increasing number of sockets in one of these transitory states might indicate a networking problem somewhere.

The valid states are listed below. For each state, a brief description is given and the possible subsequent states are listed.

LISTEN — A program has indicated it will receive connections from remote sites.

Next: SYN_RECV, SYN_SENT

SYN_SENT — Either a program on the local machine is the client and is attempting to connect to remote machine, or the local machine sends data from a LISTENing socket (less likely).

Next: ESTABLISHED, SYN_RECV or CLOSED

SYN_RECV — Either a LISTENing socket has received an incoming request to establish a connection, or both the local and remote machines are attempting to connect at the same time (less likely)

Next: ESTABLISHED, FIN_WAIT_1 or CLOSED

ESTABLISHED — Data can be sent to/from local and remote site.

Next: FIN_WAIT_1 or CLOSE_WAIT

FIN_WAIT_1	Start of an *active close*. The application on local machine has closed the connection. Indication of this has been sent to the remote machine. Next: FIN_WAIT_2, CLOSING or TIME_WAIT
FIN_WAIT_2	Remote machine has acknowledged that local application has closed the connection. Next: TIME_WAIT
CLOSING	Both local and remote applications have closed their connections “simultaneously”, but remote machine has not yet acknowledged that the local application has closed the local connection. Next: TIME_WAIT
TIME_WAIT	Local connection is closed and we know the remote site knows this. We know the remote site's connection is closed, but we don't know if the remote site know that we know this. (It is possible that the last ACK packet was lost and, after a timeout, the remote site will retransmit the final FIN packet.) To prevent the potential packet loss (of the local machine's final ACK) from accidentally closing a fresh connection, the socket will stay in this state for twice MSL timeout (depending on implementation, a minute or so). Next: CLOSED
CLOSE_WAIT	The start of a *passive close*. The application on the remote machine has closed its end of the connection. The local application has not yet closed this end of the connection. Next: LASK_ACK
LASK_ACK	Local application has closed its end of the connection. This has been sent to the remote machine but the remote machine has not yet acknowledged this. Next: CLOSED
CLOSED	The socket is not in use. Next: LISTEN or SYN_SENT
CONNECTING	A pseudo state. The transitory states when starting a connection match, specifically either SYN_SENT or SYN_RECV.
DISCONNECTING	A pseudo state. The transitory states when shutting down a connection match, specifically any of FIN_WAIT_1, FIN_WAIT_2, CLOSING, TIME_WAIT, CLOSE_WAIT or LASK_ACK match.

The states ESTABLISHED and LISTEN are long-lived states. It is natural to find sockets that are in these states for extended periods.

For applications that use “half-closed” connections, the FIN_WAIT_2 and TIME_WAIT states are less transitory. As the name suggests, half-closed connections allows data to flow in one direction

only. It is achieved by the application that no longer wishes to send data closing their connection (see FIN_WAIT_1 above), whilst the application wishing to continue sending data does nothing (and so suffers a passive close). Once the half-closed connection is established, the active close socket (which can no longer send data) will be in FIN_WAIT_2, whilst the passive close socket (which can still send data) will be in CLOSE_WAIT.

There are two pseudo states for the normal transitory states: CONNECTING and DISCONNECTING. They are intended to help catch networking or software problems.

The following example checks whether an application is listening on three well-known port numbers. This might be used as a check whether services are running as expected.

```
[tcp]
  name = listening
  count = ssh          [local_port=ssh, state=LISTEN]
  count = ftp          [port=ftp, state=LISTEN]
  count = mysql        [local_port=mysql, state=LISTEN]
```

The following example records the number of connections to a webserver. The `established` metric records the connections where data may flow in either direction. The other two metrics record connections in the two pseudo states. Normal traffic should not stay long in these pseudo states; connections that persist in these states may be symptomatic of some problem.

```
[tcp]
  name = incoming_web_con
  count = established   [local_port=80, state=ESTABLISHED]
  count = connecting    [local_port=80, state=CONNECTING]
  count = disconnecting [local_port=80, state=DISCONNECTING]
```

Attributes

`count` string, optional

the name to report for this metric followed by square brackets containing a comma-separated list of conditions a socket must satisfy to be included in the count. This option may be repeated for multiple `TCP` connection counts.

The conditions are keyword-value pairs, separated by `=`, with the following valid keywords: `local_addr`, `remote_addr`, `local_port`, `remote_port`, `port`, `state`.

The `state` keyword can have one of the following `TCP` states: LISTEN, SYN_RECV, SYN_SENT, ESTABLISHED, CLOSED, FIN_WAIT_1, FIN_WAIT_2, CLOSE_WAIT, CLOSING, TIME_WAIT, LASK_ACK; or one of the following two pseudo states: CONNECTING, DISCONNECTING.

3.4.14. Tomcat

Apache *Tomcat* is one of the projects from the Apache Software Foundation. It is a Java-based application server (or servlet container) based on Java Servlet and JavaServer Pages technologies. Servlets and `JSP` are defined under Sun's Java Community Process. More information about *Tomcat* can be found at the *Apache Tomcat home page* [http://tomcat.apache.org/].

Also under development of the Java Community Process is the Java Monitoring eXtensions (`JMX`). `JMX` provides a standard method of instrumenting servlets and `JSP`s, allowing remote monitoring and control of Java applications and servlets.

The *tomcat* plugin uses the `JMX`-proxy servlet to monitor (potentially) arbitrary aspects of a Servlet and `JSP`s. This provides structured plain-text output from *Tomcat*'s `JMX` MBean interface. Applications that require monitoring should connect to that interface for MonAMI to discover their data.

To monitor a custom servlet, the required instrumentation within the servlet/JSP must be written. Currently, there is an additional light-weight conversion needed within MonAMI, adding some extra information about the monitored data. Sample code exists that monitors aspects of the *Tomcat* server itself.

Any *tomcat* monitoring target will need a username and password that matches a valid account within the *Tomcat* server that has the `manager` role. This is normally configured in the file `$CATALINA_HOME/conf/tomcat-users.xml`. Including the following line within this file creates a new user `monami`, with password *`monami-secret`* and `manager` role, to *Tomcat*.

```
<user username="monami" password="monami-secret" roles="manager"/>
```

This line should be added within the `<tomcat-users>` context.

Warning

Be aware that Basic authentication sends the username and password unencrypted over the network. These values are at risk if packets can be captured. If you are not sure, you should run MonAMI on the same server as *Tomcat*.

In addition to connecting to *Tomcat*, you also need to specify which classes of information you wish to monitor. The following are available: ThreadPool and Connector. To monitor some aspect, you must specify the object type along with the identifier for that object within the monitoring definition. For example:

```
[tomcat]
 name = local-tomcat
 ThreadPool = http-8080
 Connector = 8080
```

ThreadPool monitors a named thread pool (e.g., `http-8080`), monitoring the following quantities:

minSpareThreads	the minimum number of threads the server will maintain.
currentThreadsBusy	the number of threads that are either actively processing a request or waiting for input.
currentThreadCount	total number of threads within this ThreadPool.
maxSpareThreads	if the number of spare threads exceeds this value, the excess are deleted.
maxThreads	an absolute maximum number of threads.
threadPriority	the priority at which the threads run.

The Connector monitors a ConnectorMBean and is identified by which port it listens on. It monitors the following quantities:

allowTrace	Can we trace the output?
clientAuth	Did the client authenticate?
compression	Is the connection compressed?
disableUploadTimeout	Is the upload timeout disabled?
emptySessionPath	Is there no session?
enableLookups	Are lookups enabled?
tcpNoDelay	Is the `TCP SO_NODELAY` flag set?
useBodyEncodingForURI	does the `URI` contain body information?

secure	are the connections secure?
acceptCount	number of pending connections this Connector will accept before rejecting incoming connections.
bufferSize	size of the input buffer.
connectionLinger	how long the connection lingers, waiting for other connections.
connectionTimeout	the timeout for this connection.
connectionUploadTimeout	the timeout for uploads.
maxHttpHeaderSize	the maximum size for `HTTP` header.
maxKeepAliveRequests	how many keep-alives before the connection is considered dead.
maxPostSize	maximum size of the information `POST`ed.
maxSpareThreads	c.f. ThreadPool
maxThreads	c.f. ThreadPool
minSpareThreads	c.f. ThreadPool
threadPriority	c.f. ThreadPool
port	the port on which this connector listens.
poxyPort	the proxy port associated with this connector.
redirectPort	the port to which this connector will redirect.
protocol	which protocol the connector uses (e.g., `HTTP/1.1`)
sslProtocol	the `SSL` protocol the connector uses (e.g., `TLS`)
scheme	which scheme the `URI` will use (e.g., `http`, `https`)

Attributes

The *tomcat* monitoring target accepts the following options:

`host` string, optional	the hostname of the machine to monitor. The default value is `localhost`.
`port` integer, optional	the `TCP` port on which *Tomcat* listens. The default value is 8080
`jmxpath` string, optional	the path to the `JMX`-proxy servlet within the application server `URI` namespace. The default path is `/manager/jmx-proxy/`
`username` string, optional	the username to use when completing Basic authentication.
`password` string, optional	the password to use when completing Basic authentication.

3.4.15. Torque

The *Torque homepage* [http://www.clusterresources.com/pages/products/torque-resource-manager.php] describes *Torque* as “an open source resource manager providing control over

batch jobs and distributed compute nodes." *Torque* was based on the original PBS/Open-PBS project, but incorporates many new features. It is now a widely used batch control system.

Torque is heavily influenced by the IEEE 1003.1 specification, in particular *Section 3 (Batch Environment Services)* [http://www.opengroup.org/onlinepubs/009695399/utilities/xcu_chap03.html] of the Shell & Utilities volume. However, it also includes some additional features, such as support for jobs in the `suspended` state.

Access control

Torque uses username-and-host based authorisation. Users may query the status of their own jobs, but may require special privileges to view the status of all jobs. Because of this, the MonAMI *torque* plugin may require authorisation to gather monitoring information.

To grant *torque* sufficient privileges to conduct its monitoring, the *Torque* server must have either `query_other_jobs` set to `True` (allowing all users to see other user's job information) or have the MonAMI user (typically `monami`) and host added as one of the `operators`. Setting either option is sufficient and both can be achieved using the *qmgr* command.

The command `qmgr -ac "list server query_other_jobs"` will display the current value of `query_other_jobs`. To allow all users to see other user's job status, run the command: `qmgr -ac "set server query_other_jobs = True"`.

The command `qmgr -ac "list server operators"` will display the current list of operators. To add user `monami` running on host `mon-hq.example.org` as another operator, use the command `qmgr -ac "set server operators += monami@mon-hq.example.org"`.

Queue groups

It is often useful to group together multiple execution queues when generating statistics. The group may represent queues with a similar purpose, or the group represents a set of queues that support a wider community. MonAMI supports this by allowing the definition of queue-groups and will report statistics for each of these groups.

A queue-group is defined by including a `group` attribute in the *torque* target. Multiple groups can be defined by repeating the `group` attributes, one attribute for each group.

A `group` attribute's value defines the group like: *`name : queue1, queue2, ...`*, where *`name`* is the name of the queue-group and *`queue1`* is the first queue to be included, *`queue2`* the second, and so on. The group statistics are generated based on all jobs that have any of the listed execution queues.

As an example, the following *torque* stanza defines four groups: `HEP`, `LHC`, `Grid OPS`, and `Local`.

```
[torque]
  group = HEP      : alice, atlas, babar, dzero, lhcb, cms, zeus
  group = LHC      : atlas, lhcb, cms, alice
  group = Grid OPS : dteam, ops
  group = Local    : biomed, carmont, glbio, glee
```

Attributes

`host` string, optional

the hostname of the *Torque* server. If not specified, a default value will be used, which is specified externally to MonAMI. This default may be `localhost` or may be configured to whatever is the most appropriate *Torque* server.

`group` string, optional

defines a new queue-group that statistics are collected against. The `group` value is like: *`name : queue1, queue2, ...`*. Each

Torque queue may appear in any number (zero or more) of queue-group definitions.

3.4.16. Varnish

The *Varnish home page* [http://varnish.projects.linpro.no/] describes *Varnish* as a "state-of-the-art, high-performance `HTTP` accelerator. *Varnish* is targeted primarily at the `FreeBSD` 6/7 and `Linux` 2.6 platforms, and takes full advantage of the virtual memory system and advanced I/O features offered by these operating systems."

Varnish offers a management interface. The MonAMI *varnish* plugin connects to this this interface and request the server's current set of statistics.

Attributes

`host` string, optional — the host on which *Varnish* is running. Default is `localhost`.

`port` integer, optional — the `TCP` port on which the *Varnish* management interface is listening. The default value is 6082.

3.5. Reporting plugins

Information needs to go somewhere for it to be useful. MonAMI's job is to take data from one or more monitoring targets and send it somewhere or (more often) to multiple destinations. Reporting plugins deal with "sending data somewhere" and the reporting targets are configured reporting plugins to which data can be sent.

As with monitoring targets, all reporting targets need a unique name. By default a reporting target will adopt the plugin's name. As with monitoring targets, it is recommended to set a unique, meaningful name for each reporting target in complex configurations.

3.5.1. filelog

The *filelog* plugin stores information within a file. The file format is deliberately similar to standard log files, as found in the `/var/log` filesystem hierarchy. New data is appended to the end of the file. Fields are separated by tab characters and each line is prefixed by the date and time when the data was taken.

If the file does not exist, it is created. When the file is created, a header line is added before any data. This line starts with the hash (#) symbol, indicating that the line does not contain data. The header consists of a tab-separated list of headings for the data. This list is correct for the first row of data. If the data is aggregated from multiple monitoring targets, then the order of those targets is not guaranteed.

Attributes

`filename` string, required — the full path of the file into which data will be stored.

3.5.2. FluidSynth

The FluidSynth project provides code (a library and a program) that accepts MIDI (a standard music interface) information and provides a MIDI-like API, providing high-quality audio output. The *fluidsynth* software is based on the SoundFont file format. Each SoundFont file contains sufficient information to reproduce the sound from one or more musical instruments. These SoundFont files might include instruments of an orchestra, special effects (e.g., explosions) or sounds taken from nature (e.g., thunder or a dog barking). More information about fluidsynth can be found on the *fluidsynth home page* [http://www.nongnu.org/fluid/].

The *fluidsynth* plugin renders information as sound. The presence of sound might indicate a problem, or the pitch of the note might indicate how hard some application is working.

To achieve sound, the plugin either connects to some fluidsynth program or uses the fluidsynth library API, depending on how it is configured. If the configuration specifies a `host` attribute, then the plugin will attempt to connect to the fluidsynth program running on that host. If no `host` attribute is specified, then the fluidsynth plugin will use the fluidsynth library to configure and start a new fluidsynth instance.

When running the embedded fluidsyth code, the plugin requires at least one `soundfont` attribute. These attributes describe where the SoundFont files are located. Each `soundfont` attribute is a comma-separated list, specifying the short name for that file (used for the `note` attributes) and the location of the SoundFont file: *`short name`*`,`*`path to SoundFont file`*

An example `soundfont` attribute is:

```
soundfont = hi, /usr/share/SoundFonts/Hammered_Instruments.sf2
```

Using remote fluidsynth

When the plugin is connecting to a SoundFont program running independent of MonAMI, all `soundfont` attributes are ignored. Instead, all SoundFonts must be loaded independently of MonAMI. The easiest way of achieving this it to specify the SoundFont files as command-line options. For example:

```
fluidsynth -nis /usr/share/SoundFonts/Hammered_Instruments.sf2
```

Making sounds

The `note` attributes describe how sound is generated. The attribute has seven comma-separated values, like this:

```
note = sf, bank, pgm, note-range, duration, source, data-range
```

These attributes have the following meanings.

`sf` (string or integer)

When no `host` attribute has been specified (i.e. using the fluidsynth library API), this is the short name for the SoundFont to use as described in `soundfont` attributes.

When connecting to a fluidsynth program, this is the (integer) number of the SoundFont to use. The first loaded SoundFont file is numbered 1.

`bank` (integer)

This is the MIDI bank within the SoundFont to use. A MIDI bank is often a family of similar instruments. The available options will depend the loaded SoundFont files, but most SoundFonts will define instruments in bank 0.

`pgm` (integer)

This is the MIDI program to use for this note. A program is a unique number for an instrument within a specified MIDI bank. General-MIDI defines certain programs to be named instruments, some SoundFonts follow General-MIDI for bank 0.

`note-range` (integer or integer range)

This details which notes (pitches) might be played. For example, *`note-range`* might be `53` if only a single note pitch is needed, or `20-59` to specify a range of notes. The range of notes must specify the lower note first.

duration (integer)
: This is the duration of the note, in tenths of a second (or deciseconds). A *duration* of `20` results in a two-second note and `5` results in notes that last for half a second (500 ms).

source (string)
: This is the path in a datatree for the information. The metric can be an integer number, a floating-point number or a string.

  If the metric is an integer or floating-point number then the metric value is used to decide whether the note should be played and if so, at which pitch.

  If the metric has type string, then the metric's value is checked to see if a note should be played. For string metrics, the *note-range* should be a single note.

data-range (string or numerical range)
: This is the valid range of data that will produce a note.

  If the metric has a string value, then the *data-range* should be a string. If the metric matches the string value, a note will be played.

  If the metric has a numerical result, the *data-range* should be a range (e.g., `0-10` or `10-0`).

  Metric values in that range will cause a note to be played. The pitch of the note increases as the metric value tends towards the second number. With the *data-range* `0-10` a metric value of 10 produces the highest pitch note; with the *data-range* `10-0` a metric value of 0 produces the highest pitch note.

  Either number (or both) can be sufficed by a caret symbol (`^`) indicating that numbers outside the range should be truncated to this value. A *data-range* of `0-10^` indicates that metric values greater than 10 should produce notes as if 10 was observed, but that any measurements less than 0 should be ignored, and so not played.

Here are some example `note` attributes with brief explanations.

```
note = hi, 0, 35, 60, 10, apache.severity, error
```

Play note 60 of program (instrument) 35, bank 0 of the `hi` SoundFont file for a duration of 10 deciseconds (or 1 s) if the `apache.severity` metric has a value of `error`. If the datatree provided contains no `apache.severity` then no note is sounded.

```
note = 1, 0, 3, 38-80, 2, apache.transferred, 0 - 4096^
```

Play program (instrument) 3, bank 0 of the first loaded SoundFont for 2 decisecond (0.2 s) with the pitch dependant on the size transferred. The note range is 38 to 80, with corresponding values of 0 kB to 4 kB: higher metric values result in higher pitch notes. Values of transfer size greater than 4 kB are played, but truncated, resulting in a note at pitch 80 being played.

```
note = hi, 0, 75, 60-80, 4, apache.Threads.waiting, 10^ - 0
```

Play program 75, bank 0 of the `hi` SoundFont for 4 deciseconds (0.4 s) based on the number of threads in `waiting` state. Note 80 is played when 10 (or more) threads are in waiting state; note 60 if there is no thread in this state; if there are 1 to 9 threads, the results are somewhere in between.

There are a number of other options that may improve the performance of the embedded fluidsynth engine. They are described briefly in the summary of this plugin's options below,

Attributes

`soundfont` string, ignored/required	a comma-separated list of a nickname and an absolute path to the SoundFont file. The attribute may be repeated to load multiple SoundFont files. When using the fluidsynth library, the `soundfont` attributes are required; when connecting to a external fluidsynth program these attributes are ignored.
`note` string, required	Each `note` attribute indicates sensitivity to some metric's value. Multiple `note` attributes may be specified, one for each metric. The `note` attribute values are a comma-separated list. The seven items are: the SoundFont short-name or instance count, bank (integer), program (integer), note-range, duration (integer), source (datatree path), data-range. The SoundFont short-name is defined by the `soundfont` attribute.
`bufsize` integer, optional	the desired size for the audio buffers, in Bytes. This is ignored when connecting to an external fluidsynth program.
`bufcount` integer, optional	how many audio buffers there should be. Each buffer has size given by the `bufsize` attribute. This attribute is ignored when connecting to an external fluidsynth program.
`driver` string, optional	the output driver. The default is “ALSA”. Other common possibilities are “OSS” and “JACK”. This attribute is ignored when connecting to an external fluidsynth program.
`alsadevice` string, optional	the output ALSA device. Within MonAMI, the default is “`hw:0`” due to performance issues with the ALSA default device “`default`”. This attribute is ignored when connecting to an external fluidsynth program.
`samplerate` integer, optional	the sample rate to use (in Hz). The default will be something appropriate for the sound hardware. This attribute is ignored when connecting to an external fluidsynth program.
`reverb` integer, optional	whether the reverb effect should be enabled. “0” indicates disabled, “1” enabled. Default is enabled. Disabling reverb may reduce CPU impact of running fluidsynth. This attribute is ignored when connecting to an external fluidsynth program.
`chorus` integer, optional	whether the chorus effect should be enabled. “0” indicates disabled, “1” enabled. Default is enabled. Disabling chorus may reduce CPU impact of running fluidsynth. This attribute is ignored when connecting to an external fluidsynth program.
`maxnotes` integer, optional	the maximum number of concurrent notes. If more than this is attempted, some notes may be silenced prematurely. This attribute is ignored when connecting to an external fluidsynth program.

3.5.3. Ganglia

Ganglia is a monitoring system that allows multiple statistics to be gathered from many machines and those statistics plotted over different time-periods. By default, it uses multicast to communicate within

a cluster, and allows results from multiple clusters to collated as a single “grid”. More information about Ganglia can be found within the *Ganglia project site* [http://ganglia.sourceforge.net/] and a review of the Ganglia architecture is presented in the paper *the ganglia distributed monitoring system: design, implementation, and experience.* [http://ganglia.info/papers/science.pdf].

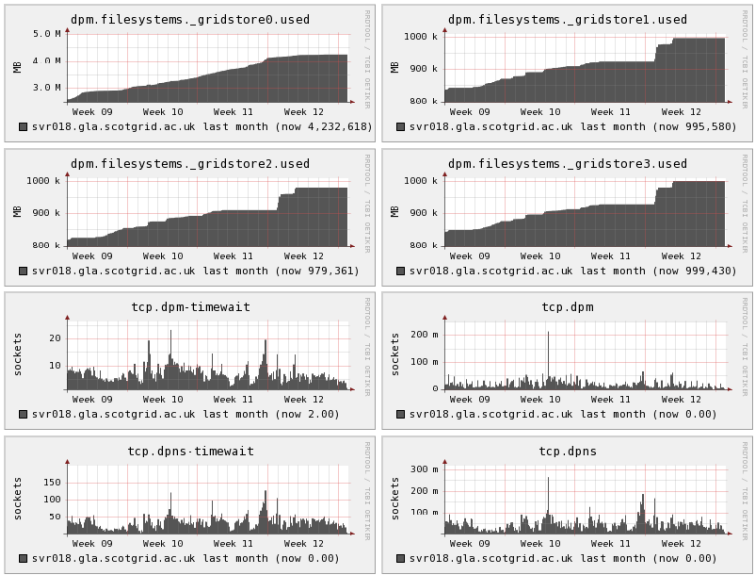


Figure 3.2. Ganglia graphs showing data from *dpm* and *tcp* targets

Ganglia comes with a standard monitoring daemon (*gmond*) that monitors a standard set of statistics about a particular machine. It also includes a command-line utility (*gmetric*) that allows for the recording of additional metrics.

The MonAMI *ganglia* plugin emulates the *gmetric* program and can send additional metrics within a Ganglia-monitoring cluster. These appear automatically on the ganglia web-pages, either graphically (for graphable metrics) or as measured values.

Note

Please note that there is a bug in Ganglia prior to v3.0.0 that can result in data corruption when adding custom data. MonAMI will trigger this bug, so it is strongly recommended to upgrade Ganglia to the latest version.

Network configuration

The Ganglia *gmond* daemon loads its configuration from a file `gmond.conf`. For some distributions, this file is located at `/etc/gmond.conf`, for other it is found at `/etc/ganglia/gmond.conf`. The *ganglia* plugin can parse the `gmond.conf` file to discover how it should deliver packets. It searches both standard locations for a suitable file. If found, it will use the setting contained within the file, so no further configuration is necessary. If a suitable *gmond* configuration file exists at some other location, the plugin can still use it. The `config` attribute can be set to the config file's location.

Although it is recommended to run *MonAMI* in conjunction with *gmond*, this is not a requirement. In the absence of a suitable *gmond* configuration file, the multicast channel and port to which metric updates should be sent can be set with the `multicast_ip_address` and `multicast_port` attributes respectively. By default, the kernel will choose to which network interface the multicast traffic is sent. If this decision is wrong, the interface can be specified explicitly using the the `multicast_if` attribute.

Serialisation

MonAMI uses a tree-structure for storing metrics internally. In contrast, Ganglia uses a flat namespace for its metrics. To send data to Ganglia, the metric names must be “flattened” to a simple name.

To obtain the Ganglia metric name, the elements of the metric's path are concatenated, separated by a period (`.`) character. For example, the metric `torque.Scheduler.period` is the period, in seconds, between successive calls Torque makes to the scheduler (see Section 3.4.15, “Torque”).

Since the period character has a special meaning to the *ganglia* plugin, it is recommended to avoid using this character elsewhere, for example, within torque group names. Although there are no problems with sending the resulting metrics, it introduces a source of potential confusion.

Avoiding metric loss

Ganglia uses multicast `UDP` traffic for metric updates, which is unreliable protocol. Unlike the reliable `TCP` protocol, `UDP` has no mechanisms for detecting if a packet was not delivered or for retransmitting missing data. However, over local area networks it is very unlikely that the network packets will be lost.

If a large number of metrics are updated at the same time, there is a corresponding deluge of packets. If these packets are delivered too quickly, the recipient *gmond* process may not be able to keep up. Those packets not accepted immediately by *gmond* will be held in a backlog queue, allowing *gmond* to process them when free. However, if the size of this backlog queue exceeds a threshold, further packets will not be queued and *gmond* will not see the corresponding metric update messages. The threshold varies, but observed values are in the range 220–450 packets.

To reduce the risk of metric updates being lost, the MonAMI *ganglia* plugin will pause after delivering a multiple of 50 metric updates. By default the pause is 100 ms, but the `delivery_pause` attribute can be used to fine-tune this behaviour. Under normal circumstances, the default `delivery_pause` value results in a negligible risk of metric updates being lost. However, if the machine receiving the metrics is under heavy load you may notice metrics being dropped.

To further reduce the risk of metric update loss, monitoring activity can be split into separate activities that are triggered at different times. In the following example, two monitoring targets (`torque` and `maui`) are sampled every minute with all metrics sent to Ganglia.

```
[torque]
 cache = 60

[maui]
 cache = 60

[sample]
 interval = 1m
 read = torque, maui
 write = ganglia

[ganglia]
```

If the resulting datatree has too many metrics there will be a risk that some of metric updates will be lost. To reduce the risk of this, the same monitoring can be achieved by splitting the activity into two parts. The following example shows the same monitoring but split into two independent activities. Both monitoring targets are monitored every minute but now at different times.

```
[torque]
 cache = 60

[maui]
 cache = 60

[sample]
 interval = 1m
 read = torque
 write = ganglia

[sample]
```

```
 interval = 1m
 read = maui
 write = ganglia

[ganglia]
```

An alternative approach is to increase the UDP packet buffer size. Increasing the buffer size will allow more packets to be queued before metric updates are lost. The following set of commands, run as root, will restart *gmond* with a larger network receive buffer (N.B. the hash character represents the prompt and should not be typed).

```
# orig_default=$(cat /proc/sys/core/rmem_default)
# cat /proc/sys/net/core/rmem_max > /proc/sys/net/core/rmem_default
# service gmond restart
# echo $orig_default > /proc/sys/net/core/rmem_default
```

Another method of setting `rmem_default` is to use the `/etc/sysctl.conf` file. A sample entry is given below:

```
#  Enlarge the value of rmem_default for gmond.  Be sure to check the
#  number against /proc/sys/net/core/rmem_max.
net.core.rmem_default=131071
```

dmax

Each metric has a corresponding dmax value. This value specifies when Ganglia should consider the metric as no longer being monitored. If a metric has not been updated for dmax seconds Ganglia will remove it. Graphs showing historical data are not purged; however, when delivery of the metric resumes there may be a corresponding gap in the historical data.

As a special case, if a metric's dmax value is set to zero, Ganglia will never purge that metric. Should MonAMI stop updating that metric, its last value will be graphed indefinitely, or until either MonAMI resumes sending fresh data or the metric is flushed manually (by restarting the *gmond* daemon).

The optimal value of dmax is a compromise. If the value is set too low then an unusually long delay whilst gathering data might trigger the metric being purged. If set too high, then Ganglia will take longer than necessary to notice if MonAMI has stopped sending data.

When updating a metric, a fresh value of dmax is also sent. This allows MonAMI to adjust the dmax value over time. For event-driven data the default value is zero, effectively disabling the automatic removal of data. With internally triggered data (e.g., data collected using a sample target), the value of dmax is calculated taking into account when next data is scheduled to be taken and an estimate of how long that data acquisition will take. Section 3.3.4, “Estimating future data-gathering delays” describes how MonAMI estimates the delay in future data-gathering.

Calculating a good value of dmax also requires knowledge of the *gmetad* polling interval: the time between successive *gmetad* requests to *gmond*. This is specified in the *gmetad* configuration file (usually either `/etc/gmetad.conf` or `/etc/ganglia/gmetad.conf`). Each `data_source` line has an optional polling interval value, expressed in seconds. If the polling interval is not specified, *gmetad* will use 15 seconds as a default value.

In general, the MonAMI *ganglia* plugin cannot discovering the *gmetad* polling interval automatically. Instead, the dmax calculation assumes the polling interval is less than two minutes. This is very likely to be sufficient; but, should the *gmetad* polling interval be longer than two minutes, the correct value can be specified (in seconds) using the `gmetad_poll` attribute.

Separate from estimating a good value of dmax, an explicit dmax value can be specified using the `dmax` attribute. For example, setting the dmax attribute to zero will set all metric update's dmax values to zero unconditionally, so preventing Ganglia from purging any metric.

It is recommended that the default value of dmax is used. If long *gmetad* polling intervals are in use, include a suitable `gmetad_poll` attribute.

Multiframe extension

Ganglia's standard web interface provides a good overview of the metrics supplied by *gmond*, but for other metrics are displayed either as a single graph or not at all.

To provide a rich view of the data MonAMI collects, an extension to the standard web interface has been developed. This supports creating tables, custom graphs and pie-charts, support for iGoogle and embedding elements within other pages.

The multiframe extension is currently maintained within the *external CVS module* [http://sourceforge.net/cvs/?group_id=151885]. Instructions on how to install and extend these graphs are available within that module.

Attributes

`multicast_ip_address` string, optional	the multicast IP address to which the data should be sent. If no IP address is specified, the Ganglia default value of `239.2.11.71` is used.
`multicast_port` integer, optional	the port to which the multicast traffic is sent. If no port is specified, the Ganglia default port of 8649 is used.
`host` string, optional	The `IP` address of the host to which `UDP` unicast traffic should be sent. Specifying this option will switch off sending metrics as multicast. The default is not to send unicast traffic, but to send multicast traffic.
`port` integer, optional	the `UDP` port to which unicast traffic should be sent. If `host` is specified and `port` is not then the default port is used. If `host` is not specified, then `port` has no effect.
`multicast_if` string, optional	the network device through which multicast traffic should be sent (e.g., “eth1”). If no device is specified, a default is chosen by the kernel. This default is usually sufficient.
`config` string, optional	the non-standard location of a *gmond* configuration file.
`gmetad_poll` integer, optional	the polling interval of *gmetad* in seconds. This is the time between successive *gmetad* requests to *gmond*. By default, the plugin assumes this is two minutes or less. If this is wrong, the correct value is specified using this attribute.
`dmax` integer, optional	the absolute period, in seconds, after the last metric update after which Ganglia should remove that metric. A value of zero disables this automatic purging of metrics. By default, the plugin will estimate a suitable value based on observer behaviour when gathering data.
`delivery_pause` integer, optional	the delay in milliseconds between an exact multiple of 50 and the following metric update. Every 50 UDP packets, the plugin will pause briefly. The default (100 ms) is an empirical value that should be sufficient. The minimum and maximum values are 5 ms and 2000 ms.

3.5.4. GridView

GridView is a Worldwide LHC Computational Grid (WLCG) project that provides centralised monitoring for the WLCG collaboration. It collates information from multiple sources, including R-GMA

and MonaLisa, and displays this aggregated information. In addition to accumulated data, it can accept data sent directly via a web-service, which is how this reporting plugin works. The protocol allows arbitrary data to be uploaded. Live data and further details are available from the *GridView homepage* [http://gridview.cern.ch/GRIDVIEW/].

The *gridview* plugin implements the GridView protocol, allowing data to be uploaded directly into GridView. Each datatree sent is directed towards a particular table, as described by the `table` attribute. The table name is arbitrary and describes the nature of the data and contains one or more fields. The number of fields and each of the fields type is table-specific.

The `send` attribute is a comma-separated list of which data, and in what order data is to be sent. Each element of the list is the name of some element within a datatree; elements are separated by a dot (`.`). Should any of the elements be missing, the corresponding field sent to GridView will be blank.

Attributes

`table` string, required	the name of the table within GridView to populate with data.
`send` string, required	the comma-separated list of data to send: one entry for each field. The data should be a path within a datatree using a dot (`.`) as the separator between names within the datatree.
`endpoint` string, optional	the SOAP endpoint to which MonAMI should contact. The default endpoint is `http://grvw003.cern.ch:8080/wsarch/services/WebArchiverAdv`

3.5.5. grmonitor

Gr_Monitor is an application that uses the OpenGL API to display monitoring information as a series of animated 3D bar charts. More information is available from the *Gr_Monitor home page* [http://users.actrix.co.nz/michael/grpage.html].

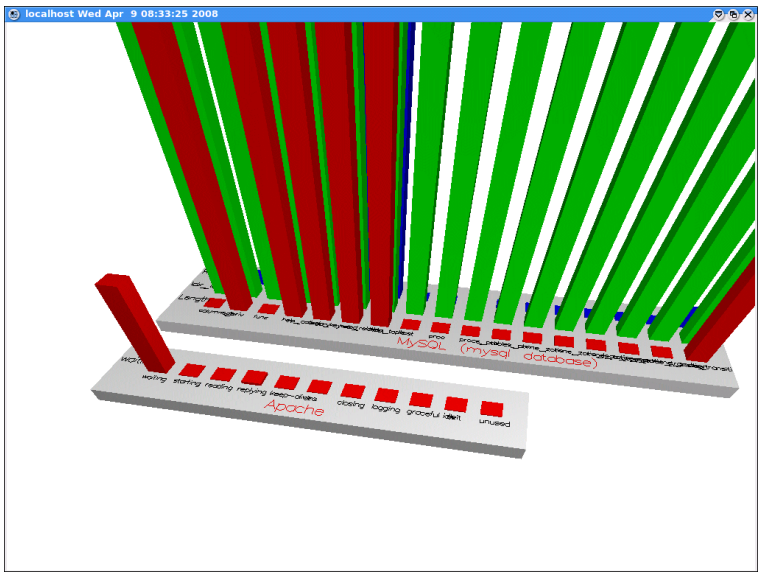


Figure 3.3. gr_Monitor showing data from *apache* and *mysql* targets

Gr_Monitor uses a flexible XML format for data exchange. This allows it to receive data from a variety of helper applications, each of which collect information from different sources. Further custom applications allow easy expansion of gr_Monitor's capabilities.

Recent versions of gr_Monitor provide the facility to receive this XML data from the network (through a `TCP` connection). The MonAMI *grmonitor* plugin provides a network socket that the gr_Monitor application can connect to. To connect gr_Monitor to MonAMI, use the -tcp option:

`gr_monitor` -tcp *`hostname`*:*`port`*

The option *`hostname`* should be replaced with the hostname of the MonAMI daemon (e.g., `localhost`) and *`port`* should be replaced by whatever `TCP` port number MonAMI is listening on (`50007` by default).

Metrics from a datatree are mapped to positions within groups of 3D bar charts, which gr_Monitor then plots. To configure this mapping, the *grmonitor* plugin expects at least one of each of the following attribute: `group`, `metric`, `metricval`, and either `item` or `itemlist`. All of the attributes may be repeated.

A group is a rectangular collection of metrics, usually with a common theme; for example, in Figure 3.3, “gr_Monitor showing data from *apache* and *mysql* targets” there are two groups: one shows Apache thread status, the other shows per-table metrics for a MySQL database. Each group has a label or title and is displayed as a distinct block in the 3D display. In the MonAMI configuration, `group` attribute values have a local-name for the group, a colon, then the display label for this group. The group local-name is used when defining how the group should look and the label is passed to gr_Monitor to be displayed.

The `item` attribute describes a specific column within a group. Typically, each `item` describes one of a list of things; for example, one filesystem of several mounted, a queue within the set of batch-system queues, a table within the many a database stores. The `item` values have the group short-name, a comma, an item short-name, a colon, then the display label for this item. An item short-name is used to identify this `item` and the display label is passed on to gr_Monitor.

A `metric` attribute describes a generic measurable aspect of the items within a group; e.g., used capacity and free capacity (for filesystems), or number of jobs in running state and number in queued state for a batch system. The `metric` correspond to the rows of related information shown in Figure 3.3, “gr_Monitor showing data from *apache* and *mysql* targets”. The `metric` values have the form group short-name, comma, metric short-name, colon, then the label. The metric short-name is used to identify this metric and the label is passed on to gr_Monitor as the label it should display for this row.

The final required attribute type is `metricval`. The metricval attributes map the incoming datatree to bars within the 3D bar-chart. There should be a metricval for each (item,metric) pair in each group. metricval attribute values have a comma-separated list of group, item and metric short-names, a colon, then the datatree path for the corresponding MonAMI metric.

The following example demonstrates configuring a *grmonitor* target. It defines a single group “Torque queue info” with three `item`s (columns) “Atlas”, “CMS” and “LHCb”. Each item has two `metric` attributes: “Running” and “Queued”. The `metricval` attributes map an incoming datatree to these values.

```
[grmonitor]
 group = g1 : Torque queue info

 metric = g1, m_running : Running
 metric = g1, m_queued  : Queued

 item = g1,i_atlas : Atlas
 item = g1,i_cms   : CMS
 item = g1,i_lhcb  : LHCb

 metricval = g1,i_atlas, m_running: \
             torque.Queues.Execution.ByQueue.atlas.Jobs.State.running
 metricval = g1,i_atlas, m_queued: \
             torque.Queues.Execution.ByQueue.atlas.Jobs.State.queued

 metricval = g1,i_cms, m_running: \
             torque.Queues.Execution.ByQueue.biomed.Jobs.State.running
 metricval = g1,i_cms, m_queued: \
             torque.Queues.Execution.ByQueue.biomed.Jobs.State.queued
```

```
 metricval = g1,i_lhcb, m_running: \
             torque.Queues.Execution.ByQueue.lhcb.Jobs.State.running
 metricval = g1,i_lhcb, m_queued: \
             torque.Queues.Execution.ByQueue.lhcb.Jobs.State.queued
```

Using `itemlist`

Writing out all `metricval` attributes can be quite tiresome and error prone. The data provided by a datatree might also change over time, perhaps dynamically whilst MonAMI is running. For these reasons, MonAMI supports an express method of describing the mapping, which uses the `itemlist` attribute. This makes the mapping more dynamic and its description more compact.

The `itemlist` replaces the need for specifying `item` attributes explicitly. A group should have at least one `item` or `itemlist` otherwise no data would be plotted.

The `itemlist` attribute is similar to an `item` but, instead of specifying the label, the value after the colon specifies a branch of the datatree. Specifying an `itemlist` also affects how `metricval` attributes are interpreted.

When a new datatree is received, the *grmonitor* target will look for the specified branch and will consider each child entry as an item. For example, if the incoming datatree has a branch `aa.bb` with two child branches `aa.bb.item1` and `aa.bb.item2`, specifying an `itemlist` attribute with `aa.bb` is equivalent to specifying two `item`s labelled “item1” and “item2”. This is most useful when the indicated branch contains a list of similar items.

The `metric` attributes are as before; they provide the graphical labels for the metrics. There must be a `metric` value for each row within the group.

The `metricval` attributes describe the path within the datatree to the desired metric, relative to the item's branch. If the `itemlist` specifies a path `aa.bb` and the `metricval` specifies `xx.yy`, then values will be plotted for: `aa.bb.item1.xx.yy` (labelled “item1”), `aa.bb.item2.xx.yy` (labelled “item2”), etc. These must be valid metrics or they will be ignored.

`metricval` attributes may take a special value: a single dot. This indicates that the immediate children of the `itemlist` path should be plotted directly. For example, if an `itemlist` attribute has a value of `aa.bb` and `metricval` is `.` then values will be plotted for `aa.bb.item1` (as “item1”), `aa.bb.item2` (as “item2”), and so on. A `metricval` with a dot will only plot metrics if the items immediately below the itemval branch are metrics, branches will be ignored.

The following example demonstrates `itemlist` and illustrates using both `metricval` to point to metrics and the special dot value. It creates two groups: one that plots the number of Apache thread in each state (for details, see Section 3.4.2, “Apache”) and another that plots three metrics from MySQL (see Section 3.4.8, “MySQL”). The MySQL group plots three table-specific metrics for all tables in the mysql database. This is the configuration that produced the output shown above in Figure 3.3, “gr_Monitor showing data from *apache* and *mysql* targets”.

```
[grmonitor]
 group = gApache : Apache
 itemlist = gApache, iThreadState : apache.Threads
 metric = gApache, mCount : Count
 metricval = gApache, iThreadState, mCount : .

 group = gMysql : MySQL (mysql database)
 metric = gMysql, mCurLen : Length
 metric = gMysql, mIdxLen : Idx length
 metric = gMysql, mRows   : Rows
 itemlist = gMysql, iDbMysql: mysql.Database.mysql.Table
 metricval = gMysql, iDbMysql, mCurLen :  Datafile.current
 metricval = gMysql, iDbMysql, mIdxLen :  Indexfile.length
 metricval = gMysql, iDbMysql, mRows   :  Rows.count
```

Attributes

`port` integer, optional	the network port on which the plugin will listen. If not specified, then the default (50007) is used.
`group` string, at least one	defines a rectangular set of data results, forming a 3D bar chart. Attribute values have the form *`group name : group label`*
`metric` string, at least one per group	hold information about a row of data within a group. Attribute values have the form *`group name, metric name : metric label`*
`item` string, at least one per group (if there are no `itemlist` attributes)	describes a column of data within a group. Attribute values have the form *`group name, item name : item label`*
`itemlist` string, at least one per group (if there are not `item` attributes)	describes a set of columns of data within a group, by specifying a branch within the incoming datatree. The immediate child of this branch are considered part a list of items. Attribute values have the form *`group name, item name : branch path`*
`metricval` string, one per (`group`,`metric`,`item`)	Definition of which MonAMI metric maps to a particular location within a group. Attributes values have the form *`group name, item name, metric name : metric path`*

3.5.6. KsysGuard

KSysGuard is a default component of the KDE desktop environment. It is designed for monitoring computers and separates monitoring into two distinct activities: gathering information and presenting it to the user. Displaying information is achieved with a GUI program *KSysGuard* (written using the KDE framework) whilst gathering data is handled by a small program, `ksysguardd`, that can run as a remote daemon. The *ksysguard* MonAMI plugin emulates the `ksysguardd` program, allowing *KSysGuard* to retrieve information.

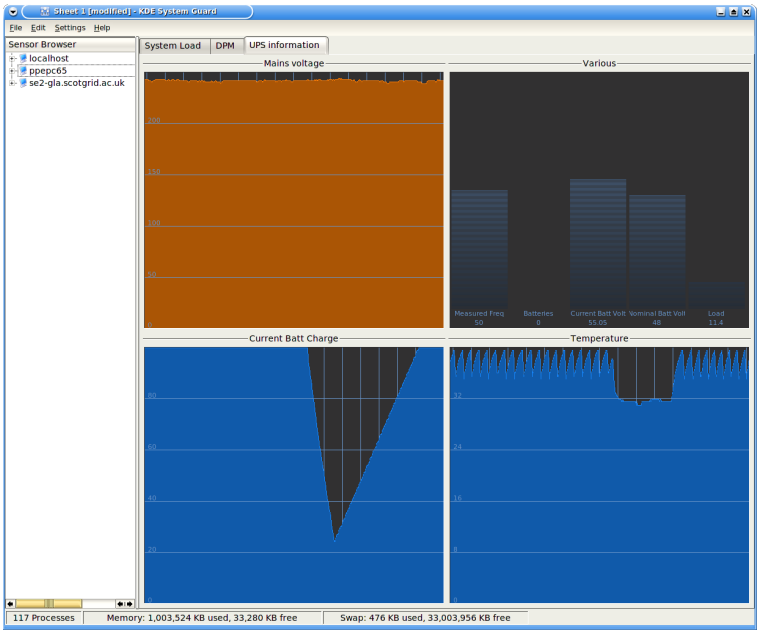


Figure 3.4. *KSysGuard* showing data from the *nut* plugin

KSysGuard supports a variety of display-types (different ways of displaying sensor data). Some of these display-types allow data from multiple sensors to be combined. Worksheets (panels with a grid of different displays) are easily updated using drag-and-drop and can be saved for later recall.

KSysGuard and `ksysguardd` communicate via a documented stream-protocol. Typical default usage has `ksysguardd` started automatically on the local machine, with communication over the process' `stdout` and `stderr` file-handles.

Collecting data from remote machines is supported by *KSysGuard* either via *ssh* or using direct `TCP` communication. With the *ssh* method, the GUI establishes an *ssh* connection to the remote machine and executes `ksysguardd` (data is transfered through *ssh*'s tunnelling of `stdout` and `stderr`). With the `TCP` method, *KSysGuard* establishes a connection to an existing `ksysguardd` instance that is running in network-daemon mode.

The MonAMI *ksysguard* plugin implements the *KSysGuard* stream-protocol and acts like `ksysguardd` running as a daemon. By default, it listens on port 3112 (`ksysguardd`'s default port) and accepts only local connections. A more liberal access policy can be configured by specifying one or more `allow` attributes.

Note

Older versions of *ksysguard* contained a bug that was triggered by a sensor name containing spaces. This was fixed in KDE v3.5.6 or later.

To view the data provided by MonAMI within *KSysGuard*, select File → Connect Host, which will open a dialogue box. Enter the hostname of the machine MonAMI is running on in the Host input and make sure the Connection Type is set to Daemon. You should see the host's name appear within the sensor-browser tree (on the left of the window). Expanding the hostname will trigger *KSysGuard* to query MonAMI for the list of available metrics. If this list is long, it can take a while for *KSysGuard* to parse the list.

More details on how to use *KSysGuard* can be found in *the KSysGuard Handbook* [http://docs.kde.org/development/en/kdebase/ksysguard/].

Within MonAMI, the *ksysguard* target configured must specify a target from which the data is requested (via the `read` parameter). This source can be either an explicit monitoring plugin (e.g., using a target from the *apache* plugin) or a named *sample* target. The named sample can either act solely as an aggregator for *KSysGuard* (i.e., with no `write` or `interval` specified) or can be part of some other monitoring activity. See Section 3.6, “sample” for more information on *sample* targets.

The following example shows the *ksysguard* plugin directly monitoring an Apache server running on *`www.example.org`*.

```
[apache]
 host = www.example.org

[ksysguard]
 read = apache
```

The following example demonstrates how to use a named-sample to monitor multiple monitoring targets with KSysGuard.

```
[apache]
  name = external-server
  host = www.example.org

[mysql]
  name = external-mysql
  host = mysql-serv.example.org
  user = monami
  password = monami-secret
```

```
  cache = 10

[apache]
  name = internal-server
  host = www.intranet.example.org

[mysql]
  name = internal-mysql
  host = mysql-serv.intranet.example.org
  user = monami
  password = monami-secret
  cache = 10

[sample]
  name = ksysguard-info
  read = external-server, external-mysql, internal-server, internal-mysql

[ksysguard]
  read = ksysguard-info
```

Attributes

`read` string, required	the name of the target from which data is to be requested
`port` integer, optional	the port on which the *ksysguard* target will listen for connections. If no port is specified, then 3112 will use, the default for `ksysguardd`.
`allow` string, optional	a host or subnet from which this plugin will accept connections. This can be specified as a simple hostname (e.g., `mydesktop`), a fully qualified domain name (e.g., `www.example.com`), an IPv4 address (e.g., `10.1.0.28`), an IPv4 address with a netmask (e.g. `10.1.0.0/255.255.255.0`) or an IPv4 subnet using CIDR notation (e.g., `10.1.0.0/24`). The plugin will always accept connections from `localhost` and from the host's fully qualified domain name. This attribute can be repeated to describe all necessary authorised hosts or networks.

3.5.7. MonALISA

This plugin pushes information gathered by MonAMI into the MonALISA monitoring system (*MonALISA home page* [http://monalisa.cacr.caltech.edu/]). It does this by sending the data within a `UDP` packet to a MonALISA-Service (ML-Service) server. ML-Service is a component of MonALISA that can be located either on the local site or centrally.

Within the MonALISA (ML) hierarchy, a cluster contains one or more nodes (computers). These clusters are grouped together into one or more farms. Farms are handled by MonALISA-Services (ML-Services), usually a single farm per ML-Service. The ML-Service is a daemon that is responsible for collecting monitoring data, and providing both a temporary store for that data and a means by which that data can be acquired.

Clients query the data provided by ML-Services via transparent proxies. There are also LookUp Services (LUSs) that contain soft-state registrations of the proxies and ML-Services. The LUSs provide a mechanism by which client requests are load-balanced across different proxies and dynamic data discovery can happen.

The ML-Services acquire data through a number of MonALISA plugins. One such plugin is XDRUDP, which allows nodes to send arbitrary data to the ML-Service. The MonALISA team provide an API

for sending this data called ApMon. It is through the XDRUDP ML-plugin that MonAMI is able to send gathered data.

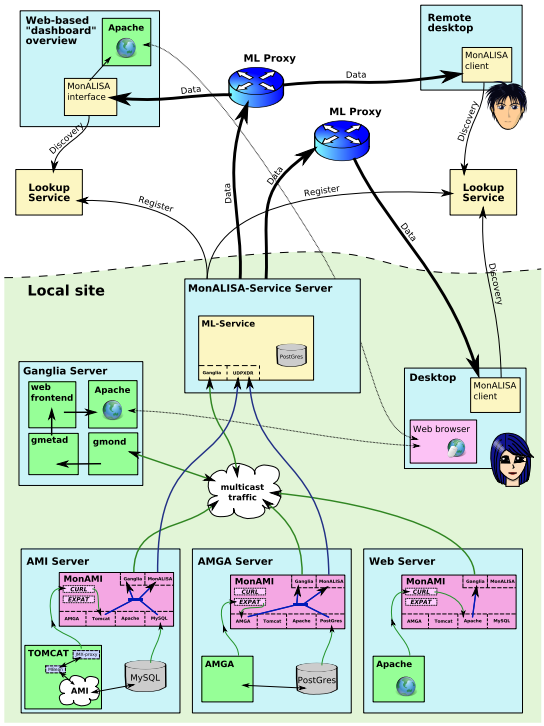


Figure 3.5. Example deployment with key elements of MonALISA shown.

Note that each MonAMI *monalisa* target reports to a specific host, port, cluster triple. If you wish to report data to multiple ML-Services or to multiple ML clusters, you must have multiple MonAMI *monalisa* targets configured: one for each host or cluster.

Attributes

`host` string, optional
: the hostname of the ML-Service. The default value is `localhost`.

`port` integer, optional
: the port on which the ML-Service listens. The default value is 8884.

`password` string, optional
: the password to access the MonAlisa service.

Warning

The password is sent plain-text: don't share a sensitive password with MonALISA! By default, no password is sent.

`apmon_version` string, optional
: the plugin reports “2.2.0” as an ApMon version string by default. This option allows you report a different version.

`cluster` string, required
: the cluster name to report.

`node` string, optional
: the node name to report. There are two special cases: if the literal string `IP` is used, then MonAMI will detect the IP address and use that value; if the literal string `FQDN` is used, then MonAMI will determine the machine's Fully Qualified Domain Name and use that. The default is to report the machine's FQDN.

3.5.8. MySQL

In addition to monitoring a MySQL server, the *mysql* plugin can also append monitoring data into a table. If correctly configured, each datatree the plugin receives will be stored as a new row within a specified table.

The two MySQL operations (monitoring and storing results) are not mutually exclusive. A *mysql* target can be configured to both store data and also to monitoring the MySQL server it is contacting.

Two attributes are required when using the *mysql* plugin for storing results: `database` and `table`. These specify into which MySQL database and table data is to be stored.

If the database named in the `database` attribute does not exist, no attempt is made to create it. This will prevent MonAMI from storing any data.

If the table does not exist, the plugin will attempt to create it when it receives data. The plugin determins the types for each field from the field's corresponding metric. If, when creating the table, a field attribute has no corresponding metric within the incoming datatree, the corresponding field within the database table is created as TEXT.

Privileges

In order to insert data, the MySQL user the plugin authenticates as must have been granted sufficient privileges. Additional privileges are needed if you wish to allow the plugin to create missing tables as needed.

The following SQL commands describes how to create a database mon_db, create a MySQL user account monami with password *`monami-secret`*, and grant that user sufficient privileges to create tables within the monitoring database and insert new data.

```
CREATE USER 'monami' IDENTIFIED BY 'monami-secret';
CREATE DATABASE mon_db;
GRANT CREATE,INSERT ON mon_db.* TO monami;
```

A lightly more secure, but more awkward solution is to manually create the storage tables. The following SQL commands describe how to create a database mon_db, create an example table roomstats, create a MySQL user account monami with password `monami-secret`, and grant that user sufficient privileges to insert data only for that table.

```
CREATE USER 'monami' IDENTIFIED BY 'monami-secret';
CREATE DATABASE mon_db;
CREATE TABLE roomstats (
        collected    TIMESTAMP,
        temperature  FLOAT,
        humidity     FLOAT,
        aircon1good  BOOLEAN,
        aircon2good  BOOLEAN);
GRANT INSERT ON mon_db.roomstats TO monami;
```

Fields

One must describe how to fill in each of the table's fields. To do this, the configuration should include several `field` attributes, one for each column of the table.

A `field` attribute value has the form: *`field : metric path`* where *`field`* is the column name in the MySQL database and *`metric path`* is the path within the datatree to the metric value.

The collected field

The collected field is a special case. It stores the timestamp of when the datatree data was obtained. The table must have a column with this name with type TIMESTAMP. This field is filled in automatically: there is no need for a `field` attribute to describe the collected field.

The following example shows a suitable configuration for storing gathered data within the above room_stats table. The datatree is fictitious and purely illustrative.

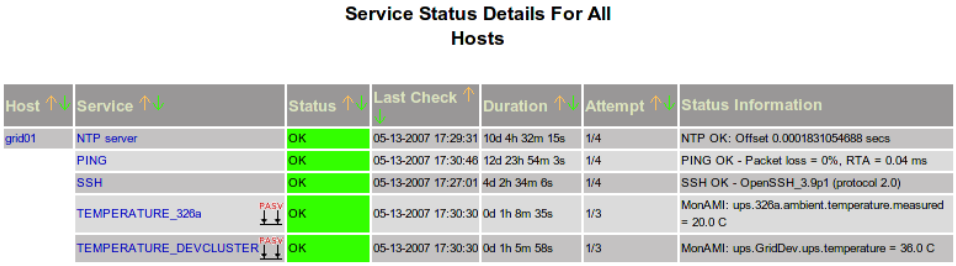
```
[mysql]
 user = monami
 password = monami-secret
 database = mon_db
 table = room_stats
 field = temperature : probes.probe1.temperature
 field = humidity    : probes.probe1.humidity
 field = aircon1good : aircons.aircon1.good
 field = aircon2good : aircons.aircon2.good
```

Attributes

`host` string, optional	the host on which the MySQL server is running. If no host is specified, the default `localhost` is used.
`user` string, required	the username with which to log into the server.
`password` string, required	the password with which to log into the server
`database` string, required	the database in which the storage table is found. If this database does not exist then no data can be stored.
`table` string, required	the table into which data is stored. If the table does not exist, it is created automatically.
`field` string, at least one	a mapping between a metric from a datatree and a database field name. This attribute should be specified for each table column and has the form *`field : datatree path`*

3.5.9. Nagios

Nagios is a monitoring system that provides sophisticated service-status monitoring: whether a service's status is OK, Warning or Critical. Its strengths include support for escalation and flexible support for notification and potentially automated service recovery. A complete description of Nagios is available at the *Nagios home page* [http://nagios.org/].



Service Status Details For All Hosts

Host	Service	Status	Last Check	Duration	Attempt	Status Information
grid01	NTP server	OK	05-13-2007 17:29:31	10d 4h 32m 15s	1/4	NTP OK: Offset 0.000183105468 secs
	PING	OK	05-13-2007 17:30:46	12d 23h 54m 3s	1/4	PING OK - Packet loss = 0%, RTA = 0.04 ms
	SSH	OK	05-13-2007 17:27:01	4d 2h 34m 6s	1/4	SSH OK - OpenSSH_3.9p1 (protocol 2.0)
	TEMPERATURE_326a	OK	05-13-2007 17:30:30	0d 1h 8m 35s	1/3	MonAMI: ups.326a.ambient.temperature.measured = 20.0 C
	TEMPERATURE_DEVCLUSTER	OK	05-13-2007 17:30:30	0d 1h 5m 58s	1/3	MonAMI: ups.GridDev.ups.temperature = 36.0 C

Figure 3.6. Nagios service status page showing two MonAMI-provided outputs.

The Nagios monitoring architecture has a single Nagios central server. This Nagios server maintains the current status of all monitored hosts and the services offered by those hosts. It is the central Nagios server that maintains a webpage front-end and that responds to status changes. For remote hosts, Nagios offers two methods of receiving status updates: active and passive.

Active queries are where the Nagios server initiates a connection to the remote server, requests information, then processes the result. This requires a daemon (*npre*) to be running and a sufficient subset of the monitoring scripts to be installed on the remote machine.

With passive queries, the remote site sends status updates to the Nagios server, either periodically or triggered by some event. To receive these messages, the Nagios server must either run the *nsca* program as a daemon, or run a *inetd*-like daemon to run *nsca* on-demand.

Caution

There is a bug in some versions of the *nsca* program. When triggered, *nsca* will go into a tight-loop, so preventing updates and consuming CPU. This bug was fixed with version 2.7.2. Make sure you have at least this version installed.

MonAMI will send status information to the Nagios server. This follows the passive query usage, so *nsca* must be working for Nagios to accept data from MonAMI.

Nagios and nsca

This section gives a brief overview of how to configure Nagios to accept passive monitoring results as provided by *nsca*. Active monitoring is the default mode of operation and often Nagios is deployed with passive monitoring disabled. Several steps may be required to enable it. The information here should be read in conjunction with the *Nagios documentation* [http://nagios.org/docs/]. Also, if *nsca* is packaged separately, make sure the package is installed.

Location of Nagios configuration

The Nagios configuration files are located either in `/etc` or, with more recent packages, in `/etc/nagios`. It is also possible that they may be stored elsewhere, depending on the local installation. For this reason, when Nagios configuration files are mentioned, just their base name will be given rather than the full path.

To run *nsca* as part of an *xinetd* make sure there is a suitable *xinetd* configuration file (usually located in `/etc/xinetd.d`). Some packages also include suitable configuration for *xinetd*, but usually disabled by default. To enable *nsca*, make sure the `disabled` field within the *nsca*'s *xinetd*-configuration file is set to `no` and restart *xinetd*.

To run *nsca* as part of *inetd*, add a suitable line to the *inetd* configuration file `/etc/inetd.conf` and restart *inetd*.

To run *nsca* as a daemon, independent of any *inetd*-like service, make sure no *inetd*-like service has adopted *nsca* (e.g., set `disabled` in the corresponding *xinetd* configuration file to `yes`, or comment-out the line in *inetd* configuration) and start *nsca* as a daemon (e.g., `service nsca start`).

Passive monitoring requires that Nagios support external commands. The packaged default configuration may have this switched off. To enable external commands, make sure the `check_external_commands` parameter is set to `1`. This option is usually located in the main configuration file, `nagios.cfg`. Nagios will need to be restarted for this to have an effect.

Make sure Nagios can create the external command socket. The default location is within the `/var/log/nagios/rw` directory. You may need to change the owner of that directory to the user the Nagios daemon uses (typically `nagios`).

If there are problems with communication between MonAMI and *nsca*, the *nsca* debugging option can be useful. Debugging is enabled by setting `debug=1` in the *nsca* configuration file: `nsca.cfg`. The debug output is sent to syslog, so which file the information can be found in will depend on the syslog configuration. Typically, the output will appear in either `/var/log/messages` or `/var/log/daemon`.

Adding passive services to Nagios

Nagios only accepts passive monitoring results for services it knows about. This section describes how to add additional service definitions to Nagios so MonAMI can provide status information.

Nagios supports templates within its configuration files. These allow for a set of default service values. If a service inherits a template, then the template values will be used unless overwritten. The following section gives a suitable template for a MonAMI service; you may wish to change these values to better suite your environment.

```
define service {
     name                       monami-service
     use                        generic-service
     active_checks_enabled      0
     passive_checks_enabled     1
     register                   0
     check_command              check_monami_dummy
     notification_interval      240
     notification_period        24x7
     notification_options       c,r
     check_period               24x7
     contact_groups             monami-admins
     max_check_attempts         3
     normal_check_interval      5
     retry_check_interval       1
}
```

Note how the active checks are disabled, but passive checks are allowed. Also, the `contact_groups` has been set to `monami-admins`. Either this contact group must be defined, or a valid group be substituted.

In the above template, a `check_command` was specified. Nagios requires this value to be set, but as active checks are disabled, any valid command will do. To keep things obvious, we use the explicit `check_monami_dummy` command. The following definition is valid and can be placed either in `commands.cfg` or in some local collection of extra commands.

```
define command {
   command_name    check_monami_dummy
   command_line    /bin/true
}
```

The final step is to add the services Nagios is to accept status information. These definitions will allow MonAMI to upload status information. The definitions should go within one of the Nagios configuration files mentioned by `cfg_file=` in `nagios.cfg`.

The following two examples configure specific checks for a named host.

```
define service {
     use                        monami-service
     host_name                  grid01
     service_description        TOMCAT_WEB_THREADS_CURRENT
}

define service {
     use                        monami-service
     host_name                  grid01
     service_description        TOMCAT_WEB_THREADS_INUSE
}
```

The following example shows a service check defined for a group of hosts. Hosts acquire the service check based on their membership of the hostgroup. This is often more convenient when several machines are running the same service.

```
define hostgroup {
     hostgroup_name    DPM_pool_nodes
     alias             All DPM pool nodes.
     members           disk001, disk002, disk003, disk005, disk013
}

define service{
     use                        monami-service
     hostgroup_name             DPM_pool_nodes
     service_description        DPM_free_space
}
```

Configuring MonAMI

To allow MonAMI to report the current state of various services, one must configure a *nagios* reporting target. This describes both the machine to which MonAMI should connect, and the services that should be reported.

The `host` attribute describes the remote host to which status information should be sent. If no host is specified, MonAMI will attempt to contact *nsca* running on the machine on which it is running (`localhost`). The `port` attribute describes on which `TCP` port the *nsca* program is listening. If no `port` is specified, then the *nsca* default port is used.

To be useful, each *nagios* target must define at least one service. Each service must have a corresponding definition within Nagios (as described above), else Nagios will ignore the information. To define a service, the `service` attribute is specified. The `service` values have the following form: *`short name : Nagios name`*

`short name` a simple name used to associate the service with the various `check` attributes.

`Nagios name` the name of the service within Nagios. This is the `service_description` field (as shown above). It is also the name the Nagios web interface will show.

Two example service definitions are given below. A *nagios* target can have an arbitrary number of definitions.

```
service = tcat-threads, TOMCAT_WEB_THREADS_INUSE
service = tcat-process, TOMCAT_PROCESS
```

Given a service definition, one or more `check` attributes must be defined. The `check`s determine the status (OK, Warning or Critical) of a service. The `check` values have the following form: *`short name : data source, warn value, crit value`*

These fields have the following meaning:

`short name` the short name from the corresponding `service` definition.

`data souce` the path within a datatree to the metric under consideration.

`warn value` the first value that metric can adopt where the check is considered in Warning status.

`crit value` the first value that metric can adopt where the check is considered in Critical status.

When multiple `check` attributes are defined for a `service`, all the `check`s are evaluated and the `service` adopts the most severe status. In order of increasing severity, the different status are OK, Unknown, Warning Critical.

Examples of MonAMI configuration

The following is an example of a complete definition. A single service is defined that has a single `check`, based on output from the *nut* plugin (see Section 3.4.10, “NUT”.

```
[nagios]
 service = ups-temp, Temperature
 check = ups-temp, nut.myups.ups.temperature, 25, 35
```

The status of `Temperature` depends on `nut.apc3000.ups.temperature`. If it is strictly less than 25 `Temperature` has status OK. If 25 or more, but strictly less than 34 it has status Warning and if 35 or greater it has status Critical.

Another example, again using output from the *nut* plugin.

```
[nagios]
 service = ups-volt, Mains
 check = ups-volt, nut.myups.input.voltage.instantaneous, 260, 280
 check = ups-volt, nut.myups.input.voltage.instantaneous, 210, 190
```

The `Mains` service is OK if the mains voltage lies between 210 V and 260 V, between 190 V and 210 V or between 260 V and 280 V its Warning and either less than 190 V or greater than 280 V its considered Critical.

Attributes

`host` string, optional	the hostname to which the reporting plugin should connect. The default value is `localhost`.
`port` integer, optional	the port to which the plugin should connect. The default value is 5667, the default for *nsca*.
`password` string, optional	the password used for this connection. Defaults to not using a password.
`service` string, optional	defines a service that is to be reported to Nagios. The format is *`short name : Nagios name`*.
`check` string, optional	defines a check for some service. A `check` is something that can affect the status of the reported service. The format is *`short name : data source, warning value, critical value`*.
`localhost` string, optional	defines the name the *nagios* plugin reports for itself when sending updates. By default, the plugin will use the FQDN. Specify this attribute if this is incorrect.

3.5.10. null

In addition to providing data (albeit, an empty datatree), the *null* plugin can also act as a reporting plugin, but one that will discard any incoming data.

A *null* target will act as an information sink, allowing monitoring activity to continue without the information being sent anywhere.

Attributes

The *null* plugin, used as a writer, does not accept any attributes.

3.5.11. SAM

The Service Availability Monitoring (SAM) is an in-production service monitoring system based in CERN. The *GOC Wiki* [http://goc.grid.sinica.edu.tw/gocwiki/Service_Availability_Monitoring_Environment] describes SAM further. Also available is a webpage describing the *latest results* [https://lcg-sam.cern.ch:8443/sam/sam.cgi].

The *sam* plugin allows information to be sent to a SAM monitoring host based on the methods described in the GOC Wiki.

Note

This module will have no effect unless the tests are registered prior to running the code.

The CERN server is firewalled, so running tests may not result in immediate success.

This is work-in-progress.

Attributes

`VO` string, required	the VO name to include with reports.
`table` string, required	the name of the table into which the data is to be added.
`node` string, optional	the node name to report. This defaults to the machine's FQDN.
`endpoint` string, optional	the end-point to which the reports should be sent. This defaults to `http://gvdev.cern.ch:8080/gridview/services/WebArchiver`

3.5.12. Snapshot

The *snapshot* reporting plugin stores a representation of the last datatree it received in a file. Unlike the *filelog* plugin, *snapshot* provides no history information; instead, it provides a greater depth of information about the last datatree it received.

Attributes

`filename` string, required	the filename of the file into which the last datatree is stored.

3.5.13. R-GMA

R-GMA (Relational Grid Monitoring Architecture) is an information system that allows data to be aggregated between many sites. It is based on the Open Grid Forum (formerly Global Grid Forum) architecture for monitoring, Grid Monitoring Architecture. R-GMA uses a Producer-Consumer model, with a Registry to which all producers register themselves periodically. Interactions with R-GMA are through a subset of SQL. Further information on R-GMA is available from the *R-GMA project page* [http://www.r-gma.org/] and the *R-GMA in 5 minutes* [http://www.r-gma.org/fivemins.html] document.

A typical deloyment has a single R-GMA server per site (within WLCG, this is the MON box). Within the R-GMA architecture, the producers are located within this R-GMA server. Local data is submitted to the R-GMA server and held there. External R-GMA clients (R-GMA Consumers) contact the R-GMA Producers to query the gathered data.

Locating the server

The *rgma* plugin allows MonAMI to upload data to an R-GMA server. Often this will *not* be the same machine on which MonAMI is running, so MonAMI must either discover the location of the server or use information in its configuration.

If the machine on which MonAMI is running has a properly installed R-GMA environment, it will have a file `rgma.conf` that states which machine is the R-GMA server and details on how to send the data. Unfortunately, this file can be located in many different locations, so its location must be discovered too.

If the `rgma_home` attribute is specified, MonAMI will try to read the R-GMA configuration file *`rgma_home`*`/etc/rgma/rgma.conf`.

If the `rgma_home` attribute is not specified, or does not locate a valid R-GMA configuration file, several environment variables are checked to see if they can locate a valid R-GMA configuration file. MonAMI will tries the environment variables `RGMA_HOME`, `GLITE_LOCATION` and `EDG_LOCATION`, each time trying to load the file *`VAR`*`/etc/rgma/rgma.conf`.

If neither the `rgma_home` attribute nor any of the environment variables, if specified, can locate the `rgma.conf` file, a couple of standard locations are tried. MonAMI will try to load `/opt/glite/etc/rgma/rgma.conf` and `/opt/edg/etc/rgma/rgma.conf`.

If the file `rgma.conf` does not exist, the host and `TCP` port of the R-GMA server may be specified explicitly within the configuration file. The attributes `host`, `port` and `access` state to which host, on which port and how securely the connection should be made. Usually specifying just the `host` is sufficient.

In summary, to allow the *rgma* plugin to work, you must satisfy one of the following:

1. have a valid `rgma.conf` file in one of its standard locations (`/opt/glite/etc/rgma/` or `/opt/edg/etc/rgma/`), or
2. make sure the MonAMI process has the correct `RGMA_HOME`, `GLITE_LOCATION` or `EDG_LOCATION` environment variable set, or
3. specify the `rgma_home` attribute, locating the `rgma.conf` file, or
4. explicitly set one or more of the following attributes: `host`, `port`, `access`, or
5. run MonAMI on the same machine as the R-GMA server.

Sending data

The R-GMA system resembles a relational database with data separated into different tables. Each table may have many columns, with data being supplied to any or all of those columns with one set of data.

Each *rgma* target delivers data to a single R-GMA table. The table name must be specified and is given by the `table` attribute. How data is delivered within that table is defined by `column` attributes. Each `column` attribute defines a mapping between some metric within a datatree and an R-GMA column name. The value of a `column` attribute has the form *`R-GMA column : metric name [option, option]`*, where *`metric name`* is the path to the metric within the datatree, the square brackets are optional additional parameters. The following is a simple example that maps the metric located at `transfer.size` in the datatree to the R-GMA column size.

```
column = size  : transfer.size
```

The optional square brackets within the `column` attribute values contain options that adjust *rgma*'s behaviour for this data. These options are a comma separated list of keyword,value pairs, where the following keywords are available:

`maxsize` The maximum length of a string metric. If a string metric would be too long for this column, it is truncated so the last five characters are `[...]`.

The following example configures MonAMI to send a string metric that is never longer than 255 characters; a string will be truncated if it is longer.

```
column = filename  : downloaded.filename [maxsize = 255]
```

R-GMA query types

R-GMA supports four types of query: continuous, history, latest and static.

A *continuous query* of a table will return data whenever it is inserted into that table. All matching data added to R-GMA will appear in a continuous query. It is possible to issue a continuous query that includes all old data before waiting for new data. Although this will return historic data, there is no guarantee for how long the R-GMA server will retain the data.

A reliable archive of the recent history of measurements or events is possible. A *history query* will return all matching data still present, but with a defined retention policy. To be a candidate for history queries, data must be marked for historic queries when it is inserted into a table. Any data not marked will be ignored by history queries.

R-GMA also understands the concept of the “latest” result. An R-GMA *latest query* selects the most recent measurement. However, to be considered, data must be marked as a candidate for latest queries when added. Any data that is not so marked is ignored.

A *static query* is a query that uses R-GMA's support for on-demand monitoring. Currently, *rgma* has no support for this query type.

When adding data, MonAMI will mark whether it should be considered for latest or historical queries (or both). This is controlled by the `type` attribute, a comma-separated list of query-types for which the data should be a candidate.

Data will always appear in continuous queries. By default, that is the only query type data will appear in. If the `type` list contains `history` then data is marked for history queries and will also show up in history queries. If it contains `latest` then it will also show up in R-GMA latest queries.

Storage and retention of data

Data can be stored on the R-GMA server in one of two locations: either in memory or within a database. By default, data is stored in memory; however, the MonAMI `storage` attribute can specify where R-GMA will store data. The valid values are `memory` and `database` (for storing in memory and within a database, respectively).

Note

The current implementations of R-GMA support history- and latest- queries only when data is stored within a database.

In general, data will be retained within R-GMA for some period. How long data is retained depends on several factors. If the data is neither marked for history nor latest queries then the retention period is not guaranteed.

The *latest retention period* is how long data is kept if it is marked for latest queries. R-GMA makes no guarantee to expunge the data at that precise time. The MonAMI default value is 25 minutes. This can be changed by setting the `latest_retention` attribute to the required duration, in minutes. If the data is not marked (by the `type` attribute) for latest queries then this has no effect.

The *history retention period* is the period of time after data is added that it is retained for history queries. R-GMA will guarantee to store for that period, but may retain it for longer. The MonAMI default value is 50 minutes, but this value can be changed by setting the `history_retention` attribute to the required duration, in minutes. If the data is not marked for history queries then this has no effect.

Security

The R-GMA service can accept commands through either an insecure (`HTTP`) or secure (`HTTPS`) connection. With the insecure connection, no authentication happens: anyone can insert data. Adding data insecurely is the more simply and robust, but as anyone can send fake data it is not recommended.

With Public Key Infrastructure (PKI), a host proves its identity with credentials that are split into two separate parts: one part is kept secret and the other is made public. The public part is the *X509 certificate*, which describes who the server claims to be and is *signed* by a trusted organisation. The secret part is the host's *private key*. This file must be kept securely and is needed when establishing a secure connection to verify that the server really is as claimed in the certificate.

When attempting to send data via a secure connection, the R-GMA server will only accepted connections established with a valid X509 certificate, one that the server can verify the complete trust-chain. A valid X509 host certificate has a common name (CN) that is identical to the host's fully qualified domain name (FQDN). To be useful, the certificate must have been issued by a certificate authority (CA) that the R-GMA server trusts. Trust, here, is simply that the CA's own certificate appears within the R-GMA server's CA directory (as specified within the R-GMA server's configuration).

The private key is precious: all security gained from using PKI depends on the private key being kept secret. It is common practice to allow only the `root` user (and processes running with `root` privileges) access to the private key file. However, many programs need to prove they are running on a particular machine without running "as `root`", so cannot access the private key directly. To allow this, short-lived (typically 1 hour) certificates, called *proxy certificates*, are generated that are signed by the host certificate. The signing process (and so, generating proxy certificates) requires access to the host's private key. However, once generated, these short-lived certificates can have more liberal access policies because, if stolen, they are only valid for a short period.

Unless the host's private key is directly readable (which is *not* recommended), MonAMI needs to have access to a supply of valid proxy certificates so it can upload data to an R-GMA server securely. To achieve this, an external script is run periodically (once an hour, by default) to generate a short-lived proxy host certificate. Some MonAMI installations will have no X509-PKI files and no need to upload data to R-GMA. Because of this, the script **rgma-proxy-renewal.sh** (in the directory `/usr/libexec/monami`) is designed to fail quietly if there is no host key and no certificate installed in their default locations (`/etc/grid-security/hostkey.pem` and `/etc/grid-security/hostcert.pem`, respectively).

To generate a proxy certificate, the script will search for one of the proxy generating commands (`voms-proxy-init`, `lcg-proxy-init`, ...) in standard locations. It will work "out of the box" if it can find a suitable command. If it fails, or its behaviour needs to be adjusted, the file `/etc/sysconfig/monami` should be edited to altered how the script behaves.

All the following options start `RGMA_`. To save space, the `RGMA_` prefix is not included in the list below; for example, the option listed as `HOST_CERT` is actually `RGMA_HOST_CERT`.

`HOST_CERT`	The location of the host certificate, in PEM format. The default value is `/etc/grid-security/hostcert.pem`
`HOST_KEY`	The location of the host private key, in PEM format. The default value is `/etc/grid-security/hostkey.pem`
`HOST_PROXY_DIR`	The absolute path to the directory in which the proxy will be stored. Any old proxy certificates within this directory will be deleted. The default value is `/var/lib/monami/rgma`
`HOST_PROXY_BASENAME`	The constant part of a proxy certificate filename. Proxy certificate filenames are generated by appending a number to this basename. The default value is `hostproxy` and an example proxy certificate is `hostproxy.849`
`PROXY_RENEW_CMD`	The absolute path to an `globus-proxy-init`-like command. By default, the script will look for one of several commands within several standard locations. Unless the proxy generating command is located in a non-standard location or is called something unusual, it is not necessary to specify this option.
`MONAMI_USER`	The user account MonAMI runs as. By default this is `monami`.
`PERIOD`	How often the script is run (in hours). By default, this is 1 (i.e., one hour). This variable controls only for how long a freshly made proxy certificate is valid; to change the rate at which proxy certificates are made, the cron entry (the file `/etc/cron.d/monami-rgma`) must be altered to a corresponding value.

Dealing with failures

It is possible that, for whatever reason, an R-GMA server may not be able to receive data for a period of time; for example, this might happen if the R-GMA server is down (e.g., for software upgrade) or

from network failures. If a *rgma* target is unable to send the data, it will store the data in memory and attempt transmission later. Transmission of unsent data is attempted before sending new data and also automatically every 30 seconds.

Storing unsent data uses memory, which is a finite resource on any computer. The default behaviour on some computers is to kill programs that have excessive memory usage; those computers that do not kill such programs outright will often “swap” memory to disk, resulting much poorer performance of the computer overall.

To prevent an unavailable R-GMA server from adversely affecting MonAMI, a safety limit is placed on how much unsent data is stored. If the length of the unsent data queue exceeds this limit then the oldest data is thrown away to make space for the new data.

The default behaviour is to limit the backlog queue to 100 datatrees. How quickly this limit is reached will depend on how fast data is sent to an rgma plugin. The backlog queue limit can be altered through the `backlog` attribute, although a minimum `backlog` value of 10 is enforced.

Example usage

The following example configuration monitors the “myservice” processes every minute and records the number that are in running (or runable), sleep and zombie states. The data is stored in the (fictitious) R-GMA table myServiceProcessUsage. The table has three fields: running, sleeping and zombie. The data delivered from the *process* target (`srv_procs`) is uploaded to the *rgma* target (`srv_rgma`) and matches each of the three column names.

```
[process]
  name = srv_procs
  count = procs_running  : myservice [state=R]
  count = procs_sleeping : myservice [state=S]
  count = procs_zombie   : myservice [state=Z]

[sample]
  interval = 1m
  read = srv_procs
  write = srv_rgma

[rgma]
  name = srv_rgma
  table = myServiceProcessUsage
  column = running  : srv_procs.count.procs_running
  column = sleeping : srv_procs.count.procs_sleeping
  column = zombie   : srv_procs.count.procs_zombie
```

Attributes

`table` string, required

the table name MonAMI will append data to.

`column` string, required

the mapping between a MonAMI metric name and the corresponding R-GMA column name. In general, there should be a `column` attribute for each column in the corresponding R-GMA table.

The `column` attribute takes values like:

```
rgma column : metric name [options]
```

where *`metric name`* is the path to some metric within the datatree and *`options`* is a comma-separated list of keyword,value pairs. If no options are needed, the square brackets can be omitted.

`rgma_home` string, optional	If the usual environment variables are not specified or do not point to a valid `rgma.conf` file and `rgma_home` has been specified, MonAMI will attempt to parse the file `rgma_home/etc/rgma/rgma.conf` for details on how to contact the R-GMA server.
`host` string, optional	the host to which MonAMI should connect for submitting data. Default value is `localhost`. It is recommended that this value is only used if you do not have an `rgma.conf` file.
`port` integer, optional	the `TCP` port to which MonAMI should connect when submitting data. Default value is `8080` when connecting insecurely and `8443` when connecting securely.
`access` string, optional	this attribute will determine whether to use `SSL`/`TLS`-based security when connection to the R-GMA server. A value of `secure` will result in attempting `SSL`/`TLS`-based mutual authentication; a value of `insecure` will use an insecure `HTTP` transport. By default, secure access will be used.
`type` string, optional	a comma-separated list of R-GMA queries for which the data should be a candidate. Added data will always show up during continous queries. Specifying `history` will mark the data so it is also a candidate for history queries. Similarly, specifying `latest` marks data so it is also a candidate for latest queries.
`storage` string, optional	the type of storage to request. This can be either `memory` or `database`. The default value is `memory`.
`latest_retention` integer, optional	when inserting data that is marked for "latest" queries, this is the period of time after data is added that it is guaranteed to be present. The value is in minutes, the default value is 25 minutes.
`history_retention` integer, optional	when inserting data that is marked for "history" queries, this is the period of time after data is added that it is guaranteed to be present. The value is in minutes, the default being 50 minutes.
`backlog` integer, optional	The maximum length of the unsent data queue whilst waiting for an R-GMA server. If the backlog of datatrees to send to an R-GMA server exceeds this value, then the oldest datatree is thrown away. The default value is 100 with a minimum value of 10 being enforced.

3.6. sample

The configuration file can have one or more *sample* targets (or *sample* for short). A *sample* target aggregates information collected from one (or more) targets. The aggregated data is then sent off to one (or more) targets. The targets do this based on either the current time or when another target requests the data. Generally speaking, you want at least one *sample* target in MonAMI configuration files.

3.6.1. The read attribute

The `read` attribute describes from which monitoring targets a *sample* target should get its data. In its simplest form, this is a comma-separated list of monitoring targets. When fresh data is needed, the *sample* target will acquire data from all the named targets and aggregate the data. The following example takes data from a *mysql* and *apache* target.

```
[mysql]
 user     =  monami
```

```
 password =  not-very-secret

[apache]
 name = my-apache

[sample]
 read = my-apache, mysql
```

Data is made available in a tree structure. *sample* targets can select parts of the datatree rather than taking all available data. Parts of a datatree are specified by stating the path to the metric or branch of interest. A dot (`.`) is used to separate branches within the datatree. Also, parts of the tree can be excluded by prefixing an entry with the exclamation mark (`!`).

In the following example, the *sample* target takes the `threads` data from the `my-apache` target, but not the number of threads in keep-alive state. The sample also aggregates data from the *mysql* target's “uptime” value.

```
[mysql]
 user     =  monami
 password =  not-very-secret

[apache]
 name = my-apache

[sample]
 read = my-apache.Threads, !my-apache.Threads.keep-alive, \
        mysql.uptime
```

3.6.2. Timed sample targets

Timed *sample*s are *sample* targets that have an `interval` attribute specified. Specifying an `interval` will result in MonAMI attempting to gather data periodically. This is useful for generating graphs or “push”ing data to reporting targets, such *ganglia* (see Section 3.5.3, “Ganglia”) or *filelog* (see Section 3.5.1, “filelog”).

The `interval` value specifies how long the sample section should wait before requesting fresh data. The time is given in seconds by default or as a set of qualified numbers (an integer followed by a multiplier). Following a number by `s` implies the number is seconds, `m` implies minutes, `h` implies hours, `d` implies days and "w" implies weeks.

Here are some examples:

`interval = 5` every five seconds,

`interval = 5s` every five seconds,

`interval = 2m` every two minutes,

`interval = 3h 10s` every three hours and 10 seconds.

When triggered by the timer, the *sample* target collects data and sends the aggregated data to one or more reporting targets. The `write` attribute is a comma-separated list of reporting targets to which data should be sent.

The following example records the number of threads in each state in a log file every 2 minutes.

```
[apache]

[sample]
 interval = 2m
 read = apache.Threads
 write = filelog

[filelog]
```

```
 file = /tmp/output
```

3.6.3. Named vs Anonymous samples.

As with monitoring and reporting targets, a *sample* target can be assigned a name using the `name` attribute. These *sample* targets are *named samples*. If no `name` is specified then the *sample* is an *anonymous sample*. As with all other targets, named *sample*s must have names that are unique and not used by any other target.

However, unlike named monitoring and reporting targets, it is OK to have multiple anonymous (unnamed) *sample* targets. Anonymous *sample*s are given automatically generated unique names. Although it is possible to refer to an anonymous *sample* by its generated name, the form of these names or the order in which they are generated is not guaranteed. Using an anonymous *sample*'s generated name is highly discouraged: don't do it!

Named *sample*s can be used as if they were a monitoring target. When data is requested from a named *sample*, the *sample* requests data from its sources and returns the aggregated information. The following example illustrates this.

```
[mysql]
 user = monami
 password = something-secret

[apache]

[sample]
 name = core-services
 read = apache, mysql
 cache = 60s

[sample]
 interval = 60s
 read = core-services
 write = filelog

[filelog]
 file = /tmp/output
```

3.6.4. Adaptive monitoring

Adaptive monitoring is a form of internally-triggered monitoring that is not necessarily periodic. Under stable conditions, adaptive monitoring will be periodic; however, if the monitored system takes increasingly longer to reply (e.g., suffers increased load), adaptive monitoring will adjust by requesting data increasingly less often.

Overview

Fixed-period monitoring (e.g., monitoring once every minute) is commonly used to monitor services. This data can be plotted on a graph to show trends in activity, service provision, resource utilisation, etc. It can also be recorded for later analysis. It also allows status information (e.g., number of connected) to be converted into event-based information (e.g., too many connections detected) within a guaranteed maximum time.

When monitoring a service, the data-gathering delay (between the monitored system receiving a request for the current status and delivering the data) should be small compared to the time between successive requests. If you are asking a database for its current status once every minute, it should not take this database 50 seconds to reply! There are two reasons why this is important:

First, it is important that the monitored system is not overly affected by MonAMI. There may be no way of knowing whether an observed large data-gathering delay is due to MonAMI; but whatever the cause, it suggests that MonAMI should not be monitoring so frequently.

Second, MonAMI has no idea whether the data-gathering delay occurred before the service recorded its current state or after. If the size of this uncertainty is about the same size as the *sample*'s `interval`, then there's little point sampling this often.

Rather than maintaining a constant sampling period (e.g., once every minute), adaptive monitoring works by maintaining a constant *duty-cycle*. The duty-cycle is the percentage of the period spend "working". If an activity is repeated every 40 seconds with the system active for the first 10 seconds the duty cycle is 25%; if the situation changes so it's now active for 30s every 40s then the duty cycle will have increase to 75%.

Whenever MonAMI acquires data from a monitored service, it keeps a record of how long it took to get the monitoring data. It uses that information to adjust an estimate of how long the next data acquisition will take. The process is described in Section 3.3.4, "Estimating future data-gathering delays". This estimate, along with the desired sampling period allows MonAMI to estimate the duty-cycle of the next sample. MonAMI can then adjust the sampling period to try to keep this close to the desired duty-cycle.

In addition to the desired duty-cycle, there are two other parameters that affect adaptive monitoring: a lower- and upper- bound on the delay.

The lower-bound on the delay is the smallest delay between successive requests MonAMI will allow. If a service is so lightly loaded that it is responding almost instantaneously then the lower-bound limit will prevent MonAMI from sampling too fast. The `interval` attribute gives the lower-bound when MonAMI is adaptively sampling.

The upper-limit is the largest delay between successive requests: the adaptive monitoring will not sample less frequently that this limit. This is useful should, for whatever reason, a service takes an anomalously long time to reply. Without an upper-limit, MonAMI would adjust the sampling interval to compensate for this anomalous delay and might take an arbitrarily long time to return to a more normal sampling period. The *sample*'s `limit` attribute provides this upper-limit to adaptive monitoring.

Adaptive monitoring as a safety feature

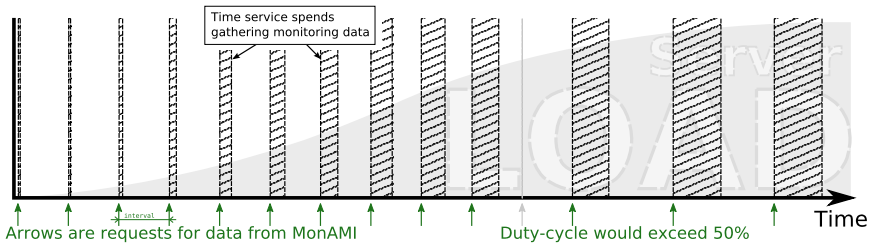


Figure 3.7. Adaptive monitoring increasing sampling interval in response to excessive server load.

Adaptive mode is enabled by default with a target duty-cycle of 50%. This is meant as a safety feature and anticipates that the observed duty-cycle, under normal conditions, will be less than 50%: if sampling once every minute, we expect gathering of data to take less than 30 seconds.

Whilst the duty-cycle is low, MonAMI will conduct periodic sampling; however, should the measured duty-cycle exceed the 50% limit, the monitoring will switch into an adaptive mode and MonAMI will sample less often. This could be due to any number of reasons; but, once the system has recovered and the duty-cycle has dropped to below the 50% limit, MonAMI will switch off the adaptive timing and resume periodic monitoring.

If MonAMI switches to adaptive monitoring too often then the 50% target may be too low or the sample interval is set too small. Either sample less often (increase the `interval` attribute) or set an explicit `dutycycle` attribute value greater than 50%. Specifying a `dutycycle` value of zero will disable adaptive mode, and so enforce periodic monitoring.

There is currently no support within MonAMI for extending the adaptive monitoring support to include on-demand monitoring flows. This is because none of the currently available on-demand reporting systems provide the facility to indicate that they should sample less frequently.

Adaptive monitoring by default

If a sample target's `dutycycle` attribute is set to a desired duty-cycle and the `interval` attribute value is set sufficiently small then the sample will operate in adaptive mode by default. Adaptive monitoring is then elevated from a safety feature to being the normal mode of operation for this *sample* target.

If no `interval` is set, a default interval value of one second is used. This places a lower-bound on the sampling frequency: MonAMI will not attempt to monitor more frequently than once per second.

Adaptive monitoring has strengths and weaknesses compared to periodic monitoring. There is greater certainty that the monitoring is not overly affecting your monitored systems. However, adaptive monitoring is a new feature. Support within the various reporting systems for this mode of operating will vary, and analysing the resulting data is more complex.

3.6.5. Sample attributes

In summary, each *sample* section accepts the following options:

`interval` period, optional

specifies how often data should be collected. The format is a series of numbers, optionally qualified, separated by white space, for example `1h 2m 30s` would repeat every 1 hour, 2 minutes and 30 seconds. Seconds is assumed if no qualifier is specified. The total interval is the sum of all numbers present.

If no interval and no duty-cycle is specified, the *sample* will never trigger data acquisition. Instead it will act as an aggregator of data, requesting data only on-demand.

If a `dutycycle` attribute is specified, the `interval` attribute specifies a lower-bound on the sampling period during adaptive mode monitoring. If no `interval` is specified, a default lower-bound of one second is used. Setting an `interval` of zero permits arbitrarily short sample periods (not recommended).

`read` string, required

a read string specifies which sources to query and which information to report back. The format is a comma-separated list of definitions. Each definition is either a target name or a target name, followed by a period (`.`), followed by the name of some part of that target's datatree. If only the target is specified, the whole datatree is referred to; if the part of the datatree referred to is a branch-node, then any data below that branch is referred to. Any definition can be negated by starting with an exclamation mark (`!`), which makes sure that element is not included in the report. For example:

```
foo, bar, !bar.unimportant, baz.important
```

would include all data from `foo`, all from `bar` except that within the `bar.unimportant` branch, and data from `baz` contained within the `important` branch. The names `foo`, `bar` and `baz` are either defined by some target's `name` attribute, or the default name taken from the target's plugin name.

`write` string, optional	a comma-separated list of targets to whom the collected information will be sent. This attribute must be specified if the *sample* is internally triggered (either `interval` or `dutycycle` attributes are set).
`dutycycle` percent, optional	the desired or threshold duty-cycle value for monitoring using adaptive mode. MonAMI will measure and adjust the sampling period to keep the measured duty-cycle less than or equal to this value. Upper- and lower-bounds will prevent sampling too infrequently or too often. If the `interval` attribute is specified but `dutycycle` is not, a default value of 50% is used.
`limit` period, optional	The upper limit to the sampling period for adaptive monitoring. MonAMI will never sample less frequently that this. If not specified, a default value is used. The default value is twenty times the interval attribute, if specified, or twenty minutes if not.

3.7. Configuring Event-based Monitoring

Some monitoring involves capturing that a particular activity happened, when it happened and some metadata associated with the activity. A concrete example of event monitoring is watching file transfers from a web-server: one might wish to monitor for requests for missing files (404 `HTTP` status-code) to be alert to some broken part of a web-site. One might also look for which parts of a website are under heavy load, so to better load-balance the operation.

With any event there is some associated metadata. For a web request, this metadata includes the web-browser's User-Agent string, the browser's hostname (or `IP` address), how much data was transferred, etc. Within MonAMI, this information is presented as a datatree. Events are merely new datatrees that can be directed to one (or more) reporting targets.

A monitoring target that provides events typically will split those events into separate channels. The channels form a hierarchy of different activity. For example, an *apache* target can be configured to provide events based on `HTTP` requests the Apache server receives. These events can be provided as the `access` channel. Events from the `access` channel can be further divided into events from the `access.1xx`, `access.2xx`, `access.3xx` and `access.4xx` channels based on the resulting `HTTP` status-code. The `access.4xx` channel is further subdivided based on the actual code, so into `access.4xx.401`, `access.4xx.402` and so on.

3.7.1. dispatch

The *dispatch* targets describe which events are to be monitored, what information is to be send and to which reporting targets the information is to be sent. Event monitoring works using a subscription model. The *dispatch* target subscribes to one or more *channels* to receive events that match. A *dispatch* that subscribes to a branch (within a channel hierarchy) will receive all events that match any of the more-specific events: subscribing to `access.4xx` will receive events on channel `access.4xx.401`, `access.4xx.402`, `access.4xx.403`, and so on.

When receiving a datatree, the *dispatch* can select some subset of the available data. Each event might have a large amount of information that, in some particular case, is not needed. The `select` attribute specifies which data is needed. It uses the same format as the *sample* target's `read` attribute (see Section 3.6.1, “The read attribute”).

Finally, a *dispatch* section must specify to which reporting target the datatree is to be sent. The `send` attribute contains a comma-separated list of reporting targets to which the data should be sent.

A simple example is:

```
[apache]
```

```
  log = access: /var/log/apache/access.log [combined]

[dispatch]
 subscribe = apache.access.4xx.404
 select    = apache.user-agent
 send      = apache-404-useragent-log

[filelog]
 name = apache-404-useragent-log
 filename = /tmp/monami-apache-ua.log
```

3.8. Example configurations

The following section contains some example configurations. The first three examples show examples of the three data-flows: on-demand, polling and event monitoring. The fourth example shows a more complicated example, which includes all three monitoring flows.

For simplicity, all examples are presented as a single file. This file could be `/etc/monami.conf`, or (with the default configuration) some file within the `/etc/monami.d/` directory. With complex configuration, the monitoring targets, reporting targets, and *sample* or *dispatch* targets may be in separate files (as described in Section 3.2.3, “Auxiliary configuration file directories”). However the configuration is split between files, provided the targets are defined the examples will work.

3.8.1. On-demand monitoring example

This example shows how to configure MonAMI to monitor multiple targets: a local MySQL database, a local and remote Apache webservers with KSysGuard. The *sample* acts as an aggregator, allowing KSysGuard to see all three monitoring targets.

The results are cached for ten seconds by the *sample* target. This prevents the KSysGuard target from sampling too fast, whilst allowing other (undefined, here) monitoring activity to continue at faster rates.

```
# Our local MySQL instance
[mysql]
 user = monami
 password = monami-secret

# Our local Apache server
[apache]
 name = apache-test

# A remote Apache server
[apache]
 name = apache-public
 host = www.example.com

# Put together monitoring targets for ksysguard.
[sample]
 name = ksysguard-sample
 read = apache-test, apache-public, mysql
 cache = 10

[ksysguard]
 read = ksysguard-sample
```

3.8.2. Polling monitoring example

The following example configuration has MonAMI recording the Apache server's thread usage and a couple of MySQL parameters. The results are sent to Ganglia for recording and plotting. The Apache and MySQL monitoring occur at different rates (30 seconds and 1 minute respectively).

```
# Our local apache server
[apache]

# Our database
[mysql]
 user = monami
 password = monami-secret

# Every 30 seconds, send current thread usage to our internal
# ganglia.
[sample]
 interval = 30
 read = apache.Threads
 write = internal-ganglia

# Every minute, send some basic DB usage stats
[sample]
 interval = 1m
 read = mysql.Network.Connections.current, \
        mysql.Execution.Open.tables.current
 write = internal-ganglia

# Ganglia, making sure we send data to an internally connected NIC.
[ganglia]
 name = internal-ganglia
 multicast_if = eth1
```

3.8.3. Event monitoring example

The following example shows event-based monitoring. The *apache* target is configured to watch the access log file, which contains a log of accesses to the "public" virtual host.

The *dispatch* subscribes to those transfer requests that result in a HTTP 404 error code ("file not found"). Of the available datatree, only the referrer and user-agent are selected for forwarding to the `public-404-logfile` *filelog* target.

```
# Our local apache server
[apache]
  log = public_access : /var/log/apache/public/access.log [combined]

# Subscribe to those 404 events, sending them to the filelog
[dispatch]
  subscribe = apache.public_access.4xx.404
  select = referrer, user-agent
  send = public-404-logfile

#  Log these results.
[filelog]
  name = public-404-logfile
  filename = /var/log/apache/public/404.log
```

3.8.4. A more complex example

The following example combines all three previous monitoring flows in a single configuration file. Graphs of Apache thread usage and MySQL database statistics are produced with Ganglia, HTTP requests that result in a 404 error code are recorded and KSysGuard can connect to MonAMI (whenever the user decides) allowing more detailed monitoring either of the Apache or MySQL services.

Although this example groups similar sections together, this is mainly for readability: the order in which the targets are defined does not matter, and may be split over several files (see Section 3.2.3, "Auxiliary configuration file directories").

```
##
##  Reader targets: sources of information.
```

```
##

[mysql]
  user     =  monami
  password =  monami-secret

[apache]
  log = public_access : /var/log/apache/public/access.log [combined]


##
##   Samples
##

# Every 30 seconds, send current thread usage to our ganglia.
[sample]
 interval = 30
 read = apache.Threads
 write = ganglia

# Every minute, send some basic DB usage stats
[sample]
 interval = 1m
 read = mysql.Network.Connections.current, \
        mysql.Execution.Open.tables.current
 write = ganglia

# Put together monitoring targets for ksysguard.
[sample]
 name = ksysguard-sample
 read = apache, mysql
 cache = 10


##
##    Dispatches: directing events to writer targets.
##

# Subscribe to those 404 events, sending them to the filelog
[dispatch]
  subscribe = apache.public_access.4xx.404
  select = referrer, user-agent
  send = public-404-logfile


##
##    Writer targets: those that accept data.
##

# Log for any 404s
[filelog]
  name = public-404-logfile
  filename = /var/log/apache/public/404.log

# Listen for ksysguard requests for data.
[ksysguard]
 read = ksysguard-sample

# Ganglia, making sure we send data to an internally connected NIC.
[ganglia]
 name = internal-ganglia
 multicast_if = eth1
```

Chapter 4. Security

When running any software some consideration must be made towards the security impact of that software. MonAMI, like any software, will have an effect on a machine's security risk. This section aims to give a brief overview of the likely security risks and what can be done to to reduce them.

4.1. General comments

It is worth pointing out that running MonAMI does not, in and of itself, provide any greatly increased security risk. There are no known vulnerabilities in the software and the dangers described here are common for any software that attempts the monitoring activity MonAMI undertakes.

Although this section gives information on running MonAMI it is not, nor can it be, exhaustive. Many of the security issues will arise from site-specific details so a full analysis can only be done in knowledge of the MonAMI configuration in use along with other factors: technical factors (firewalls, network topology, information storage configuration, ..), usage policies (who else uses the machines MonAMI runs on?) and other issues ("what information is considered secret?").

Security as a process, not a check list.

One cannot express security as solely a list of things to check or actions to undertake; this includes the comments in this section. Best-practice (once established) is a guide: a minimal set of activities or configuration. There will always be aspects too general (e.g. management processes) or too site-specific (e.g. has software X been configured with option Y disabled) to be included within best-practice. Security will always require thinking, not just following procedure.

Security in depth.

One cannot rely on any one technology or process to fully protect a site. Limitations in software (or understanding of that software) may lead to a vulnerability in what is thought to be a perfectly protected system. Moreover, local policies might require running software so there are additional vectors of attack: risks might have to be balanced against inconvenience.

An effective way of reducing the impact of security exposure is to provide multiple barriers one must penetrate before a system is compromised. Although each barrier may be imperfect, each will provide a sufficient challenge that either the attacker will give up (and look for an easier target) or the attack is discovered and counter-measures taken.

To illustrate this, consider the *mysql* monitoring plugin (Section 3.4.8, “MySQL”). This plugin needs a MySQL account with which it can log into the database server. The login credentials could be any valid MySQL user. Although strongly discouraged, this could be the MySQL root user, which has all administrative privileges.

Whatever MySQL user is used, one would try to ensure no one can discover the username-password pair. But, if MonAMI is using a MySQL user with no unnecessary privileges, should someone discover the username-password pair they would gain little without subsequently defeating the user-privilege separation within the MySQL server. The barriers they would have to overcome would be:

1. gaining access to the machine (presumably as some user other than user monami)
2. defeating the server's file-system permissions (to read the MySQL password)
3. defeat the MySQL server permissions (to gain privileges)

Each barrier is formidable yet potentially vulnerable (either through software bug or from being misconfigured). Together, the steps required to obtain full access to the database is much harder, sufficiently hard that an attacker would most likely use some other route.

4.2. Risks arising from running MonAMI

This section describes some explicit risks that one encounters when running MonAMI. For each section, there are a few suggested things to check. The checks are hopefully straightforward; verifying these items should greatly reduce the risk.

As stated earlier, a list of checks should not be confused with having a secure system. Following best practise should eliminate or greatly reduce the impact of these risks, but the user should be aware of them and plan accordingly.

4.2.1. Information distributed too readily.

Sending out information is MonAMI's modus operandi. However, some information is dangerous or sensitive.

Information might be sensitive for any number of reasons. Monitoring might give an indication of capacity or utilisation, or the broad direction in which activity is going. Such information might be sensitive for business. Thieves might target rooms in which computers have been idle for some time.

Dangerous information is not sensitive now, but might be sensitive in the future. Information that indicates which software and software version is being run could be correlated against databases of known vulnerabilities. Distributing software version numbers is the most obvious example of this, but other information might indicate which software is being run.

Check that...

a. information being sent is not sensitive,
b. the information systems are sufficiently secure,
c. no information that might identify which version of some software is being run is distributed where it might be discovered.

4.2.2. Passwords being stored insecurely

The danger here is that someone discovers the username-password pair needed to gain access to some system. The most likely cause is inappropriate file-system permissions.

Using the "security in depth" concepts, passwords should be created with limited functionality, ideally with only sufficient privileges to retrieve monitoring information.

Many password-based authentication systems have the option of restricting from which hosts it will accept credentials. By limiting login via monitoring credentials to be only from the MonAMI host (which is perhaps "localhost"), any stolen username-password pair is useless unless the MonAMI host is also compromised.

Check that...

a. the MonAMI configuration files are owned by user monami and have read-only permission for that user and no read permission for anyone else.
b. that user-password pairs used by MonAMI have limited functionality and (ideally) are not shared with other users.
c. wherever possible, the monitoring username-password pair should be restricted so it only functions from the machine on which MonAMI is running.

4.2.3. A bug in MonAMI is exploitable

Any software can have bugs; MonAMI is no exception. Bugs range from the annoying (doesn't work as specified) through to the dangerous. Perhaps the most dangerous is if, through MonAMI, a remote user can control files or run commands on the local machine.

Although there are no known bugs in MonAMI, it is prudent to assume they exist and to reduce the impact of them. For this reason, MonAMI supports "dropping root privileges" to switch to running as some other user. We recommend that this feature be used and the other user be distinct (i.e. not to use some generic user "daemon" or "nobody"). Someone exploiting MonAMI (should that be possible), would then only gain the use of an unprivileged user.

To achieve monitoring activity, certain MonAMI configurations accepts some network traffic. Wherever possible, the traffic to MonAMI should be firewalled. Only network traffic from trusted machines can reach MonAMI.

Check that...

a. the *monamid* process is running as an unprivileged user,
b. the unprivileged user cannot cause trouble,
c. network traffic to MonAMI's ports is sufficiently protected; for example, it passes through a suitably configured firewall.

4.2.4. MonAMI tricked into providing a Denial-of-Service attack

Monitoring impacts on the service that is to be monitored. If MonAMI is run such that it attempts to gather information with high frequency, then it might impact strongly on the service, even providing a denial-of-service attack.

If properly configured, monitoring that is triggered internally (see Section 3.6.2, “Timed sample targets”) should pose no problem. On-demand monitoring (for example, the *ksysguard* plugin, Section 3.5.6, “KsysGuard”) could potentially request monitoring data sufficiently quickly to saturate MonAMI-core. This might lead to problems with MonAMI and the services being monitored. To reduce this, suitable caches can be defined (see Section 3.3.2, “The cache attribute”) and access to on-demand monitoring should be limited through correctly configured firewalls.

Check that...

a. suitable cache values are specified, especially for any on-demand monitored targets.
b. any on-demand monitoring network port is suitably protected; for example, by using a suitably configured firewall.
c. the MonAMI configuration files are not world-writable and that any auxiliary configuration directories (as defined in a `config_dir` attribute) does not permit normal users to write additional monitoring configuration.

Chapter 5. Further Information

There are a number of sources for further information:

- The *MonAMI website* [http://monami.sourceforge.net/] contains up-to-date information about monitoring and reporting plugins
- The *MonAMI blog* [http://monami-at-large.blogspot.com/] has comments and ideas on monitoring.
- There are various mailing lists for the MonAMI community.

  monami-announce — a very low volume list for people want to know about future releases of MonAMI. To subscribe, visit the *mailman page* [https://lists.sourceforge.net/lists/listinfo/monami-announce].

  monami-users — a list for people who are using MonAMI. To subscribe, visit the *mailman page* [https://lists.sourceforge.net/lists/listinfo/monami-users].

  monami-devel — a list for people who are working on improving MonAMI. To subscribe, visit the *mailman page* [https://lists.sourceforge.net/lists/listinfo/monami-devel].

Please send feedback about this document (including any omissions or errors) to the developers' mailing list.