Prophasis - An IT Infrastructure Monitoring Solution

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Abstract

Prophasis is an IT infrastructure monitoring system that is designed to suit small to medium size businesses where a system needs to be intuitive to manage. Management of the entire system can therefore be handled from a single, responsive web interface. It is also suitable as a one-stop tool with support for both time series monitoring in addition to real time alerting. Traditionally two different tools would be needed to gain this level of monitoring.

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Chapter 1

Introduction

1.1 Background

In recent years, almost all businesses have been expanding their IT infrastructure to handle the modern demand for IT systems. As these systems grow and become increasingly important for business operation it is crucial that they are sufficiently monitored to prevent faults and periods of downtime going unnoticed. There is already a large market of tools for monitoring IT systems however they are designed for use on massive scale networks managed by teams of specialised systems administrators. They are therefore complicated to set up and manage and multiple tools are often required to gain a suitable level of monitoring.

For example, tools generally either fall into the category of real time alerting (i.e. telling someone when something breaks) and time series monitoring (i.e. capturing data about the performance of systems and presenting graphs and statistics based on it), there is a large gap in the market for tools that provide both of these in one package. This reduces the time required to manage the system as it eliminates the need to set up and configure two completely separate tools.

These tools are also generally managed and configured through various configuration files split across different machines on the network. This means that in order to efficiently use these tools a configuration management system such as Puppet must be used. In a small business with limited IT resources, a completely self contained system is often preferable.

1.2 Current Landscape

This section will review current IT infrustructure monitoring systems and evaluate them on several points as follows:

- Support for timeseries monitoring and real time alerting
- How they can be configured to monitor custom metrics
- How are alert thresholds defined
- How configuration and custom code is delivered to nodes (if requried)
- How the user configures the system
- How dependencies are handled

1.2.1 Nagios

Timeseries monitoring and real time alerting Nagios is primarily focused at real time alerting and therefore has very little in the way of timeseries monitoring. Additional plugins are available which can be used to graph metrics over time but these cannot be used to make decisions on the status of a given system or service. All that is supported in terms of alerting on historical data is to refrain from alerting until a given condition has been observed in the previous n checks, there is no support for alerting based on trends in historical data. Supports basic display of changes in state of hosts/services over time but not individual metrics.

Support for custom metrics Nagios has support for custom metrics through the NRPE (Nagios Remote Plugin Executor) plugin. These plugins can be any sort of executable which prints out a message to represent the data read as well as a specific exit code which defines the status, for example ”OK”, ”Critical” .etc

Alert threshold definition Thresholds for NRPE agents must be set on the remote server itself. These thresholds are passed into the remote plugin as an argument when it is executed and are used internally by the script to output the approprate alert level.

Code/Config delivery to nodes Nagios does not have any in built functionality to distribute configuration files or plugin code to remote nodes. In order to automate this, additional software such as Puppet would be required.

How the user configures the system Configuration for Nagios is primarily managed through text files stored on disk. Third party configuraiton tools are available to allow the system to be configured through a web interface. Configuration lives on both the Nagios server as well as on the machines being monitored.

How dependencies are handled Rigid tree - No way to define that a service/host is dependant on a given host OR another host being available. This reduces its usefulness in modern networks where redundancy and failover is commonplace. These are defined in config files that live on the Nagios server.

1.2.2 Icinga 2

Timeseries monitoring and real time alerting Like Nagios, Icinga's primary focus is around real time alerting however it has now introuced support for graphing performance metrics. No support for alerting based on trends in historical data beyond Nagios's idea of a state change changing to HARD once it has been observed *n* times.

Support for Custom Metrics Custom metrics can be written as scripts in any language as long as they echo a message to describe the status of what they are checkign and use a certain exit code to define the status e.g. "OK", "CRITICAL", "WARNING".etc.

Alert threshold definition Thresholds are passed into the check commands as command line arguments. Therefore they are defined on the machines being monitored individually.

Code/Config delivery to nodes Icinga 2 does not have any built-in mechanism to distribute code and config files to remote hosts. In order for this to be achieved, additional software such as Puppet would be required.

How the user configures the system Configuration is managed through configuration files stored on disk. Configuration files exist both on the Icinga server as well as the nodes being monitored.

How dependencies are handled Same as Nagios with a rigid tree. No way to define a host/service as being dependent on one of several different machines as is common in modern environments with redundancy/failover systems.

1.2.3 Munin

Timeseries monitoring and real time alerting Munin is targeted primarily as a timeseries monitoring tool. It therefore has good functionality for graphing data over time. However, it does not have much power in the way of alerting other than some very basic functionality where plugins must manually send out emails/syslog alerts. This is not really sufficient for any sort of production use and it instead recommended to use a tool such as Nagios and push the data from Munin into it.

Support for custom metrics Munin has a simple interface for custom plugins where a plugin is a simple script that prints out the name and value of the data being collected. This is then served by the Munin node which the Munin server contacts over the network to fetch values from the nodes.

Alert threshold definition Nothing built in, plugins however can create thresholds internally and use them for alerting (as detailed above) although this isn't really the intended use of Munin.

Code/Config delivery to nodes Nothing built in, code and config must be distributed manually or automatically through the use of additional software such as Puppet.

How the user configures the system Configuration is handled through text files stored on disk. These are stored on both the Munin server as well as machines being monitored.

How dependencies are handled No dependency functionality.

1.3 Improvements

Prophasis is designed for use in a small to medium business with limited IT resources. They may have a small IT team with limited resources or may not even have

a dedicated IT team at all, instead relying on one or two employees in other roles who manage the business's IT systems on the side of their regular jobs. Therefore the system needs to be quick to deploy and manage with a shallow learning curve. In order to use the system efficiently there should be no requirement for additional tooling to be deployed across the company.

1.3.1 Configuration Management

It should be possible to manage the configuration of the system from a single location. Prophasis therefore provides a responsive web interface where every aspect of the system's operation can be configured, Prophasis then handles distributing this configuration to all other machines in the system in the background. Custom code for plugins is handled in the same way; it is uploaded to the single management machine and is then automatically distributed to the appropriate remote machines when it is required.

1.3.2 Time Series Monitoring & Real Time Alerting

Prophasis provides both the ability to alert administrators in real time when a fault is discovered with the system alongside functionality to collect performance metrics over time and use this data to generate statistics about how the system has been performing. This time series data can be used to both investigate the cause of a failure in post-mortem investigations in addition to being able to be used to predict future failures by looking at trends in the collected data.

1.3.3 Expandability

It is important that a monitoring tool can be expanded to support the monitoring of custom hardware and software. An example of this would be hardware RAID cards. Getting the drive health from these types of devices can range from probing for SMART data all the way to communicating with the card over a serial port. It is therefore crucial that Prophasis can be easily expanded to support custom functionality such as this. Therefore Prophasis supports a system of custom ”plugins” which can be written and uploaded to the monitoring server where they can then be configured to monitor machines. These plugins are designed to be self contained and to follow a well defined and documented structure. This provides scope for a plugin ”marketplace” therefore eliminating the need for every user to implement custom monitoring

code for the systems they are using.

Chapter 2

Design

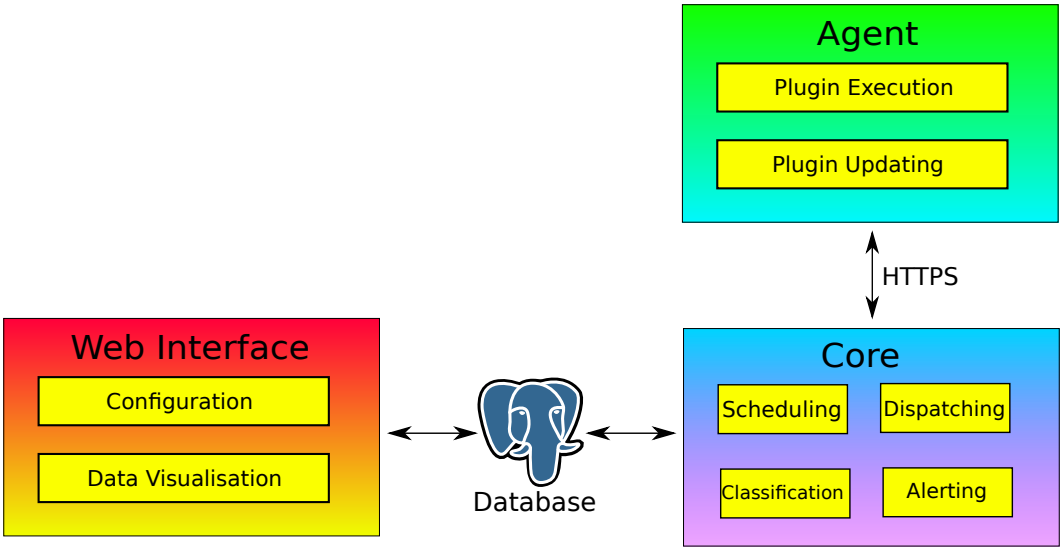
2.1 Technology Choice

2.1.1 Why Python?

2.1.2 Why HTTPS?

2.2 System Structure

The system is split up into three separate components; Web, Core and Agent. Web and core both share the same relational database allowing data to be shared between them.



2.2.1 Agent

The agent runs on every machine that is being monitored and provides an API for communication with the monitoring server. It listens on port 4048 (by default) and exposes an HTTPS API. This API includes methods to check the version of a plugin currently installed on the agent, a method to push updated plugins to the agent and another method to execute a plugin and to retrieve the value and message produced by it.

The agent's API is authenticated using a long, pre-shared key of which a salted hash is stored on the agent in a configuration file. Being hashed prevents users who may have access to read the configuration file (possibly through misconfiguration) from getting the key to be able to communicate with the agent.

2.2.2 Core

The core runs on the machine that is performing the monitoring, it has several different roles; scheduling, dispatching, classification and alerting.

Scheduling The core is responsible for looking at the schedules stored in the database and executing the appropriate checks on the correct hosts at the correct time. There is a configuration value for ”maximum lateness” that defines how late after its defined time slot a check can be executed. The core repeatedly checks the database looking at the intervals for each schedule along with the time at which a given schedule was last executed. If it decides that a schedule is due to be executed it passes this onto the dispatcher.

Dispatching The dispatcher component of the core is responsible for issuing checks to agents when they are due to be run (as decided by the scheduler). Checks may take some time to execute so executing these all in series would all be impractical. The solution for this was for the dispatcher to spawn a process for each agent that it is currently executing checks for. Each process maintains a queue of plugins that are due to be executed and issues them to the agent in the order that they were dispatched. This way only one plugin can be executing on a given agent at any moment in time. This both prevents agents from becoming overwhelmed and means that plugin developers do not need to be concerned about other plugins interfering with their plugin.

Classification When data is collected from an agent, it needs to be classified as ”ok”, ”major”, ”minor”, ”critical” or ”unknown”. Classification is performed by lua code that is stored alongside each plugin. When the core finishes collecting a from an agent it will retrieve the classification code for the plugin and execute it in a sandboxed lua runtime environment. The result of the classification is then stored in the database.

Alerting Once the core has classified a piece of data, the core now needs to work out whether it needs to send an alert or not. To do this it looks at the previous state for the plugin and host along with the current state. It then looks through the database for alerts that match that state transition and are applicable to the host/plugin combination. If any alerts match it will call the alert module to send the alert out to inform the necessary people about the state change.

2.2.3 Web Interface

Prophasis provides a web interface for both configuring the system and viewing collected data. The interface is designed to be clear and easy to understand for users. It is also built to be fully responsive so will work correctly on mobile device without any loss of functionality. Designing it to be responsive was the aim from the outset as servers often fail when the administrator may not currently be in easy reach of a computer so will need to use a mobile device to investigate the issue.

The web interface will connect to the same database as the core, the web interface will update the configuration data stored in this database and will retrieve the data about hosts.

The web interface provides dashboards for visualisation of data collected from plugins. The collected data can then be displayed using graphs, tables, lists of messages or any other way that suits the type of data collected.

2.3 Monitoring Methodology

2.3.1 Host Management

In Prophasis, a ”host” refers to a single machine that is being monitored. To aid management and organisation, it is possible to organise hosts into ”Host Groups.” These

can be comprised of hosts or other groups and can be used in place of hosts when defining services and checks. Hosts can be grouped in various ways such as their role (Webserver, VM Host), hardware configuration (Hardware RAID, Contains GPU), location (Edinburgh Office, Datacenter) or any other way that makes sense given the specific implementation.

2.3.2 Plugins

A ”plugin” is a package that checks a single attribute of a system. For example a plugin could check the CPU load of a given machine or be used to check the health of all the hard drives in a system. Plugins are implemented as Python modules that implement a specific API, they can return both a ”value” (a numerical representation of the data they collected) and/or a ”message” (a string representation of the collected data). Plugins are then packaged in a .tar.gz archive along with a manifest JSON file which contains information about the plugin for use when it is installed.

Plugins are automatically distributed from the core to remote machines and when executed by the agent the value and message are returned to the core for classification and storage in the database.

2.3.3 Checks

A ”check” is a named set of hosts/host groups and a set of plugins to be executed on them. When a check is executed, all of the plugins specified in the check will be executed across all of the hosts specified in the check.

Checks allow logical grouping of various plugins. For example you may have a check for ”Webserver Resource Usage” which will execute plugins to check the CPU load and memory across all hosts in the ”Webservers” host group.

2.3.4 Schedules

A schedule defines when one or more checks are to be executed. Each schedule can contain multiple ”intervals” which define when the check is run. An interval has a start date/time and a time delta that defines how regularly it is to be implemented.

2.3.5 Services

Services can be used to define a more fine grained representation of how the availability of a host affects the performance of the system overall. A service is defined in terms of ”dependencies” and ”redundancy groups”. Each dependency represents a host that must be operational for the service to work. A redundancy group can contain multiple hosts where at least one must be operational for the service to work.

As an example, you may have a ”Website” service that has a dependency on the single router but has a redundancy group containing multiple webservers. Therefore, if the router fails then the website will be marked as failed however if one of the webservers fails but at least one other webserver is still operational, the website service will only be marked as degraded.

The use of services provides a clearer view of the impact of a given failure on the functionality of the network. It also allows alerts to be set up so that they are only triggered when the service functionality is severely impacted and prevents alerts from being sent out for host failures that do not have a severe impact.

2.3.6 Alerts

In Prophasis, alerts are set up to communicate with a specific person/group of people in a certain situation. Alerts are defined in terms of to/from stage changes where an alert will be sent if the state of a host/service changes from one state to another (e.g. ”ok” to ”critical”). These can then be restricted to certain hosts, host groups, services, plugins and checks.

The system supports ”alert modules” - Python modules that are used to send alerts using various methods. Examples of alert modules could be email, SMS or telephone call.

Multiple alerts can be set up to handle different severities of issues. For example, if a redundant service becomes degraded, a SMS or email message may be sufficient but if a service becomes critical it may be desirable to use a telephone call to gain quicker attention.

Chapter 3

Implementation

3.1 Technologies

The vast majority of the system is implemented in Python 3. This allows for a large variety of modules to be used during development. Python is also widely available on UNIX systems and is easy to install on machines where it is not included.

The Python ”Virtual Environment” (Virtualenv) system is also extremely useful in this system. It allows all dependencies to be kept totally separate from the rest of the system, this is particularly important for the agent as it ensures that the agent cannot interfere with the Python environment of the systems it is running on.

3.1.1 Agent

The agent is built using the Flask web framework which handles routing URLs to the correct Python functions as well as handling request data and building the correct HTTP responses. The agent then uses the Tornado HTTP server to handle the actual socket connections to the outside world. Tornado was used as it can be easily built into the agent and does not require any external webserver to operate.

3.1.2 Web Interface

Like the agent, the web interface also uses the Flask web framework. However, in this case it also uses the Jinja2 templating engine to render the pages that provide the web interface.

3.1.3 Database

All database functionality in Prophasis is handled through the SQLAlchemy ORM which abstracts the database into a set of Python classes (known as models). This not only reduces development time, it also reduces the likelihood of errors as all of the database queries are generated by the library rather than being handwritten. The SQLAlchemy models file can also be shared between both the web interface and the core preventing duplication of database query logic.

Prophasis has been officially developed to support PostgreSQL databases, however through the use of an ORM it is possible to easily move to different database platforms such as MySQL or Oracle. SQLAlchemy transparently handles the difference between different database platforms when generating its queries.

3.2 Plugin Interface

- Explain structure of a plugin
- UML Diagram?
- Why Lua for classification logic?

3.3 Database Design

3.4 Web Interface

- Go into detail about web structure WRT templates, assets.etc

3.5 Core

- Scheduling
- Multi-threaded dispatcher

3.6 Agent

- Communication

- Authentication

Chapter 4

Testing

- Unit testing
- Use within Tardis & Lynchpin

Chapter 5

Evaluation

Chapter 6

Conclusion