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NETWORK MONITORING : Using Nagios as an Example Tool

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ABSTRACT

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Name of thesis NETWORK MONITORING: Using Nagios as an Example Tool		
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The aim of this thesis is to implement a network monitoring using an open source network management utility to check the state of network elements and associated services. Such management tools must have capability to detect and respond to faults in the network by generating appropriate alert to notify the system administrator accordingly.

Nagios core was used as the network management utility for the network for demonstration of monitoring exercise. Theoretical functions of the Nagios Core were presented and a concise description of SNMP was addressed in relation to the Nagios functionalities. Nagios was configured with its plug-ins and used against a test-laboratory network run in the Linux environment. The test network comprised of two switches, one router and the Nagios server. The results from the Laboratory demonstration exercises are presented in the framework.

Furthermore, the implementations of Nagios for optimal performance can be laborious, but my experiences with Nagios and its resourceful outcomes proved to be worthwhile. Nagios is therefore recommended for use in companies and institutions for monitoring their networks. Also, the laboratory part of this thesis could be used as a learning module for students to acquire skills and to identify the importance of network monitoring.

Key words
Network Management, Nagios core, Simple Network Management Protocol

Table of Contents

ABBREVIATIONS

CGI	Common Gateway Interface
CMIP	Common Management Internet Protocol
CMISE	Common Management Information Service Element
GUI	Graphical User Interface
IP	Internet Protocol
MIB	Management Information Base
NMA	Network Management Architecture
NMS	Network Management System
NMT	Network Management Tool
OID	Object Identifier
PDU	Packet data Unit
SNMP	Simple Network Management Protocol
TCP	Transport Control Protocol
UDP	User Datagram Protocol

1 INTRODUCTION

As the computer networking became more popular, every aspect of life has been shifted to network technologically inclined, which results to increased computing power, sharing of resources and communication between users. The proliferation in the network technologies poses challenges to the network administrator on how to manage and control the emerged network. In computer networks, challenges may arise, which may disrupt the state of such network. Typically, computer network management challenges grow as the computer network expands. Thus, the need to manage the network arises upon the network growth.

However, network management systems have been utilized in the past in attempts to address such network challenges. These early network management systems were typically operated by monitoring and logging a large volume of information from the network devices. Such information was interpreted and evaluated by an experienced network administrator. Despite the skillful knowledge of the network administrator, it became burdensome to network administrator to handle. This is particularly the case as the networking devices became more intelligent and more effective technologies emerged, couple with the complexity in the present network.

Based on the foregoing, it is therefore desirable to provide an automated network management system which can systemize the knowledge of the networking-expert such that common problems can be detected, isolated and fixed by alerting the network personnel before such problems become critical. In this regard, in an attempt to ensuring a healthy network, it is necessary to adopt an automated mechanism to organize and manage the network. These mechanisms are generally implemented in a form of one or more computer programs known as network management systems or applications.

There are numerous open source and off-the-shelf network management applications that can be used to handle network management issues while the selection can be based on the network requirement. In this work, an open source network management application named Nagios will be employed. This network management application is used to examine and demonstrate network monitoring of the network infrastructure and provision of alerts when modifications or problems are detected. This exercise will be the focus of this thesis.

The aim of this thesis is to explore the network management and to demonstrate how network-related problems that arise from the network can be monitored and attended to, with the aid of an open source monitoring application. This aim will be achieved by setting up NAGIOS, an open source monitoring tool and designing a prototype network that will be basis for demonstrating the efficacy of the Nagios to monitor running hosts, available services, and associated server load thresholds on the proposed network.

The outline of the remaining part of this work is highlighted as follows: Chapter 2 gives explanation of network management and highlights the division of network management. Network monitoring techniques and scopes are presented. Selected network management protocols are also presented.

Chapter 3 introduces selected network monitoring software and gives a brief look into their features. Also, justifications for choosing Nagios over other network monitoring software are discussed.

Chapter 4 presents Nagios in details from its set-up requirement, installation, and its architecture. It briefly introduces the concept of plug-in enhancement.

Chapter 5 presents the prototype of laboratory framework for the demonstration of network monitoring using Nagios. Definitions of network devices and enabling of services are presented for monitoring to be functional. Also the snapshots of the monitoring activities are presented accordingly. Chapter 6 entails the conclusion followed by references with appendices.

2 NETWORK MANAGEMENT

2.1 What is Network Management?

Network management (NM) refers to the broad subject of managing computer networks. NM consists of a set of functions to control, plan, deploy, allocate, coordinate, and manage network resources. It involves a number of software and hardware products that system administrators use to manage a network. (Webopedia 2011.)

Network Management can be identified as any approach that includes monitoring the performance of the network, detecting and recovering from faults, configuring the network resources, maintaining accounting information for cost and billing purposes, and providing security by controlling access to the information flows in the network. However, network management covers a wide area, including security, performance, fault, and configuration. These aspects will be detailed later in this work. However, this thesis primarily focuses on performance management, both monitoring (detection) and control (resolution). (Jianguo 2009, 10.)

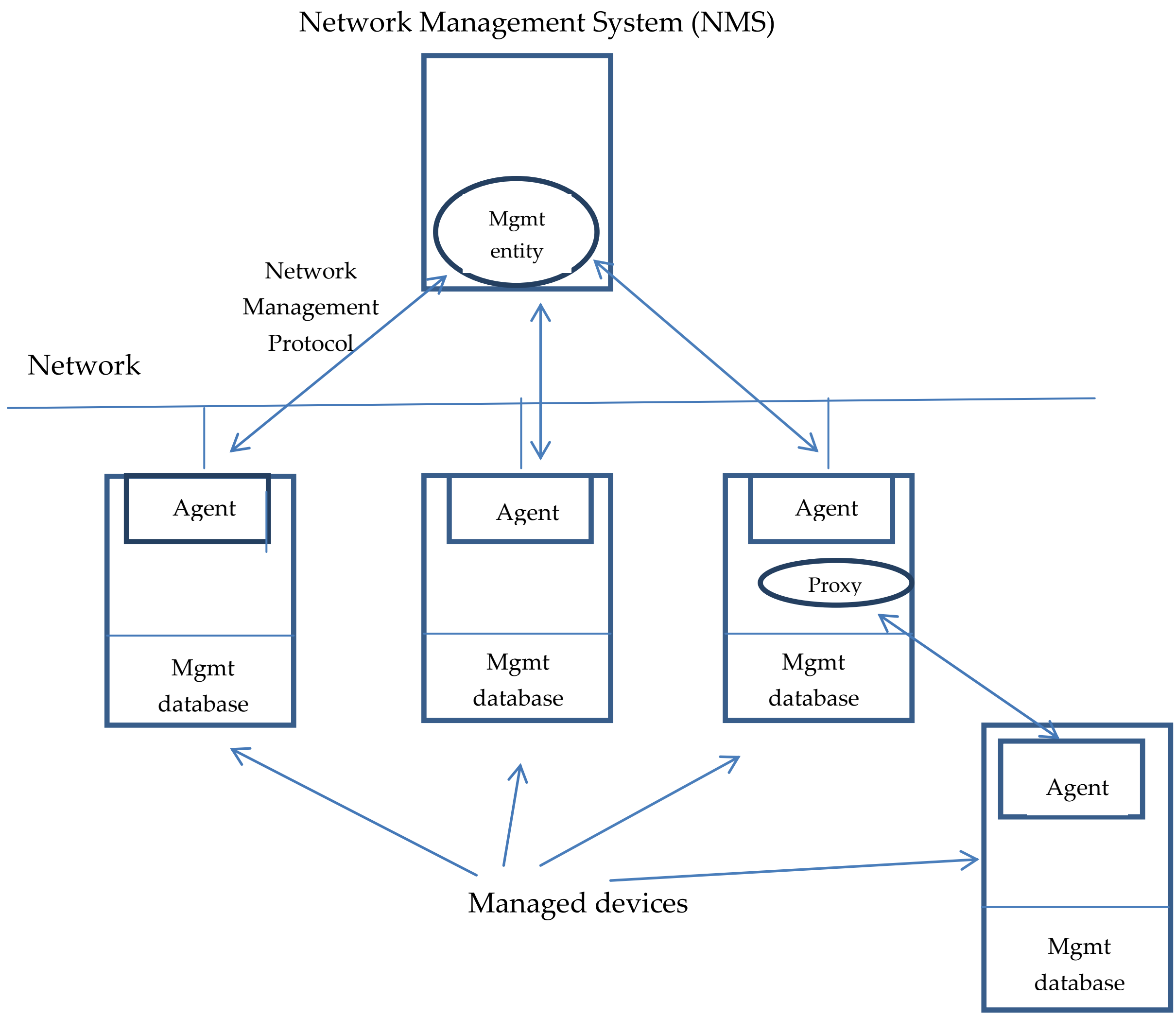
In general, network management functions include verification of the status of all network devices such as routers, switches, hubs and computers. NM also entails recording and analyzing error messages from all the aforementioned devices in order to monitor the health of all devices. (Sebastian & Adrian 2009,79.)

2.2 Network Management Architecture

Network management architecture (NMA) illustrates the hierarchy in which the participating devices are arranged in a network. The NM arrangement resembles management structures at workplaces where there will be a manager and group of employees reporting to the manager. There are certain rules or norms governing communication between the manager and the employees. The components of the network management system (NMS) include: manager, a set of agents, and a management protocol for the manager to interact with the agents, and the management information base (MIB) or management database that stores information about the network elements being managed. (Haojin 1999, 26.)

A manager is a management entity that resides at a host computer that has a collection of network applications and plays the role of controlling the network nodes. Its main responsibilities include maintaining a network view of the network being managed, regular interval collection of information from each network element, and analyzing the collected information to decide if control actions are necessary or not. (Haojin 1999, 26.)

An agent is also a management entity that is responsible for executing the management instructions sent from the manager and reporting to the manager any abnormal conditions that may arise at the network element. However, an agent communicates occasionally through a proxy to act on network elements. In other words, it does not act directly on network elements. As shown in Graph 3, the proxy appears as a link between agent and the network elements in the network architecture. A management protocol provides mechanism for interaction between the manager and the agents. The standard management protocol used for this mechanism is simple network monitoring protocol (SNMP), which resides at the application layer of the internet network hierarchy. And, an MIB is a database for storing the management information. In other words, MIB stores the information of network elements that are being managed. (Haojin 1999, 26.)



GRAPH 1. Network Management Architecture (adapted from Haojin, 1999)

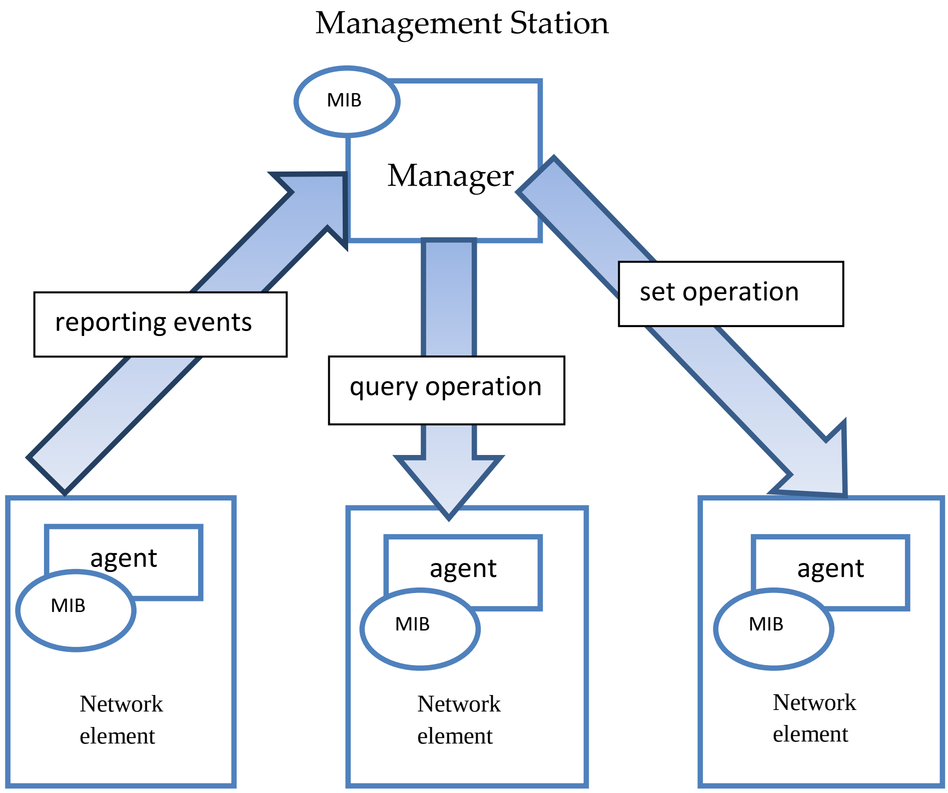
2.3 Network Management Operation

Having identified and explained the components of the network management system above, it is necessary to discuss the operation of network management. A network management operation can be initiated either from both management entities (manager or agent). Such an operation can only be completed with participation from both management entities. All the management operations allowed for the SNMP can be group into three generic categories namely the query operation, the set operation and the reporting event.

Query Operation: Here a manager queries an agent for information on the network element such as status, states or statistics. (Haojin 1999, 27.)

Set Operation: With this second category, the manager requests that an agent modify the information in the agent's MIB to achieve the effect of changing the attributes of the network elements. (Haojin 1999, 27.)

Reporting Events: This operation is initiated by the agent. The agent reports an abnormal event to the manager that has occurred at the agent side. The three types of operations associated with the network management protocols are shown in the Graph 4 below. (Haojin 1999, 27.)



GRAPH 2. Component and Operation of a Network Management System (adapted from Haojin, 1999)

2.4 Functional Division of Network Management

In general, network management can be grouped into five functional divisions. These divisions are sometimes described as FCAPS (Fault, Configuration, Accounting, Performance and Security) for convenience. However, this thesis will focus on the performance/fault management that entails both controlling and monitoring of the network resources. (Martin 2003, 399; Tejinder & Stephen 2002, 2.)

2.4.1 Fault Management

The main purpose of fault management is detecting, diagnosing, repairing and reporting network equipment and services failure in order to keep the network running efficiently. Fault management includes functions such as alarm surveillance, fault localization, test management, correcting the fault and trouble administration. Fault management informs the manager what the network is doing. This report can be seen in the Graph 2 above which shows the reporting event arrow from the managed device to the manager. (Haojin 1999, 344.)

2.4.2 Configuration Management

Configuration management is a very complicated area of network management. It is responsible for the monitoring and controlling the configuration information of the network. Configuration management covers five areas such as network planning and engineering, installation, service planning and negotiation, provisioning, and status and control. Configuration management informs the manager where everything resides in the network. (Haojin 1999, 272.)

2.4.3 Accounting Management

Accounting management is responsible for keeping the records of usage of network resources and computes charges/billings for such usage. Accounting management tells the manager when the network is being used and computes cost of resources consumed (Strategic Planning Bureau 1999).

2.4.4 Performance Management

Performance management is the top level network management operation. It is responsible for monitoring, controlling and optimizing the overall network performance, both within and across network services. Performance management includes functions such as gathering statistical information, maintaining and examining logs of the system state histories and altering system modes of operation for the purpose of conducting performance management activities. (Tejinder et al., 2002, 18.)

2.4.5 Security Management

Security management is responsible for securing the network, the management system that manages the networks and management transactions. In addition, security management is intended to prevent intrusion if at all possible, to detect intruders in case of intrusions promptly and to recover from and limit the consequences of such intrusions as efficiently as possible. Here, the manager is informed of who is using the network. (Haojin 1999, 433.)

All of these functional divisions are what make up the monitoring and controlling parts of the network management. When considering network monitoring, fault management, accounting management and performance management are very important. However, the controlling part of the network uses configuration management and security management.

2.5 Network Monitoring Technique

Having discussed NMS in the preceding sections, it is pertinent to streamline the focus of this thesis to the network monitoring, which is a subset of functions involved in the network management. Network monitoring entails a system that constantly observes and analyzes the status and behavior of network which comprises network devices such as switches, hubs, routers, printers, computers and their associated services. This system notifies the network administrator either via e-mails, pagers, or SMS. The method for notification is solely based on the user-defined method. (Ethan 2011.)

To that end, a number of software applications and tools are available for performing network monitoring. At the most basic level, network monitoring is done by sending a ping, which is a monitoring tool that requires instantaneous reply from each computer or network device on the network. If such a network device fails to respond or takes too long to respond, the network monitoring system notifies the network administrator of the problem. (Dev, Emery, Rustici, Brown, Wiggin, Gray & Scott, 1996.)

However, network monitoring software handles the monitoring of the network by continuously taking regular virtual snapshots of the network's workflow. Also track records of irregularities discovered in the workflow are kept. In the event whereby such irregularities are so deviated from the recorded snapshots, the network administrator will be notified. Nagios is the main network monitoring software application used in this thesis to explore the aforementioned scenario.

(Dev et al., 1996.). Some other selected monitoring applications are discussed in chapter three.

2.6 Network Management Protocol

Network management protocols are used by the NMS to access managed devices. In this thesis, two most commonly used network management protocols are discussed, namely: Simple Network Management Protocol (SNMP) and Common Management Information Protocol (CMIP).

2.6.1 SNMP

SNMP (Simple Network Management Protocol) is a widely used internet-standard protocol in the network management arena. It was created in 1988 to meet the growing need for a standard for managing internet protocol (IP) devices. (Douglas & Kevin 2005, 1.)

An SNMP is a simple set of operations (and the information these operations gather) that give the administrators the ability to change the state of some SNMP-based device. Usually, SNMP is associated with managing routers, but it is pertinent to identify the fact that there are other devices that can be managed as well. Such devices are hubs, bridges, printers, workstations, servers, uninterruptible power supplies (UPSs). (Douglas & Kevin 2005, 1.)

The SNMP can be employed in many ways such as to monitor the health of the routers, switches and other network hardware, but can also be used to control network devices, or take other automatic actions if problems arise. SNMP can monitor information ranging from the relatively simple to standardized items like the amount of traffic flowing into and out of an interface, or state of the air temperature inside a router. (Douglas & Kevin 2005, ix.)

SNMP is categorized with various versions. It is denoted as SNMPv1, SNMPv2 and SNMPv3. The sequence of the versions is based on the ongoing development on the design of SNMP for its additional functionalities. The earliest version SNMPv1 was characterized with its lightweight design and it is proved to be good for managing relatively small networks and could not scale to large network (geographical dispersed enterprises). (Douglas & Kevin 2005, 19; Damianos 2001, 16-17.)

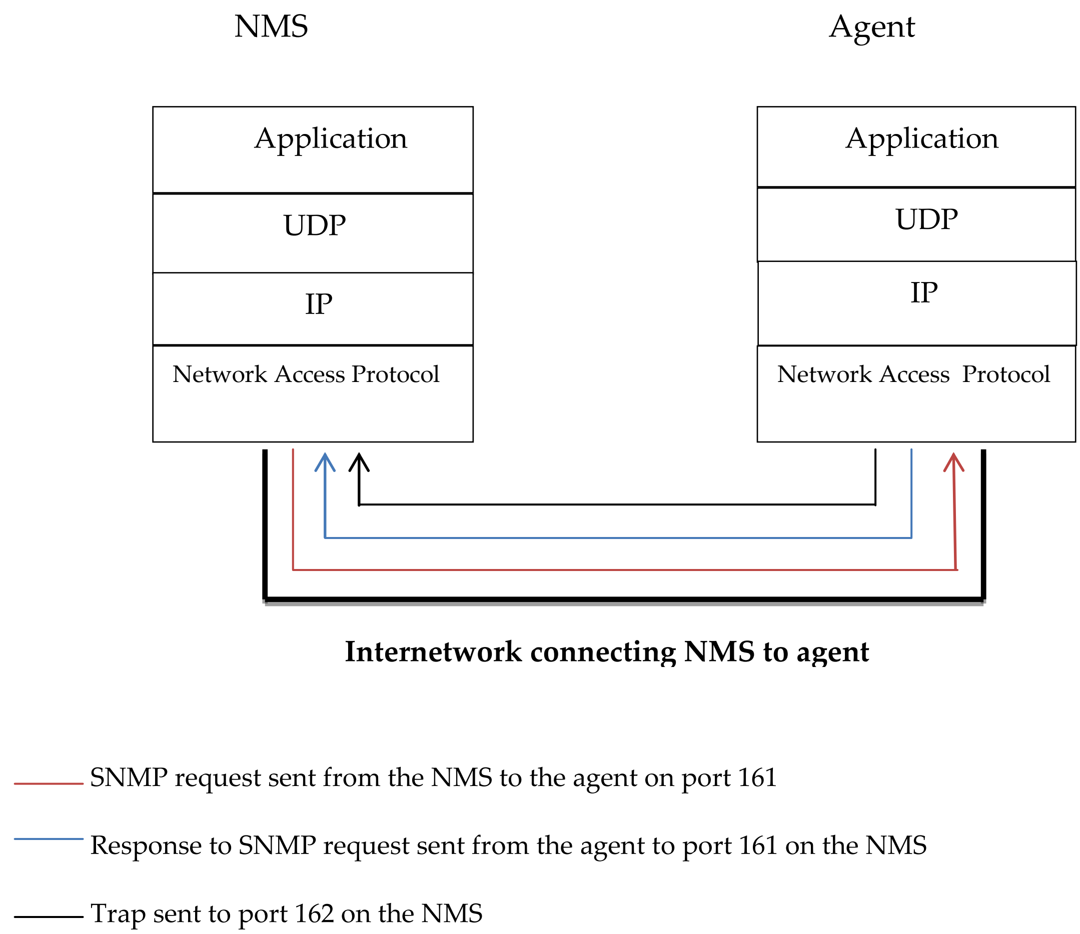
The second generation of the SNMP standard known as SNMPv2 was developed to overcome shortcomings of SNMPv1 by expanding its functionalities to include OSI-based as well as TCP/IP-based networks. SNMPv2 makes SNMP a more robust management protocol by offering better efficiency, error control and manager-manager communication. As for SNMPv3, its main focus is on the security, not scalability. In effect, SNMPv2 will be employed in this thesis rather than SNMPv3 as the security is not the interest of this work. (Douglas & Kevin 2005, 73.)

2.6.2 User Datagram Protocol

Having discussed SNMP's versions in the previous section, it is necessary to highlight details of protocol used by SNMP in order to facilitate the exchange of management information between the manager and the agent. SNMP uses the User Datagram Protocol (UDP) as the transport protocol for passing data between the manager and the agent. In contrary to Transport Control Protocol (TCP) that is connection-oriented, UDP does not establish connection between the agent and the NMS while exchanging datagram (packets) as defined in RFC 768. Though, SNMP over the TCP can be implemented in special-case situations whereby agent is being developed for proprietary piece of equipment. Such a situation will result to the network being flooded in a heavily congested network while retransmitting to achieve TCP reliability. (Douglas & Kevin 2005, 19.)

SNMP uses UDP port 161 for sending and receiving requests and port 162 for receiving traps from managed devices. The aforementioned port numbers are default for every device that implements SNMP, but some vendors allow changes to be made to the default ports in the agent's configuration. However, if such changes are made, NMS must be aware of the changes so that the device can be queried on the correct ports. (Douglas & Kevin 2005, 20.)

In an attempt to understand how an SNMP message passes through the protocol layers at the manager and the agent, a TCP/IP protocol suit is used as shown in the Graph 5 below. This model is often referred to as a protocol stack since each layer uses the information from the layer directly below it and provides a service to the layer directly above it. (Douglas & Kevin 2005, 20.)



GRAPH 3. TCP/IP communication model and SNMP (adapted from Douglas & Kevin 2005, 20)

Referring to the above protocol stack in Graph 4, each layer represents an event that occurs when either an NMS or an agent wishes to perform an SNMP function (e.g. a request or trap). These functions are discussed in the next passage.

2.6.3 SNMP Messages Types

SNMP uses a limited number of Packet Data Units (PDU) for messages exchange between the manager and the agent. The SNMP PDUs are defined by the ASN.1 (Abstract Syntax Notation one) data types. There are five PDUs that have been defined in the first version of the standard (SNMPv1) to enhance inspection or alteration to the managed objects of an SNMP agent's MIB (Martin 2003, 384). The five PDUs are:

- Get-Request: this PDU is sent from SNMP manager to SNMP agent to request status information for the purpose of monitoring the network.

- Get-Next-Request: this is similar to a Get Request message, but it is specifically designed to allow the SNMP manager to scan through a MIB (a table or matrix of data) in the SNMP agent to locate a specific value.

- Set-Request: it is used to change the value of a MIB object.

- Get-Response: it is the response message sent by an SNMP agent to an SNMP manager in response to GetRequest, GetNextRequest or SetRequest that was discussed earlier.

- Trap: this allows SNMP agent to send report to SNMP manager unsolicited that is without a request and notifies of an event, i.e. change of status, or alarm condition.

TABLE 1: SMNP PDU format (Adapted from Haojin 1999, 91)

(a) Generic format of SNMP message

Version	Community name	SNMP PDU

(b) The structure of GetRequest, GetNextRequest, SetRequest, GetResponse, SMNPv2-Trap, and InforRequest PDUs

PDU-type	request-id	error-status	error-index	variable-bindings

(c) The Structure of GetBulkRequest PDU

PDU-type	request-id	non-repeater	max-repetitions	variable-bindings

(d) Variable-bindings Field

name1	value1	name2	value2	……..	nameN	valueN

The fragmented TABLE 1 indicates structures of SNMP PDU format. Each field is briefly described in TABLE 2 below.

TABLE 2. Fields in the SNMP message

Field	Description
SNMP Version	An integer value in the range (0...2147483617- a 32-bit value). The value '0' represents SNMPv1
Community Name	An alphanumerical value (i.e. an OCTET-STRING) which indicates community name that the SNMP message belongs
PDU- Type	An integer representation for type of an SNMP PDU, i.e., GetRequest, GetNextRequest, SetRequest, GetResponse, or Trap.
Request-ID	An integer to uniquely identify a request (i.e., GetRequest, SetRequest, or GetNextRequest) sent from a manager to an agent

Continues

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Error-Status	An integer value assigned by an agent to indicate an error condition in response to manager request. 0 - no error found 1 - **too Big**- Protocol message exceeds allowable maximum size on a local host computer 2 - **no such name**- requested name does not exist in agent's MIB view. 3 - **bad value** - value found in the agent's MIB view does not match that requested by the manager 4 - **read-only** - value that is presented if a manager try to write on an object whose access is read-only 5 - **genErr** – any error other than one above listed
Error-Index	In case of an error, Error-Index points to the object that caused the error; otherwise it remains value zero.
Variable-Bindings (Varbind)	A set of object-name-object-value pairs. An object name is an object instance identifier (OID) and the value is the object instance value.

The first five PDUs are the basic functions of standard SNMP, which is specifically associated with SNMPv1. However, later versions (SNMPv2, SNMPv3) have added two additional operations to the earlier described PDUs. These are:

- Get-BulkRequest: it is designed to minimize the large number of protocol message exchanges which are required to retrieve large volume of management data. It includes two fields that are not found in other PDUs:

non-repeater and max-repeater. Non-repeaters field specifies the number of variables in the variable bindings list for which a single lexicographical successor is to be returned. Max-repeater field indicates the number of lexicographical successors to be returned for the remaining variables.

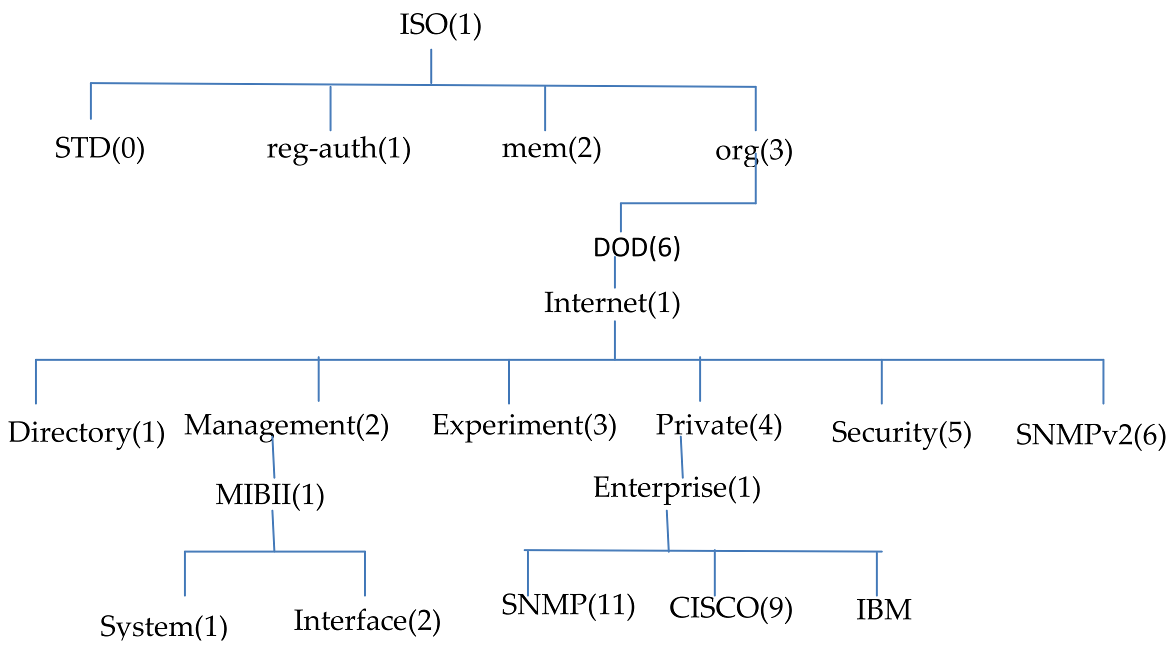
- GetInformationRequest: this PDU is used in manager-to-manager communication i.e. it is generated and sent by an entity acting in a manager role, on behalf of an application, to another SNMP entity acting in an agent role, to provide management information. (Martin 2003, 385.)

2.6.4 SNMP Management Information Base (MIB)

Management Information Base is a database that comprises a set of objects for management purpose. Such MIB's object is a software representation of a managed network element such as routers, switches, workstations or even a piece of software related to the management perspective. The NMS communicate to the managed devices through the managed objects. A subset of Abstract Syntax Notation One (ASN.1) is used to specify an object. Each managed object in the MIB is uniquely denoted by an object identifier (OID). A naming scheme is used to construct the OID for the managed objects of the SNMP MIB. This can be followed through the MIB tree hierarchical structure in the GRAPH 5 below. (James 2006, 25.)

Referring to the Graph 5, the standard SNMP MIB known as MIB-II is identified as 1.3.6.1.2.1. Its name is denoted as ISO.org.DOD.Internet.Management.mib-2. Also, Cisco has unique OID that is associated to all the Cisco devices which is

1.3.6.1.4.1.9. Cisco associated name is ISO.org.DOD.Internet.Private.Enterprise.CISCO.



GRAPH 4. OSI registration tree (adapted from Haojin 1999, 34)

2.6.5 CMIP Common Management Information Protocol

Common Management Information Protocol is used for the exchange of management information between two entities (manager and agent). CMIP activities are achieved by a related service known as Common Management Information Service Element (CMISE). CMISE provides access to managed information in the managed objects and uses CMIP to issue requests for the management services. Such services can be categorized into two groups: management operation services initiated by a manager to request an agent to provide certain services or information. The other is notification services used by the management agents to inform the managers of occurred events. (Haojin 1999, 32.)

Both cases are specified in terms of primitives that can be viewed as commands or procedure calls with parameters. The seven services are listed below:

- M-CREATE: requests the agent to create new instance(s) of a managed object class or attributes within a managed object.
- M-DELETE: requests the agent to delete existing instances of managed object class(es) or attributes within a set contained in a managed object.
- M-GET: directs the agent to return the attribute values of managed objects.
- M-SET: requests the agent to change the value of the managed object attribute(s).
- M-ACTION: directs the agent to cause one or more managed objects to execute an action.
- M-EVENT_REPORT: Here service is issued by an agent to send a notification to managers.
- M-CANCEL-GET: requests agent to cancel an outstanding M-GET request.

However, in spite the versatility in the features of the CMIP over the former SNMP protocol, it is still less adopted. This is a result of its complexity and slow evolutionary process of the standard. (Damianos 2001.)

The idea behind earlier discussed network management protocols is used by the available network monitoring tools in order to handle network management functionalities. Selected numbers of network monitoring tools are discussed in chapter 3.

3 OPEN SOURCE NETWORK MONITORING TOOLS (NMTs)

This thesis has identified Nagios as a network monitoring tool that will be explored in carrying out network monitoring activities. Under that note, it is deemed necessary to acknowledge the fact that there are other numerous available network monitoring tools that are available for the same purpose. A selected number of NMTs will be identified and described. However, the list of randomly selected NMTs is not necessarily connected to the order of preference of usage, rather selected based on popularity. The selected NMTs are as follows;

3.1 Zabbix

Zabbix is a network monitoring solution that is written and distributed under the GPL General Public License version 2, i.e. its source code is freely distributed and available for general public. It was created by Alexei Vladishev. Its latest version is Zabbix 1.8.7. (Zabbix SIA 2011.)

Zabbix is solely designed to monitor and track the status of various network services, severs and other network hardware. Zabbix users enjoy its great visualization functionalities including user-defined views, zooming and mapping. With Zabbix, multiple choices of databases are available for storing monitoring data, like MySQL, PostgreSQL, Oracle, IBM DB2 or SQLite. In addition, Zabbix offers excellent reporting and data visualization features based on the stored data. (Zabbix SIA 2011; Wikipedia 2011.)

3.2 Cacti

Cacti is an open source network monitoring tool that employs RRDtool for the network graphing solution. Information used for creating and populating the graphs is stored in a MySQL database. With its graphing utility, it enhances graphical visualization of CPU load, network bandwidth utilization, network traffic and more. (The Cacti Group 2009.)

In addition, it is also endowed with built in SNMP support that can use PHP-SNMP, UCD-SNMP, or NET-SNMP. This SNMP support is useful for creating traffic graphs with MRTG. (The Cacti Group 2009.)

3.3 Munin

Munin is actually similar to the previously described Cacti. It uses also RRDTool to present the output in a pretty graph via web interface. Munin is considerably special with its ease of creating new plug-ins and the play capability of the plug-ins. Munin stores monitoring data in RRD files and automatically updates the graphs accordingly. (Munin wiki 2006.)

3.4 Zenoss

Zenoss is also an open source application like its previously discussed counterparts. It is a network management platform based on the Zope application server. Zenoss Core presents a web interface that proffers a better solution to the system administrator to monitor availability, inventory/configuration, performance and events. Zenoss has capabilities in the following areas; monitoring availability of network devices using SNMP, SSH, WMI, monitoring of network services and host resources on most network operating systems and also supports Nagios plug-in format. (Wikipedia 2011.)

3.5 Nagios

Nagios is one of the most popular computer network monitoring software application. It is developed by Ethan Galstad, as an open source, Unix-based enterprise monitoring package with a web-based front-end or console. It provides monitoring of network services (SMTP, POP3, HTTP, FTP, SNMP, SSH) and host resources (processor load, disk usage, system logs) and essentially any device or service that have address and can be contacted via TCP/IP. It can monitor host running Microsoft Windows, Unix/Linux, Novell Netware, and other operating system. (Nagios Community 2011; James 2006, xx.)

With Nagios, own service check can be created depending on needs by developing simple plug-ins by using tools of choice (shell scripts, C++, Perl, Ruby, Python, PHP, C#, etc.). In the event of service or host problems, Nagios has contact notification in its configuration to handle and resolve such events either via email, pager, or user-defined method. (Nagios Community 2011.). Nagios installation prerequisites, configuration and plug-ins are discussed in chapter four.

3.6 Why is Nagios selected?

In this thesis, Nagios was chosen as the network monitoring tool. The reasons for this fact are not far-fetched, owing to some of its features over its counterparts. Though, previously discussed tools work in a way similar to Nagios but it has proven to be better over the others in some aspects.

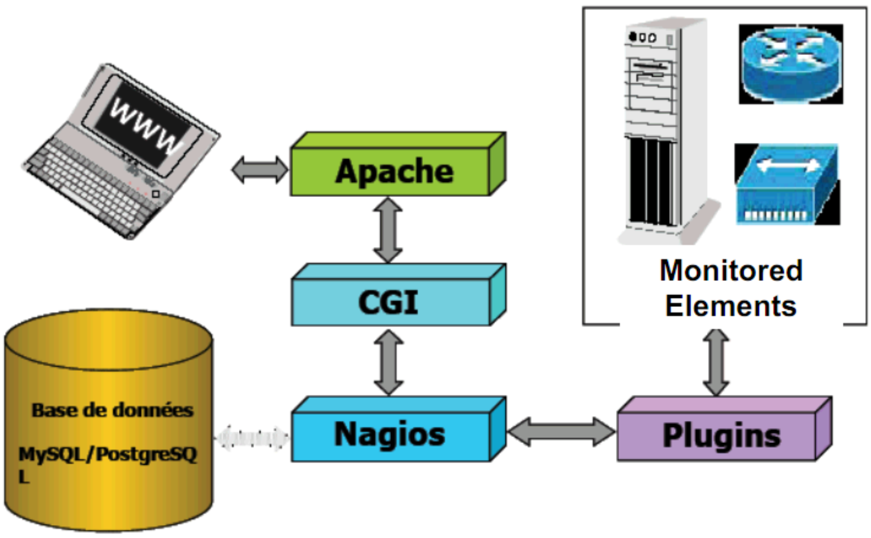
In the same vein, Nagios has been around for much longer than other and has extensions (plug-ins) that are simple to develop, using well known languages. Also, it has built professional communities that have contributed to development of plug-ins which enhance its better monitoring performances. With plug-ins, the monitoring capability of Nagios is limitless, so far a script can be written for (Perl scripts, Shell, C programs etc.) because it performs all its monitoring checks using plug-ins. (Wojceich, 2008, 9).

Similarly, considering the aspect of scanning the monitored devices, Nagios uses four states to describe status: OK, WARNING, CRITICAL, UNKNOWN rather than monitoring value or graphs that may be ignored when it needed a quick attention. Also, Nagios gives report of number of services that are up and running in both warning state and critical state with aid of its friendly GUI for service status display. This presents a good overview of infrastructure status. (Wojceich, 2008, 9.)

4 UNDERSTANDING NAGIOS SETUP

4.1 Nagios Architecture

In order to get clearer picture of how Nagios works, it is necessary to look into its architecture. Its architecture is based or built on a server/client model. This architecture can be seen in the Graph 6 below. This depicts a Nagios server running on a host, and plug-ins running on the server and all other remote hosts to be monitored. This plug-ins sends information to the server, which in turn displays them on GUI.



GRAPH 5. Nagios Architecture (Adapted from TEINS Training, 2005)

In addition, Nagios can be said to be composed of three parts namely; A scheduler, a GUI, and the plug-ins. These are described as below:

- A scheduler: is a server part of Nagios that checks plug-ins at regular interval and do some actions according to the results from the checked plug-ins.
- A GUI: is the interface of Nagios that is displayed in webpage generated by the Common Gateway Interface (CGI). The interface can display configurations, alerts, state buttons (green, OK/red, Error), MRTG graphs etc.
- The plug-ins: They are configurable by the user. They check a service and return a result to the Nagios server in order to take corresponding actions. (TEINS Training 2005.)

4.2 Nagios Setup Prerequisites

To set up a functional Nagios server, there are basic requirements that must be met before the set up can be achieved. Having known from the preceding chapter that Nagios runs on a variety of Linux, UNIX and Berkeley Software Distribution (BSD) operating system, a Linux distribution (Ubuntu 11.04) was selected and installed on a virtual machine. Virtual machine was considered because it provides easy way to test software, especially if an alternate operating system is involved. (Ethan 2011; Michael 2009.)

After installing and updating the operating system, the following packages are manually installed on the Ubuntu installation before continuing:

- Apache 2, a web server that Nagios uses to display information on web page. By using command prompt, and typing "sudo apt-get apache2", Apache 2 is installed. And to verify the installation and start Apache2 "sudo /etc/init.d/apache2 start" command is used and if everything is fine, OK response is given.

- PHP, a programming language for creating dynamic webpages that can be served on webservers. Command "sudo apt-get install libapache2-mod-php5" is issued to install PHP.
- GCC Compiler and development libraries which are needed to compile some plug-ins and Perl Modules
- GD development libraries, required to produce graphs and status map. Command "sudo apt-get install libgd2-xpm-dev" is issued to install gd2 (Ethan 2011.) The subsequent section gives detail information for Nagios installation.

4.3 Nagios Installation

Having completed installation of prerequisite packages discussed in the preceding section, the next exercise is to download the latest Nagios core from Nagios website at www.nagios.org. Before installing Nagios core, a user was created to run the service and a group to run external commands. To achieve this, the following commands are issued sequentially in the command prompt.

```
sudo passwd nagios

sudo groupadd nagcmd

sudo usermod -a -G nagcmd nagios

sudo usermod -a -G nagcmd www-data
```

At this point, a directory was made for storing the previously downloaded Nagios source code tarballs which were extracted with commands "tar xzf nagios-3.2.3.tar.gz" as used below and followed by changing the directory to extracted folder and install with the following command:

```
mkdir ~/downloads

cd ~/downloads

wget http://prdownloads.sourceforge.net/sourceforge/nagios/nagios-3.2.3.tar.gz

wget http://prdownloads.sourceforge.net/sourceforge/nagiosplug/nagios-plug-
ins-1.4.11.tar.gz

tar xzf nagios-3.2.3.tar.gz

cd nagios-3.2.3

 ./configure --with-command-group=nagcmd

 make all

 make install

 make install-init

 make install-config

 make install-commandmode

 make install-webconf
```

Afterwards, a user account for logging into Nagios interface was created in a given directory by issuing: "sudo mkdir /usr/local/nagios/etc".

And a new password was created: "sudo htpasswd -c /usr/local/nagios/etc/htpasswd.users nagiosadmin". This password is required to login to the Nagios web interface. After the created password, Apache2 was restarted to make the new settings take effect: “sudo /etc/init.d/apache2 restart”. The next task is to compile and install the Nagios plug-ins. This was achieved by extracting the Nagios plug-ins source code tarball, and changing the directory to the extracted folder. The command issued is shown below:

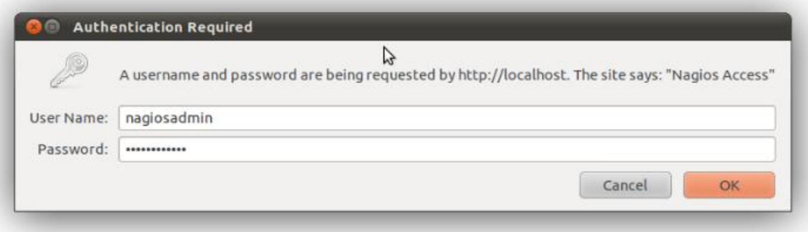
```
tar xzf nagios-plug-ins-1.4.11.tar.gz

cd nagios-plug-ins-1.4.11

./configure --with-nagios-user=nagios --with-nagios-group=nagios

make

make install
```

Nagios was configured to automatically start when the system boosts with this line of command: “sudo ln -s /etc/init.d/nagios /etc/rcS.d/S99nagios”.

To verify the sample Nagios configuration files, command “sudo /usr/local/nagios/bin/nagios -v /usr/local/nagios/etc/nagios.cfg” was run.

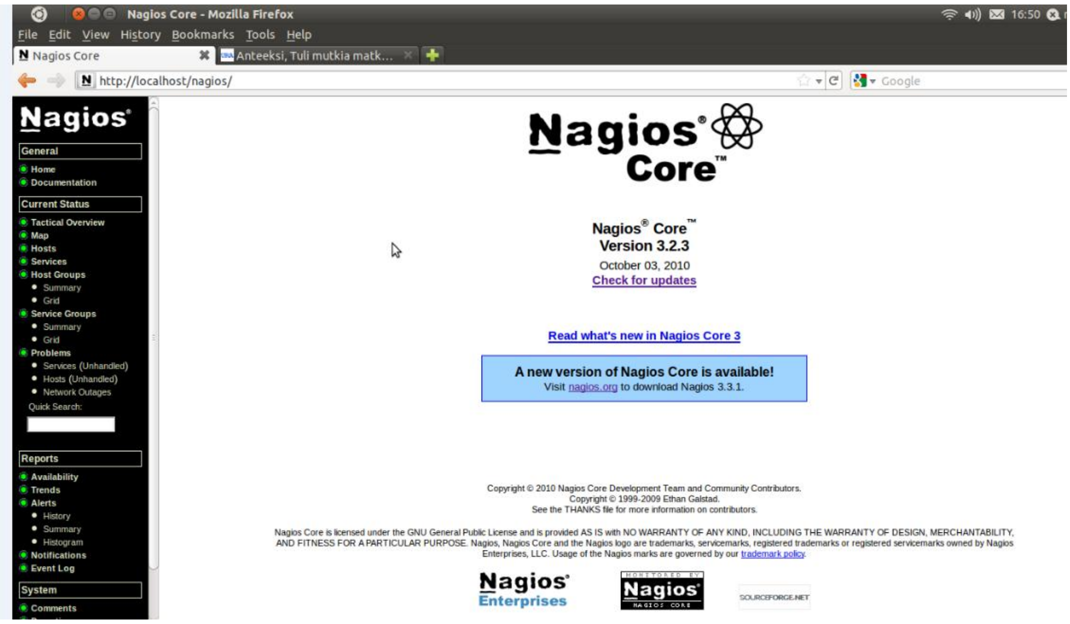
And if the output from the last issued command shows no errors, then Nagios can be started with the command: “/etc/init.d/nagios start”

At this stage, Nagios server can be accessed through the web browser by typing: http://hostname/nagios or http://127.0.0.1/nagios. The Graph 6 shows Nagios access interface with username as nagiosadmin and password, which was issued during the installation.



GRAPH 6. Nagios Access Interface

After clicking OK button in the above screenshot, front page of Nagios server will be displayed along with its features itemized in the left sections. This is as shown in Graph 7 below.



GRAPH 7. Nagios Front Page

The above screenshot illustrates basic setup of Nagios server. However, there is need for further configuration of the Nagios server according to the network requirements. This can be achieved by working on the configuration files of the Nagios. To this end, it is necessary to understand the configuration files in Nagios and these are described in the next chapter.

4.4 Nagios Configuration

During manual installation of Nagios as discussed in the previous section, some configuration files are installed by default in the /usr/local/nagios/etc/ directory. However, there are several other configuration files that need to be created or edited before monitoring can be started in Nagios. Though, configuring Nagios can be complex and take quite a while, but it allows a great deal of flexibility on completion. (Ethan 2009.)

To this end, Nagios has two main configuration files, cgi.cfg and nagios.cfg. These files are discussed below.

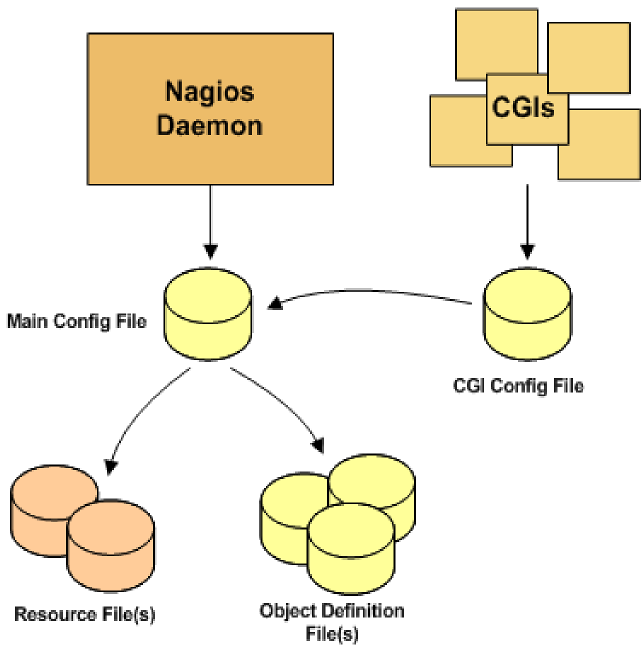
4.4.1 nagios.cfg (Main Config file)

The nagios.cfg file is the main configuration file that controls all other program operations. This file is actually read by both the Nagios daemon and the CGIs. It contains a number of directives that influence how the Nagios daemon operates. Its cfg_file and cfg_dir directives allow configuration to be split into manageable groups using resource file and object definition files as shown in Graph 9 below. (Ethan 2009.)

The resource files are mainly used for storing sensitive configuration information like password without making the information available to the CGIs. Also stores user-defined macros. While object definition files are locations where all the devices to be monitored are defined and how they are monitored. (Ethan 2009; Michael 2009.) The objects in Nagios are displayed in the Table 3 below.

TABLE 6. Nagios objects

Object	Used for
hosts	servers or devices being monitored
hostgroups	group of hosts
services	services being monitored
servicegroups	groups of services
timeperiod	scheduling of checks and notifications
commands	checking hosts and services notifying contacts event handling
contacts	individuals to alert
contactgroups	groups of contacts



GRAPH 8. Nagios configuration relationship (Adapted from Ethan 2009)

4.4.2 Cgi.cfg file

The cgi.cfg file is primarily used to control the Web interface and its associated CGI (Common Gateway Interface) programs. This file contains a reference to the main configuration file, so the CGIs know how the Nagios is being configured and where the object definitions are stored. (Ethan 2009.)

As part of this thesis undertaking, a number of object definitions and services enabling will be made in the next chapter so as to buttress the information in the current section.

4.5 Plug-ins Enhancement

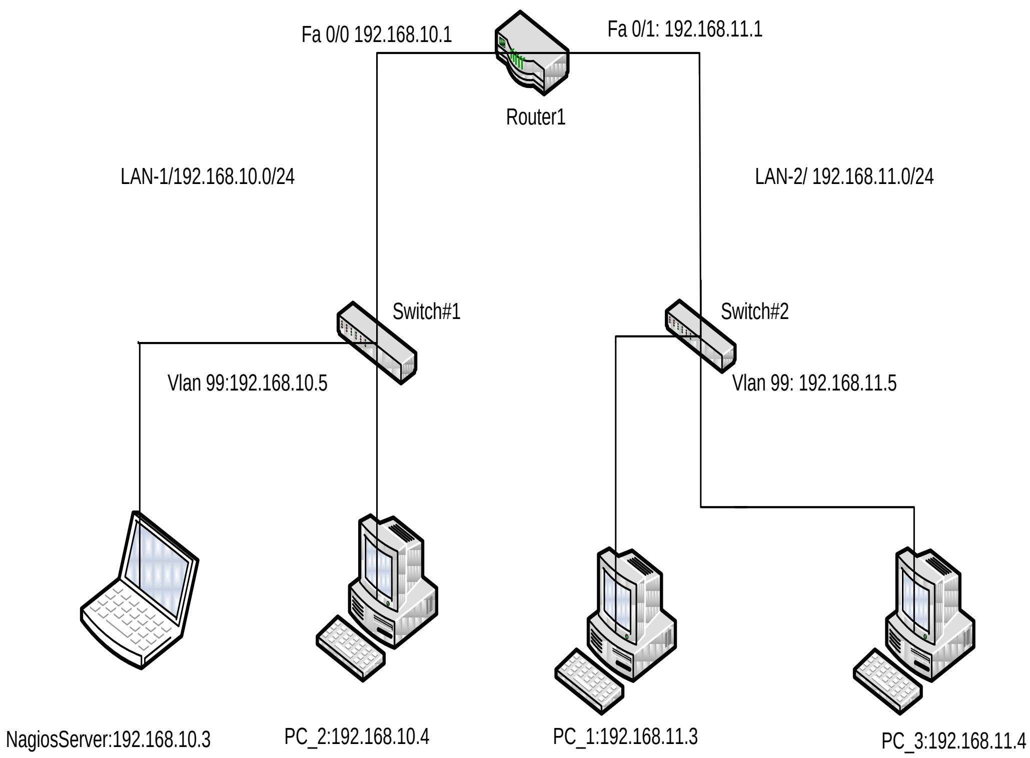
Nagios alone cannot perform any monitoring act unless it runs external programs called plug-ins. This is as result of the fact that Nagios does not include any internal mechanisms for checking the status of hosts and services on the network. This checking is achievable by running plug-ins (compiled executables or scripts like Perl scripts, shell scripts etc.) via the command line. However, the results from the plug-ins are used by the Nagios to determine the current status and necessary actions (running event-handling, sending-out notifications) are made. (Ethan 2009.)

From the preceding section 4.3, a number of plug-ins including the check-host-alive, check_ping, check_http, check_tcp commands are made available from the Nagios plug-ins package during installation. By default, the plug-ins are installed in /usr/lib/nagios/plug-ins directory. But, some distributions may install them in a different directory. Additionally, Nagios supports writing of individual or customized plug-ins if needed. Also, there is possibility of downloading or checking for suitable plug-ins from the Nagios community from either the links; Nagios plug-ins project at http://nagiosplug.sourceforge.net/, Nagios downloads page at http://www.nagios.org/download/, http://www.nagiosexchange.org/. (Ethan 2009; Michael 2009.)

5 LAB ASSIGNMENT AND DEMONSTRATION

This chapter describes implementation of the network management system, Nagios to demonstrate the monitoring of a number of network devices (hosts) and associated services residing in the hosts. This is achieved by setting up a test network and configuring Nagios's object configuration files to implement the monitoring of the network. In this view, a number of snapshot views of the Nagios's outcome in respect to monitored states of the network elements are presented accordingly.

5.1 Prototype of Laboratory Task



GRAPH 9. TOPOLOGY DIAGRAM

TABLE 7. Addressing Table

Device (Hostname)	Interfaces	IP Address	Subnet Mask	Default gateway
NagiosServer	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC_1	NIC	192.168.11.3	255.255.255.0	192.168.11.1
PC_2	NIC	192.168.10.4	255.255.255.0	192.168.10.1
PC_3	NIC	192.168.11.3	255.255.255.0	192.168.11.1
Switch#1	Vlan 99	192.168.10.3	255.255.255.0	192.168.10.1
Switch#2	Vlan 99	192.168.11.3	255.255.255.0	192.168.11.1
cisco_router	Fa0/0 Fa0/1	192.168.10.1 192.168.11.1	255.255.255.0 255.255.255.0	N/A

Learning Objectives

Setup the network according to the given Topology

Configure the PCs, Switches, Router and Nagios Server

Configure and Enable SNMP on the Switches and Router

Create and define host devices in the Nagios Server

Define services associated to the host devices in the Nagios Server

Verify changes to Nagios configuration files

Scenario

In this Lab exercise, a network that is similar to the one shown in the Topology will be created. Begin by cabling according to the Topology and performing initial router and switches configurations required for connectivity. IP addresses that are provided in the addressing table are used to apply an addressing scheme to the network device. Also, this Laboratory introduces how to configure router and switches to send SNMP traps to Network Management System (Nagios). Note, all operations will be implemented in Linux Environment. A root user level password would be required in the command line in order to effect changes to Nagios server.

Task 1: Setup the network according to the given Topology

Step 1: Cable a network that is similar to the one in Topology

Step 2: Power-on Ubuntu virtual machines on four different PCs and cable according to the Topology

Task 2: Configure the PCs, Switches, Router and Nagios Server

Step 1: Perform basic configuration tasks on network devices (Switches & Router)

Set hostname

Set DNS lookup to "disabled"

Set EXEC mode password

Configure console connection and virtual terminal line passwords

Save running configuration to NVRAM

Step 2: Refer to addressing table to assign IP addresses and subnet masks to the PCs and Nagios Server

Step 3: Create a management vlan 99 to assign IP addresses to both switches with appropriate default-gateway

Note, the configuration is done through the Tera terminal. Enter the configuration mode and issue the following commands for each switch.

Switch#1	*Switch#2*
interface vlan 99 *ip address 192.168.11.5 255.255.255.0* *no shutdown* *exit* *ip default-gateway 192.168.11.1*	*interface vlan 99* *ip address 192.168.10.5 255.255.255.0* *no shutdown* *exit* *ip default-gateway 192.168.10.1*

Task 3: Configure and Enable SNMP on the Switches and Router

Step 1: Create optional settings for identifying devices.

Note SNMP configuration commands are issued at the configuration mode. Do the following for router and both switches.

```
Cisco_Router(config)# snmp-server contact Yusuff-Network Admin
Cisco_Router(config)# snmp-server location COU, Kokkola, FIN
```

Step 2: Create a community string for NMS to access the devices.

This community string gives NMS to access the SNMP enabled devices. Now, issue the command below.

```
Cisco_Router (config)# snmp-server community public RO
```

RO gives the NMS the right to only view the device configuration and statistics unlike RW that allows NMS to read and write to the device configuration.

Step 3: Configure both switches and router to send SNMP traps to NMS

To achieve this, issue command with the community string (public) and specify IP address of the NMS. And configure SNMP to send traps if interface go down or system is rebooted.

```
Cisco_Router (config)# snmp-server host 192.168.10.3 version 2c public
Cisco_Router (config)# snmp-server enable traps snmp linkdown linkup coldstart warmstart
```

To verify the SNMP configuration, snmpwalk command was issued on NMS to retrieve management information from the monitored devices (router and switches). The commands for snmpwalk for router and switches are shown below respectively.

```
snmpwalk –v 2c –c public 192.168.10.1
snmpwalk –v 2c –c public 192.168.10.3
snmpwalk –v 2c –c public 192.168.11.3
```

On issue one of the above commands, list of management information like OID and MIB view etc are displayed accordingly.

Task 4: Create and define host devices in the Nagios Server

Step 1: On the Nagios server, enter as a root user in the terminal with appropriate password. Issue this command:

sudo –s

Step 2: Change directory to the nagios.cfg file and edit the file as discussed in section 4.4.1. This is done at the root level from the step 1. Afterwards, create an object file where the hosts and their services will be defined.

```
root@ubuntu: cd /usr/local/nagios/etc
root@ubuntu: /usr/local/nagios/etc#
root@ubuntu: /usr/local/nagios/etc#sudo gedit nagios.cfg

Now we can define an object configuration file here named iwolomo.cfg in the nagios.cfg file.
This is done by writing two lines below. Save and close the whole nagios.cfg file.

#Definitions for monitoring an afeezgreen network
cfg_file=/usr/local/nagios/etc/objects/iwolomo.cfg

After saving nagios.cfg file, change to object.cfg directory as shown below
root@ubuntu: /usr/local/nagios/etc#cd objects/
root@ubuntu: /usr/local/nagios/etc/objects#

Open the created objects file "iwolomo.cfg" where the hosts and associated services are defined.
root@ubuntu: /usr/local/nagios/etc/objects# gedit iwolomo.cfg
```

The output from the last "*gedit iwolomo.cfg*" will be a plain text editor. This is where hosts and services are defined. One host and service definition will be discussed here and the complete definitions are provided in the appendix section of this literature.

Definition for switch is as shown below. Note, both router and switches are defined in the same template, so both have same definition except for unique IP address differences.

```
define host{
        use            generic switch
        host_name      switch#1
        alias          switch#1
        address        192.168.10.5
        hostgroups     switches
        }
```

Task 5: Define services associated to the host devices in the Nagios Server

Below is the definition of service to monitor port status of the switch via SNMP

```
# Monitor Port 1 status via SNMP
define service{
        use                  generic-service
        host_name            switch#1
        service_description Port 1 Link Status
        check_command        check_snmp!-C public -o ifOperStatus.1 -r 1 -m RFC1213-MIB
        }
```

Refer to the appendix section to see the remaining part of the definition. After completion of host and services to be monitored save and close the editor.

Task 6: Verify changes to Nagios configuration files

It is important to verify changes made to the nagios configuration. This is done to check if there is any error or warning that must be attended to before restarting the nagios server in order to effect the changes in the main file. To achieve this, issue the command below:

```
/usr/local/nagios/bin/nagios -v /usr/local/nagios/etc/nagios.cfg
```

If everything looks fine, the following lines will be shown otherwise number of errors/warnings will be shown and indicates the line number that need correction.

```
Nagios Core 3.2.3
Copyright (c) 2009-2010 Nagios Core Development Team and Community Contributors
Copyright (c) 1999-2009 Ethan Galstad
Last Modified: 10-03-2010
License: GPL

Website: http://www.nagios.org
Reading configuration data...
   Read main config file okay...
Processing object config file '/usr/local/nagios/etc/objects/commands.cfg'...
Processing object config file '/usr/local/nagios/etc/objects/contacts.cfg'...
Processing object config file '/usr/local/nagios/etc/objects/timeperiods.cfg'...
Processing object config file '/usr/local/nagios/etc/objects/templates.cfg'...
Processing object config file '/usr/local/nagios/etc/objects/localhost.cfg'...
Processing object config file '/usr/local/nagios/etc/objects/iwolomo.cfg'...
   Read object config files okay...

Running pre-flight check on configuration data...

Checking services...
                Checked 32 services.
Checking hosts...
                Checked 7 hosts.
Checking host groups...
                Checked 2 host groups.
```

Continues

Continues

```
Checking service groups...
        Checked 0 service groups.
Checking contacts...
        Checked 1 contacts.
Checking contact groups...
        Checked 1 contact groups.
Checking service escalations...
        Checked 0 service escalations.
Checking service dependencies...
        Checked 0 service dependencies.
Checking host escalations...
        Checked 0 host escalations.
Checking host dependencies...
        Checked 0 host dependencies.
Checking commands...
        Checked 24 commands.
Checking time periods...
        Checked 5 time periods.
Checking for circular paths between hosts...
Checking for circular host and service dependencies...
Checking global event handlers...
Checking obsessive compulsive processor commands...
Checking misc settings...

Total Warnings: 0
Total Errors:   0

Things look okay - No serious problems were detected during the pre-flight check
```

If this appears, then Nagios can be reloaded to effect the changes with the below command.

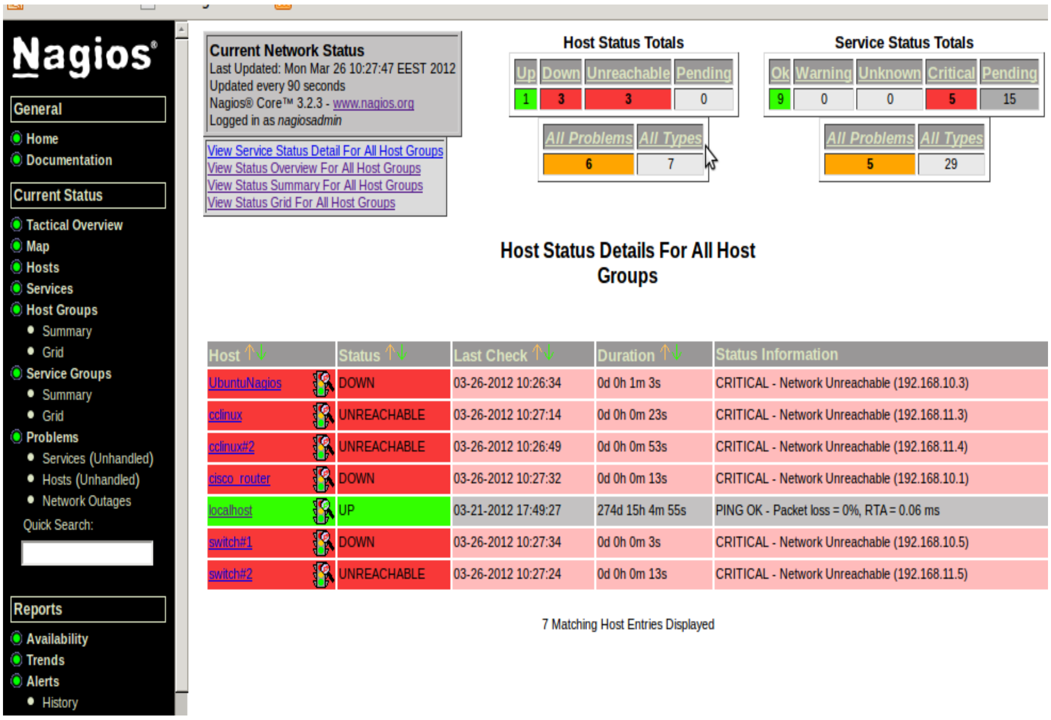
```
To reload Nagios: /etc/init.d/nagios reload
```

5.2 Hosts Status Display

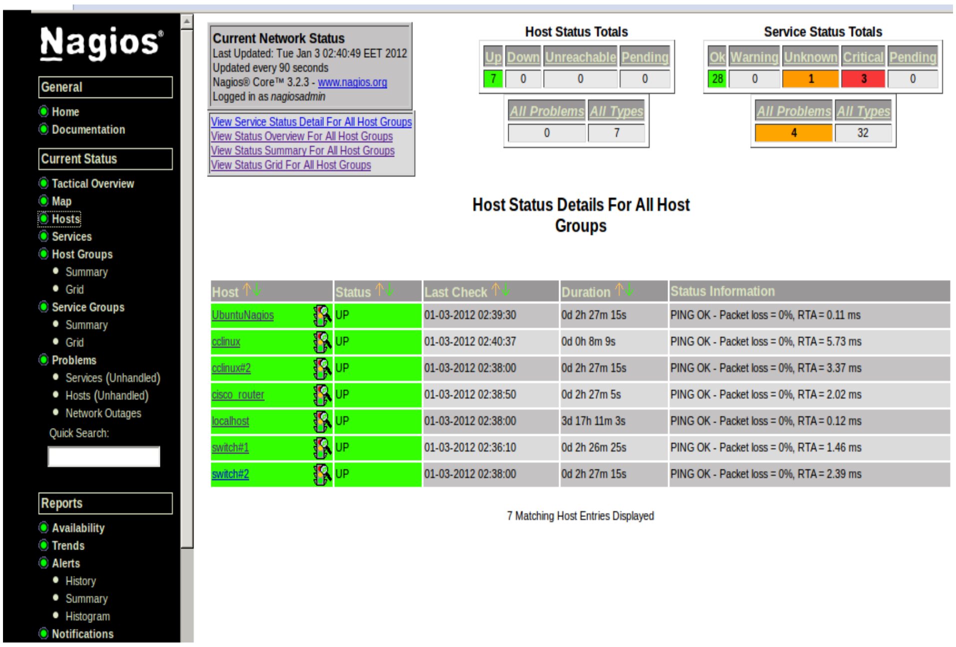
Having reload Nagios server, changes made can be viewed from the Nagios graphical user interface. All defined network devices and associated services to be monitored are displayed by clicking on the appropriate item in the left panel of

Nagios GUI. The graph 9a shows hosts detail display from the test network. The output from the display indicates that Nagios server has features that distinguish between network devices that are down and those unreachable. Also, it presents color differences for indicating UP and DOWN states. Thus, reduces response time to correct defects in the networks.

However, examining output of the display in Graph 9a indicates that there are technical corrections that have to be made. This could be as a result of error in cabling test network or the configuration issues. After thorough examining and appropriate corrections were made, the output of the current host details is shown in the Graph 9b.

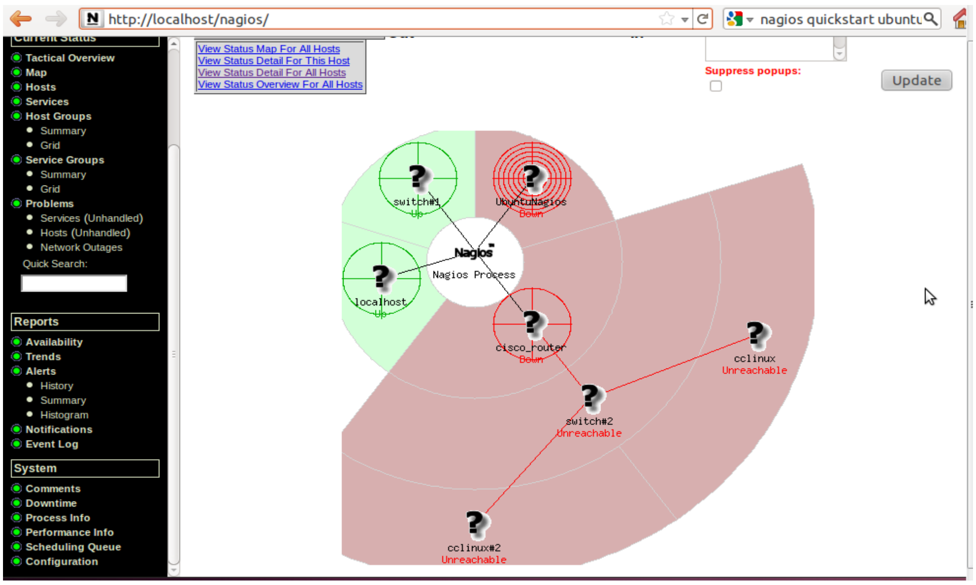


GRAPH 9a. Hosts Status Details Display



GRAPH 9b. Host Status Details Display

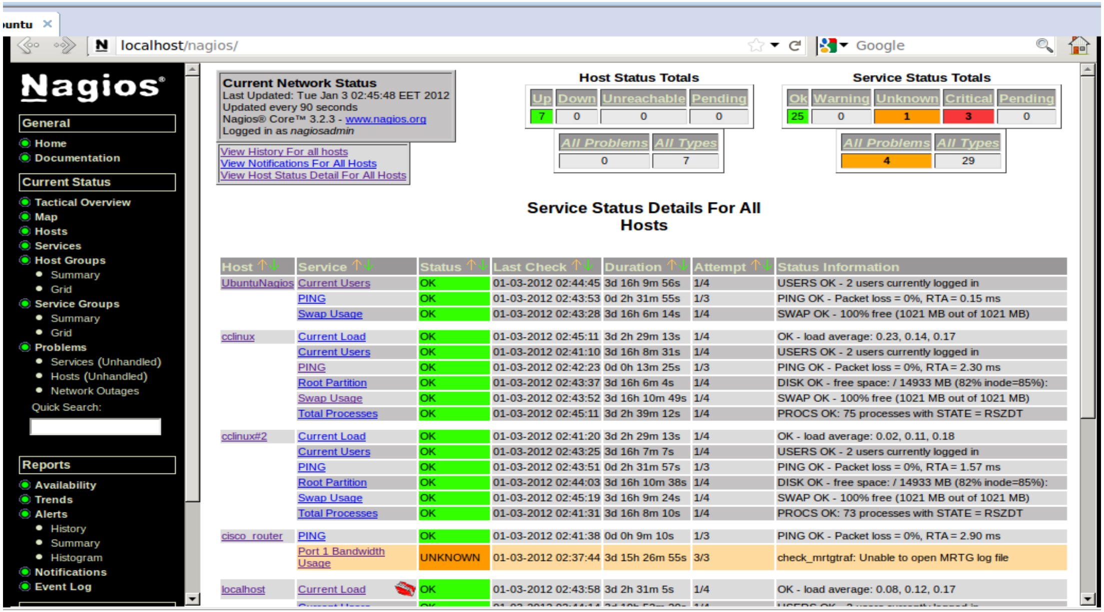
Alternatively, host status details can be viewed in structural representation of the network elements. This can be seen by clicking on the map in the left panel. The Map view shown below presents color partition in which green stands for UP state for the networked devices while other color presents either down or unreachable state.



GRAPH 10. Map View of Hosts Status Details

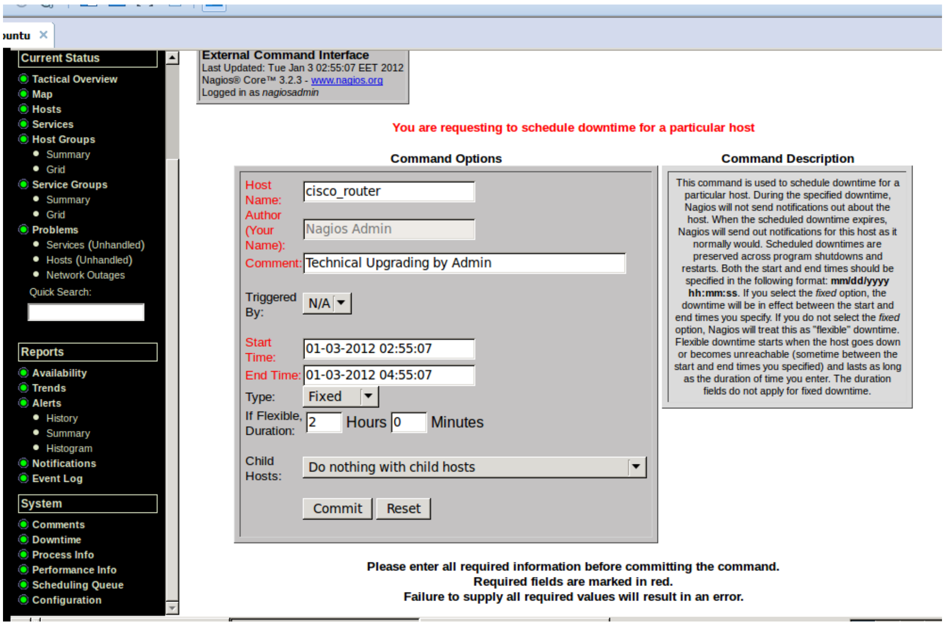
5.3 Services Status Display

All services attached to each network devices are presented in this section. The current services' status along with time the last check took place on each network monitored devices are displayed. Such detail information is resourceful because it allows the network administrator to act accordingly. The graph below indicates the service status information.



GRAPH 11. Services Status Display

However, if reported errors on either monitored hosts or services required to be fixed, a control measure is created, whereby monitoring checks on the concerned hosts or services are suspended. This is achieved by scheduling a downtime for the hosts/services for the period of time to fix the problems. However, Nagios automatically resume monitoring checks on the hosts/service as soon as the scheduled time elapses. The Graph 12 below shows scheduled downtime for cisco_router.



GRAPH 12. Downtime scheduling for cisco_router

From the above view, a downtime was scheduled for two hours and a comment was added to explain the reasons that warranted downtime on the cisco_router. This prevents false notifications from the cisco_router during the scheduled period. Additionally, other configuration parts of the monitoring for Nagios are presented in the appendix.

6 CONCLUSION

Network monitoring is widely employed for the purpose of observing and analyzing the status and behaviors of the network and providing notifications to a network administrator through a messaging system, usually, emails, when a device fails. This thesis' goals are to explore the network management of a simple network and demonstrate how issues that arise from the network can be monitored and attended to, with the aid of an open source monitoring application, Nagios.

During the course of the project it became evident that the thesis writer had to make a thorough research to understand the intricacies abound the subject matters, and also to understudy documentations in order to configure Nagios to perform the monitoring activities, the effect of which assisted to complete this work. Afterwards, to demonstrate network resources monitoring, a prototype laboratory exercise was developed and Nagios server was used as NMS for hosts and associated services status analysis.

However, benefits for monitoring network resources were realized during the laboratory exercise in the following area: improvement in quality which was uncovered as the Nagios server presented the problem as soon as it occurred; better faults determination that provides means of identifying real source of problems; and prompt errors notifications that allowed immediate response to faults. The three listed benefits were studied in this thesis work and it was notable from the outcomes that configuring a monitoring system that proffers such benefits will result to an improved state for network devices and services involved. These successful outcomes meet the objectives set at start of the thesis work.

In conclusion, in order to maintain and periodically verify the health status of network devices and associated services, the three earlier discussed benefits must be established while implementing a network management system. However, it is therefore clear that if organizations could implement a management system that meets the mentioned benefits requirements, hence, the outcome will essentially improve the network uptime and reduce the cost and save time of running the faults troubleshooting. Also laboratory part of the thesis work could be recommended as the learning module for students to identify the significance of network monitoring.

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Zabbix SIA, 2011. Available: http://www.zabbix.com. Accessed 20 September 2011.

Router Configuration Scripts

cisco_router#sh run

```
 hostname cisco_router
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$FsHj$pvGBm8dDRJnm6W/br.ciF1
enable password cisco
!
ip source-route
!
ip cef
multilink bundle-name authenticated
!
interface FastEthernet0/0
 ip address 192.168.10.1 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 ip address 192.168.11.1 255.255.255.0
 duplex auto
 speed auto
```

```
interface Serial0/1/0
 no ip address
 shutdown
 no fair-queue
 clock rate 125000
!
interface Serial0/1/1 no ip address
 shutdown
 clock rate 125000
!
router rip
 network 192.168.10.0
 network 192.168.11.0
!

ip forward-protocol nd
!
no ip http server
!
snmp-server community Bon2go_monlo RO 1
snmp-server trap-source FastEthernet0/0
snmp-server location Kokkola, COUniversity
```

snmp-server contact Afeez Yusuff-Network Admin

snmp-server enable traps snmp linkdown linkup coldstart warmstart

snmp-server host 192.168.10.3 version 2c Bon2go_monlo

!

control-plane

!

line con 0

 password cisco

 login

line aux 0

line vty 0 4

 password cisco

 login

!

scheduler allocate 20000 1000

end

Switch Configuration Scripts

end

switch#1#sh run

!

version 12.2

```
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname switch#1
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$.uDU$w1dDGpHYmctbAN8pcQmRS/
!
no aaa new-model
system mtu routing 1500
ip subnet-zero
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
```

```
!
interface FastEthernet0/1
 switchport access vlan 99
 switchport mode access
!
interface FastEthernet0/2
 switchport access vlan 99
 switchport mode access
 spanning-tree portfast
!
interface FastEthernet0/3
 switchport access vlan 99
 switchport mode access
 spanning-tree portfast
!
interface Vlan1
 no ip address
 no ip route-cache
 shutdown
!
interface Vlan99
 ip address 192.168.10.5 255.255.255.0
 no ip route-cache
```

```
!
ip default-gateway 192.168.10.1
ip http server
ip http secure-server
snmp-server community Bon2go_monlo RO
snmp-server location Kokkola, COUniversity
snmp-server contact Afeez Yusuff-Network Admin
snmp-server enable traps snmp linkdown linkup coldstart warmstart
snmp-server host 192.168.10.3 version 2c Bon2go_monlo
!
control-plane
!
banner motd ^Cotd#You are accessing Yusuff'Lab#

!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 logging synchronous
 login
```

```
line vty 5 15
 login
!
end
```

switch#2#sh run

```
Building configuration...


Current configuration : 3695 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname switch#2
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$dA6N$Y/gQeHLD1fUjmPIeB62XJ/
!
```

```
no aaa new-model
system mtu routing 1500
ip subnet-zero
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport access vlan 99
 switchport mode access
!
interface FastEthernet0/2
 switchport access vlan 99
 switchport mode access
 spanning-tree portfast
!
interface FastEthernet0/3
 switchport access vlan 99
 switchport mode access
```

```
 spanning-tree portfast
!
interface Vlan1
 no ip address
 no ip route-cache
 shutdown
!
interface Vlan99
 ip address 192.168.11.5 255.255.255.0
 no ip route-cache
!
ip default-gateway 192.168.11.1
ip http server
ip http secure-server
snmp-server community Bon2go_monlo RO
snmp-server location Kokkola, COUniversity
snmp-server contact Afeez Yusuff-Network Admin
snmp-server enable traps snmp linkdown linkup coldstart warmstart
snmp-server host 192.168.10.3 version 2c Bon2go_monlo
!
control-plane
!
banner motd ^C You are accessing Yusuff's Lab^C
```

```
!
line con 0
 password cisco
 logging synchronous
line vty 0 4
 password cisco
 logging synchronous
 login
line vty 5 15
 login
!
end
```

Nagios Object Configuration File "iwolomo.cfg"

```
define host{

        use             generic-switch
        host_name       cisco_router
        alias           cisco_router
        address         192.168.10.1
        hostgroups      switches
  }
```

```
# Define the switch that we'll be monitoring


define host{
        use             generic-switch
        host_name       switch#1
        alias           switch#1
        address         192.168.10.5
        hostgroups      switches
  }
define host{
        use             generic-switch
        host_name       switch#2
        alias           switch#2
        address         192.168.11.5
        hostgroups      switches
        parents     cisco_router
 }
define hostgroup{
         hostgroup_name    switches
         alias                  Network Switches
         members              switch#1, switch#2
}
```

```
# Define the Nagios Server (NMS)

define host{

        use             linux-server
        host_name       UbuntuNagios
        alias           UbuntuNagios
        address         192.168.10.3
    }

# Define host for the adjoining PCs

define host{
        use             linux-server
        host_name       cclinux
        alias           cclinux
        address         192.168.11.3
        parents         switch#2
    }

define host {
        use             linux-server
        host_name       cclinux#2
        alias           cclinux#2
        address         192.168.10.4
        parents         switch#2
    }
```

#SERVICE DEFINITIONS

```
# Create a service to PING to switch
define service{
        use                     generic-service
        host_name               switch#1, switch#2, cclinux, cclinux#2,
UbuntuNagios, cisco_router
        service_description     PING
        check_command           check_ping!200.0,20%!600.0,60%
        normal_check_interval   5
        retry_check_interval    1
    }

# Monitor uptime via SNMP
define service{
        use                     generic-service
        host_name               switch#2
        service_description     Uptime
        check_command           check_snmp!-C public -o sysUpTime.0
}
```

```
# Monitor Port 1 status via SNMP

define service{

                use                         generic-service

                host_name                   switch#1

                service_description         Port 1 Link Status

                check_command               check_snmp!-C public -o ifOperStatus.3 -r 1
-H 192.168.10.5

}


# Monitor bandwidth via MRTG logs

define service{

                use                         generic-service

                host_name                   cisco_router

                service_description         Port 1 Bandwidth Usage

                check_command
                            check_local_mrtgtraf!/var/lib/mrtg/192.168.10.1_2.log!
AVG!1000000,1000000!5000000,5000000!10

}

# Define a service to check for PCs.

define service {

            use                         local-service

            host_name                   cclinux, cclinux#2

            service_description         Root Partition

            check_command               check_local_disk!20%!10%!/ }
```

```
define service{
        use                     local-service
        host_name               cclinux, cclinux#2, UbuntuNagios
        service_description     Current Users
        check_command           check_local_users!20!50
    }
define service{
            use                     local-service
            host_name               cclinux, cclinux#2
            service_description     Total Processes
           check_command            check_local_procs!250!400!RSZDT
           }

# Define a service to check the load on the PCs
define service{
         use                     local-service
         host_name               cclinux, cclinux#2
         service_description     Current Load
        check_command            check_local_load!5.0,4.0,3.0!10.0,6.0,4.0
    }
```

```
define service {
        use                     local-service
        host_name               cclinux, cclinux#2, UbuntuNagios
        service_description     Swap Usage
        check_command           check_local_swap!20!10
    }
```