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Visual Networking

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VISUAL NETWORKING

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Abstract

This research presents a case study of the Regis Academic Research Network (ARNe). It will focus on network bandwidth graphs and the information collected over a six month period of time. The case study will provide comparison of network bandwidth graphs. This case study will be used to theorize what is happening on the ARNE. In addition it will be used for creating hypotheses on what will happen to the network in the future.

The research will also include a project. The project is to provide the setup and planning of the installation of open source tool set. This project will give Regis network administrators a useful tool in troubleshooting and planning with regards to the ARNE.

Acknowledgements

I would like to thank my teachers, classmates and family for their knowledge and support while pursuing this project. I would also like to thank the all the in the open source software community for providing robust free enterprise tools to customize, create and implement however needed. Lastly, I would like to thank Steven Huart a Doctor in an unrelated field for providing an unbiased critique of the project and its components.

Table of Contents

List of Figures

List of Tables

Chapter 1 - Introduction

Thesis Statement

In this case study a small network of network devices will be monitored in the Regis Academic Research Network (ARNe). There are 13 network devices that will be a part of the case study. These devices will have data collected from them by the associated project. The data collected from the project will be observed and compared over a 6 month period of time in order to develop trends or patterns to understand network traffic. At the end of the six months the data will be extracted in the form a graph. The network traffic will then be used to determine if this method is sufficient infer problems or aid in planning of future projects on the ARNe. The hypothesis is that a visual network monitoring system would be an effective and efficient way for Regis network engineers to monitor their network devices.

Statement of Technical Problem

Computer networks can experience many problems such as packet loss, data corruption and latency (Marchette, 2001). Monitoring and managing a network on an ongoing basis is a daunting task (Frisch, 2002). A network monitor is a system designed to monitor traffic in and out of the network for the purpose of determining whether the network is working properly. (Marchette, 2001) How fast can a network monitoring system identify potential problems in the network compared to a person doing the same work?

When a computer network is up and all the applications are functioning great the users are typically happy with the service provided by the network. What happens when things change in the network or add a new service that utilizes the computer network? How will it be determined if the current computer network will support adding services?

What level of service can be provided a user and/or application if there is no way to measure it? These problems go unanswered every day because monitoring network traffic is considered a luxury that is not critical in order for a computer network to function. Other reasons that computer network monitoring isn’t thought of as an immediate need is the time it takes to setup a solution, the knowledge base required to implement the solution, and money. Setting up enterprise network monitoring solutions takes time and expertise and they are expensive.

Project Relevance

The goal of this research is to explain and implement a method of capturing statistical data from the ARNE. It is the intent of the research to provide analysis of the data as well as a monitoring application for RUSP to be used in the future long after the initial research is over. The monitoring application will have to be user friendly, easy to use and support a variety of different devices that may be connected to the computer network.

The results of the case studied and corresponding project should be verified by the activities and cases that have historically already happened over the past six months in ARNE. This can be done by comparing open and closed ARNE tickets with the results and data collect with this project. That can be accomplished by comparing incidents and time lines with the dates and times of data collection in this project. However this case study will not compare or contrast those other cases or incidences and will be deemed out of scope for this project.

What to Expect

The discussion in the following chapters will focus on the details of the project. Chapter Two will describe the research methods and resource requirements utilized. Chapter Three will include terms and definitions plus a review of the literature and existing research to support the thesis of this project. Chapter Four analyze the data and present the results of the project. Chapter five defines how the project was designed and implemented plus the setup of the monitoring tool. The last chapter, Six will end with a conclusion and summary.

Chapter 2 - Review of Literature and Research

Terms and Definitions

To grasp the concepts of the project let’s review some terminology. This is a detailed list of terms and definitions discussed in the following chapters. It is recommended the reader review and become familiar with them before continuing.

The project is being built from the ground up and is not an addition or add-on to any other project. To start off the project a review of basic computer terms and progress to software terminology and, finally, network terms.

Computer

The project that has been built for the case study requires a personal computer (PC) or server. There are technical differences between the two however they are irrelevant for this discussion. For this project a PC was chosen for the fact as it was donated, and met minimum specification as set before the project. There are too many components of a computer to talk about all of them so let's focus on the CPU, memory and storage.

The CPU, or central processing unit, is the brains or logic behind the computer. The CPU will dictate how fast the project will respond to querying and gathering data. CPUs are normally measured in megahertz (MHz) or gigahertz (GHz) and it reflects the number of cycles per second a processor can perform. The cycles per second are how many times a CPU can change its voltage from high to low and back again. This project is has one purpose and that is to collect network data which is a low processor intensive action. For that reason the minimum CPU requirements are low.

Memory in a computer is a fast temporary storage place for instructions or data for the CPU. This type of memory requires electrical power for it to retain data. If power is lost, data is lost. Memory is measured in megabytes and gigabytes. You can fit 500 pages of text on 1 megabyte of electronic memory (Conjecture, 2009). In context to this case study and corresponding project the memory will be mainly used to support the functions of the operating system it will be used slightly for the monitoring application that collect the network data but memory usage for that application will not exceed 128 megabytes.

Storage in this project is important because the project relies not only on gathering data but also keeping it for a period of time. Storage allows the function of keeping data for a long period of time even if power is lost. Storage in 2009 is going to be measured in gigabytes or terabytes. You can fit 133251 Full Pages and 5266 Characters of text on 1 gigabyte of storage. The storage for this project will be collected on a single hard drive. The data collection for six months will not exceed 10 gigabytes of hard drive storage space.

Software

The case study and its corresponding project are built off of another project called LAMP (Linux Apache MySql PHP). The case study will rely on LAMP and its components to run the monitoring application. Linux is the very first component in LAMP and it is an computer operating system. This is crucial because Linux is the core that makes LAMP work. Without Linux it would be like trying to run a car without an engine. The objective of Linux is to provide the operating system that will run the rest of the parts of LAMP. There are many different types of Linux distributions and some are tailored to installing the other three components. A distribution is simply a group or organization that has packaged a Linux kernel with other tools and programs to make an operating system. Linux operating systems or distributions are almost always free. There are exceptions, but in this case it won't be an issue.

Installing Linux can be really easy or really hard depending on which distribution is chosen. This project will take on an installation of a Linux distribution that is at a high level.

The second component of LAMP is Apache. Apache is a web server that is installed on the Linux operating system. Apache is a service that serves web pages. When going to a website from your browser, in order to get the content for that website, the browser actually contacts and communicates to a web server owned by the website owner. One of the more interesting industry surveys shows that in 2006 nearly 70 percent of all web servers were Apache (Rosen, Host, Klee, Farber and Rosinski 2007).

Apache is not just for Linux. Apache can be installed with many different operating systems like UNIX and Windows. The Apache project was created in 1995 (Rosen, Host, Klee, Farber and Rosinski 2007). It was created from a spin off of another project that was no longer being developed. It has been said that Apache received its name from the fact that it was used to patch the other project that was not getting developed anymore (Rosen, Host, Klee, Farber and Rosinski 2007).

MySql, or my sequel, is a database and is the third component of LAMP. A database allows website and applications developers to manipulate a lot of data without having to specify or hard code software to do the same function. A database is like a smart piggy bank. It's a container for money or leftover change. However this piggy bank is smart and it can tell how many dimes are in it or where the dimes were minted. MySql is a piggy bank for data. It is a central place where data can be kept for other programs or applications to use. It keeps data in order and accessible.

MySql was developed by T.c.X. DataKonsultAB (Rosen, Host, Klee, Farber and Rosinski 2007). It is not limited to Linux use but has cross operation system capabilities. MySql features include speed, ease of use and reliability (MySql AB, 2007). MySql is a multi-threaded program used for different software program libraries and has multiple different API's (application programming interface). An API can be very useful in a database, especially if all the commands that are needed are unknown to the user. MySql can be one the hardest parts to setup and get working properly. In the installation of MySql it is easy to install, however, what is not seen is how hard it is to actually create a database for it to function.

The last part of LAMP is Hypertext Preprocessor (PHP). PHP is primarily a scripting language for server side computing. PHP is a powerful language that can connect to the databases just created with MySql. It can also be embedded in html code that the Apache server displays. PHP was created by Rasmus Lerdorf in 1995 and was officially released in November 1997 (The PHP Group, 2007).

One issue with PHP is with Apache. To recognize PHP as a scripting language a PHP module in Apache will need to be loaded. The way to load modules is to edit the httpd.conf file normally located in the /etc/httpd directory.

What does LAMP do? What is the history? How did these four items come together to create what has become one of the most dynamic set of tools in web application development? In December 1998 author Michael Kunze published an article, "Let There Be Light" (Kunze, 1998). The article centers on free web publishing tools used to create dynamic customer accessible databases. Since then, LAMP has grown in popularity. One indication of this is the number of career opportunities that are available related to LAMP applications.

What is a real life application of LAMP? Imagine there was a small business that wanted to create a website and sell snowmobile parts online to riders. This business consisted of the owner and an idea. The owner had shopped around different technology firms looking for one that would create, design and host this website for the least amount of money. During his investigation the owner found out that the up front cost was thousands of dollars more then he had expected. He turned to an acquaintance that was in the technology field who recommended the open-source tool set called LAMP. The acquaintance said if he was given a used desktop computer with good hardware he could build it for him for a flat fee of $200 dollars. The flat fee sounded great and the actual software was free so the owner of the snowmobile website did not have to pay any large licensing fees for comparable software. The computer builder installed the server with LAMP on it in a couple of hours.

The owner had the server connected to the Internet via his existing business's internet connection because it was not necessary to get a dedicated line while in the startup. Needless to say, the owner had a fully functional web server with a database to build the best online snowmobile parts website. However, without content and the application, the parts of LAMP do absolutely nothing. The owner asked the person who built the LAMP server for him how to get the website up and running. The server builder told the owner to hire freelance software developers to build it.

After exhaustive research, the owner found the cost of hiring someone to create his site was the same as before even though he had his own server and network. The owner again went back to the LAMP builder for advice. The LAMP builder told the owner about software that was already made that would instantly give him an online store. The snowmobile parts website owner wanted to know how much that software would cost him. The LAMP builder told him it was free but there would be a fee to pay to have it installed by someone who knew what they were doing and he would do it for another $200 dollars.

The software that was installed was a combination of a database, html and PHP code. All the software was installed in the web directory. In that directory there is an install.php file that would run via a web browser that asks for information like the database password for MySql. After entering a minimal amount of information the software creates all the databases and files on the web server in order to run an online shopping cart website. The software that was chosen for this site is called Zen Cart. It features a full shopping cart with pay pal integration. The owner is given a web interface to add products, change prices, view orders and perform other accounting functions. The snowmobile parts owner now had a fully functional LAMP server with a website and online shopping cart with a database backend and only paid $400 dollars out of pocket. The biggest limitation for him was cost; he absolutely did not want to pay the $1000 to $2000 dollars just to get a website up plus the monthly costs to keep it running.

One limitation with these already predefined LAMP compatible software packages like Zen Cart is limited styles that affect the way the web site can look. Without a lot of customization the website will look like everyone else’s that downloaded the same freeware software.

The second case study is not about a website to make money but a productivity web application. John is a member of a network engineering team that manages 2000 devices for different clients. For security reasons, all 2000 devices have a unique username and password. The problem for John to solve was how to manage all those passwords and still make them secure. Currently the team is using an excel spreadsheet to do this function and there have been issues with not updating the spreadsheet or having the wrong version that does not have the passwords for new devices.

John knew the best way to keep a lot of data was to put it into a database. However John was not going to be given any resources or money for this project. John was also not going to get a database administrator or software to create this database. He started looking at open-source tools and came across LAMP. John already knew about

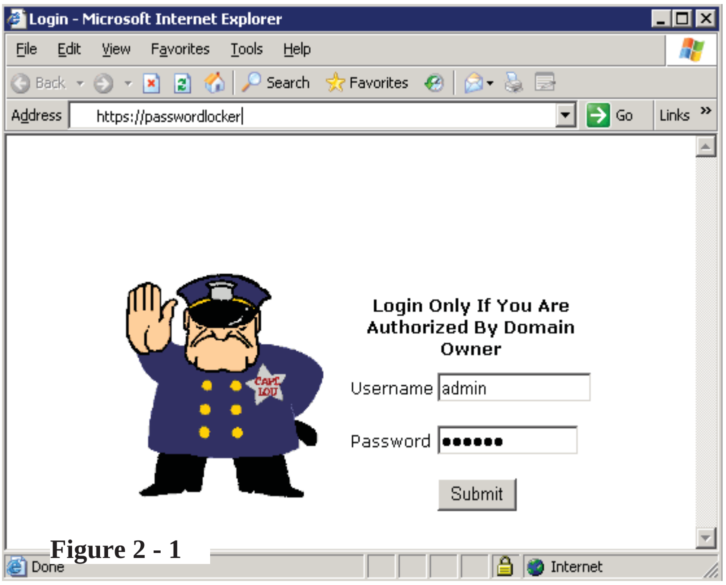
Linux and Apache so he would have to leARNe two more programs, PHP and MySql, to be successful in creating a password manager. Linux and Apache would be used to display the application to the users, PHP would be developed as the user interface, and MySql would store the passwords.

Since John used a database to store all the passwords he was able take his time getting familiar with PHP. In fact, he got so good at inserting and displaying database items with PHP that he was able to create an application that allowed all fields to be edited. In addition to all these pluses, adding new devices and clients could be done by the lowest level technician.

John had one thing left to do and that was to make sure that the passwords would not be compromised by outside hackers. For this he used all parts of LAMP to secure the data. In Linux he deployed iptables which is a firewall and removed all non-essential services. With Apache he was able to configure it so that it would only accept SSL (secure socket layer) connections. This is equivalent to typing https:// in the web browser. SSL makes sure that the connection between the user and server is encrypted so no one can eavesdrop on the traffic to try and steal passwords. PHP code was developed so that no passwords could be viewed from looking at the source code of the application, not even the ones talking to MySql. For MySql, encryption was placed on the actual passwords stored in the database.

John created this application out of necessity even though he did not make any money from it. John chose LAMP because it was free and he already knew half of the total tool set it took to complete this project. John and his co-worker enjoy a rich customizable application for storing their 2000 passwords with customized searches to find the right password fast.

Take a look at John’s project and point out one security feature mentioned previously. Figure 2-1 above is of the main login page of the application John built. The first security feature that was implemented is that in the address bar it shows https://passwordlocker. This means Apache is doing its job and securing the connection between user and the server. The second security feature is that the password to login to the site is unreadable meaning PHP is doing its job. Take a look at the source file from this page and will notice no password to the database can be found either. Because this is a real application no other screenshots can be shown.


Login - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address
Go Links
CAPT LOU
Submit
Done
Internet

Address https://passwordlocker

Login Only If You Are Authorized By Domain Owner

Username admin

Password ●●●●●●

Figure 2 - 1

The two examples above have demonstrated the power and ease of using LAMP. There are some down sides to using LAMP that are worth noting. The biggest one and the main reason some corporations will not go to LAMP is that it is open-source. Open-source operating systems and programs are almost exclusively developed and supported by a user base peer group. What this means to a corporation is that support is limited and for a large corporation that intends to make money, that normally is an aspect of open-source they can not risk. This is also why companies like Microsoft and Oracle still are large players because they offer a variety of tools with support options that large corporations feel more comfortable with.

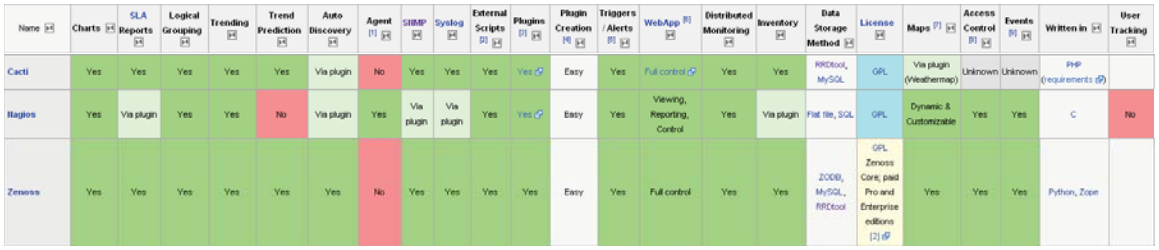
The term open-source also stems from the fact that the source code to that software is available to anyone who wants it. That can also be problematic because it's easier to find holes in software when given the source code. Add the fact that open-source software is mostly unsupported by the creates for individuals it is hard to patch a security hole if ones found and that makes corporations shy away from open-source software. LAMP is a powerful set of tools but when to use them must be chosen wisely. Not every situation calls for the use of LAMP. In a high volume production web application this author personally would stick with a manufacturer supported product line like Microsoft software.

Why LAMP for this project. LAMP has been proven faster, cheaper, more flexible, and easier than any alternative for the project. In June 2005 CNET published an article called "Open-Source LAMP a beacon to developers" where it states that more corporations are moving toward LAMP and calling on developers to fill the positions (LaMonica, 2005). This allows future developers on the project to use skill sets that corporations are looking for. LAMP and its components are also requirements for a lot of the open source monitoring software. There is a strong push to LAMP by vendors ranging from IBM to Oracle to numerous startups—and these vendors are adding enterprise-grade capabilities and management to LAMP. There is no question that LAMP is not a passing trend, but now entering the mainstream as a serious contender to J2EE and .NET (Yared, 2005). Software like Cacti, Nagios, NeDi, Zenoss all have installation software that are based off of at least one or more components of LAMP.

This project is solely based of the software Cacti which relies on every component of LAMP.

LAMP is not the only thing required for this project to work. Round robin database tool (RRDTool) is software that will make all graphing and data collection happen for the network monitoring tool. “RRDtool is the open-source industry standard, high performance data logging and graphing system for time series data. Use it to write the custom monitoring shell scripts or create whole applications using its Perl, Python, Ruby, TCL or PHP bindings.” (Oetiker, 2009) There are other options to the RRDtool like Torrus. The monitoring application Cacti that was chosen is engineered and setup to use the RRDtool to use a different one like Torrus would mean going to a different monitoring application. This is the brains behind the monitoring software and it is a key part of making the graphs to be analyzed in the case study.

Cacti is the last piece of software to discuss. It was chosen out of a list of well known open source network monitoring software packages. How this software was chosen was by doing a comparison of features then picking the features that would best suit the case study. The comparison chart feature on Wikipedia is one the most comprehensive comparison charts that is kept up to date. It list both commercial and open source monitoring software so it was easy to narrow down which software was exclude completely based on cost. Out of the list on Wikipedia 3 monitoring software packages were chosen for a more detailed comparison. The 3 packages chosen were Cacti, Nagios and Zenoss and below are their features from Wikipedia.



Name	Charts	SLA Reports	Logical Grouping	Trending	Trend Prediction	Auto Discovery	Agent [1]	SNMP	Syslog	External Scripts [2]	Plugins [3]	Plugin Creation [4]	Triggers / Alerts [5]	WebApp [6]	Distributed Monitoring	Inventory	Data Storage Method	License	Maps [7]	Access Control [8]	Events [9]	Written in	User Tracking
Cacti	Yes	Yes	Yes	Yes	Yes	Via plugin	No	Yes	Yes	Yes	Yes	Easy	Yes	Full control	Yes	Yes	RRDtool, MySQL	GPL	Via plugin (Weathermap)	Unknown	Unknown	PHP (requirements)	
Nagios	Yes	Via plugin	Yes	Yes	No	Via plugin	Yes	Via plugin	Via plugin	Yes	Yes	Easy	Yes	Viewing, Reporting, Control	Yes	Via plugin	Flat file, SQL	GPL	Dynamic & Customizable	Yes	Yes	C	No
Zenoss	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Easy	Yes	Full control	Yes	Yes	ZODB, MySQL, RRDtool	GPL Zenoss Core; paid Pro and Enterprise editions [2]	Yes	Yes	Yes	Python, Zope	

Table 1

The comparison chart (table 1) has 23 different characteristics that each of the 3 monitoring software packages were evaluated from. Each of the 23 different characteristics was given a weighted value in table 2. Each individual monitoring package was be given zero, total or half credit depending on the type of characteristic. The weights were then added together and the one with highest number was the monitoring application that would be chosen. In the case of a tie the author of the case study would objectively pick base on screenshots of the monitoring application.

Name	Max Value	**Cacti**	Nagios	Zenoss
Access Control	10	10	10	10
Agent	10	10	0	10
Alerts	10	10	10	10
Auto Discovery	5	3	3	5
Charts	10	10	10	10
Data Storage	10	10	5	5
Distrubited Monitoring	1	1	1	1
Events	10	10	10	10
External Scripts	1	1	1	1
Inventory	1	1	1	1
License	10	10	10	5
Logical Grouping	10	10	10	10
Maps	1	1	1	1
Plugin Creation	10	10	10	10
Plugins	10	10	10	10
SLA Reports	1	1	1	1
SNMP	10	10	5	10
Syslog	1	1	1	1
Trend Prediciton	10	10	0	10

Trending	10	10	10	10
User Tracking	5	5	0	5
WebApp	1	1	0	1
Written in	5	5	5	5
Totals	152	**150**	114	142

Table 2

Network

The end goal of this project is to have a working application to monitor the performance and load of network devices. To start with, the network that is being referred to is a computer network. This is a group of devices such as switches, routers, firewalls and computers or servers connected physically or logically together to transfer data.

Before discussing networking devices it is important to introduce a model that is an industry standard guide line for communication between devices. That model is the Open Systems Interconnect (OSI) reference model. The OSI model has seven layers total and each layer is allowed to communicate to the layers adjacent to itself. The layers are physical, data link, network, transport, session, presentation and application. It is common for each layer to be referred to as a number starting with layer 1 which is the physical layer next layer is 2 which is the data link layer and continue in the same order as they are listed above. In the project and case study a consider amount of knowledge on the OSI model will be referenced when evaluating the data collected. The project will use all the layers behind the scenes in order to collect the required data for the project. Each of the devices in the study also fit into one or more layers of the model and knowing which layer the devices apply to goes directly to the understanding of how the case study will be presented and reported. The following paragraphs will discuss the network devices that are a part of the study and which layer or layers of the OSI model they typically associate themselves with.

A switch is a network device that connects multiple computers together (Mitchell, 2009). Switches come in all shapes, sizes and manufacturers. Switches have different port density which is how many devices can be connected to one switch. A typical switch resides at the layer 2 or data link layer. In the case study the switches at this layer are responsible for connecting smarter or decision make devices together such as PC's, servers, routers and firewall. Layer 2 controls physical addressing and the flow of traffic between devices. The data link layer provides sequencing and flow control for connection and connectionless oriented services.

Routers are devices that join multiple wired or wireless networks together (Mitchell, 2009). Routers forward Internet Protocol packets from one network segment to another. Routers also come in different sizes and from different manufacturers. Routers operate at the network layer or layer 3 of the OSI model. The network layer controls logical addressing and most notably indentified as the layer where Internet Protocol (IP) addresses are defined. Routers operate at the network layer by mapping and storing different networks and choosing the best path to those networks. In the case study and corresponding project the routers are analyzed by their utilization of resource on the router and not specifically for their layer three abilities.

Firewalls are network devices that protect networks from unauthorized access (Mitchell, 2009). Firewalls are most commonly the first layer of defense within a network. Applying firewalls is a given when trying to secure a network. There are two types of firewalls, perimeter firewalls and personal firewalls. Simply put, a perimeter firewall is a firewall that is placed between the network and unknown networks. Perimeter firewalls are typically hardware devices that normally sit on the outside of the internal network protecting it from unknown networks. A personal firewall is one that resides on the computer or servers and can do more application level blocking. A personal firewall will also protect the computer or server from unknown networks. The internet is an example of the biggest unknown network. For this project, perimeter firewalls are the only type of firewall that will be considered. Firewalls can operate at the network layer through the application layer depending on firewall type. As with routers the information from the firewall is utilization and not information specifically about a particular layer.

Personal computers and servers are a part of the network but are not going to be monitored or reported on as a part of this project. Most computers and servers on a network sole function are not as network devices when referring to network devices these will include switches, routers and firewalls. This project will only gather information at network devices not at computers and servers in order to make an analysis of the network. Switches, routers and firewalls are the three most common devices in any network and are the only network devices located as part of the RUSP network.

SNMP

The premise of the entire project rests on the understanding of Simple Network Management Protocol (SNMP). This is the frame work that allows the gathering of information from a network device or server. SNMP can be divided into two main categories, GETs and TRAPs. An SNMP GET is when the monitoring software queries a network device or server. An SNMP TRAP is when a network device or server sends a notification that something happened. This project will only be concerned with SNMP GETs. Without SNMP there would be no monitoring software or RRDTools.

There are three other terms that are required knowledge when dealing with any type of network monitoring tool; Management Information Base (MIB), Object Identifier (OID) and community string. The MIB is a tree structure with individual variables, such as point status or description, being represented as leaves on a branch (Alvestrand, 1997). A loft numeric tag or OID is used to distinguish each variable uniquely in the MIB and SNMP messages. A community string is an access key to the network devices statistics.

When it comes to SNMP there are many possible versions. Each version adds specific functionality to it. For this project snmp version 2c will be used which is one of the most common and default setting for a lot of network devices. The basic difference between the versions is how security is implemented. Since SNMP hosts a wealth of information about the device it is very important to protect SNMP from unauthorized use. In summary, SNMP is the protocol that network devices and servers use to communicate with network monitoring systems in order to gather data and report on it.

MIB

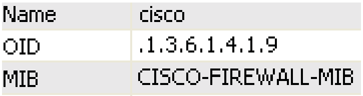
MIBs are like a structured database of all the statistics that can be read from a network device or servers. OIDs are the specific stat that is reported on. For example, in measuring a piece of paper, the ruler would be the SNMP, measuring in standard or metric would be the MIB, and the height and width would be the OID.

To help aid in troubleshooting SNMP for this project there are three utilities that were used; snmpwalk, snmpget and MIB Browser. These tools query the network device and server taking software monitoring applications out of the picture to narrow down where a problem might occur. SNMPwalk is a command line utility bundled into a software package called snmp-utilities. What this command does is attach itself to a leaf on the MIB tree and scan the rest of the leaves displaying the output of all the leaves it finds for that tree. SNMPget is also a command line utility bundled into the snmp-utilities software package. It will query a specific OID and display the results. The last troubleshooting utility is MIB Browser by iReasoning. This allows the user to load MIBs that are supplied by the network device manufacture and browse the tree structure graphically. MIB browser can then do a SNMPwalk or SNMPget from any given MIB or OID.

OID

"Object identifiers are, basically, strings of numbers. They are allocated in a hierarchical manner, so that, for instance, the authority for "1.2.3" is the only one that can say what "1.2.3.4" means. They are used in a variety of protocols. The formal definition of OIDs comes from ITU-T recommendation X.208 (ASN.1), which is available from the ITU. The definition of OID is in chapter 28; the assignment of the "top of the tree" is given in appendixes B, C and D. The encodings - how to transfer an OID as bits on the wire - is defined in X.209" (Alvestrand, 1997).

Each position in the OID or string of numbers is a category. Take a Cisco Firewall MIB for example. It can be downloaded from Cisco.com without even owning a Cisco firewall, however, it is specific to Cisco firewalls so it does users no good without owning a Cisco firewall. In the ARNE computer network there is one Cisco firewall and it will be used as a practical example.



Name	cisco
OID	.1.3.6.1.4.1.9
MIB	CISCO-FIREWALL-MIB

Figure 2 - 2

Figure 2 – 2 is a generic version of an OID that really only identifies the company, which is Cisco. In this example it is critical to leARNe the OID structure so when trying to monitor a device the information can be used to find the correct string of numbers for the data or monitoring statistic. Take a closer look at figure 2 – 2. The first digit, .1, is the first category and is called the Top level OID. There can be three options here; a 0, 1 or 2. The first digit represents who assigned this particular OID. In this case the OID was assigned by an organization called ISO. Below is a list of the three different options available for the first category. All MIB information comes from an article on Object Identifiers by H. Alvestrand.

- 0 - ITU-T assigned
- 1 - ISO assigned
- 2 - Joint ISO/ITU-T assignment

(Alvestrand, 1997)

The second digit dives deeper into the different levels of who assigned the OID. The second category has more options than the first but is dependent on the first. The first digit selected dictates the options for the second digit. In our Cisco example it is .1.3

- 1.0 - ISO Standard
- 1.1 - ISO Registration Authority (retired)
- 1.2 - ISO Member Body
- 1.3 - ISO Identified Organization

The third digit, which is a 6 in our example, is the category which lists the organizations that are recognized by ISO. In the list below these have multiple options that are quite lengthy and our third digit makes this a US Department of Defense recognized OID.

- 1.3.2 - SIRENE (French national business register)
- 1.3.6 - US Department of Defense
- 1.3.12 - ECMA - European Computer Manufacturers Association
- 1.3.14 - OIW
- 1.3.16 - EWOS - European Workshop on Open Systems
- 1.3.17 - Bellcore
- 1.3.18 - IBM
- 1.3.22 - Open Software Foundation
- 1.3.23 - NORDUnet
- 1.3.24 - Digital Equipment Corporation
- 1.3.26 - Nato Identified Organisation
- 1.3.36 - TeleTrusT
- 1.3.52 - Society of Motion Picture and Television Engineers
- 1.3.69 - SITA - Societe Internationale de Telecommunications Aeronautiques
- 1.3.76 - UNINFO (Italy)
- 1.3.90 - Internet Assigned Numbers Authority
- 1.3.101 - Thawte Consulting
- 1.3.114 - Check Point's registered prefix
- 1.3.132 - Certicom Object Identifiers
- 1.3.135 - SIA Object Identifiers

The fourth digit is a 1 and it stands for Internet which is actually the only option in this category. It is also one of the most popular beginnings for OIDs that will be monitored as a network engineer for ARNE.

- 1.3.6.1 - OID assignments from 1.3.6.1 - Internet

Digit number 5 is a 4 and it represents private organizations that have a need for their own OIDs. The other options, indicated below, are not widely used.

- 1.3.6.1.1 - Directory
- 1.3.6.1.2 - Management (mgmt)
- 1.3.6.1.3 - Experimental
- 1.3.6.1.4 - Private
- 1.3.6.1.5 - Security
- 1.3.6.1.6 - SNMPv2

- 1.3.6.1.7 - mail

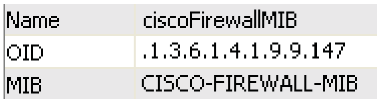
The sixth digit is interesting because the majority of the time will use 1 as is highlighted below. The options after 1 are all private enterprises like Cisco who are given their own digit and they can then create their own MIBs from there.

- 1.3.6.1.4.1 - IANA-registered Private Enterprises
- 1.3.6.1.4.1306 - MTA Exim Schema
- 1.3.6.1.4.3224 - Netscreen
- 1.3.6.1.4.3609 - Cequs Inc. c=US Virtual Directory MIB
- 1.3.6.1.4.8300 - State of Wisconsin
- 1.3.6.1.4.17434 - Bio-Imaging SAS

The last digit in the figure 2 – 2 is a 9 and this represents Cisco. All Cisco OIDs will start with 1.3.6.1.4.1.9. Below is just a sample of how many options there are. There are a lot of companies using this convention and IBM, HP and Sun are just a few. In reality, there could be an infinite number of different companies with their own seventh digit number under the ISO.ORG.DOD.INTERNET.PRIVATE.ENTERPRISE MIB.

- 1.3.6.1.4.1.2 - IBM
- 1.3.6.1.4.1.9 - Cisco
- 1.3.6.1.4.1.11 - Hewlett-Packard Company
- 1.3.6.1.4.1.18 - Wellfleet
- 1.3.6.1.4.1.23 - Novell
- 1.3.6.1.4.1.42 - Sun

In the example of the Cisco firewall the snmp string of numbers does not stop at the seventh digit. After all, Cisco makes more than one product not just firewalls.



Name	ciscoFirewallMIB
OID	.1.3.6.1.4.1.9.9.147
MIB	CISCO-FIREWALL-MIB

Figure 2 - 3

The eighth number is always Cisco Mgmt and is always 9 but the ninth digit is the product category. In this case looking at a firewall MIB and the product number is 147. Another product for Cisco is a load balancer. The eighth number for that product is 368 not 147. This is a critical category when trying to setup monitoring. Know what product you are monitoring is important in order to be able to troubleshoot and test the monitoring solution.

Community String

A SNMP String is not a cord of fiber but a generic password for network monitoring tools to be allowed to read the MIBs of network devices. The community string must be configured on the network device and the network monitoring tool. They must be the same on both devices before the network monitoring tool is allowed to read the network device's MIB. A community string can be almost any number of characters that can be found on a keyboard. The default for almost every network device is called "public". Since the default of most community strings is public, it is recommended at minimum that the default be changed. Otherwise, anybody that has access to the network can start querying the network devices and may find out information that they are not supposed to have. There are different types of community strings such are read-only and read-write. In this project the only concern is with read-only strings.

Chapter 3 - Methodology

I. Plan

In implementing this study, the researcher's intent is to measure bandwidth of the RUSP network devices interface. In this project the researcher is looking for two things: 1) what kind of bandwidth does RUSP network use and 2) what application or procedure is used to identify if a network device is being over utilized.

II. Design

The research design is the statistical analysis of visual graphs gathered from the RUSP network over a six month time period. The analysis will be performed to determine whether or not this case study supports the use of graphic analysis in managing the ARNe network to solve problems and/or aid in planning. The case study design is based on network management practices and protocols that are industry standards as defined by RFC1157. The Simple Network Management Protocol (SNMP) was to be used to manage nodes in the Internet community. The Simple Network Management Protocol (SNMP) is used to communicate management information between the network management stations and the agents in the network elements (Case, Fedor, Schoffstall, & Davin, 1990). Therefore, if the results are favorable, this project could be replicated by other network engineers. It could be used on any computer network, from a large network like Regis's with numerous devices and huge bandwidth, to a small computer network. The criteria for whether the case is successful is based on access, accuracy, ease of use and customizability.

Accessibility defines whether or not the graphical representation of the ARNe network could be seen by the network engineers over the course of the study. This is measured in uptime of the graphing application. Uptime refers to the amount of time the application has been running. Graphs that cannot be viewed cannot be analyzed. Accessibility also refers to the speed in which data is accessed which is measured in time. The faster the statistics can be graphed, the quicker analysis can start. In computer network management the speed with which a problem can be identified and corrected is directly related to quality of service expectations of the users of that network. Success factors in accessibility would be 99 to 100 percent uptime on the graphing application and less than a minute to create a graph from six months of data.

Accuracy is associated closely with reliability. The network engineers need to know that the graphs collected from the network are correct, that the statistical graphs match the information off of the devices, and that there is no deviation. This was measured two ways. First, network devices were measured manually. Second, the results were presented to ARNe network engineers to demonstrate the graphical analysis of the data and solicit their feedback. Success factors in accuracy would be 100 percent of all samples must be the same between actual statistics and graphical form.

Ease of use is how much easier it was for the engineers to use graphical data to solve problems. At the beginning of the project, the researcher held a meet and greet with Regis ARNe network engineers. The researcher asked two questions about the current ARNe network. The first question asked was, “What kind of bandwidth does the ARNe network use?” The second question was, “What do you use to tell if a network device is being over utilized?” Not one of the network engineers could answer the questions. Instead of basing the research off of a comparison between the old method of data analysis (which was none) and the graphical analysis, the researcher based the measurement of ease of use by studying similar cases and inferring the results. Success factor in ease of use would be at the end of the case study the same group of engineers can answer the questions above.

Not all computer networks are created the same so the research has to account for a wide variety of network devices and be capable of graphing them. The way this was measured in the case study was by creating graphical data from different types of network devices like firewalls, routers and switches, and by different manufactures. For the research to apply to networks in general the devices used in the research will have to incorporate a wide variety of devices. This criterion is measured by the number of different devices the research was able to graph and by how many vendors. Success factors would include creation of graphs by 3 different types of network devices and 2 different vendors of network device as found in the ARNe network.

Supporting the design of the research is going to be a statistical analysis of RUSP's network. The case study will consist of six months of statistics and the analysis of those statistics. Analysis of data in the form of a visual graph will be studied over a period of time to gather data and make inferences about growth and potential bottlenecks in the network. Through a descriptive approach it will reveal the nature of the network in different situations and time.

This study is really designed as a quantitative form of research. In the field, trends are much harder to quantify even though actual numbers are being used. This study will look closely at the trends to make judgments which represent an experience based analysis with factual data to backup the hypotheses. The study will use equipment to keep track of the data with an outside date and time stamp resource for accuracy. A computer will be required to collect the raw data. This will allow for an unbiased, objective and precise measurement of the data. Once the collection equipment is installed, data will be collected in five-minute intervals over a period of six months.

According to Yin (2009) there are four elements for judging the quality of research design; validity, internal validity, external validity and reliability. The first element, validity, is the use of correct operational measures for concepts being studied and will be defined in Chapter 3 of the research paper. The second element is internal validity. This study applies the principle of internal validity by evaluating the increase in use of the RUSP network during the months of May and August when traditional classes end and begin. The third element is external validity which means, can this study be used to describe other cases like it? The answer is yes. By using industry standards and methods described in the following chapters the results will stay the same regardless of the case, i.e., increasing bandwidth or traffic in a network will affect the performance. The fourth element is reliability. In order to achieve reliability in the current project, the researcher minimized errors by collecting raw data with a computer. This study could be replicated by another researcher with similar results.

III. Prepare

Network monitoring is one of the most overlooked and taken for granted areas of the field according to Dave Piscitello, an authority on network security with more than 30 years experience in data networking and telecommunications (Piscitello, 2005). The insight gathered from this study will help network administrators understand the tools they need to monitor and maintain a computer network.

“Network monitoring software makes a practice of regularly taking virtual snapshots of the network’s workflow (Conjecture, 2009).” With these snapshots, graphs and charts can be created from the data. The snapshots or data can also be used in trending and analysis of problems for future growth of the network. This is where the title of Visual Networking comes from. Visual Networking means taking snapshot data and creating a visual representation of the data to look at the network's workflow. For the rest of this study computer network will be referred to as just network.

Network problems come in many forms. One common network problem is packet loss. When a user requests a website from his local computer the data is transferred across the network in the form of data packets. Packet loss is data requested that is never received. In the website example above, most web browsers will help correct for packet loss by just asking for the missing data again. However, in video communications it is not as simple as just asking for the packet again. Video is very time dependant. The user's experience is greatly depreciated if packets have been lost with video.

One cause of packet loss is network congestion (Zekauskas, 2005). Network congestion is too much network traffic on one or more critical links in the network. Almost all networks have multiples links, some in the thousands. How does one look at them all to find the link or links that have too much traffic on them? A network monitoring tool will help find those links without having to go to every device and every server that is connected to a link to manually check the traffic.

The amount of data collection and correlation that needs to happen in order to monitor a network is almost impossible for a person to do by hand. Data collection must be fast and efficient in order to keep current and accurate records. Computers have the ability to do repetitive tasks very fast and this is a critical component in the gathering of data. The more data collected and the faster it can be collected, the more useful the results will be.

A computer cannot run by just turning it on. The need arises for an operating system (OS). The operating system for this research study is not as important as the application. Every operating system has its benefits and limitations. In this research the requirement for an OS is to be free because there is no funding for this project. The OS will need to be stable. Even though one of the goals is not to spend money on buying an operating system it will still need to be well built to get accurate data. CentOS is a Linux operating system that meets all these requirements. According to the creators of CentOS it is designed for people who need an enterprise class OS without the cost or dependency on paid support from a vendor (Nelson, 2005).

IV. Collect

At the heart of the research data collection is the application that will be used. To write a customized program to do this collection is out of the scope of the project and would take longer than the study's allowed timeline for research. The monitoring application requirements are that it has to be open source (free), capable of doing charts, trending, be agent less, SNMP and database data storage. An application called Cacti was chosen because it meets all these requirements. "Cacti is a complete front end to RRDTool. It stores all of the necessary information to create graphs and populate them with data in a MySql database. Along with being able to maintain Graphs, Data Sources, and Round Robin Archives in a database, Cacti handles the data gathering. There is also SNMP support for those used to create traffic graphs with MRTG" (Cacti Group, 2009). In the project the low number of devices that the case study is based it is not a concern that monitoring software package be able to scale to thousands of devices. If that were the case the Cacti would have to be analyzed for a load perspective. As is stands there are multiple reported users that have hundreds of devices being monitored from Cacti. Cacti is limited only by the time it takes to pull device information called the polling cycle. The default poller in Cacti is called cmd.php and the time it takes to run that command and complete is the key for determining the capacity that the Cacti monitoring software can handle. The Cacti group has stated that any polling cycle that is under 300 seconds and Cacti's default poller cmd.php will work fine. With the current case study the time is 15 seconds this time means that there is and will be no capacity concerns for immediate future. If there are issue Cacti has other options and ways to modify the configuration to accommodate a polling cycle time higher than 300 seconds.

V. Analysis

Accessibility is the measurement of time the graphing application was running and working in the ARNe network. It is a calculation based on when the case study started and when it finished. This is called uptime and it can accurately determine if the graphing application was useable during the period of the study. This case study was 6 months in length and uptime is measured in minutes. The total number of minutes in the case study was 220,320 and the total time the application was up and useable by ARNe engineers was 220,320. Taking the total time divided by the total time the application was useable and multiplying it by 100 gives you the total uptime in percentage. (220320/220430) * 100 = 100 percent uptime during the case study. The success factor for this accessibility was a percentage of 99 to 100 which in this case was met.

Are the visual graphs accurate enough to troubleshoot and plan changes to the ARNe network? This case took 5 different attributes from different network devices. An example of an attribute is CPU utilization and it can actually be measured manually by logging into the device and checking the CPU utilization on an ARNe network Cisco ASA device. The 5 attributes were: CPU utilization, free memory, used memory and 2 different bandwidth interface measurements. Using these 5 different attributes as test subjects the researcher compared the actual finding from manually measuring network devices to the findings from the graphical analysis format designed for the case study. In each of the 5 tests the graphs displayed the exact data from the network device. In the sample of the CPU usage from the ARNe network Cisco ASA device, the firewall reported 1 percent CPU usage and the graphing application also displayed 1 percent CPU usage. The second validation for accuracy was feedback received when this case study was presented to ARNe network engineers. In all specific statistical analysis of data the ARNe network engineers were able to explain the changes to the network. Both the sample comparisons and the feedback from ARNe network engineers led to the conclusion that, both statistically and qualitatively, the process used in this case study is accurate enough to troubleshoot and plan changes to the ARNe network.

Analyzing ease of use was the most difficult to quantify in the study. The research started out looking at the relationship between text based information and graphical based information. However, the purpose of this study is not simply to determine whether graphs are better than text. The purpose is to determine if an ARNe network engineer with no experience can readily use the proposed graphing application by just logging in and start identifying problems. This criterion was met at the presentation given to the ARNe network engineers at end of the study. By looking at the graphs gathered over the period of time in the case study ARNe network engineers could now answer the question proposed in the design, i.e., how much bandwidth is being used in the ARNe network. After a one hour presentation on the statistical analysis, the ARNe network engineers were able to tell the researcher what was happening and why it happened.

For the study to be applicable to all networks it needed to prove that a graphical analysis could help all networks. The ARNe network is an educational network meaning that its equipment is largely donated or procured second hand. This means that makes and models of network devices will vary. Having this variety of devices was a key element of this case study helping to prove that it can be applicable for other networks. The ARNe network in the case study had 2 different manufactures (Cisco and SonicWall) and 8 different models of devices. Of those 8 different models there were 3 types of network devices: firewalls, switches and routes. This study met the criteria for multiple manufacturers and devices. However, before saying that all networks can use this method, more qualifiers and additional studies would have to be preformed and reported on. Suggestions for future research would include a larger number of test subjects. Surveys of engineers that use graphed data to solve network issues could be compared to engineers who do not use graphs and the amount of time to find a resolution of the problem compared between the two groups.

Supporting the analysis is Cacti and the collection of data from ARNe. Data will be analyzed by using graphs created by the project monitoring application. Complete detail analysis is found in Chapter 6 Data Analysis.

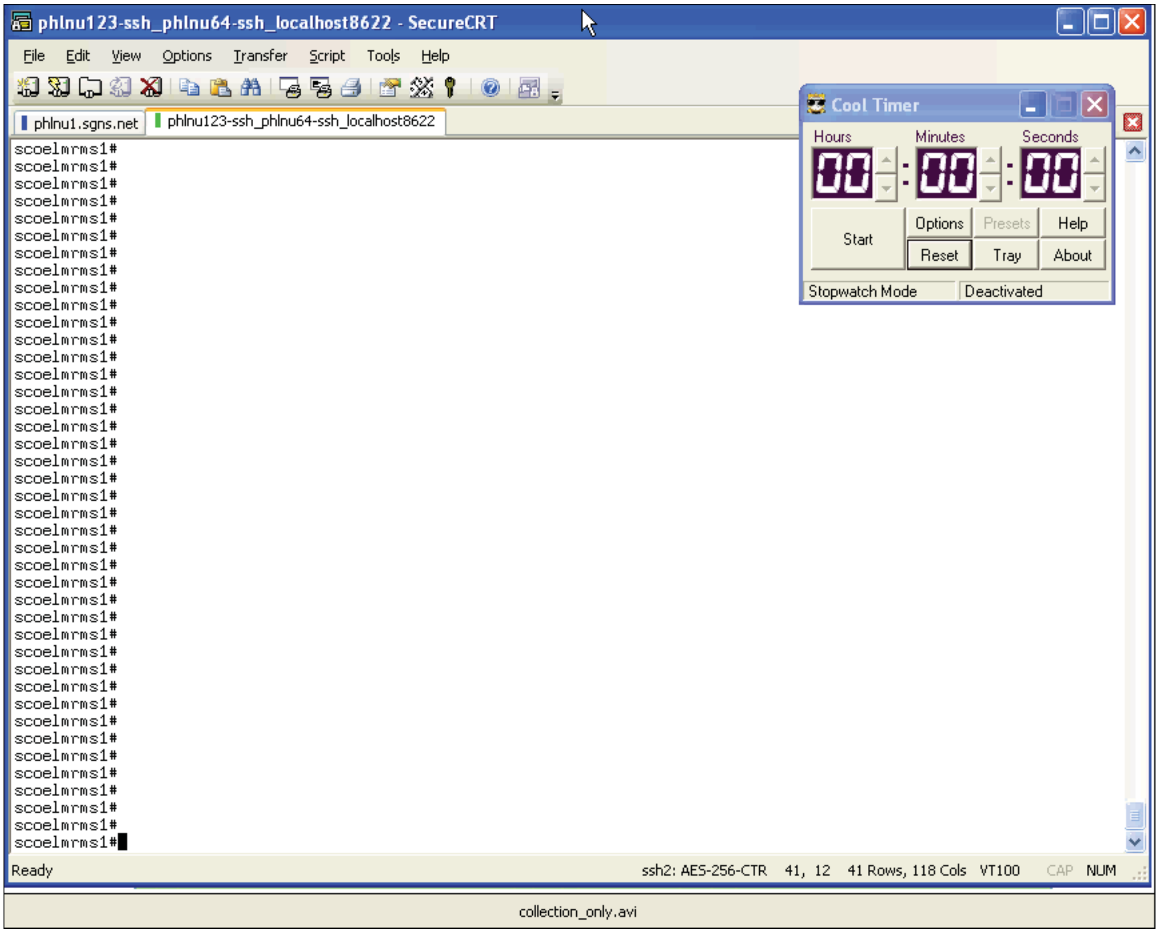
Chapter 4 - Results

Data Analysis

Six months of data from the Cacti project was exported from the Cacti server on November 1st, 2009. It was placed in Appendix B and comprises all data in graphical format. The data is about 36 megabytes compressed zip files. It has daily, weekly, monthly and yearly graphs. The data analysis is based off of information by category, rather than a graph by graph basis. The three categories are time and accuracy, planning and implementation, and troubleshooting.

Time and Accuracy

Six months have passed and it is time to analyze the data gathered. First, take a look at the video. The video in Figure 6-1 is an exact replication of the data that was just gathered (clicking on Figure 6-1 will play the video). This sample was done by collecting the data manually. The start of the video is designed so that the device is already connected and the spreadsheet was already made. The only time that was calculated was the time required for data collection.



phlnu123-ssh_phlnu64-ssh_localhost8622 - SecureCRT
File Edit View Options Transfer Script Tools Help
phlnu1.sgns.net
phlnu123-ssh_phlnu64-ssh_localhost8622
Cool Timer
Hours Minutes Seconds
00 : 00 : 00
Start
Options Presets Help
Reset Tray About
Stopwatch Mode Deactivated
Ready
ssh2: AES-256-CTR 41, 12 41 Rows, 118 Cols VT100 CAP NUM
collection_only.avi

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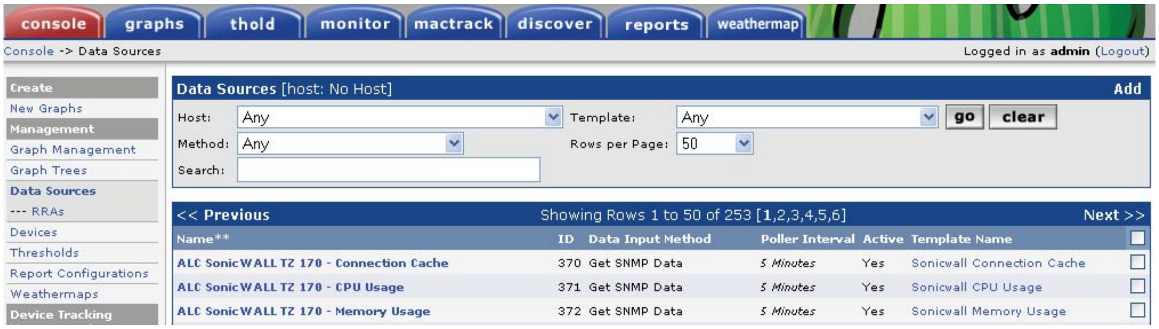
Figure 6 - 1

In the video it takes three minutes and 12 seconds to collect 10 data source. A data source is like an OID, it is anything that will be graphed. A data source could be bandwidth of an interface on a switch or it could be a firewall CPU usage. In the video it is an example of collecting bandwidth from 10 interfaces. In the project there are 13 network devices comprised of switches, firewalls and routers for a total there of 253 data sources. The total number of data sources for this project is shown in figure 6-2.



Data Sources [host: No Host]

Host: Any Template: Any

Method: Any Rows per Page: 50

Search:

Showing Rows 1 to 50 of 253 [1,2,3,4,5,6]

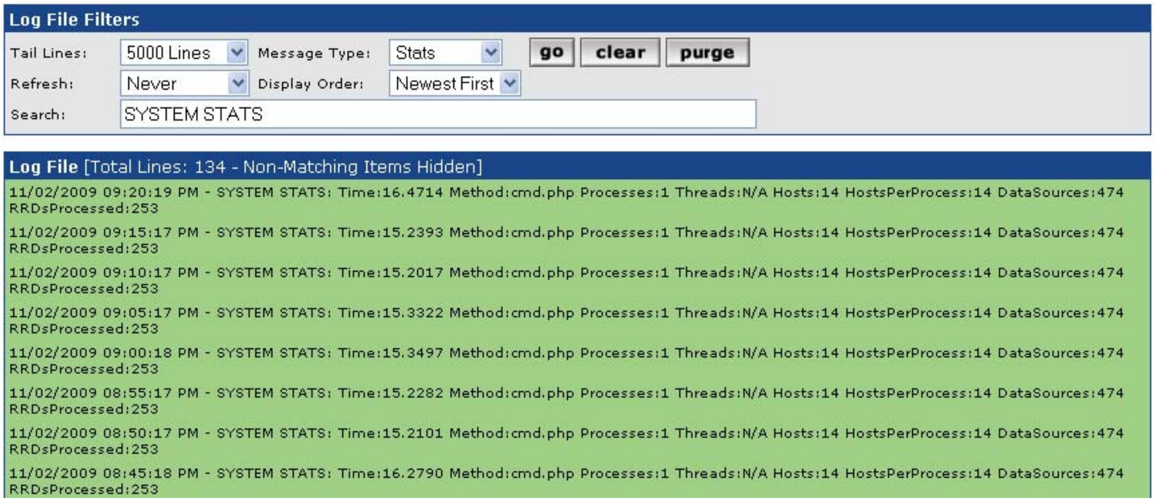
Name**	ID	Data Input Method	Poller Interval	Active	Template Name	□
ALC SonicWALL TZ 170 - Connection Cache	370	Get SNMP Data	*5 Minutes*	Yes	Sonicwall Connection Cache	□
ALC SonicWALL TZ 170 - CPU Usage	371	Get SNMP Data	*5 Minutes*	Yes	Sonicwall CPU Usage	□
ALC SonicWALL TZ 170 - Memory Usage	372	Get SNMP Data	*5 Minutes*	Yes	Sonicwall Memory Usage	□

Figure 6 - 2

Taking the time from the video and performing a calculation of the number of data sources calculate the amount of time it would take to manually collect data from 253 different data sources.

((192 / 10) * 253) / 60 = 80.96 minutes

It would take over an hour to manually collect all the data from 253 data sources. Even if the user could reduce the time in the video by a minute it would still take about 50 minutes. In the project there is a defined parameter for the frequency of data collection and that was for all data sources to be polled every five minutes. It is clear that manually collecting 253 data sources is impossible to do within five minutes let alone doing it every five minutes. Figure 6-3 shows the statistics for Cacti collecting 253 data sources. The times range from 15 seconds to a maximum of 16 seconds. There is no more then a two second variance. Each collection cycle starts every five minutes. All this leads to integrity and accuracy of the Cacti application and the data it collects.



Log File Filters

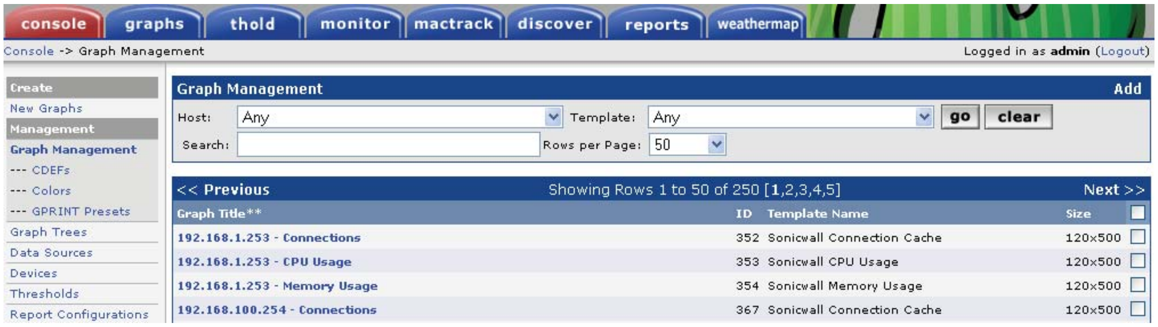
Tail Lines: 5000 Lines Message Type: Stats
Refresh: Never Display Order: Newest First
Search: SYSTEM STATS

Log File [Total Lines: 134 - Non-Matching Items Hidden]

```
11/02/2009 09:20:19 PM - SYSTEM STATS: Time:16.4714 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 09:15:17 PM - SYSTEM STATS: Time:15.2393 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 09:10:17 PM - SYSTEM STATS: Time:15.2017 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 09:05:17 PM - SYSTEM STATS: Time:15.3322 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 09:00:18 PM - SYSTEM STATS: Time:15.3497 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 08:55:17 PM - SYSTEM STATS: Time:15.2282 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 08:50:17 PM - SYSTEM STATS: Time:15.2101 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
11/02/2009 08:45:18 PM - SYSTEM STATS: Time:16.2790 Method:cmd.php Processes:1 Threads:N/A Hosts:14 HostsPerProcess:14 DataSources:474
RRDsProcessed:253
```

Figure 6 - 3

In the video there are no graphs only data and numbers. However while Cacti is collecting the data it is also working on displaying them in graphical form. Not all data sources in Cacti have a graph. In fact, the Figure 6-4 shows that there are only 250 graphs that Cacti will display. This means that one or more graphs have multiple data sources on them.



Console -> Graph Management Logged in as **admin** (Logout)

Graph Management

Host: Any Template: Any
Search: Rows per Page: 50

<< Previous Showing Rows 1 to 50 of 250 [1,2,3,4,5] Next >>

Graph Title**	ID	Template Name	Size	☐
192.168.1.253 - Connections	352	Sonicwall Connection Cache	120x500	☐
192.168.1.253 - CPU Usage	353	Sonicwall CPU Usage	120x500	☐
192.168.1.253 - Memory Usage	354	Sonicwall Memory Usage	120x500	☐
192.168.100.254 - Connections	367	Sonicwall Connection Cache	120x500	☐

Figure 6 - 4

Planning and Implementing

With Cacti and export of all 250 graphs can be obtained with one click of the mouse. These can be used for planning and implementation purposes. In a network, devices change and connections to those devices change. Documentation is the only way to know what is where at any given point. In the absence of documentation another way to figure this out is to pull data directly off the device. In the time and accuracy section of the video the same concept applies. It is unrealistic for a network engineer to access every device to see if an interface is being used. One way to do this quickly is to export all the graphs and see if there is any data on them. If there is no data on graphs marked as interface assume that those interfaces are not being used and mark them available. This method of port allocation is not recommended but is necessary for networks that are not well documented.

An export of all the graphs can easily identify high usage on any of the data sources. The eye can quickly scan multiple graphs and identify which network device might have an issue. For example, adding more services or bandwidth could affect existing devices or the implementation of the new services themselves. These high usage areas are easily identified using graphs.

Analyzing the data gathered from the summary reveals there are a couple of issues that need to be addressed. The first issue is that the three switches host names dtcswc94back02, dtcswc94backinternet and dtcswcrouter_room, all have 60 percent CPU utilization. This could affect new network services if they were plugged into these switches. 60 percent CPU is high for the corresponding bandwidth that the interfaces are reporting for each of their respective switches.

The second issue is more administrative than functional but it is hard to implement or plan with outdated information. About 90 percent of all interfaces have no description. Of those that do have a description, many have no data. The ones with a description and no data probably indicate that this service was removed or decommissioned without removing the description. This a nightmare when trying to implement new services and assigning ports where there is no description or documentation. Without a tool like Cacti doing historical data collection the network administrators would never know if these ports were ever used. With Cacti the application can basically tell when the service or port was removed or decommissioned because that’s when the data stops.

Historical data graphing is one of the best features of Cacti. This can also tell how a business is doing or not doing by the data it graphs. In Figure 6-5 there is six months of data from the outside interface of the ASA in RUSP network. This graph indicates a slight increase in internet traffic, however, that doesn’t always mean an increase is good. If the business has no internet facing revenue generating applications this could mean that more of the users inside the network are surfing the internet which means this is an expense. The expense is twofold, one of users not working and the other is the cost of the internet usage from a service provider. It could mean that a new application came online and is currently working on processing new transactions and as it grows so does the bandwidth this is normally good for business. This graph won’t tell exactly why this has happened. For that, the network engineer will need to go farther than the graph. The graph is an investigative tool that can be used to identify trends for planning purposes.

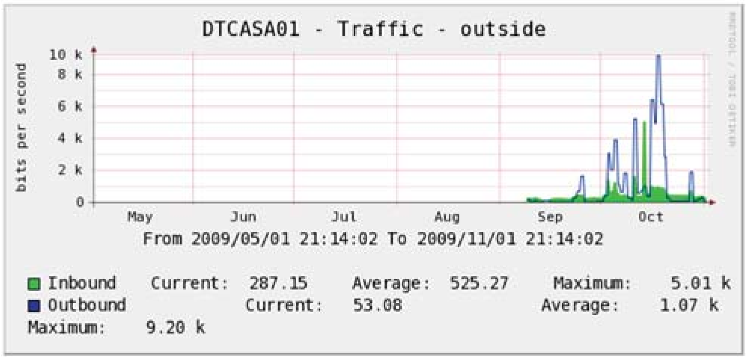
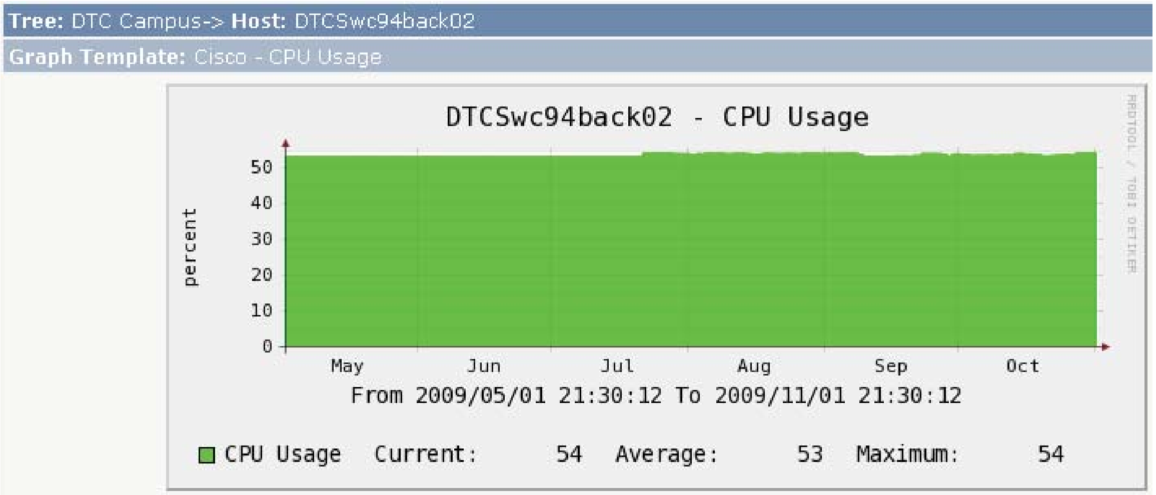


Figure 6 - 5

Troubleshooting

One of the best reasons for having the Cacti network monitoring solution is for troubleshooting. The figures and graphs below were taken directly from the RUSP network. By using the summary graphs to identify which graphs had data and which ones didn't. These graphs are six months worth of data and can be used to help troubleshoot issues that have happened. These troubleshooting inferences are solely based on the graphs and further investigations would need to be made before any network changes would be made.

In the planning stage it was identified that one or more switches had high CPU utilization which may affect new services being installed. Cacti and the graphs it generates can help troubleshoot this issue. There a three switches in the DTC campus all indicating above 50 percent usage. Below are the CPU graphs (Figure 6-7, 8, 9) for hostnames dtcswc94back02, dtcswc94backinternet and dtcswcrouter_room. The six month analysis of the CPU usage graphs shows that there is a constant percentage and it fluctuates very little. This indicates that nothing on these switches has demanded any more or any less CPU resources and that they have reached stability in the network. This is a good thing for the network and indicates that it could support more resources or network devices added to these switches.



Tree: DTC Campus-> **Host:** DTCSwc94back02

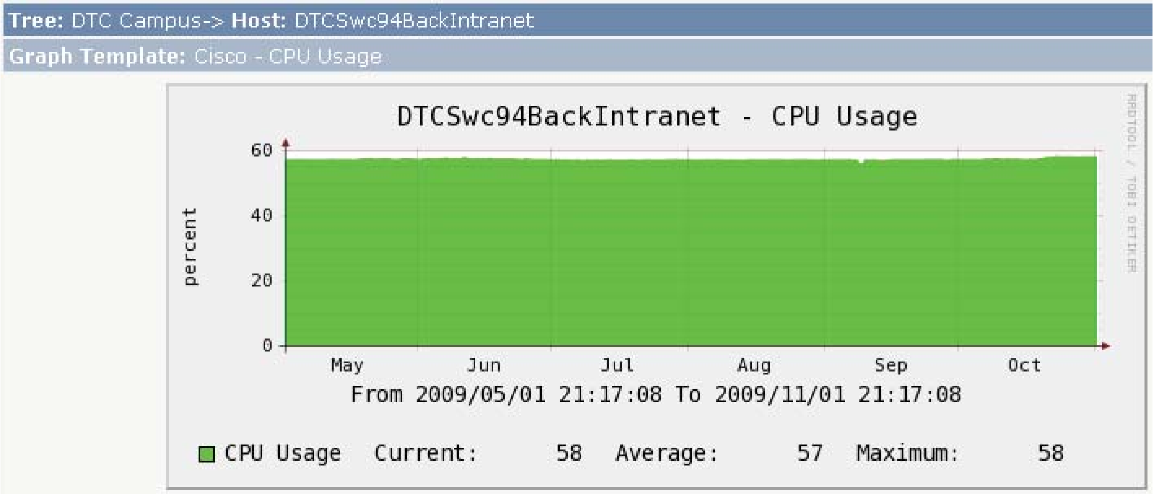
Graph Template: Cisco - CPU Usage

DTCSwc94back02 - CPU Usage

From 2009/05/01 21:30:12 To 2009/11/01 21:30:12

🟩 CPU Usage Current: 54 Average: 53 Maximum: 54

Figure 6 - 6



Tree: DTC Campus-> **Host:** DTCSwc94BackIntranet

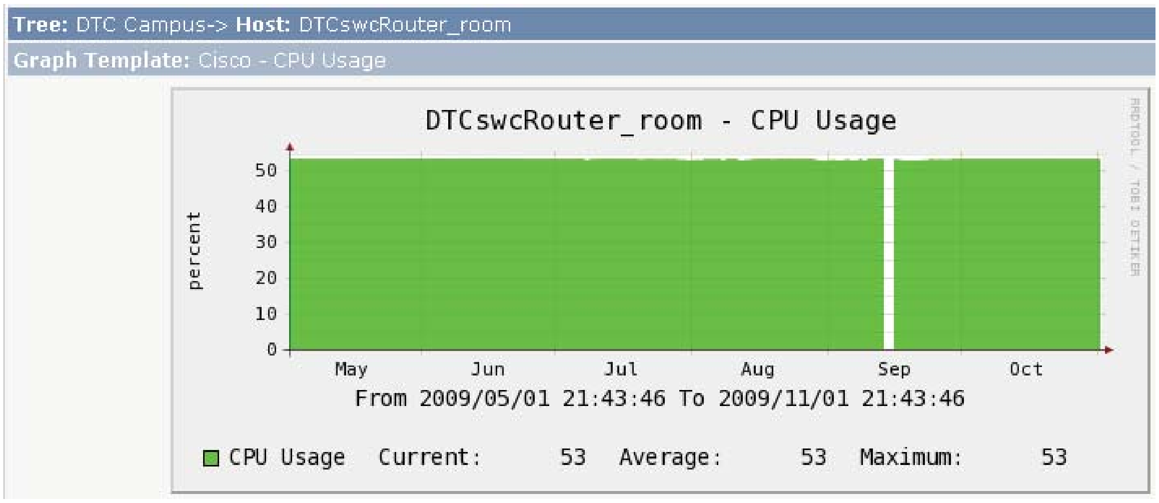
Graph Template: Cisco - CPU Usage

DTCSwc94BackIntranet - CPU Usage

From 2009/05/01 21:17:08 To 2009/11/01 21:17:08

🟩 CPU Usage Current: 58 Average: 57 Maximum: 58

Figure 6 - 7



Tree: DTC Campus-> **Host:** DTCswcRouter_room

Graph Template: Cisco - CPU Usage

DTCswcRouter_room - CPU Usage

From 2009/05/01 21:43:46 To 2009/11/01 21:43:46

🟩 CPU Usage Current: 53 Average: 53 Maximum: 53

Figure 6 - 8

The next step is to identify why these switches would be just over 50 percent. By using only the graphs and the monitoring tool that was just implemented analyzing the individual interfaces and look for a load that would cause a high CPU utilization. For switches to have high CPU usage it would take multiple interfaces on each switch. The following is a list of all interfaces for switches dtcswc94back02, dtcswc94backinternet and dtcswcrouter_room identified above. Not one of these switches has an interface that is over utilized, let alone multiple interfaces over utilized. In fact, dtcswcrouter_room has only three active interfaces (Figure 6-42, 43, 44) on the entire switch for the last six months and nothing over 200 kbps (Figure 6-43). These levels are not enough to create a 50 percent CPU usage for these switches.

With this data there are two possible conclusions. One is that the switches are at 50 percent usage because the software version they are running requires 50 percent of the CPU just to run idle. This also depends on the CPU in the switches. Old switches have a smaller CPU. If the switch is running a newer software version that version may require more processing power to run than originally intended for the switch. It is possible to put a non recommended version of software on a switch that could also be causing a higher CPU utilization at idle. This conclusion would require more research to include finding a current version of the software and cross referencing it with a vendor recommended solution.

The second possibility is the SNMP OID is incorrect and the data are wrong. This can be ruled out easily by logging on to the switch and looking at the CPU usage. If the current setting is around 50 percent then the chances that the readings have been wrong are low.

The next steps are to watch the CPU for these switches when connecting new devices to them. At 50 percent with few network devices connected, it could be a wARNeing that something is wrong or could just be the way this switch works with the current software version. Either way, with Cacti monitoring the setup on these switches it will be able to see a change even when new devices are connected to the switches.

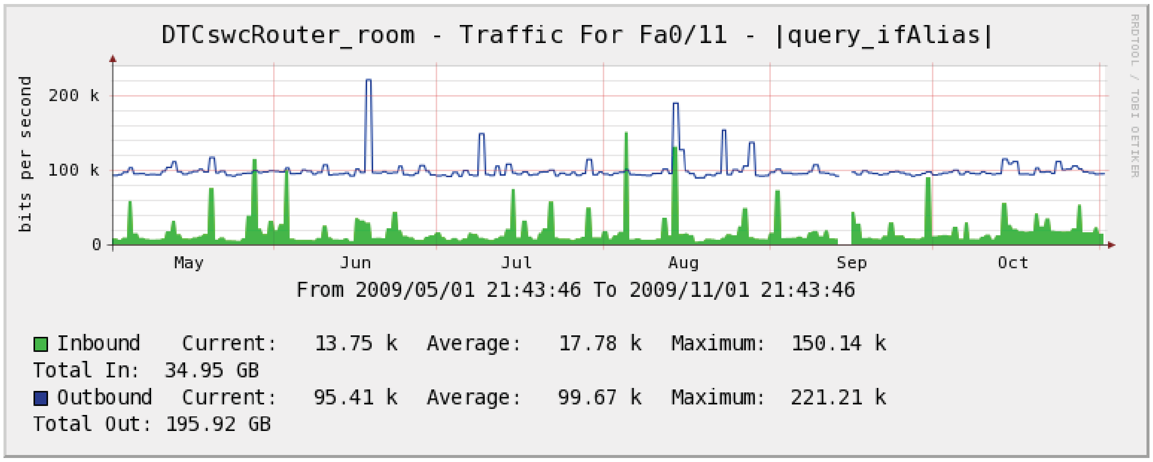


Figure 6 - 9

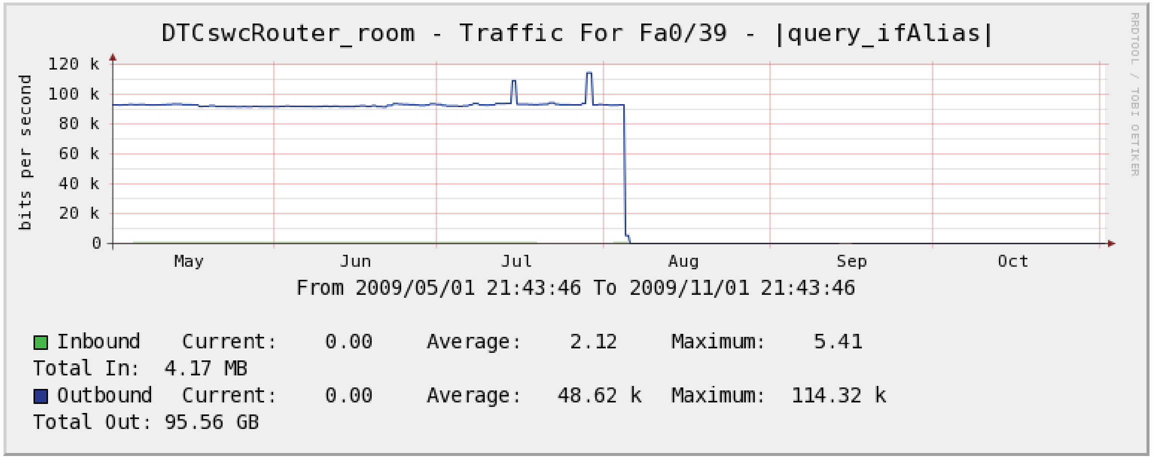
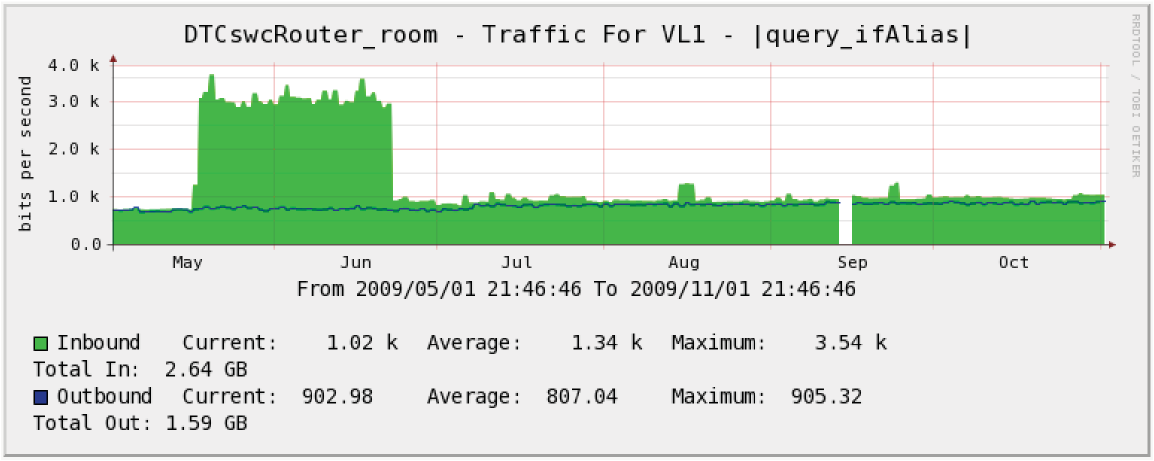


Figure 6 - 10



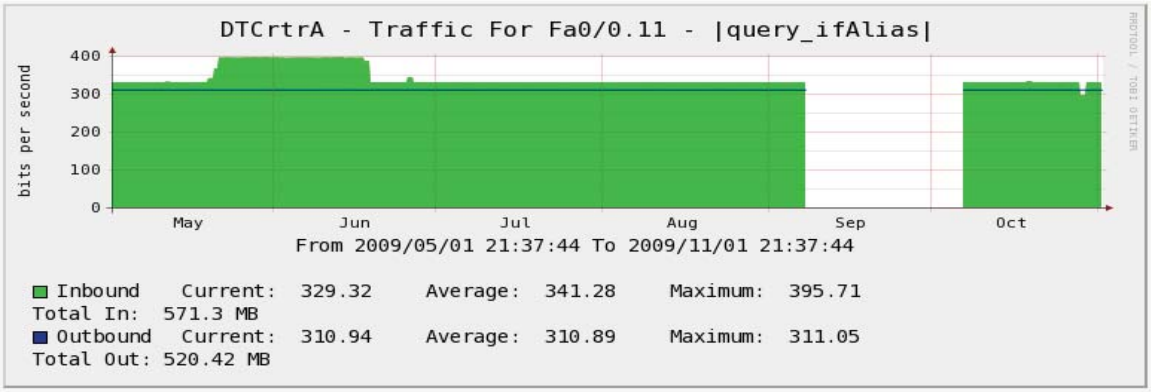
```
🟩 Inbound    Current:     1.02 k   Average:     1.34 k   Maximum:     3.54 k
Total In:   2.64 GB
🟦 Outbound   Current:   902.98     Average:   807.04     Maximum:   905.32
Total Out:  1.59 GB
```

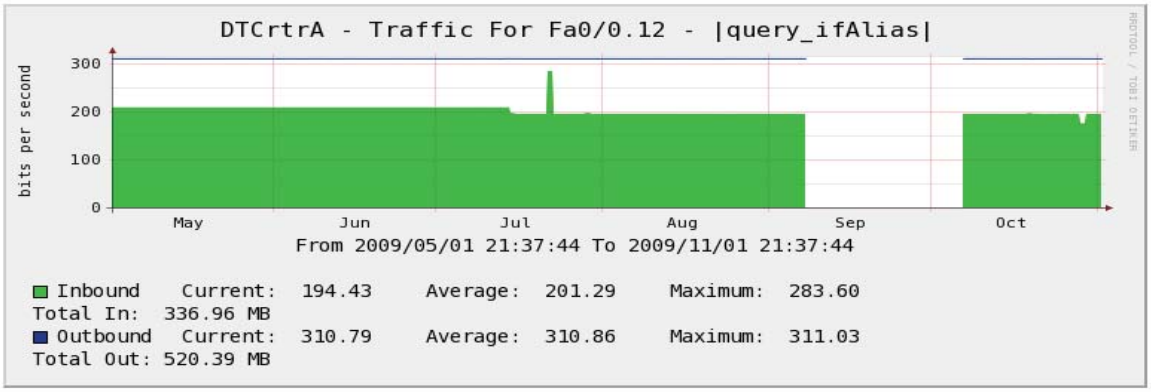
Figure 6 - 11

Troubleshooting a network from a graph requires experience but the numbers provide a reliable source of information for analysis. In the graphs below are that of routers that are used in the RUSP network. There a couple of interesting points on these graphs that would help with troubleshooting. The graphs for the router called dtc2821rtr have nothing really special to say but they do indicate that the Cacti monitoring for the last six months for this device has worked flawlessly.

The next router is device dtcrtrA. Results shown in Figures 6-53 and 6-54 suggest what seems to be a void for the month of September. This could indicate a problem. One, the device could have been taken offline. Two, the device went down for a month until someone fixed it. Three, Cacti could not reach the interface for the device. Since routers can have multiple interfaces and IPs it does not automatically indicate that this device was completely offline. Like other analysis, there would have to be more investigation to find out why this happened. If Cacti had been used in the RUSP on a routine basis this could have been identified earlier and possibly fixed in less than a month.

DtcrtrB is the last router in the study. It also indicates that something was wrong with dtcrtrA. The inbound traffic on Figure 6-56 and 6-57 went to zero at the same time that dtcrtrA appeared to go offline. The outbound traffic on dtcrtrB indicates that this router was still up and trying to communicate with dtcrtrA. Also interesting about dtcrtrB is that in the beginning of July something stopped. On dtcrtrB the traffic went from 100K of bandwidth on the interfaces to almost zero. The reason for that maybe school let out for summer or a project or service ended.





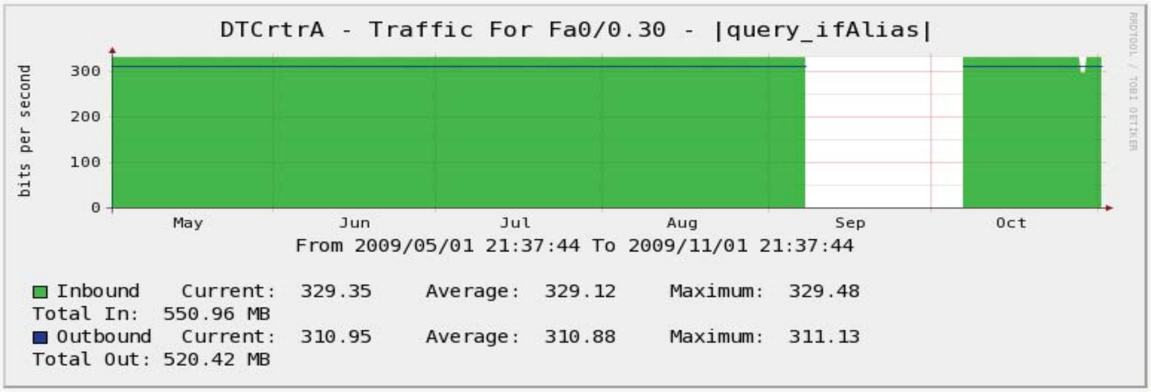


Figure 6 - 12

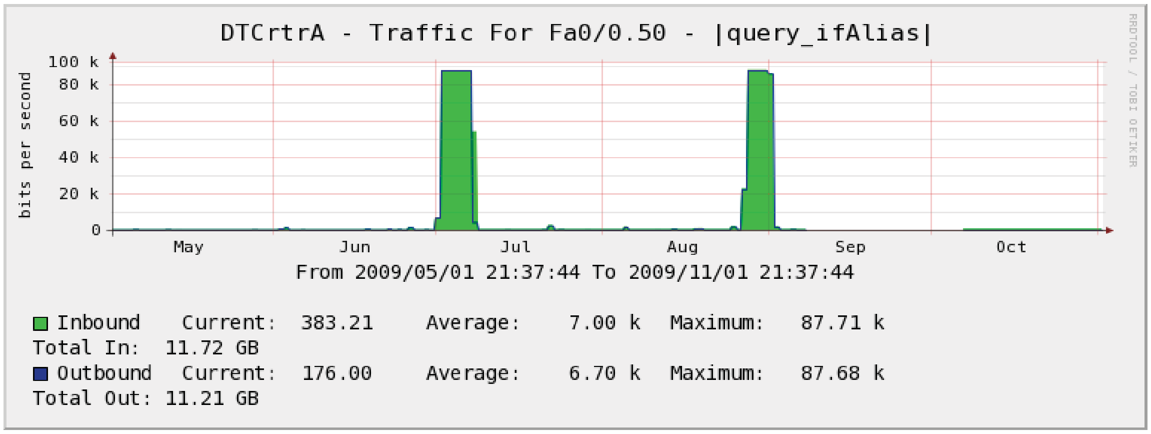
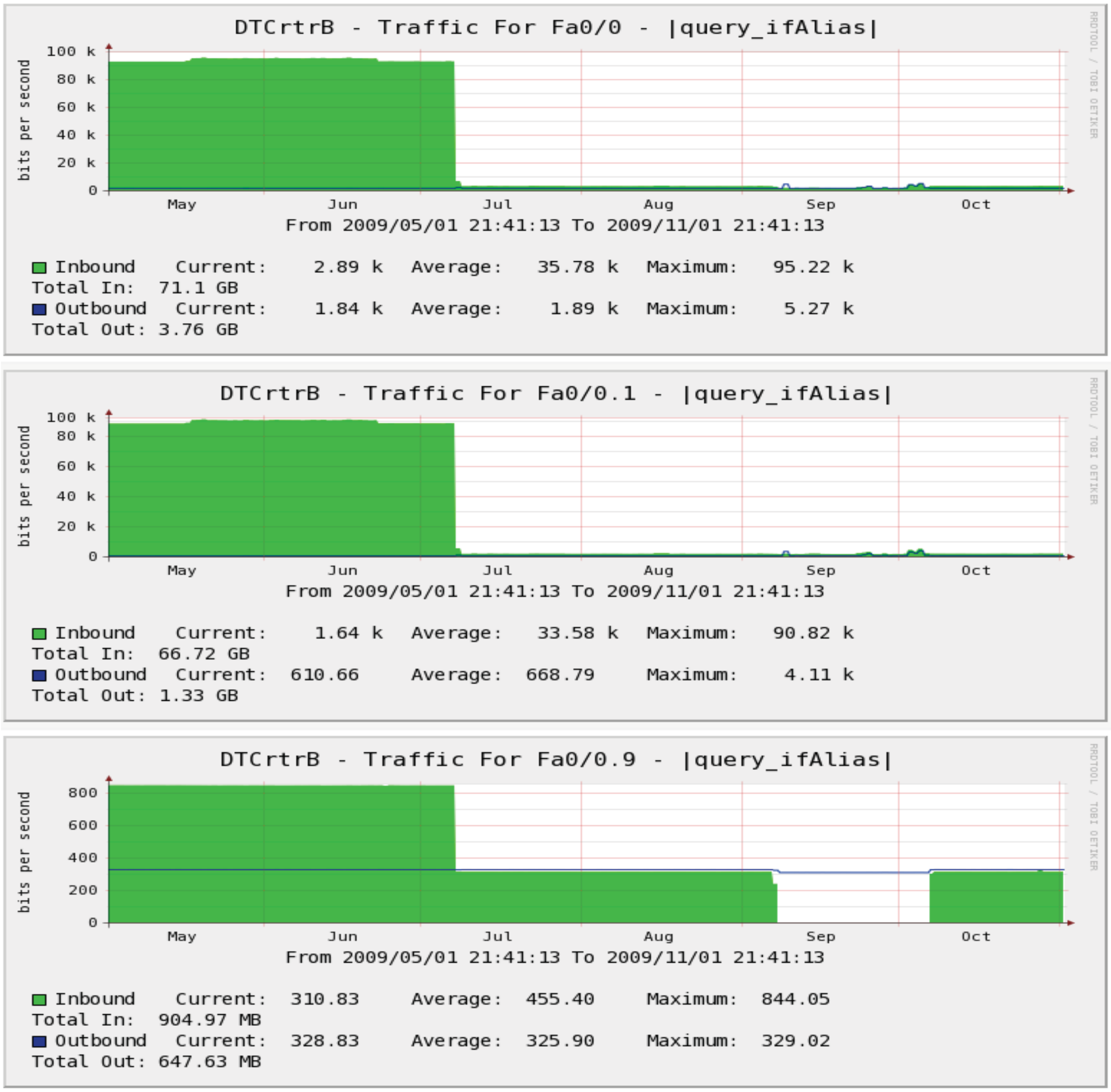


Figure 6 - 13



```
DTCrtrB - Traffic For Fa0/0 - |query_ifAlias|
From 2009/05/01 21:41:13 To 2009/11/01 21:41:13

🟩 Inbound   Current:    2.89 k   Average:   35.78 k   Maximum:   95.22 k
Total In:  71.1 GB
🟦 Outbound  Current:    1.84 k   Average:    1.89 k   Maximum:    5.27 k
Total Out: 3.76 GB
```

```
DTCrtrB - Traffic For Fa0/0.1 - |query_ifAlias|
From 2009/05/01 21:41:13 To 2009/11/01 21:41:13

🟩 Inbound   Current:    1.64 k   Average:   33.58 k   Maximum:   90.82 k
Total In:  66.72 GB
🟦 Outbound  Current:  610.66     Average:  668.79     Maximum:    4.11 k
Total Out: 1.33 GB
```

```
DTCrtrB - Traffic For Fa0/0.9 - |query_ifAlias|
From 2009/05/01 21:41:13 To 2009/11/01 21:41:13

🟩 Inbound   Current:  310.83     Average:  455.40     Maximum:  844.05
Total In:  904.97 MB
🟦 Outbound  Current:  328.83     Average:  325.90     Maximum:  329.02
Total Out: 647.63 MB
```

Figure 6 - 14

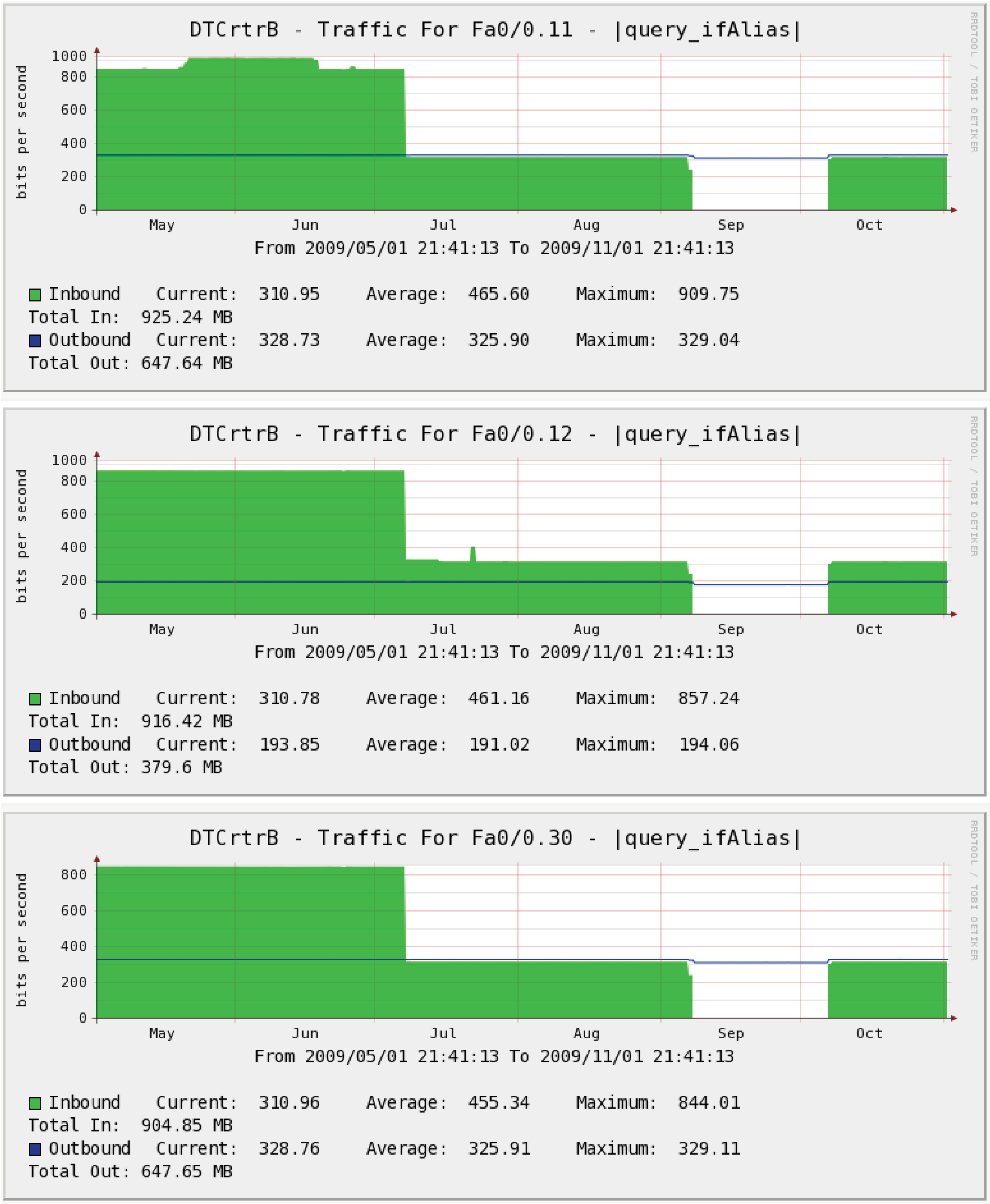

DTCrtrB - Traffic For Fa0/0.11 - |query_ifAlias|
bits per second
1000
800
600
400
200
0
May
Jun
Jul
Aug
Sep
Oct
From 2009/05/01 21:41:13 To 2009/11/01 21:41:13
🟩 Inbound Current: 310.95 Average: 465.60 Maximum: 909.75
Total In: 925.24 MB
🟦 Outbound Current: 328.73 Average: 325.90 Maximum: 329.04
Total Out: 647.64 MB
RRDTOOL / TOBI OETIKER
DTCrtrB - Traffic For Fa0/0.12 - |query_ifAlias|
bits per second
1000
800
600
400
200
0
May
Jun
Jul
Aug
Sep
Oct
From 2009/05/01 21:41:13 To 2009/11/01 21:41:13
🟩 Inbound Current: 310.78 Average: 461.16 Maximum: 857.24
Total In: 916.42 MB
🟦 Outbound Current: 193.85 Average: 191.02 Maximum: 194.06
Total Out: 379.6 MB
RRDTOOL / TOBI OETIKER
DTCrtrB - Traffic For Fa0/0.30 - |query_ifAlias|
bits per second
800
600
400
200
0
May
Jun
Jul
Aug
Sep
Oct
From 2009/05/01 21:41:13 To 2009/11/01 21:41:13
🟩 Inbound Current: 310.96 Average: 455.34 Maximum: 844.01
Total In: 904.85 MB
🟦 Outbound Current: 328.76 Average: 325.91 Maximum: 329.11
Total Out: 647.65 MB
RRDTOOL / TOBI OETIKER

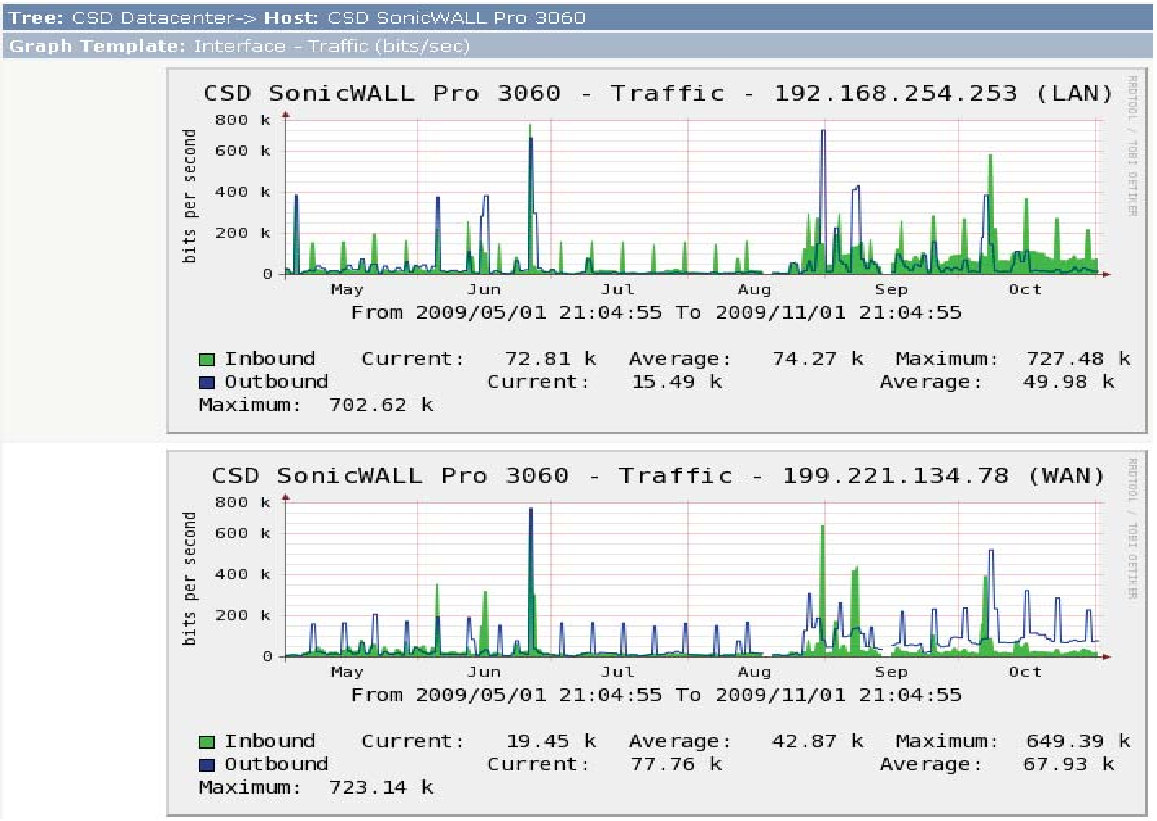
Figure 6 - 15

The last set of data analyzed is going to be the firewalls. The firewalls are placed at the entry point for each location that the RUSP network needed to reach. There are five total firewalls. Four of them are made by SonicWall and one is made by Cisco. These devices were the hardest to setup in Cacti. It was discovered after many hours in setup that the MIBs for the devices were correct but they still didn't work because of the version of software the devices were running.

The data collected were still good to analyze. For the Sonic Wall firewalls Cacti was only able to pull bandwidths on the inside interfaces and outside interfaces. These interfaces will tell the network engineer about the traffic coming in from and out to the Internet and the other location of the RUSP. From the Figure 6-59 below it can determine that the DTC location is the heaviest user of bandwidth but the biggest single spike came from Figure 6-58, the CSD data center location, at 649 kbps.

In troubleshooting slow networks or applications, the internet links are typically going to be the slowest part of the network. The internet link is the link that is paid for by either usage or dedicated bandwidth at a certain rate. If the internet link is paid for and set at 500 kbps for CSD data center locations, there will be an issue every time that environment tries to push their max of 649 kbps. Users will notice a slowness they haven't experienced before under regular use. Data packets will be dropped by the internet routers that are handled off the internet link that was purchased. Since the packets are dropped they will be retransmitted by the sender of the packet causing latency for whatever application is being used. This is why it is important to be able to monitor these links for troubleshooting purposes.

Another interesting part of the graphs is in Figure 6-58, 59 and 60. You can see a small gap in data in September. It is on every SonicWall firewall but not the Cisco. This could indicate that the connection from DTC was compromised. Since the Cacti monitoring tool resides in the DTC network and the connections to the other sites are through the DTC SonicWall firewall it means that the issue was most likely on the DTC SonicWall firewall. The next step in troubleshooting would be to go directly to the logs of the DTC SonicWall firewall and verify this at the September time frame.



Tree: CSD Datacenter-> **Host:** CSD SonicWALL Pro 3060

Graph Template: Interface - Traffic (bits/sec)

CSD SonicWALL Pro 3060 - Traffic - 192.168.254.253 (LAN)

From 2009/05/01 21:04:55 To 2009/11/01 21:04:55

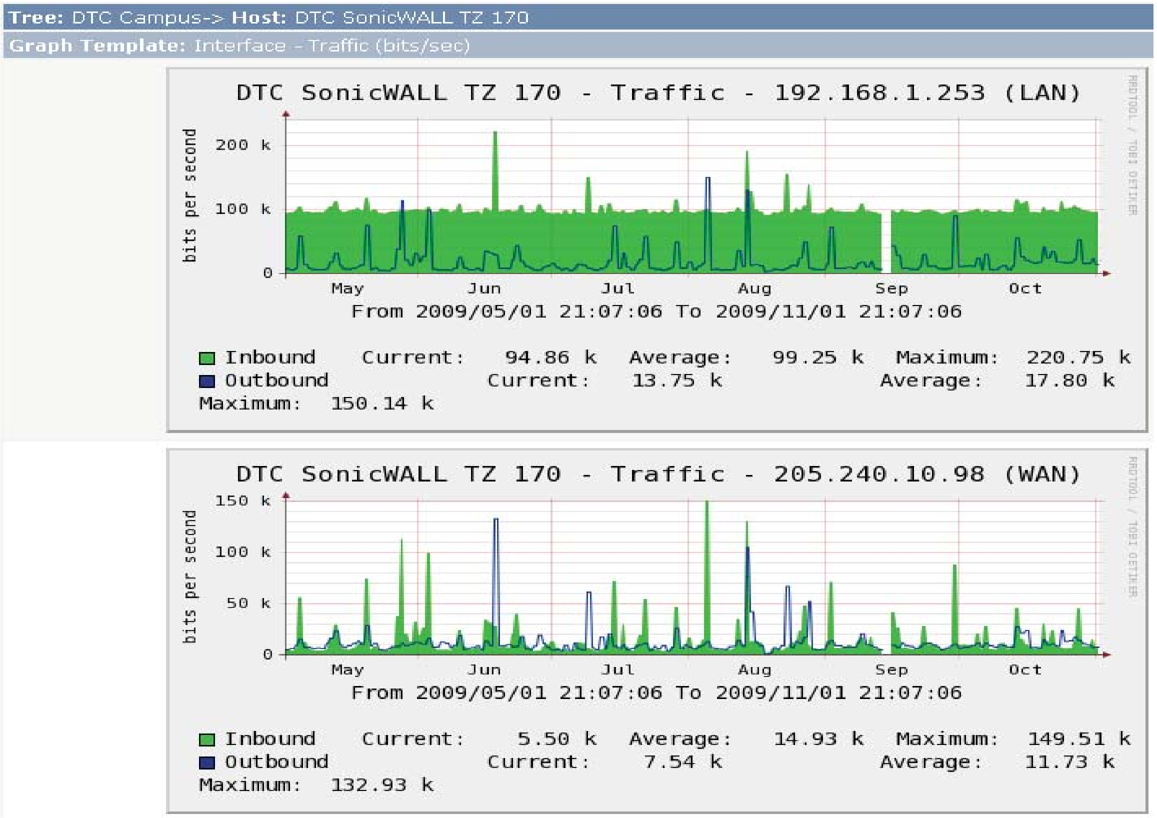
```
🟩 Inbound     Current:    72.81 k   Average:    74.27 k   Maximum:   727.48 k
🟦 Outbound              Current:    15.49 k              Average:    49.98 k
Maximum:   702.62 k
```

CSD SonicWALL Pro 3060 - Traffic - 199.221.134.78 (WAN)

From 2009/05/01 21:04:55 To 2009/11/01 21:04:55

```
🟩 Inbound     Current:    19.45 k   Average:    42.87 k   Maximum:   649.39 k
🟦 Outbound              Current:    77.76 k              Average:    67.93 k
Maximum:   723.14 k
```

Figure 6 - 16



Tree: DTC Campus-> **Host:** DTC SonicWALL TZ 170

Graph Template: Interface - Traffic (bits/sec)

DTC SonicWALL TZ 170 - Traffic - 192.168.1.253 (LAN)

From 2009/05/01 21:07:06 To 2009/11/01 21:07:06

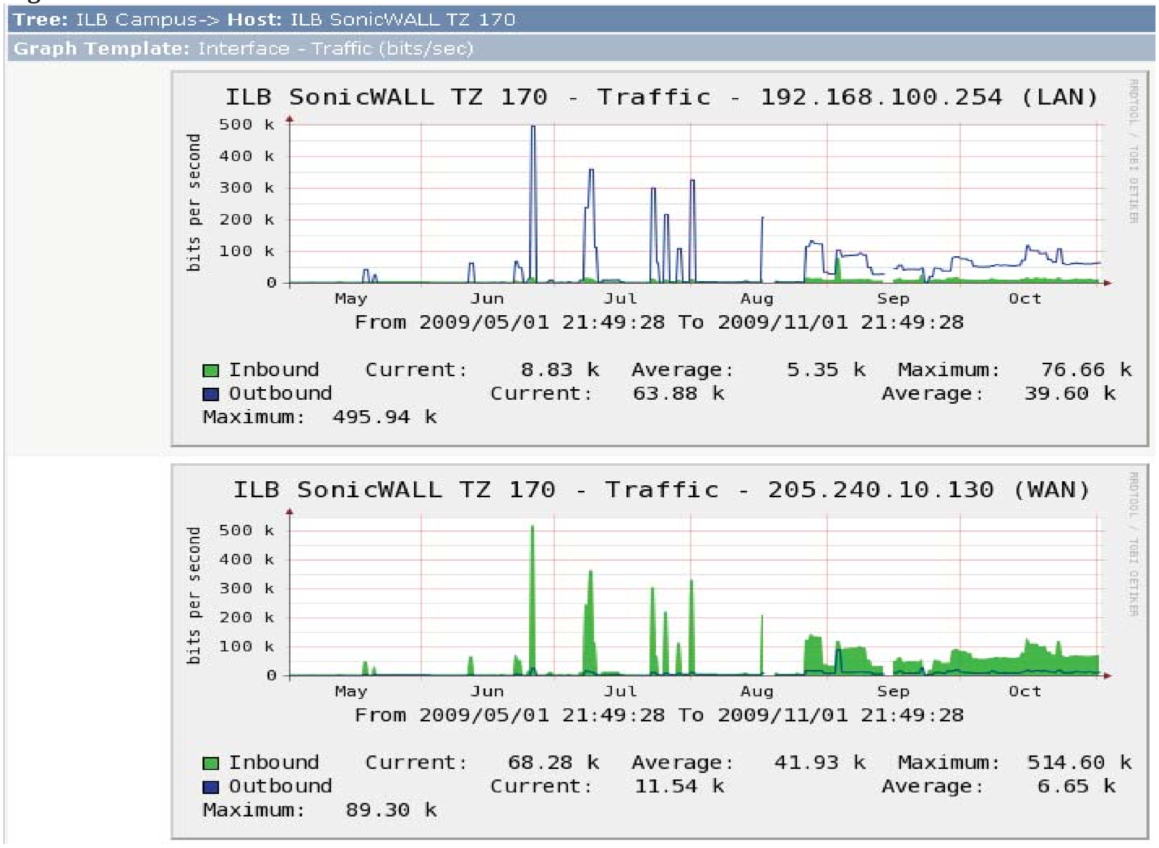
```
🟩 Inbound    Current:    94.86 k   Average:    99.25 k   Maximum:   220.75 k
🟦 Outbound             Current:    13.75 k             Average:    17.80 k
Maximum:   150.14 k
```

DTC SonicWALL TZ 170 - Traffic - 205.240.10.98 (WAN)

From 2009/05/01 21:07:06 To 2009/11/01 21:07:06

```
🟩 Inbound    Current:     5.50 k   Average:    14.93 k   Maximum:   149.51 k
🟦 Outbound             Current:     7.54 k             Average:    11.73 k
Maximum:   132.93 k
```

Figure 6 - 17



Tree: ILB Campus-> **Host:** ILB SonicWALL TZ 170

Graph Template: Interface - Traffic (bits/sec)

ILB SonicWALL TZ 170 - Traffic - 192.168.100.254 (LAN)

From 2009/05/01 21:49:28 To 2009/11/01 21:49:28

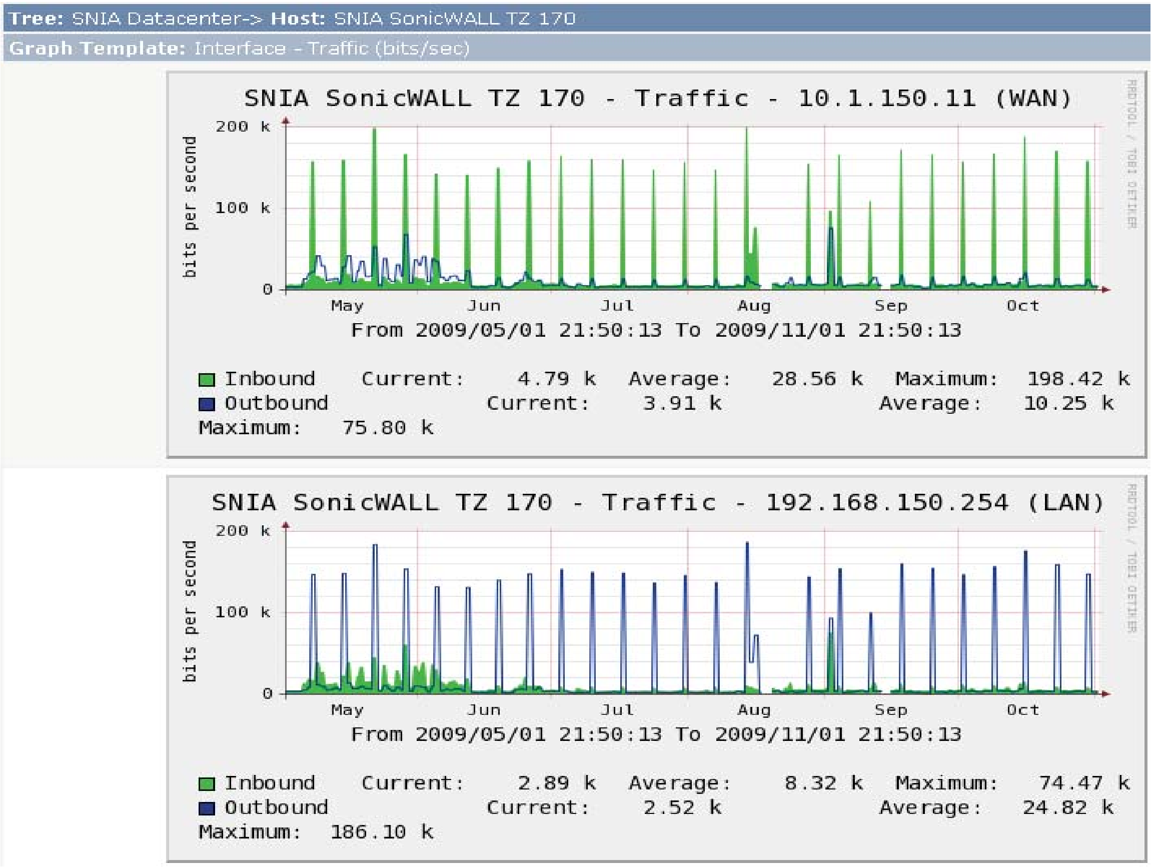
```
🟩 Inbound    Current:     8.83 k   Average:     5.35 k   Maximum:    76.66 k
🟦 Outbound             Current:    63.88 k             Average:    39.60 k
Maximum:   495.94 k
```

ILB SonicWALL TZ 170 - Traffic - 205.240.10.130 (WAN)

From 2009/05/01 21:49:28 To 2009/11/01 21:49:28

```
🟩 Inbound    Current:    68.28 k   Average:    41.93 k   Maximum:   514.60 k
🟦 Outbound             Current:    11.54 k             Average:     6.65 k
Maximum:    89.30 k
```

Figure 6 - 18



Tree: SNIA Datacenter-> **Host:** SNIA SonicWALL TZ 170

Graph Template: Interface - Traffic (bits/sec)

SNIA SonicWALL TZ 170 - Traffic - 10.1.150.11 (WAN)

From 2009/05/01 21:50:13 To 2009/11/01 21:50:13

```
🟩 Inbound    Current:     4.79 k  Average:    28.56 k  Maximum:  198.42 k
🟦 Outbound             Current:     3.91 k             Average:   10.25 k
Maximum:   75.80 k
```

SNIA SonicWALL TZ 170 - Traffic - 192.168.150.254 (LAN)

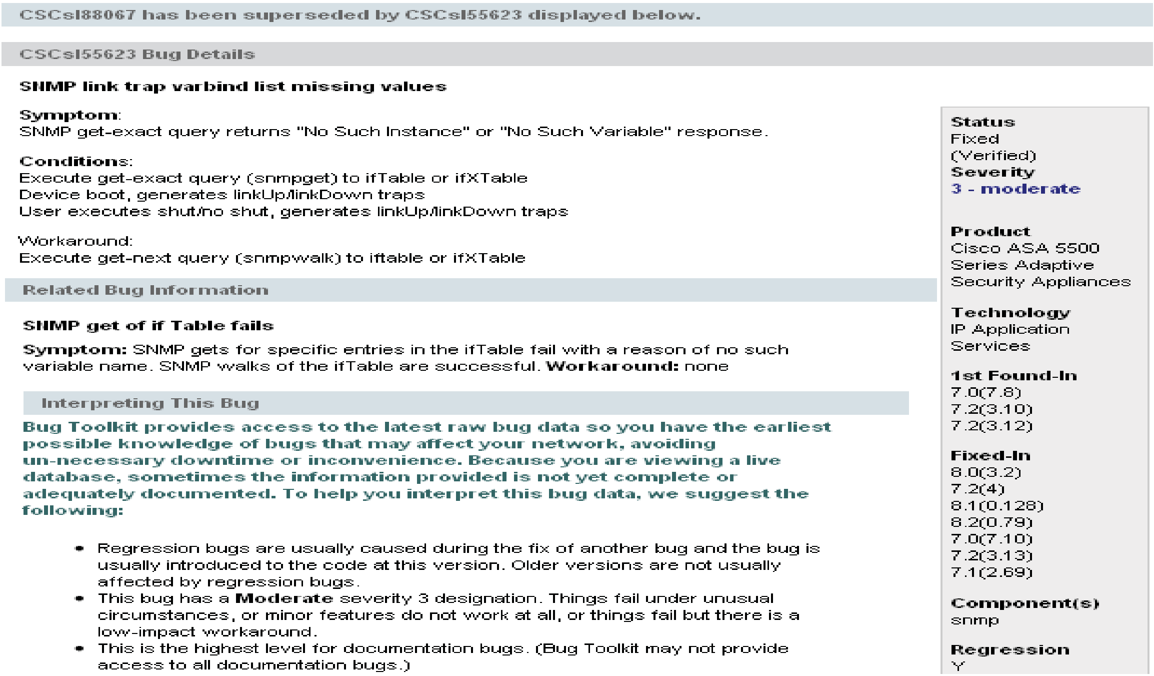
From 2009/05/01 21:50:13 To 2009/11/01 21:50:13

```
🟩 Inbound    Current:     2.89 k  Average:     8.32 k  Maximum:   74.47 k
🟦 Outbound             Current:     2.52 k             Average:   24.82 k
Maximum:  186.10 k
```

Figure 6 - 19

Unlike the SonicWall firewall, the Cisco firewall was able to pull more data from the devices. However, it too had its issues with the MIBs. All the monitoring was setup and configured correctly on Cacti but the version of software would not allow Cacti to pull the interface statistics. Cacti is always on so this led to an interesting discovery. Some time in September someone upgraded the devices and at that point pulling of the interface statistics started working, see Figure 6-65. This analysis is based off of a Cisco bug CSCsl88067 as shown in Figure 6-62. This bug was fixed in newer versions of software.

In Figure 6-63 titled “connections for the Cisco ASA” notice that the connections also dropped off dramatically. This would indicate that a change was made to the configuration. Since then, internet access is not allowed when logged into the VPN. This could mean two things, someone changed the VPN configuration or they changed the firewall rules to not allow internet traffic outbound. It is clear that something changed in the beginning of September that would warrant further investigation by reviewing the log for that device.



CSCsl88067 has been superseded by CSCsl55623 displayed below.

CSCsl55623 Bug Details

SNMP link trap varbind list missing values

Symptom:
SNMP get-exact query returns "No Such Instance" or "No Such Variable" response.

Conditions:
Execute get-exact query (snmpget) to ifTable or ifXTable
Device boot, generates linkUp/linkDown traps
User executes shut/no shut, generates linkUp/linkDown traps

Workaround:
Execute get-next query (snmpwalk) to iftable or ifXTable

Related Bug Information

SNMP get of if Table fails

Symptom: SNMP gets for specific entries in the ifTable fail with a reason of no such variable name. SNMP walks of the ifTable are successful. **Workaround:** none

Interpreting This Bug

Bug Toolkit provides access to the latest raw bug data so you have the earliest possible knowledge of bugs that may affect your network, avoiding un-necessary downtime or inconvenience. Because you are viewing a live database, sometimes the information provided is not yet complete or adequately documented. To help you interpret this bug data, we suggest the following:

- Regression bugs are usually caused during the fix of another bug and the bug is usually introduced to the code at this version. Older versions are not usually affected by regression bugs.
- This bug has a **Moderate** severity 3 designation. Things fail under unusual circumstances, or minor features do not work at all, or things fail but there is a low-impact workaround.
- This is the highest level for documentation bugs. (Bug Toolkit may not provide access to all documentation bugs.)

Status
Fixed
(Verified)
Severity
3 - moderate

Product
Cisco ASA 5500
Series Adaptive
Security Appliances

Technology
IP Application
Services

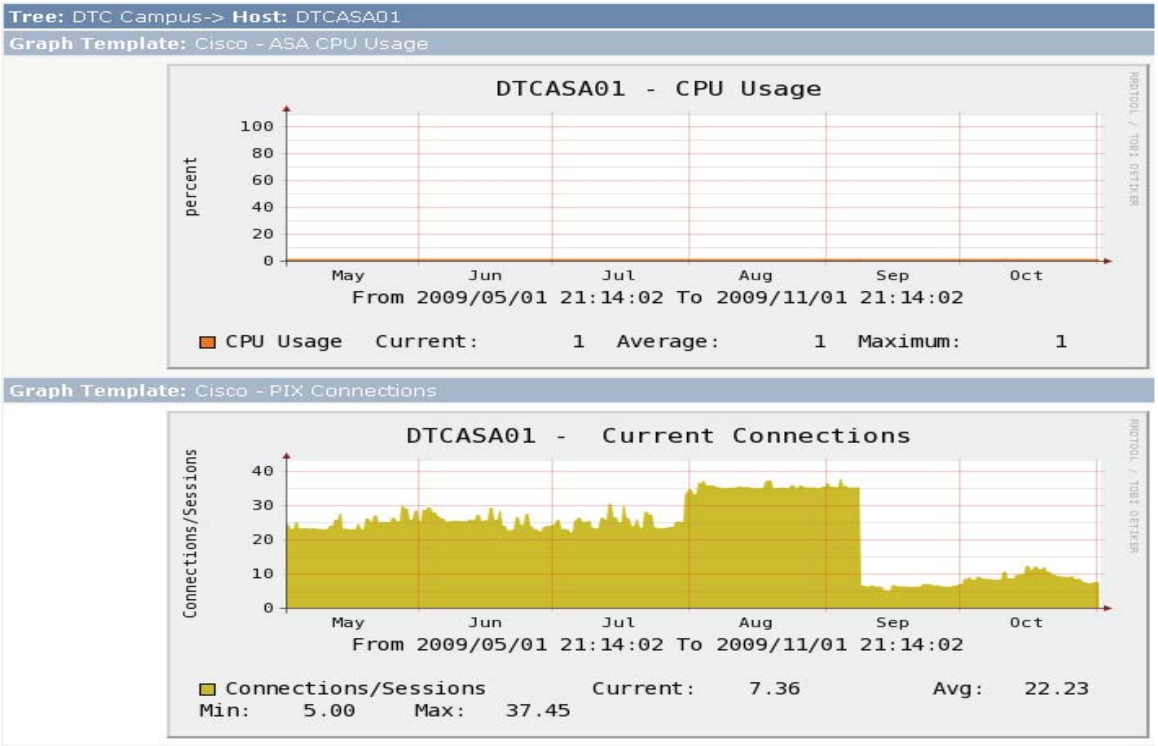
1st Found-In
7.0(7.8)
7.2(3.10)
7.2(3.12)

Fixed-In
8.0(3.2)
7.2(4)
8.1(0.128)
8.2(0.79)
7.0(7.10)
7.2(3.13)
7.1(2.69)

Component(s)
snmp

Regression
Y

Figure 6 - 20



Tree: DTC Campus-> **Host:** DTCASA01

Graph Template: Cisco - ASA CPU Usage

From 2009/05/01 21:14:02 To 2009/11/01 21:14:02

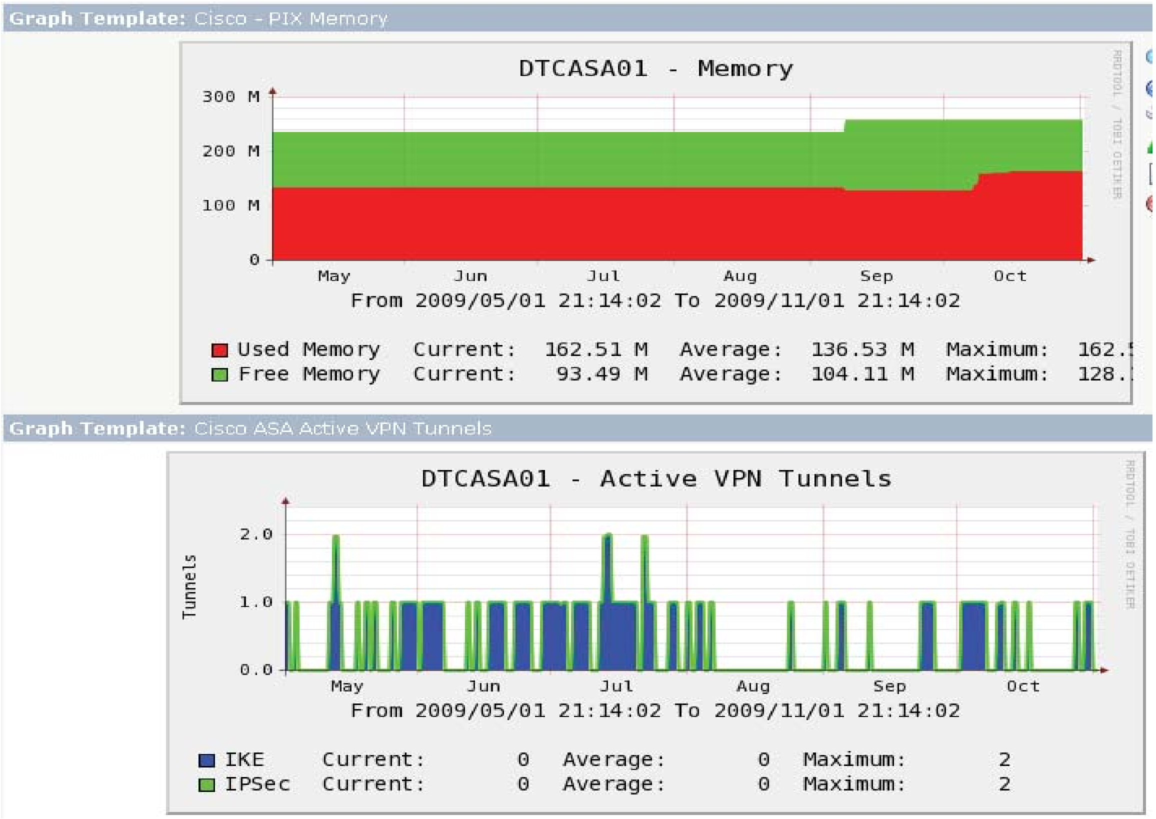
🟧 CPU Usage Current: 1 Average: 1 Maximum: 1

Graph Template: Cisco - PIX Connections

From 2009/05/01 21:14:02 To 2009/11/01 21:14:02

🟨 Connections/Sessions Current: 7.36 Avg: 22.23
Min: 5.00 Max: 37.45

Figure 6 - 21



Graph Template: Cisco - PIX Memory

From 2009/05/01 21:14:02 To 2009/11/01 21:14:02

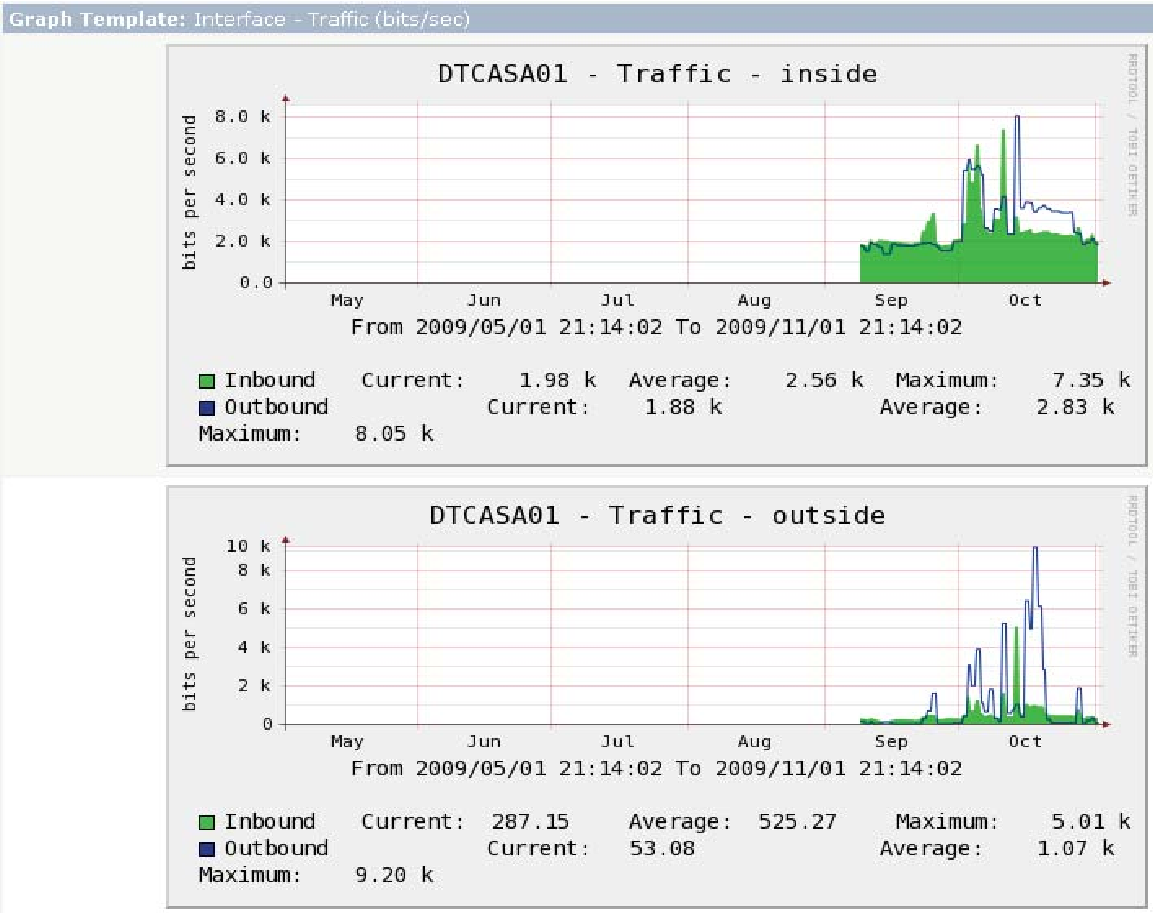
🟥 Used Memory Current: 162.51 M Average: 136.53 M Maximum: 162.
🟩 Free Memory Current: 93.49 M Average: 104.11 M Maximum: 128.

Graph Template: Cisco ASA Active VPN Tunnels

From 2009/05/01 21:14:02 To 2009/11/01 21:14:02

🟦 IKE Current: 0 Average: 0 Maximum: 2
🟩 IPSec Current: 0 Average: 0 Maximum: 2

Figure 6 - 22


Graph Template: Interface - Traffic (bits/sec)
DTCASA01 - Traffic - inside
bits per second
8.0 k
6.0 k
4.0 k
2.0 k
0.0
May
Jun
Jul
Aug
Sep
Oct
From 2009/05/01 21:14:02 To 2009/11/01 21:14:02
RRDTOOL / TOBI OETIKER
DTCASA01 - Traffic - outside
bits per second
10 k
8 k
6 k
4 k
2 k
0
May
Jun
Jul
Aug
Sep
Oct
From 2009/05/01 21:14:02 To 2009/11/01 21:14:02
RRDTOOL / TOBI OETIKER

```
🟩 Inbound    Current:     1.98 k  Average:     2.56 k  Maximum:     7.35 k
■ Outbound             Current:     1.88 k            Average:     2.83 k
Maximum:     8.05 k
```

```
🟩 Inbound    Current:   287.15    Average:   525.27    Maximum:     5.01 k
■ Outbound             Current:    53.08               Average:     1.07 k
Maximum:     9.20 k
```

Figure 6 - 23

Chapter 5 – Project History

Implementation

The first order of business when starting the implementation was to gather all known network information about RUSP network. This was one of the hardest tasks because the network is an educational network that has minimal documentation and is constantly changing. As people graduate, documentation and knowledge transfers depreciate which makes this first step hard. Appendix C shows a series of communications. It required over a month of prep work to get the correct information before the new monitoring server could even be turned on to start capturing data.

After information was gathered, a server, or the hardware that the monitoring server was going to run on, needed to be selected. Since the project scope was only to cover known network devices on the RUSP network the hardware did not have to be the newest or fastest equipment. The server specs are defined below.

```
Hostname: netmon.ARNe-regis.org
OS: Centos 5.2
CPU: 634 Mhz
Disk Space: 30GB
RAM: 512k
```

OS

The server Operating System installation is a CentOS 5.2 install and is based on LAMP as described in definitions. Not all computers are created equally. When building a new server each physical component must have a driver. That means the network interface card, the hard drives, and any and all other peripherals. The very first computer selected had a driver issue with the version of CentOS and it would not recognize the hard drives that were installed. After four hours into the build it was no closer to completion than the first step. This should have been one of the easiest tasks and should have taken no longer than an hour from start to finish. Since the computer was not the focal point of the project it was decided to replace the computer with a similar model which is the one detailed in the above specifications. After replacing the computer the install went as planned so no special drivers were needed. Basic setup was completed successfully. No packages (i.e., Apache, MySql or PHP) were installed. The packages were installed after the base Operating System.

The fist step in installing the operating system was to download it. Since CentOS is open source there are plenty of places to download it from. The download comes in the form of an ISO image that has to be converted to a disc for installation on the server. To do this a Window XP computer to download the CentoOS ISO image and a program called Image Burn. Image Burn is a freeware program that allows the user to convert ISO images and burn them to CD. Once on a CD it can be put into the CD-Rom drive of the computer and the computer can be powered up. Once the computer is turned on the BIOS setting must confirm that the computer will boot from CD-Rom before booting to the hard drive. If so, the CD-Rom drive and the CentOS image on the CD will take over. The complete installation steps and screen shots are shown in Appendix D.

Packages

Packages were briefly discussed before. A package can be a program, an application, or a script. The goal is to have a complete monitor solution base of an application called Cacti. The Cacti application has a lot of dependency. A dependency is an application or program that requires another application or program for it to work properly. On the Cacti website there is an entire chapter dedicated to installation. Using the online manual (http://www.cacti.net/downloads/docs/pdf/manual.pdf) created by The Cacti Group was critical in identify the dependant packages needed to complete the install of Cacti. (Berry, Roman, Adams, Pasnak, Scheck & Conner, 2007). The dependant packages are:

- `httpd`
- `php`
- `php-mysql`
- `php-snmp`
- `mysql`
- `mysql-server`

- `net-snmp`

The following text will cover what is not in the manual rather than copying what is already there. It took a lot of research to figure out and to finish the installation of the Cacti monitoring application. Therefore, it is worth describing so future users of Cacti can leARNe from this experience.

These packages are installed using a program called YUM (Yellowdog Updater Modified). Why YUM for this project? The reason for YUM is to install software package and their dependencies. Just as Cacti is dependent on the software mentioned above (httpd, php, mysql …) those software packages also have their own dependencies. Without a program like YUM adding packages is a multi-step processes that will add time and complexity to the build process because dependencies have to be installed before you can use any software that has them. However, before YUM is used to find all the packages required, there has to be some configuration changes to the default installation that comes with the base install of CentOS. YUM uses repositories that are database packages that can be used for easier installation of packages. In order to get all the packages installed additional repositories. If there are not enough repositories when installing the packages required, a wARNeing message “package not found” will be displayed. There is a complete guide on CentOS’s website showing how to add the repositories needed (Herrold, 2009).

Once YUM is configured installing the required packages can be started. Using YUM requires a very simple command to install the dependant packages. From a command line prompt in Linux, entering the following commands will install all the dependencies above:

```
[root@netmon ~]# yum install httpd
[root@netmon ~]# yum install php
[root@netmon ~]# yum install php-mysql
[root@netmon ~]# yum install php-snmp
[root@netmon ~]# yum install mysql
[root@netmon ~]# yum install mysql-server
[root@netmon ~]# yum install net-snmp
```

It is pretty easy to install packages as the commands above show. Back to the Cacti installation manual, there are two steps that were not completed that were in the manual. With the install of Cacti on CentOS version 5.2 it was not a requirement to change the way PHP or Apache were configured. The httpd.conf and php.conf files were not edited.

Missing from the dependency list were all of the packages needed to install the RRDTool. This was such a big omission they probably assumed this is pre-existing and already installed. Either way, installing the RRDTool posed one of the biggest challenges to get it to work properly. The first attempt to installing the RRDTool went just like the others above. It did not install because the RRDTool has its own set of dependencies listed here:

```
[root@netmon ~]# yum install rrdtool
Error: Missing Dependency: cairo >= 1.4.6 is needed by package rrdtool
Error: Missing Dependency: dejavu-fonts-lgc-sans is needed by package rrdtool
Error: Missing Dependency: dejavu-fonts-lgc-serif is needed by package rrdtool
Error: Missing Dependency: pango >= 1.17 is needed by package rrdtool
Error: Missing Dependency: dejavu-fonts-lgc-sans-mono is needed by package rrdtool
```

The second attempt was to install all the dependencies listed above and try to re-install the RRDTool. This didn't work either. No matter what dependencies were installed, when installing the RRDTool it always said it was missing one or had a conflict with a different one. Below is an example of a conflict message received when trying to install the RRDTool.

```
--> Processing Conflict: dejavu-fonts conflicts fontconfig >= 2.3.0
```

After three hours of trying to resolve the dependency issue a new approach was attempted. An older version of the RRDTool was installed in the hope that it would not have the same issue with the other version of the dependencies that were installed. Install RRDTool version 1.2.30 fixed the issue of the Errors and Conflicts that displayed previously. Below is the actual command that it took in order to get the RRDTool installed. Notice that all dependencies resolved and at the end of the command sequence below it completed which means it was successful.

```
[root@netmon localrepo]# yum install rrdtool
Loading "priorities" plugin
Loading "fastestmirror" plugin
Loading mirror speeds from cached hostfile
 * rpmforge: fr2.rpmfind.net
 * base: mirror.sourceshare.org
 * updates: mirror.chpc.utah.edu
 * addons: mirror.chpc.utah.edu
 * extras: mirrors.gigenet.com
342 packages excluded due to repository priority protections
Setting up Install Process
Parsing package install arguments
Resolving Dependencies
--> Running transaction check
---> Package rrdtool.i386 0:1.2.30-1.el5.rf set to be updated
--> Processing Dependency: libart_lgpl_2.so.2 for package: rrdtool
--> Processing Dependency: perl(RRDs) for package: rrdtool
--> Processing Dependency: perl(RRDp) for package: rrdtool
--> Running transaction check
---> Package libart_lgpl.i386 0:2.3.17-4 set to be updated
---> Package perl-rrdtool.i386 0:1.2.30-1.el5.rf set to be updated
--> Finished Dependency Resolution

Dependencies Resolved

=============================================================================
 Package                 Arch       Version          Repository        Size
=============================================================================
Installing for dependencies:
 libart_lgpl             i386       2.3.17-4         base              76 k
 perl-rrdtool            i386       1.2.30-1.el5.rf  rpmforge          49 k
 rrdtool                 i386       1.2.30-1.el5.rf  rpmforge         951 k

Transaction Summary
```

```
================================================================================
Install      3 Package(s)
Update       0 Package(s)
Remove       0 Package(s)

Total download size: 1.1 M
Is this ok [y/N]: y
Downloading Packages:
(1/3): perl-rrdtool-1.2.3 100% |=========================|  49 kB    00:00
(2/3): rrdtool-1.2.30-1.e 100% |=========================| 951 kB    00:10
(3/3): libart_lgpl-2.3.17 100% |=========================|  76 kB    00:00
Running rpm_check_debug
Running Transaction Test
Finished Transaction Test
Transaction Test Succeeded
Running Transaction
  Installing: libart_lgpl                  ######################### [1/3]
  Installing: perl-rrdtool                 ######################### [2/3]
  Installing: rrdtool                      ######################### [3/3]

Dependency Installed: libart_lgpl.i386 0:2.3.17-4 perl-rrdtool.i386 0:1.2.30-1.el5.rf rrdtool.i386 0:1.2.30-1.el5.rf
Complete!
```

The actual commands and logs for the installation of packages and dependencies can be found in Appendix A.

NTP

Network time protocol (NTP) is a way for servers to keep accurate time. This is necessary when using hardware from a server that may be years old and the internal clocks don't necessarily keep accurate time. Why is time necessary? The University of Michigan uses NTP as a security measure by protecting them against time base attack. Another study by David Mills at the University of Delaware says NTP is necessary for application transactions across a network. Mills also explains in his study how NTP works in detail. NTP is built on the Internet Protocol and User Datagram Protocol which provide a connectionless reliable path over the Internet. There are other time protocols like Simple Network Time Protocol (SNTP) which are very similar to NTP and the difference between them is the complexity of the algorithms. NTP typically will use multiple sources to calculate time where as SNTP uses just one.

For this case study it is the application transactions that are a concern not necessarily time based attacks security risk. The monitoring server that is being built relies on accurate time. Without it all the benefits of having a monitoring server go away. For example, using this monitoring server for troubleshooting and it didn’t keep accurate time the network engineer would think a problem happened at one time when it could have happened at some other time. This time error makes the troubleshooting useless. This server hardware is on the older side of computers so configuring NTP is an absolute requirement. The complete configuration of this server is in Appendix A and the NTP configuration is based on a how to guide found on Linux Home Networking dot com. (Linux Home Networking, 2009)

In the server “netmon” configuration a NTP source that has already been configured for ARNE engineer will be used. Where applicable in the how to guide, substitute NTP source server with an IP address identified in the network section later on in the implementation.

Cacti

The installation of Cacti is a simple process and can be done by downloading a tarball from Cacti.net. Once the tarball is downloaded extract it into the location (file path) of the web server. In this configuration it was extracted to /var/html as shown in the screen captures below from the installation of Cacti on server hostname netmon.

```
[root@netmon www]# tar xzvf cacti-0.8.7d.tar.gz
cacti-0.8.7d/
cacti-0.8.7d/color.php
cacti-0.8.7d/data_sources.php
cacti-0.8.7d/settings.php
cacti-0.8.7d/poller.php
```

```
cacti-0.8.7d/graph_templates_items.php
cacti-0.8.7d/logout.php
cacti-0.8.7d/data_templates.php
cacti-0.8.7d/auth_changepassword.php
cacti-0.8.7d/host_templates.php
cacti-0.8.7d/about.php
cacti-0.8.7d/script_server.php
cacti-0.8.7d/LICENSE
```

In picking the path /var/www/cacti, the web service “httpd” that was installed in the very beginning had to be configured to know how to get to the Cacti path location. This information is not clearly defined in the Cacti installation manuals. You must know Linux and Apache web servers in order to read between the lines in the Cacti installation manual. Below is a configuration reference to an additional step needed to be added to Apache in order for Apache to locate Cacti.

```
[root@netmon files-0.8.7d]# vi /etc/httpd/conf.d/cacti.conf
Alias / /var/www/cacti/
<Directory /var/www/cacti/>
   DirectoryIndex index.php
   Options -Indexes
   AllowOverride all
   allow from all
   AddType application/x-httpd-php .php
   php_flag magic_quotes_gpc on
   php_flag track_vars on
</Directory>
```

The database has to be setup before continuing to the Cacti web user interface and start configuring it. Installing the database has been described previously, however, like everything else the Cacti application has to be configured to work with the database that was installed. Databases are complex but the idea is simple - it is a place where data is stored logically. Cacti’s developers make installing the database for Cacti almost effortless. The Cacti instruction manual is clear and it worked without any issues.

Cacti Plugin Architecture

"The Plugin Architecture for Cacti was designed to be both simple in nature and robust enough to allow freedom to do almost anything in Cacti. Cacti itself is designed nicely enough that integrating into it is fairly easy with very little modifications necessary. Eventually Cacti will come with a standard plugin architecture that will allow addons to be created without the need to modify the installation, but until that time comes follow the directions below." (Cacti Users, 2009) This architecture is required for the plugins that are going to be installed to add functionality to the Cacti application. The manual used to install the Plugin Architecture is located at http://cactiusers.org/wiki/PluginArchitectureInstall and a completed list of installation specific steps is in Appendix A.

Plugins

The installation of plugins are as simple as the Cacti installation. Download the plugin from any site that advertises Cacti plugin compatibility and extract the tarball to the directory called plugins. The plugin directory was created when the installation of Cacti was completed. In our server "netmon" that location is /var/html/plugins.

Download

```
   [root@netmon plugins]#wget http://cactiusers.org/downloads/mactrack.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/discovery.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/monitor.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/loginmod.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/tools.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/syslog.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/thold.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/update.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/settings.tar.gz
   [root@netmon plugins]#wget http://cactiusers.org/downloads/ssl.tar.gz
```

Extract

```
    [root@netmon plugins]#tar -zxvf mactrack.tar.gz
    [root@netmon plugins]#tar -zxvf discovery.tar.gz
    [root@netmon plugins]#tar -zxvf monitor.tar.gz
    [root@netmon plugins]#tar -zxvf loginmod.tar.gz
    [root@netmon plugins]#tar -zxvf tools.tar.gz
    [root@netmon plugins]#tar -zxvf syslog.tar.gz
    [root@netmon plugins]#tar -zxvf thold.tar.gz
    [root@netmon plugins]#tar -zxvf update.tar.gz
    [root@netmon plugins]#tar -zxvf settings.tar.gz
    [root@netmon plugins]#tar -zxvf ssl.tar.gz
```

The last step is to get Cacti to recognize the new plugin that was installed.

For this step a configuration file in Cacti has to be modified.

```
[root@netmon cacti_plugins]# vi /var/www/html/include/global.php
```

In the file global.php find the line that starts like the character below.

```
$plugins = array();
```

Next, add these lines right under the line that was found above. The complete setup should look exactly like the lines of code below.

```
$plugins = array();
$plugins[] = 'mactrack';
$plugins[] = 'discovery';
$plugins[] = 'monitor';
$plugins[] = 'loginmod';
$plugins[] = 'tools';
$plugins[] = 'thold';
$plugins[] = 'update';
$plugins[] = 'settings';
$plugins[] = 'ssl';
```

This is the basic installation of how all plugins are installed on Cacti. (Cacti Users, 2009)

When some plugins are extracted they will have a file called installation or readme that will give further installation steps if they are needed in order for the plugin to work properly. If there is an installation file or readme document and only do the basic install, Cacti will look like the plugin is installed but it will not function properly.

SSL

A major concern in today's world is security. There are many ways to secure transactions over a network. Rivest, Shamir and Adleman (RSA), Elliptic curve cryptography **(**ECC), secure socket layer (SSL) and transport layer security (TLS) are all for security data transmitted over a network. All of these methods deploy a public key method of securing data. A public key is something that is known to all and is used to derive a way for two devices to share data that only those two devices can understand. How they differ is the procedure and algorithms they use to secure data. Taking a closer look at SSL and TLS the biggest difference between the two other then TLS being newer are the ability to define new crypto ciphers. A cipher is the algorithm that performs the encryption and decryption. TLS is much easier to add new ciphers then SSL. For this case study SSL was chosen for 3 reasons. The first reason is it's most popular with website security method and since Cacti's user interface is a website one is needed base off of Netcraft SSL data mining survey and VeriSign who is an industry leader in SSL. Secondly the Apache web server installed for Cacti has existing add-on software package that make the installation easy. Third Cacti also has a premade add-on plugin for SSL and no other encryption method.

The current default web server configuration does not turn on secure socket layer (SSL). SSL is a way to have encrypted communication over a public area like the internet. The web server needs to be configured for this to work and before that can be done two new packages must be installed.

```
[root@netmon httpd]# yum install openssl
[root@netmon conf]# yum install mod_ssl
```

“SSL uses the public-and-private key encryption system from RSA, which also includes the use of a digital certificate.” (Cusack, 2009) On this server not having the money to pay for third party verification service it will be installed as a self signed certificate. This means creating both public and private keys to distribute to whoever accesses the Cacti application web user interface. It will be up to the user to decide whether or not to trust the Cacti application. This case study is a closed network meaning there shouldn’t be any direct access from the internet to the Cacti application. This security technique wouldn’t be absolutely necessary but, none the less, the Cacti application will have sensitive data that could be used for unethical purposes so best practices apply. A screen capture from the SSL installation is supplied below. It came from the Cacti server build and complete installation which can be found in Appendix A.

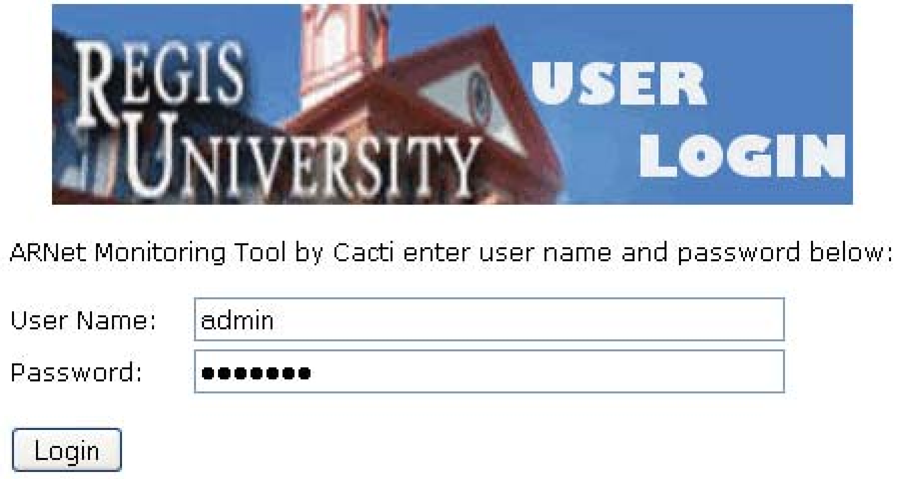
```
[root@netmon private]# openssl genrsa -out ca.key 1024
Generating RSA private key, 1024 bit long modulus
....++++++
...........................++++++
e is 65537 (0x10001)
[root@netmon private]# openssl req -new -key ca.key -out ca.csr
You are about to be asked to enter information that will be incorporated
into the certificate request.
What is entered is what is called a Distinguished Name or a DN.
There are quite a few fields but some can be left blank
For some fields there will be a default value,
Entering '.', the field will be left blank.
-----
Country Name (2 letter code) [GB]:US
State or Province Name (full name) [Berkshire]:Colorado
Locality Name (eg, city) [Newbury]:Denver
Organization Name (eg, company) [My Company Ltd]:Regis
Organizational Unit Name (eg, section) []:ARNe
Common Name (eg, the name or the server's hostname) []:netmon.ARNe-regis.org
Email Address []:
```

```
Please enter the following 'extra' attributes
to be sent with the certificate request
A challenge password []:
An optional company name []:
[root@netmon private]# ls
ca.csr  ca.key
[root@netmon private]# cd ..
[root@netmon certs]# ls
ca-bundle.crt  localhost.crt  make-dummy-cert  Makefile  private
[root@netmon certs]# cd private/
[root@netmon private]# ls
ca.csr  ca.key
[root@netmon private]# openssl x509 -req -days 1825 -in ca.csr -signkey ca.key -out ca.crt
Signature ok
subject=/C=US/ST=Colorado/L=Denver/O=Regis/OU=ARNe/CN=netmon.ARNe-regis.org
Getting Private key
```

After the server configuration is completed to allow for SSL connections, the Cacti application has to be told it’s using SSL. This is a common request in Cacti and it has a plugin for SSL which was installed using the same techniques described in the plugin section. The SSL plugin does not require any other installation steps other than the basic installation.

Login Page

This project is for the sole use of Regis University and its practicum network therefore implementing a redesigned customized login page for the users instead of the Cacti default login screen is helpful. The purpose of this screen is both aesthetics and to ensure that anyone who stumbles on it will know that this server requires a user name and password to get into it.



ARNet Monitoring Tool by Cacti enter user name and password below:

User Name: admin

Password: ●●●●●●●

Figure 4 - 1

Access

User access must be documented. Password management is a key element to the case study for the simple fact that the monitoring application project is built by one student. In order for the project to live on past one student access has to be document for future use of other students. Every username and password needed to access this server from the OS to the Cacti user interface is listed below.

Server Operating System
hostname: netmon
username: root
password: Gimm3aBr3ak

Database: mysql
Active DB
database: cactidb
username: cactiuser
password: mycactipw

Backup Blank
database: cacti
username: root
password: a11acsDBpa55

Cacti Web User Interface

Read and write privileges
username: admin
password: M0n1t0r

Read only
username: guest
password: guest

Network

The network configuration is the last step in the implementation process. These are the network settings used for the monitor so it can access the network. The server "netmon" must be placed on the network that has access to all of the network devices it will monitor. Also identified is the source for NTP server that will be used for accurate time measurements. This concludes the implementation process. All remaining installation information can be found in the capture file in Appendix A.

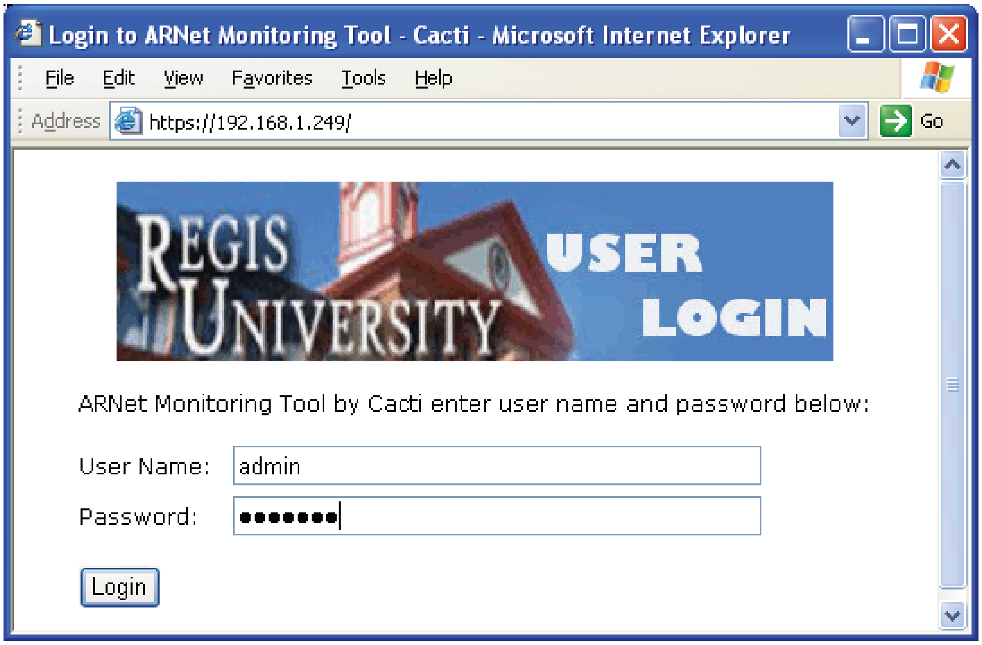
IP:	192.168.1.249
Subnet:	255.255.255.0
Gateway:	192.168.1.253
DNS:	208.67.222.222
	208.67.220.220
NTP:	192.168.1.1

Cacti Setup

Up until now nothing has been monitored. All of the previous work was to get to a point where a monitoring network device is possible. Cacti is now working on the same network as the devices that need to monitor. Cacti must also be told how to get there and what community string it will be using. Cacti will be told how to get to a device by the IP address that the device already has. The community has already been identified as K1t3sFlyH1gh and configured on the network devices that will be monitored.

For details on how the community string was configured on the network devices see Appendix C.

To create a new network device to monitor using the Cacti web user interface first the user must be on one of the ARNE local area networks. For this project, the easiest way to accomplish this was to establish a Cisco VPN directly to the ARNe Cisco ASA on the Denver Tech Center campus. The next step was to open a browser, connect to the url in Figure 5-1, and login using the admin username and password supplied in the Access section in Chapter 4 - Implementation.


Login to ARNet Monitoring Tool - Cacti - Microsoft Internet Explorer
File
Edit
View
Favorites
Tools
Help
Go
REGIS UNIVERSITY
USER LOGIN
Login

Address https://192.168.1.249/

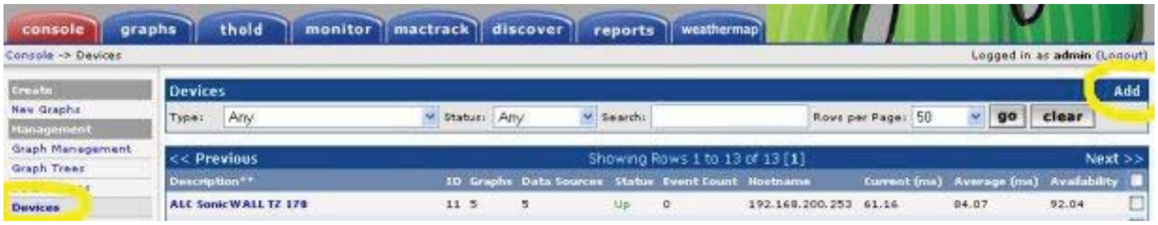
ARNet Monitoring Tool by Cacti enter user name and password below:

User Name: admin

Password: •••••••

Figure 5 - 1

Once logged in there will be tab at the top of the browser console that should be highlighted in red. Select Device from the menu on the left and then select Add on the upper right hand side.



Devices

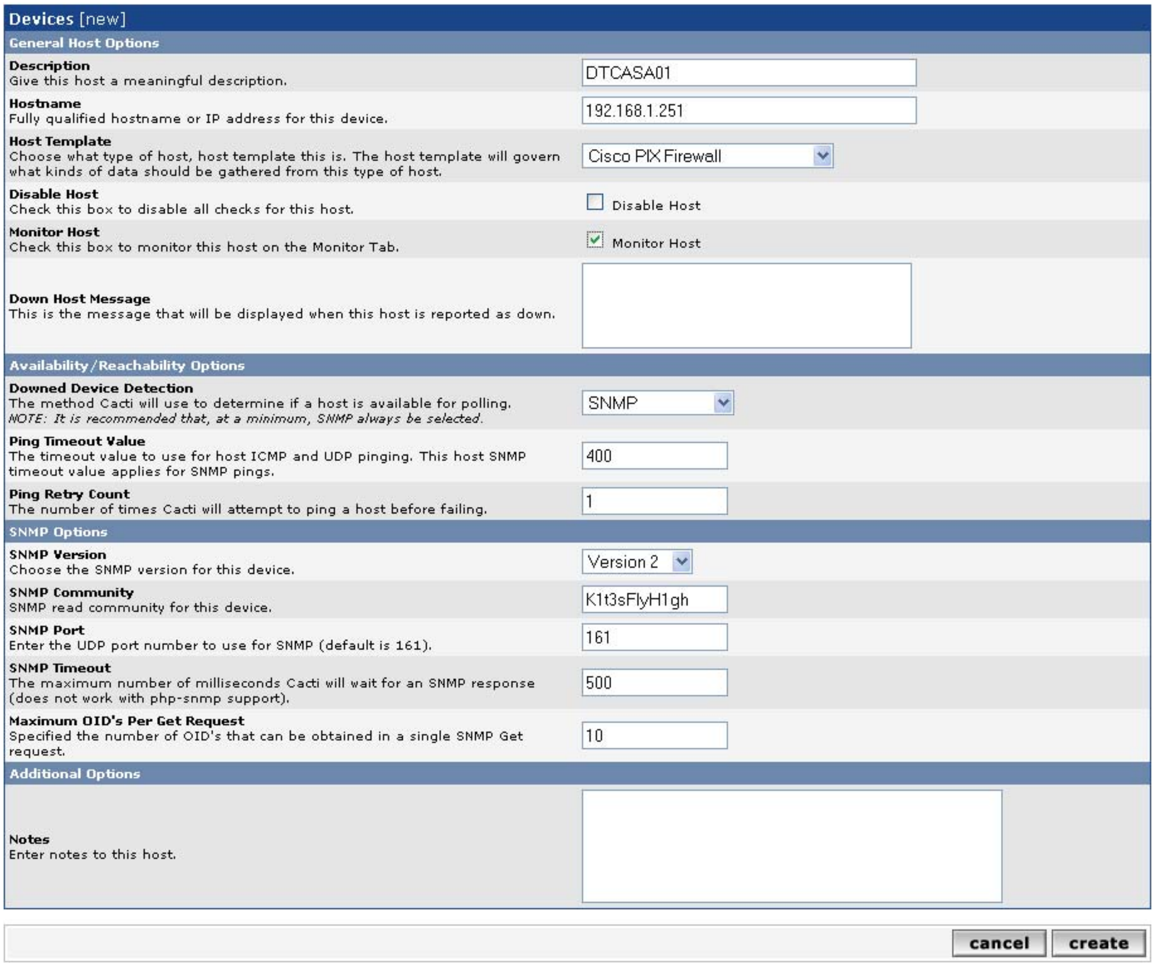
Type: Any Status: Any Search: Rows per Page: 50

Showing Rows 1 to 13 of 13 [1]

Description**	ID	Graphs	Data Sources	Status	Event Count	Hostname	Current (ms)	Average (ms)	Availability	□
ALC SonicWALL TZ 170	11	5	5	Up	0	192.168.200.253	61.16	84.07	92.04	□

Figure 5 - 2

This will open another page where entering the details of the network device needed to be monitored will be done. In the example below the Cisco ASA, the same one used for the VPN, is the added device to be monitored. All the information for adding a network monitored device is in Appendix C. This includes all the hosts that will be monitored. The only option that isn't readily available is the Host Template. This option allows specific monitoring features per manufacturer or device. Typically this setting is either set to generic switch or generic router. In the example dealing with a Cisco ASA which is identical to the Cisco Pix Firewall so that is why it was selected in this case. Once all the information has been filled in correctly as seen in Figure 5-3, click on the create button.



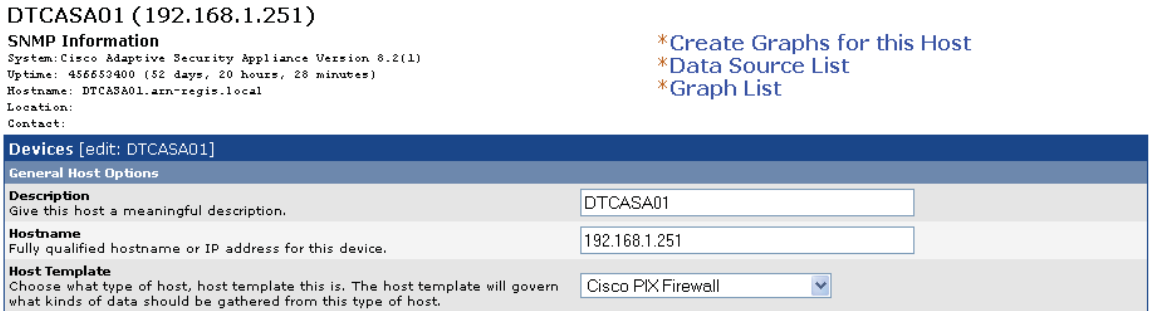
Devices [new]

General Host Options	
Description Give this host a meaningful description.	DTCASA01
Hostname Fully qualified hostname or IP address for this device.	192.168.1.251
Host Template Choose what type of host, host template this is. The host template will govern what kinds of data should be gathered from this type of host.	Cisco PIX Firewall
Disable Host Check this box to disable all checks for this host.	□ Disable Host
Monitor Host Check this box to monitor this host on the Monitor Tab.	☑ Monitor Host
Down Host Message This is the message that will be displayed when this host is reported as down.	
Availability/Reachability Options	
Downed Device Detection The method Cacti will use to determine if a host is available for polling. *NOTE: It is recommended that, at a minimum, SNMP always be selected.*	SNMP
Ping Timeout Value The timeout value to use for host ICMP and UDP pinging. This host SNMP timeout value applies for SNMP pings.	400
Ping Retry Count The number of times Cacti will attempt to ping a host before failing.	1
SNMP Options	
SNMP Version Choose the SNMP version for this device.	Version 2
SNMP Community SNMP read community for this device.	K1t3sFlyH1gh
SNMP Port Enter the UDP port number to use for SNMP (default is 161).	161
SNMP Timeout The maximum number of milliseconds Cacti will wait for an SNMP response (does not work with php-snmp support).	500
Maximum OID's Per Get Request Specified the number of OID's that can be obtained in a single SNMP Get request.	10
Additional Options	
Notes Enter notes to this host.	

Figure 5 - 3

If everything works correctly the return screen is the same screen as above with two exceptions. The heading will have SNMP information for the device just added. The SNMP information is pulled directly from the device that is to be monitored and is an indication that SNMP is working and the community string used was correct. The system, uptime and hostname all match what is already know about the device. From the heading there is an option to create graphs for this host. The footing is the other exception. It has two tables with options that weren't there when just adding the device. The two tables are Associated Graph Templates and Associated Data Queries. The Associated Graph Templates was created by the host template that was selected while creating the device. The Associated Data Queries is the MIB that will be queried once a graph is created.

Heading



DTCASA01 (192.168.1.251)

SNMP Information

```
System:Cisco Adaptive Security Appliance Version 8.2(1)
Uptime: 456653400 (52 days, 20 hours, 28 minutes)
Hostname: DTCASA01.arn-regis.local
Location:
Contact:
```

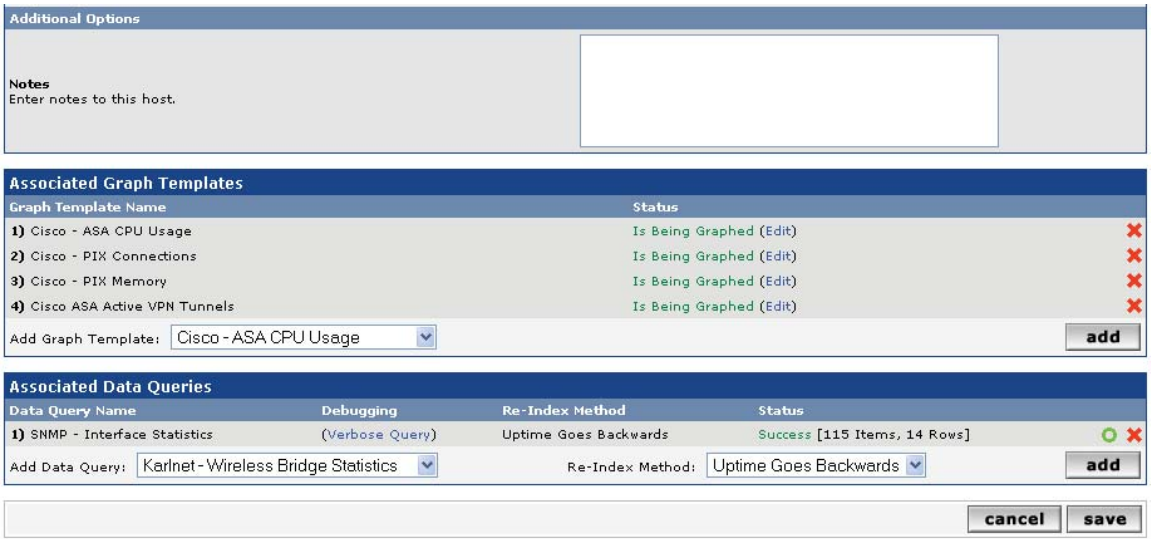
Devices [edit: DTCASA01]

General Host Options

Description Give this host a meaningful description.	DTCASA01
Hostname Fully qualified hostname or IP address for this device.	192.168.1.251
Host Template Choose what type of host, host template this is. The host template will govern what kinds of data should be gathered from this type of host.	Cisco PIX Firewall

Figure 5 - 4

Footing



Additional Options

Notes
Enter notes to this host.

Associated Graph Templates

Graph Template Name	Status
1) Cisco - ASA CPU Usage	Is Being Graphed (Edit)
2) Cisco - PIX Connections	Is Being Graphed (Edit)
3) Cisco - PIX Memory	Is Being Graphed (Edit)
4) Cisco ASA Active VPN Tunnels	Is Being Graphed (Edit)

Add Graph Template: Cisco - ASA CPU Usage

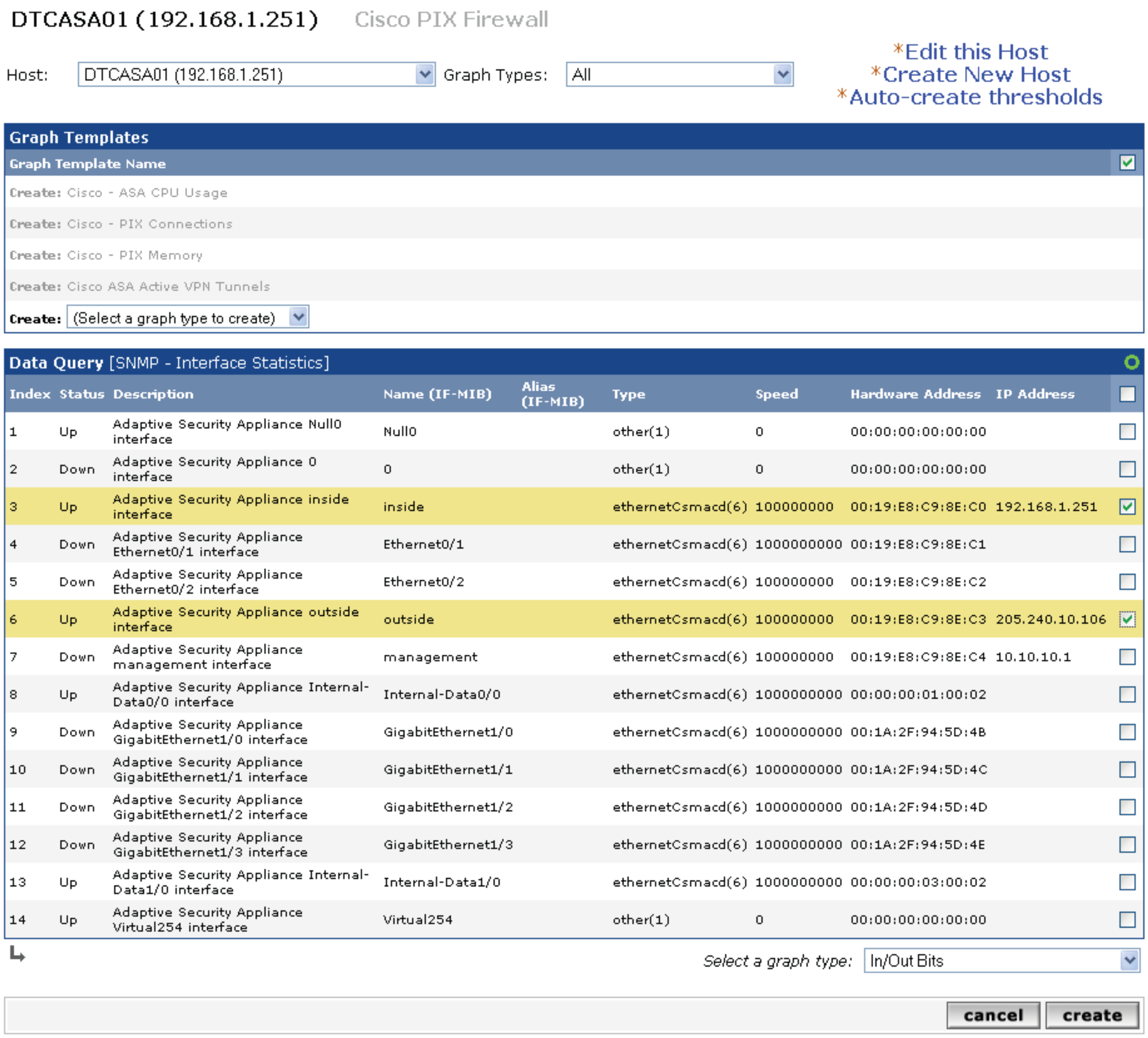
Associated Data Queries

Data Query Name	Debugging	Re-Index Method	Status
1) SNMP - Interface Statistics	(Verbose Query)	Uptime Goes Backwards	Success [115 Items, 14 Rows]

Add Data Query: Karlnet - Wireless Bridge Statistics Re-Index Method: Uptime Goes Backwards

Figure 5 - 5

The goal here is to create a graph for this host. Selecting the “Create Graphs for this Host” will load another page as shown in Figure 5-6.



DTCASA01 (192.168.1.251) Cisco PIX Firewall

Host: DTCASA01 (192.168.1.251) Graph Types: All

Graph Templates

Graph Template Name	☑
Create: Cisco - ASA CPU Usage	
Create: Cisco - PIX Connections	
Create: Cisco - PIX Memory	
Create: Cisco ASA Active VPN Tunnels	
Create: (Select a graph type to create)	

Data Query [SNMP - Interface Statistics]

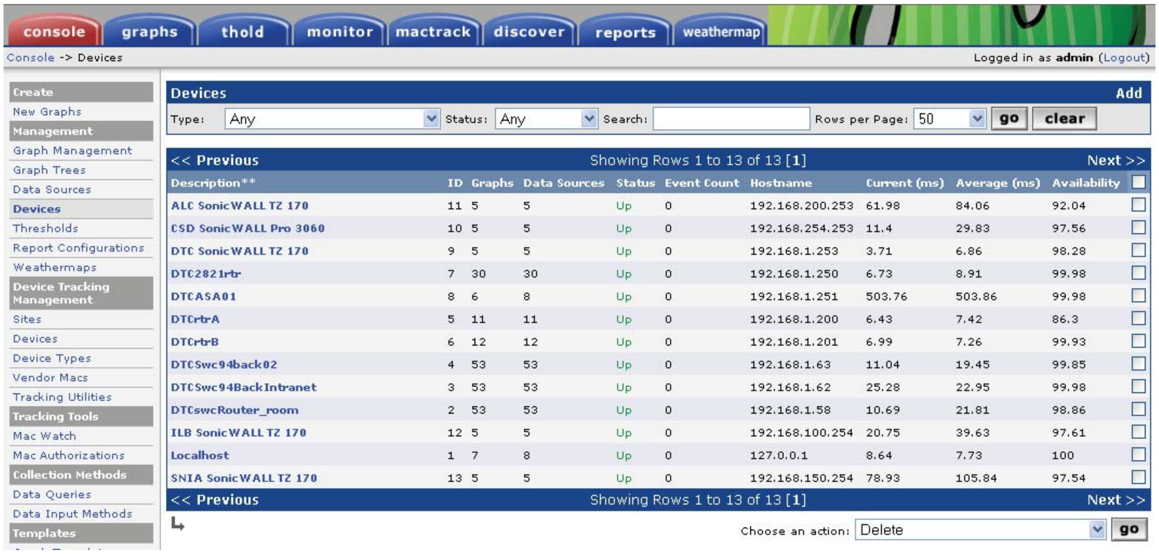
Index	Status	Description	Name (IF-MIB)	Alias (IF-MIB)	Type	Speed	Hardware Address	IP Address	□
1	Up	Adaptive Security Appliance Null0 interface	Null0		other(1)	0	00:00:00:00:00:00		□
2	Down	Adaptive Security Appliance 0 interface	0		other(1)	0	00:00:00:00:00:00		□
3	Up	Adaptive Security Appliance inside interface	inside		ethernetCsmacd(6)	100000000	00:19:E8:C9:8E:C0	192.168.1.251	☑
4	Down	Adaptive Security Appliance Ethernet0/1 interface	Ethernet0/1		ethernetCsmacd(6)	1000000000	00:19:E8:C9:8E:C1		□
5	Down	Adaptive Security Appliance Ethernet0/2 interface	Ethernet0/2		ethernetCsmacd(6)	100000000	00:19:E8:C9:8E:C2		□
6	Up	Adaptive Security Appliance outside interface	outside		ethernetCsmacd(6)	100000000	00:19:E8:C9:8E:C3	205.240.10.106	☑
7	Down	Adaptive Security Appliance management interface	management		ethernetCsmacd(6)	100000000	00:19:E8:C9:8E:C4	10.10.10.1	□
8	Up	Adaptive Security Appliance Internal-Data0/0 interface	Internal-Data0/0		ethernetCsmacd(6)	1000000000	00:00:00:01:00:02		□
9	Down	Adaptive Security Appliance GigabitEthernet1/0 interface	GigabitEthernet1/0		ethernetCsmacd(6)	1000000000	00:1A:2F:94:5D:4B		□
10	Down	Adaptive Security Appliance GigabitEthernet1/1 interface	GigabitEthernet1/1		ethernetCsmacd(6)	1000000000	00:1A:2F:94:5D:4C		□
11	Down	Adaptive Security Appliance GigabitEthernet1/2 interface	GigabitEthernet1/2		ethernetCsmacd(6)	1000000000	00:1A:2F:94:5D:4D		□
12	Down	Adaptive Security Appliance GigabitEthernet1/3 interface	GigabitEthernet1/3		ethernetCsmacd(6)	1000000000	00:1A:2F:94:5D:4E		□
13	Up	Adaptive Security Appliance Internal-Data1/0 interface	Internal-Data1/0		ethernetCsmacd(6)	1000000000	00:00:00:03:00:02		□
14	Up	Adaptive Security Appliance Virtual254 interface	Virtual254		other(1)	0	00:00:00:00:00:00		□

Select a graph type: In/Out Bits

Figure 5 - 6

Selecting all Graph Templates will allow the monitoring of CPU usage, connections, memory and VPN tunnels. This is done by selecting the “check all” feature in the title in the upper right hand corner in Figure 5-6. However, for the data query sections do not select everything. Select only the inside interface and the outside interfaces. This is done by placing a check next to each interface separately. Clicking “create” button on the bottom will then create all the graphs that have been checked.

This same process was repeated for all the devices listed below and that were identified in Appendix C, thirteen network devices in total.



Devices

Type: Any Status: Any Search: Rows per Page: 50

Showing Rows 1 to 13 of 13 [1]

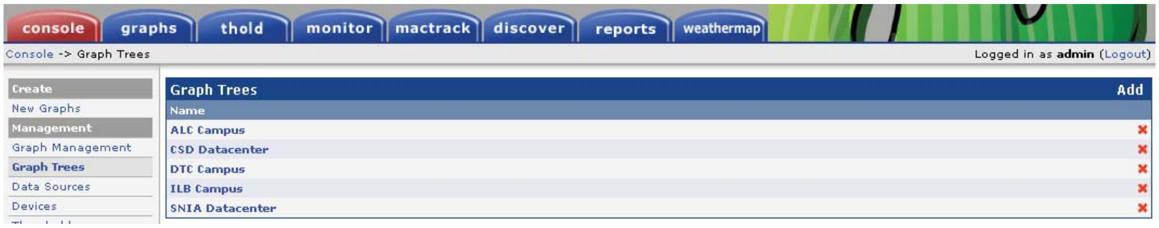
Description**	ID	Graphs	Data Sources	Status	Event Count	Hostname	Current (ms)	Average (ms)	Availability	□
ALC SonicWALL TZ 170	11	5	5	Up	0	192.168.200.253	61.98	84.06	92.04	□
CSD SonicWALL Pro 3060	10	5	5	Up	0	192.168.254.253	11.4	29.83	97.56	□
DTC SonicWALL TZ 170	9	5	5	Up	0	192.168.1.253	3.71	6.86	98.28	□
DTC2821rtr	7	30	30	Up	0	192.168.1.250	6.73	8.91	99.98	□
DTCASA01	8	6	8	Up	0	192.168.1.251	503.76	503.86	99.98	□
DTCrtrA	5	11	11	Up	0	192.168.1.200	6.43	7.42	86.3	□
DTCrtrB	6	12	12	Up	0	192.168.1.201	6.99	7.26	99.93	□
DTCSwc94back02	4	53	53	Up	0	192.168.1.63	11.04	19.45	99.85	□
DTCSwc94BackIntranet	3	53	53	Up	0	192.168.1.62	25.28	22.95	99.98	□
DTCswcRouter_room	2	53	53	Up	0	192.168.1.58	10.69	21.81	98.86	□
ILB SonicWALL TZ 170	12	5	5	Up	0	192.168.100.254	20.75	39.63	97.61	□
Localhost	1	7	8	Up	0	127.0.0.1	8.64	7.73	100	□
SNIA SonicWALL TZ 170	13	5	5	Up	0	192.168.150.254	78.93	105.84	97.54	□

Showing Rows 1 to 13 of 13 [1]

Choose an action: Delete

Figure 5 - 7

The last step is to see the graph just created which requires an extra step. That extra step is called a graph tree and it allows one to organize the devices in a meaningful way. The devices that are currently being monitored are geographically in different campuses or data centers. The graph tree will be laid out like Figure 5-8. By selecting "Add" in Figure 5-8 it allows the user to add the locations by name. No other options are required, just a name. It was identified in discovery that there are five locations where these 13 devices are located.

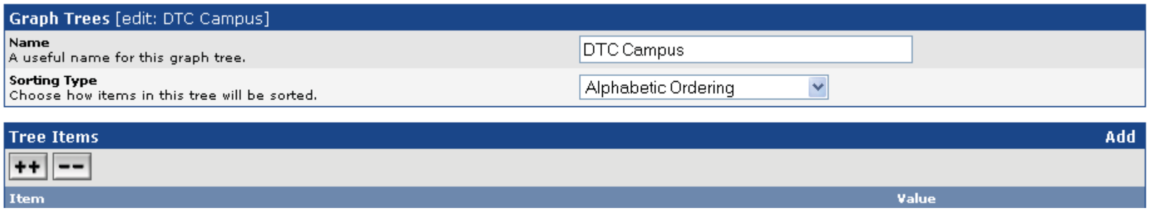


Graph Trees

Name	
ALC Campus	✖
CSD Datacenter	✖
DTC Campus	✖
ILB Campus	✖
SNIA Datacenter	✖

Figure 5 - 8

The ASA that is in the previous examples is in DTC Campus. Selecting that link pulls up a page that looks like Figure 5-9 below.



Graph Trees [edit: DTC Campus]

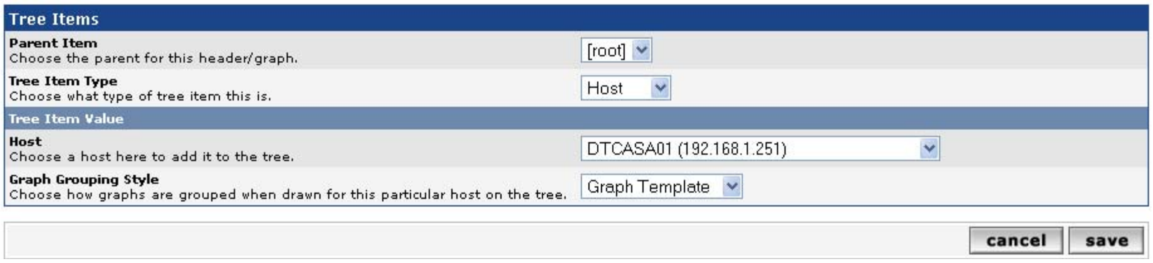
Name A useful name for this graph tree.	DTC Campus
Sorting Type Choose how items in this tree will be sorted.	Alphabetic Ordering

Tree Items **Add**

Item	Value

Figure 5 - 9

By selecting “Add” in Figure 5-9 another screen will pop up that looks like Figure 5-10

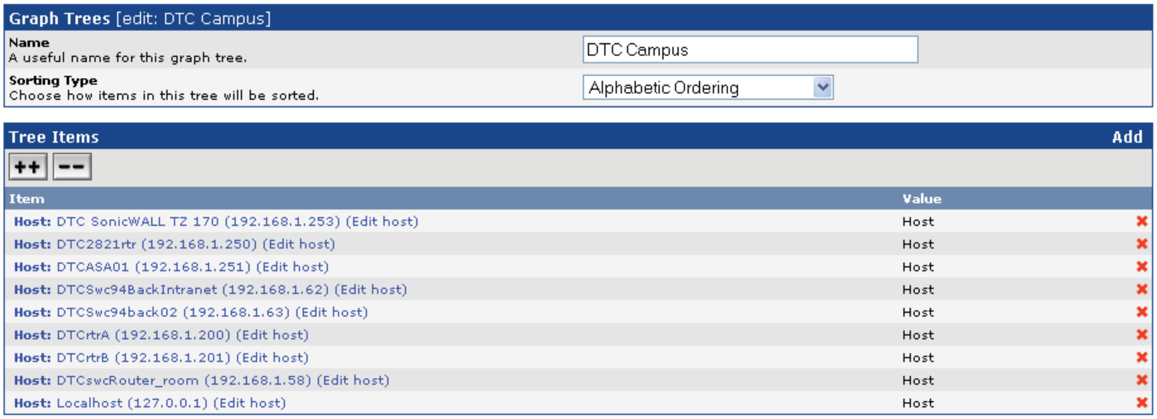


Tree Items

Parent Item Choose the parent for this header/graph.	[root]
Tree Item Type Choose what type of tree item this is.	Host
Tree Item Value	
Host Choose a host here to add it to the tree.	DTCASA01 (192.168.1.251)
Graph Grouping Style Choose how graphs are grouped when drawn for this particular host on the tree.	Graph Template

Figure 5 - 10

From here where it says “Parent Item” select “root” and in the “Tree Item Type” select “Host”. In the “Tree Item Value” section for “Host” option select the drop down items as listed above. In this case look for the hostname of the ASA in Figure 5-10 and click the save button. This will have to be done for all the network monitored devices and their corresponding locations. The DTC Campus has the most network monitored devices and is displayed below in Figure 5-11.



Graph Trees [edit: DTC Campus]

Name A useful name for this graph tree.	DTC Campus
Sorting Type Choose how items in this tree will be sorted.	Alphabetic Ordering

Tree Items **Add**

Item	Value	
Host: DTC SonicWALL TZ 170 (192.168.1.253) (Edit host)	Host	✖
Host: DTC2821rtr (192.168.1.250) (Edit host)	Host	✖
Host: DTCASA01 (192.168.1.251) (Edit host)	Host	✖
Host: DTCSwc94BackIntranet (192.168.1.62) (Edit host)	Host	✖
Host: DTCSwc94back02 (192.168.1.63) (Edit host)	Host	✖
Host: DTCrtrA (192.168.1.200) (Edit host)	Host	✖
Host: DTCrtrB (192.168.1.201) (Edit host)	Host	✖
Host: DTCswcRouter_room (192.168.1.58) (Edit host)	Host	✖
Host: Localhost (127.0.0.1) (Edit host)	Host	✖

Figure 5 - 11

Chapter 6 - Conclusions

The thesis assertion as tested was to determine a method to give the RUSP network a way to monitor its network devices. This was accomplished by building an open source monitoring solution in the form of Cacti. Cacti used a combination of other open source applications like RRDTool, PHP, and MySql to fully implement the desired functionality. The scope and relevance of this case in relation to similar situations is also designed to prove that no one could manually pull all the statistics needed for a historic graphic analysis of the network. The project also showed how a network monitoring tool can identify problems with the network at a glance.

One thing that could have been done differently in the project is to have a detailed checklist and evaluate more open source network monitoring applications. During the study some limitations with the monitoring application were found. Cacti could not receive SNMP trap information from a network device and report on it. SNMP traps are error messages or information that the network device sends out to let the users know that the device is having issues. It would have been helpful to have a monitoring application that could receive SNMP traps from the network devices and alert on those. With evaluating more monitoring application this type of SNMP trap monitoring could have been implemented. Cacti has another limitation and the fact that logs and graphs cannot be correlated together by time line is one of them. From the case study it refers to looking at the log for root cause. Cacti can tell if there was a problem it can’t always tell why it happened.

This project was bigger than originally expected. The time it took to install the base server operating system and installing the Cacti application took days. Then, configuring Cacti to make it work properly took weeks. The learning experience from creating a network monitoring tool has greatly increased my current skill set. Network engineers are rarely offered the opportunity to make global monitoring decisions for a large corporation. This project provided the opportunity to develop and implement a system to overcome shortcomings in monitoring that can leave a void in data collection. Having completed this project using open source software and applications will allow network administrators to benefit from this research and correct this void without an increase in cost.

In conclusion the data gathering methods and graphical representations are a part of network management and created a significant understanding of the ARNe network. The study showed that graphical representations can be used for troubleshooting networks. The study also demonstrated that graphical representation can be used in future planning when adding or modifying network resources. Suggestions for future research would include replicating the study with a larger number of network devices and engineers. In addition, a future study should include surveys of engineers that use graphed data to solve network issues compared to engineers who do not use graphs and the amount of time required by each study group to find a resolution to the problem.

References

Conjecture Corporation . (2009). How Much Text is in a Kilobyte or Megabyte. *Wise Geek*. Retrieved from http://www.wisegeek.com/how-much-text-is-in-a-kilobyte-or-megabyte.htm

> This explains how memory works in a computer. This is a common definition and provides analogies in order to explain computer memory. The information is current and relevant today.

Mitchell, B (2009). *switch (network switch)*. Retrieved from http://compnetworking.about.com/od/hardwarenetworkgear/g/bldef_switch.htm

> This article identifies what a switch is and what it does. It explains the function and which layer of the OSI model switches operate at. Switches are used to breakup collision domains. It also explains the differences between a switch and other network devices like routers. This article is current and relevant in today networking world. It provides background and supporting information.

Conjecture Corporation, (2009) "What is Network Monitoring?," What is Network Monitoring, Retrieved March 19, 2009, from http://www.wisegeek.com/what-is-network-monitoring.htm.

> The article is a high level overview of what network monitoring is and why network administrators need network monitoring. The website lays out specific examples of types of network monitoring and what its function is. There is no new information presented in the article however it does support the reason for my thesis.

Matt Zekauskas et al., (2005) "NDT Cookbook," Network Performance Measurement Tools: An Internet2 Cookbook, Retrieved April 3, 2009, from http://209.85.173.132/search?q=cache:lg_DV8SyiGkJ:www.internet2.edu/pubs/tools-cookbook.pdf+Network+Performance+Measurement+Tools:+And+Internet2+Cookbook&cd=1&hl=en&ct=clnk&gl=us.

> This article describes in detail how to troubleshoot a network issue by using monitoring tools. It cites case studies and the techniques used to troubleshoot the network issues. The article was written in 2005 which is old in the technology world however the core information is still relevant today. The way that the author describes network issues is clear and concise.

Donavan Nelson, Lance Davis, and CentOS ltd, (2005). "www.centos.org - centos.org content," Purpose of CentOS, Retrieved April 4, 2009, from http://www.centos.org/modules/tinycontent/index.php?id=3.

> This article explains why someone would choose the operating system called "CentOS". It also explains the reason why the operating system exists. My thesis project has operating system requirements and this article explains why "CentOS" meets those requirements.

Frisch, A. (2002). Essential System Administration. Sebastopol, CA, O'Reilly.

> This book is a guide how to administer a computer system. The text is not limited to servers but also includes networks. It explains how large a task monitoring a computer network really is. The book is old and is only used to support the reason why automation in computer network monitoring is needed. No new information is presented in this book.

cpu. (2009). In Merriam-Webster Online Dictionary.
Retrieved September 19, 2009, from http://www.merriam-webster.com/dictionary/cpu

> This link directs to a text book definition of a computer central processing unit. It provides a definition of what it does and what it is used for. This definition is limited and does not provide any examples or added usage. For the purpose of the project this definition will suffice.

Oetiker, T (2009, September 15). *About RRDtool*. Retrieved from http://oss.oetiker.ch/rrdtool/

> This is the complete definition of what RRDtool does and what it's used for. This is an open source standard for high performance data logging and graphing. It is a critical component for the Cacti application. This application is currently and continually being improved so the information collected at this site is up to date.

Rosen, K, Host, D, Klee, R, Farber, J & Rosinski, R (2007). *Unix : The Complete Reference* . US: McGraw-Hill.

> This book is a complete reference for Unix. It provides background and commands used to install and maintain a Unix server. This book is over two years old but still provides the necessary references for this project.

AB, MySql (2007). What is MySql. Retrieved December 5, 2008, from MySql AB Web site: http://dev.mysql.com/doc/refman/5.0/en/what-is-mysql.html

> This article is a detailed description of what MySql is and why it was created. This site also provides command references for maintaining a MySql database. MySql is still in development and actively being updated. The information in this link is current even though it's two year old.

Group, PHP (2007). History of PHP and related projects. Retrieved December 5, 2008, from PHP Web site: http://us.php.net/history

This reference gives the history of PHP. It outlines the different versions of PHP and what was the driving force behind them. This reference has the history of PHP related projects. PHP is also a technology that is continually being developed. The information on this site is current.

Kunze , Michael (1998). Let There be Light. Retrieved December 6, 2008, from LAMP: Freeware Web Publishing System with Database Support Web site: http://www.heise.de/ct/english/98/12/230/

This is a detailed description of LAMP. LAMP is Linux, Apache, MySql and PHP. The article explains why the surge in popularity of LAMP. It also goes over some uses for the LAMP. This article provides no new information on the subject but does support all other findings. The article is out of date but useful for the project.

LaMonica, Martin (2005, June 14). Open-source LAMP a beacon to developers. Retrieved December 5, 2008, from CNET News Web site: http://www.news.com/Open-source-LAMP-a-beacon-to-developers/2100-7344_3-5744767.html

This article details the reasons why companies are moving to LAMP. It is because LAMP is stable and for the most part free. It is based on open source applications that can be developed by any one with a computer. This article also compares LAMP to other proprietary offerings like Microsoft, Net and Sun Java. The article is relatively old, written in 2005, but the message in it still applies today.

Berry, I, Roman, T, Adams, L, Pasnak, J, Scheck, R & Conner, J. (2007). *Installing under unix*. Retrieved from http://www.cacti.net/downloads/docs/html/install_unix.html

This document was a critical component to this research. This is part of the "how to" manual for Cacti. This website had the dependencies required to install Cacti on a Linux based operating system. The ideas and fundamentals were sound and most still worked even though the document is over two years old.

Herrold, R. (2009, October 20). *Installing rpmforge*. Retrieved from http://wiki.centos.org/AdditionalResources/Repositories/RPMForge

This document details how to install rmpforge repositories on CentOS to be used with YUM. It is a part of the overall installation process of the monitoring application Cacti that isn't documented. There are other repositories that can fill this requirement but this one is well known and documented.

Cusack, B. (2009). Secure Sockets Layer. *What is*. Retrieved (2009, October 26) from http://searchsecurity.techtarget.com/sDefinition/0,,sid14_gci343029,00.html#

This is a definition of SSL including what it is and what is does. The article was researched for supporting claims made in the project. The information provide in the article is current and up to date.

Users, Cacti. (2009). *Plugin architecture*. Retrieved from http://cactiusers.org/wiki/PluginArchitectureInstall

The online document used to install the plugin architecture that is needed to add functionality to Cacti. It was the only reference needed for the basic install of Cacti plugin architecture. The documentation is up to date and well maintained.

Users, Cacti. (2009). *Plugins install*. Retrieved from http://cactiusers.org/wiki/PluginsInstall

This is the document used to install all the plugins that were needed to add functionality to Cacti. It was the only reference need for the basic install of Cacti plugins. This document also details the removal and upgrade procedures that will be useful in the future. The documentation is up to date and well maintained.

Linux Home Networking. (2009, May 19). *Quick howto : ch24 : the ntp server*. Retrieved from http://www.linuxhomenetworking.com/wiki/index.php/Quick_HOWTO_:_Ch24_:_The_NTP_Server

This howto document was used for the installation of NTP. NTP is a network time protocol use for the time accuracy. The howto guide has detailed instructions for Linux users from installation to setup. The online documentation was also updated 2009. Linux and NTP haven't changed that much over the years so this site is staying current.

Linux Home Networking. (2009, May 19). *Quick HOWTO : Ch03 : Linux Networking*. Retrieved from http://www.linuxhomenetworking.com/wiki/index.php/Quick_HOWTO_:_Ch03_:_Linux_Networking

This "how to" document was used for the configuration of Linux network interfaces. The guide has detailed instructions for Linux users to setup IP addresses, gateways and domains. The online documentation was also updated in 2009. Linux networking hasn't changed that much over the years so this site is staying current.

Alvestrand, H. (1997, February 10). *Object identifiers*. Retrieved from http://www.alvestrand.no/objectid/

This article reports a complete description of object identifiers (OID). It lists the most common OIDs. It also lays out the entire tree structure for the most common OIDs. The article is crucial for the understanding of monitoring and its details. The article is over ten years old. It would typically be disqualified as a reference however the information still is relevant on monitoring even new network devices.

Yin, R. (2009). *Case study research*. United States of America: Sage Publications, Inc..

This book is an outline of how a case study should be completed. The detailed explanations helped develop the outline for the research methodology chapter. The book is current and on its fourth edition.

Case, J, Fedor, M, Schoffstall, M, & Davin, J. (1990, May). *A Simple network management protocol (snmp)*. Retrieved from http://www.ietf.org/rfc/rfc1157.txt

Appendix A

This appendix has the complete implementation steps used to create this project. It covers hundreds of pages and 3.45 Megabytes of text. It is unrealistic to put it in this study as plain text. These are log file attachments and can be opened in any text viewer.

Appendix B

Appendix C

There are two other campus's correct?

I'll need the addresses of those network devices and the snmp string
applied.
If you want to give me a username and password I can do the configs
myself.
I can send an email with any network changes and wait for your guy's
approval then apply the configs myself.

On a side note.
Do you have a network backup solution where all your network
configurations are stored?
I'm think on doing snmp config pull and porting it into subversion with
websvn implementation? If there already an acceptable solution I don't
want to re-invent the wheel.

There is also syslog web module for the monitoring tool I personally
hate webUI for syslogs but if your trying to teach someone who is new to
log surfing it maybe something good to add.

emoore@cyberetower.com wrote:
> Thanks Rob,
> JP, let me know what else we need to do allow you to keep moving.
> Erik
>
> --- On *Mon, 4/13/09, Robert Moon /<r.moon@cablelabs.com>/* wrote:
>
>
>   From: Robert Moon <r.moon@cablelabs.com>
>   Subject: RE: Fw: Re: Sead Project
>   To: emoore@cyberetower.com, paul322@regis.edu, eddy.hutson@hp.com
>   Date: Monday, April 13, 2009, 11:50 AM
>

> I made the change on ASA.
>
> Rob
>
> --
> *From:* emoore@cyberetower.com [mailto:emoore@cyberetower.com]
> *Sent:* Monday, April 13, 2009 11:44 AM
> *To:* paul322@regis.edu; emoore@cyberetower.com; Robert Moon;
> eddy.hutson@hp.com
> *Subject:* Re: Fw: Re: Sead Project
>
> Hi JP,
> Sorry, I was a bit distracted during our call. I was in the
> middle of a detailed procedure. The best is if I am not in the
> middle for this network change. Please work directly with Robert
> and/or Eddy regarding this change. Also, I we can set permission
> for you to make edits to the ASA. I will check on Tuesday night
> and make sure it is addressed.
>
> --- On *Tue, 4/7/09, JP /<paul322@regis.edu>/* wrote:
>
>
>   From: JP <paul322@regis.edu>
>   Subject: Re: Fw: Re: Sead Project
>   To: "Robert Moon" <r.moon@cablelabs.com>
>   Cc: "emoore@cyberetower.com" <emoore@cyberetower.com>,
>   "Likarish, Daniel" <dlikaris@regis.edu>, "eddy.hutson@hp.com"
>   <eddy.hutson@hp.com>
>   Date: Tuesday, April 7, 2009, 10:16 PM
>
>   Guys I realize this is the last thing you want to be doing so I
>   apologize if I'm bugging you too much,
>
>   The change I'd like to make on the ASA is:
>
>   crypto isakmp nat-traversal 20
>
>   Maybe there a pre-existing reason why you don't want this enabled.
>   I was also unable to vpn in the past two days was there
>   maintenance?
>
>   Can the 192.168.1.0 network communicate with the other
>   campus's network
>   devices. If so I would like to start monitoring those devices
>   also.
>   I'll need a list and the community string added to the network
>   gear.
>   Any diagrams you have will help.
>
>
>
>
>
>
>   JP wrote:
>   > Everyone,

```
>       >
>       > I would like to make a change on the ASA in regards to the
>       user vpn's
>       > and do some testing.
>       > What is the procedure or how does one go about submitting a
>       change request?
>       >
>       > JP
>       >
>       >
>       >
>       > Robert Moon wrote:
>       >
>       >> JP,
>       >>
>       >> It is done except for SonicWall FW.  I don't have the pw
>       for it.
>       >> I do have an old network diagram but I can update it.
>       >>
>       >> Let me know if you have any problems.
>       >>
>       >>
>       >> Rob
>       >>
>       >>
>       >>
>       ------------------------------------------------------------------------
>       >> *From:* JP [mailto:paul322@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>]
>       >> *Sent:* Sun 3/29/2009 9:09 PM
>       >> *To:* Robert Moon
>       >> *Cc:* emoore@cyberetower.com
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>;
>       Likarish, Daniel; eddy.hutson@hp.com
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=eddy.hutson@hp.com>
>       >> *Subject:* Re: Fw: Re: Sead Project
>       >>
>       >> Eddy or Rob,
>       >>
>       >> If you want I can apply the community strings I just need a
>       login.  I
>       >> would like to start capturing data as soon as possible.
>       >> If there is a community string already applied I can use
>       that I don't
>       >> need to use the one listed below.
>       >> If your not worried about security you can leave off the acl.
>       >>
>       >> access-list 7 permit 192.168.1.249
>       >> snmp-server community K1t3sFlyH1gh RO 7
>       >>
>       >> Does anyone have current network diagram with hostnames and
>       IPs?
>       >>
>       >> Robert Moon wrote:
>       >>
>       >>> JP,
```

> >>>
> >>> I can work with you on this via e-mails since I am leaving
> for a
> >>> conference in DC.
> >>> I or Eddy can provide below information you will need from
> us and we can
> >>> modify the ACL to allow your system to do SNMP walk. I
> will be in the
> >>> lab on 4/7/2009.
> >>>
> >>> List of network devices in DTC:
> >>>
> >>> Cisco Switches:
> >>> 192.168.1.58/24
> >>> 192.168.1.62/24
> >>> 192.168.1.63/24
> >>>
> >>> Cisco Routers:
> >>>
> >>> 192.168.1.200/24
> >>> 192.168.1.201/24
> >>> 192.168.1.250/24
> >>>
> >>> FW:
> >>>
> >>> 192.168.1.253/24 Sonic FW
> >>> 192.168.1.251/24 Cisco ASA FW
> >>>
> >>> Let me know if you need more info.
> >>> We will try to modify the ACL sometime this week.
> >>>
> >>>
> >>> Rob Moon
> >>>
> >>>
> >>> -----Original Message-----
> >>> From: JP [mailto:paul322@regis.edu
> <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>]
> >>> Sent: Monday, March 23, 2009 6:20 PM
> >>> To: emoore@cyberetower.com
> <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>
> >>> Cc: Likarish, Daniel; eddy.hutson@hp.com
> <http://us.mc451.mail.yahoo.com/mc/compose?to=eddy.hutson@hp.com>;
> Robert Moon
> >>> Subject: Re: Fw: Re: Sead Project
> >>>
> >>> Hello Everyone,
> >>>
> >>> I am ready with my project to move into the ARNe network.
> Is it possible
> >>> to do this tomorrow or next Tuesday?
> >>> Eric I don't see Vinny's email.
> >>>
> >>> Summary of Project:
> >>> Graphing tool using snmp polling of network devices.
> >>>

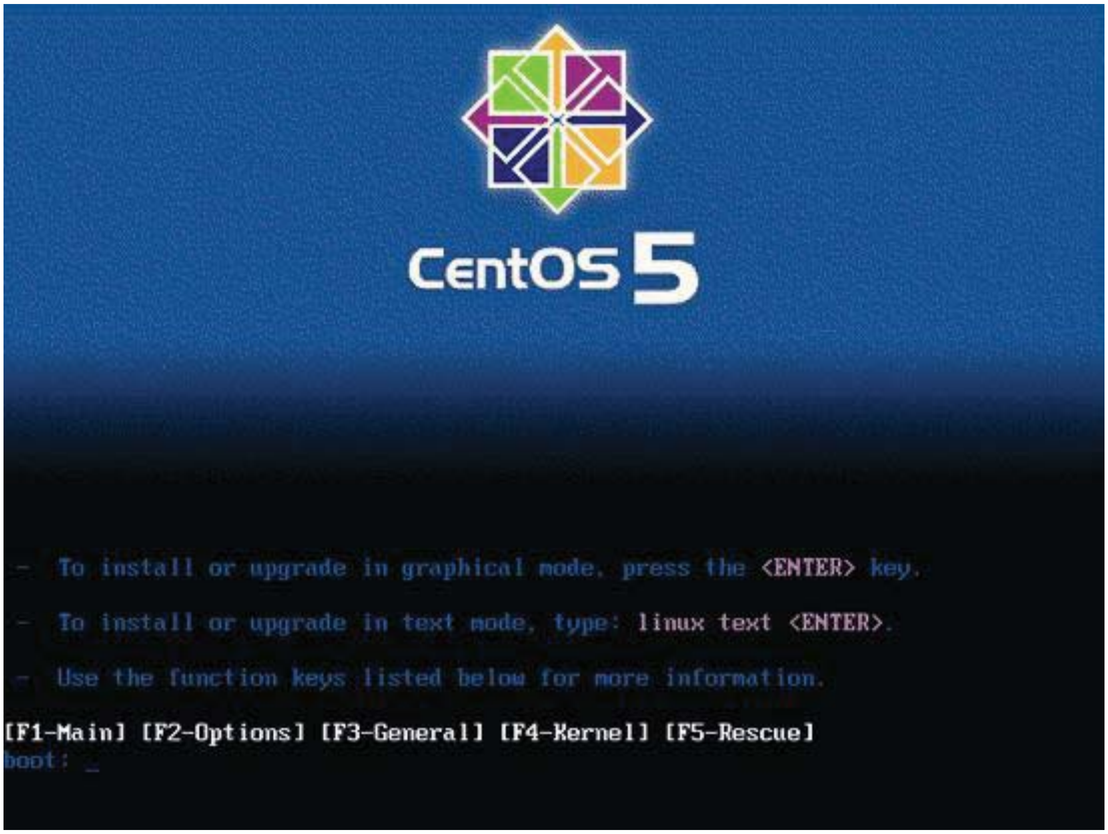
```
>       >>> What I need:
>       >>> IP address   (must have access to the same network that the
>       >>> switches/routers/firewalls are on)
>       >>> Subnet mask
>       >>> Gateway
>       >>> DNS (resolvers)
>       >>> List of IP address of network devices
>       >>> snmp string per device  (if one isn't available see below
>       for typical
>       >>> cisco config)
>       >>>             snmp-server community pleas3M0nme RO 7
>       >>>             access-list 7 permit xxx.xxx.xxx.xxx http
>       outbound
>       >>> access ( for updates) ssh and https inbound ( or what ever
>       method you
>       >>> use to remotely manage systems )
>       >>>
>       >>> Information on System:
>       >>> hostname: netmon.ARNe-regis.org
>       >>> OS: Centos 5.2
>       >>> cpu: 634
>       >>> hd: 30 gig
>       >>> ram: 512k
>       >>> some processes:
>       >>> httpd
>       >>> sshd
>       >>> mysql
>       >>> php
>       >>> syslogd
>       >>>
>       >>> What else do you need to know from me?
>       >>>
>       >>>
>       >>>
>       >>> emoore@cyberetower.com
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>
>       wrote:
>       >>>
>       >>>
>       >>>> Hi, yes, I'm working with Eddy Hutson and Robert Moon on
>       this project.
>       >>>>
>       >>>>
>       >>>
>       >>>
>       >>>> We'd be happy to have you on the team.  Robert provides
>       long-term
>       >>>> high-level support, as he is an alum.  Eddy is currently
>       leading the
>       >>>> project, and is a practicum member, but he is slated for
>       graduation in
>       >>>>
>       >>>>
>       >>>
>       >>>
>       >>>> May so we will need to hand-off.  Give me a call and we
```

> can run
> >>>> through where we're at briefly, but once we do that,
> getting in touch
> >>>> with Eddy and Robert will maximize our effectiveness in
> this area.
> >>>> Erik
> >>>> 303-589-1910 cell
> >>>>
> >>>> --- On *Wed, 3/18/09, JP /<paul322@regis.edu
> <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>>/*
> wrote:
> >>>>
> >>>>
> >>>> From: JP <paul322@regis.edu
> <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>>
> >>>> Subject: Re: Sead Project
> >>>> To: "Brown, Jeffrey A" <jabrown@regis.edu
> <http://us.mc451.mail.yahoo.com/mc/compose?to=jabrown@regis.edu>>
> >>>> Cc: "emoore@cyberetower.com
> <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>"
> <emoore@cyberetower.com
> <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>>,
> "Likarish,
> >>>> Daniel" <dlikaris@regis.edu
> <http://us.mc451.mail.yahoo.com/mc/compose?to=dlikaris@regis.edu>>
> >>>> Date: Wednesday, March 18, 2009, 9:00 PM
> >>>>
> >>>> Erik,
> >>>>
> >>>> He is a copy of my proposal. I should be ready in
> the next two
> >>>> weeks to
> >>>> actually bring as server on site to start the data
> collection and
> >>>> customization. The short version of the project is
> snmp polling
> >>>>
> >>>>
> >>> to
> >>>
> >>>
> >>>> gather near realtime and keep historical data useful for
> >>>> troubleshooting
> >>>> and planning. Any increased load or traffic should
> be minimal and
> >>>> have
> >>>> low priority. Part two may useless if there is
> already an
> >>>>
> >>>>
> >>> accepted
> >>>
> >>>
> >>>> solution.
> >>>>
> >>>> As a side note Jeff had mentioned that there was a

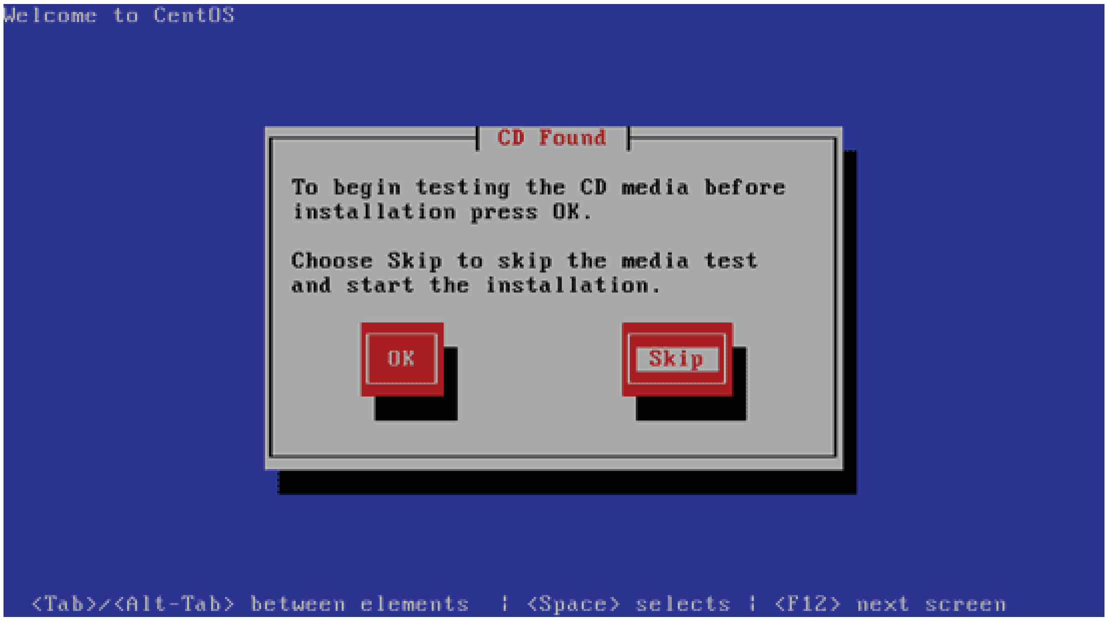
```
>	project for
>	>>>>	migrating
>	>>>>	of sonicwalls to pix.  Are you in charge of the
>	project?  I have
>	>>>>
>	>>>>
>	>>> six
>	>>>
>	>>>
>	>>>>	years managing that platform so if you would like
>	information or
>	>>>>
>	>>>>
>	>>> help
>	>>>
>	>>>
>	>>>>	doing software upgrades OS or pdm/asdm prior to
>	install even
>	>>>>
>	>>>>
>	>>> questions
>	>>>
>	>>>
>	>>>>	on how to do something feel free to use me as a resource.
>	>>>>
>	>>>>
>	>>>>
>	>>>>	Brown, Jeffrey A wrote:
>	>>>>	> Erik, I've seen the proposal and it can be used on
>	the network.
>	>>>>	I don't believe that it flows into other projects
>	underway.
>	>>>>	>
>	>>>>	> Jeff
>	>>>>	> ________________________________________
>	>>>>	> From: emoore@cyberetower.com
>	<http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>
>	>>>>
>	>>>>
>	>>>>
>	>>>
>	<http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>
>	>>>
>	>>>
>	>>>>	[emoore@cyberetower.com
>	<http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>
>	>>>>
>	>>>>
>	>>>>
>	>>>
>	<http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>]
>	>>>
>	>>>
>	>>>>	> Sent: Friday, March 13, 2009 10:05 AM
>	>>>>	> To: Likarish, Daniel; Paul, James
>	>>>>	> Cc: Brown, Jeffrey A
```

```
>       >>>>    > Subject: Re: Sead Project
>       >>>>    >
>       >>>>    > Hi, I can help you with most of those things.
>       Also, please send
>       >>>>    Jeff and me the proposal.  we are responsible for
>       monitoring and
>       >>>>    there are several projects in this area.  It would be
>       good to make
>       >>>>    sure your work cumulative for the network in relation
>       to other
>       >>>>    projects.
>       >>>>    > Erik
>       >>>>    > 303-589-1910 cell
>       >>>>    >
>       >>>>    > --- On Thu, 3/12/09, JP <paul322@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>
>       >>>>
>         <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>>
>       >>>>    wrote:
>       >>>>    >
>       >>>>    > From: JP <paul322@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>
>       >>>>
>         <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>>
>       >>>>    > Subject: Re: Sead Project
>       >>>>    > To: "Likarish, Daniel" <dlikaris@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=dlikaris@regis.edu>
>       >>>>
>         <http://us.mc451.mail.yahoo.com/mc/compose?to=dlikaris@regis.edu>>
>       >>>>    > Cc: "Erik Moore" <emoore@cyberetower.com
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>
>       >>>>
>       >>>>
>       >>>>
>       >>>
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=emoore@cyberetower.com>>,
>       >>>
>       >>>
>       >>>>    "Brown, Jeffrey A" <jabrown@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=jabrown@regis.edu>
>       >>>>
>         <http://us.mc451.mail.yahoo.com/mc/compose?to=jabrown@regis.edu>>
>       >>>>    > Date: Thursday, March 12, 2009, 8:59 PM
>       >>>>    >
>       >>>>    > Dan,
>       >>>>    >
>       >>>>    > I'm taking this as an OK to move forward.  I have
>       located a Dell
>       >>>>    > PowerEdge server that I can donate for my project.
>       I have
>       >>>>
>       >>>>
>       >>> questions
>       >>>
>       >>>
>       >>>>    > about the current network.  I have looked at a lot
>       of documents
>       >>>>    in Sead
>       >>>>    > Practicum Website shared documents but I was unable
>       to location
>       >>>>
>       >>>>
>       >>> the
>       >>>
>       >>>
>       >>>>    > information that I was looking for.  Is there a
>       person or
>       >>>>    persons that
>       >>>>    > is the network admin for all changes and requests
>       for the
>       >>>>    network?  Such
>       >>>>    > as security requirements, community strings, IP for
>       my server,
>       >>>>    find out
>       >>>>    > exactly what monitoring is in place, whats being
>       graphed, a
>       >>>>    device list
>       >>>>    > ect...
>       >>>>    >
>       >>>>    > Thanks,
>       >>>>    >
>       >>>>    >
>       >>>>    > Likarish, Daniel wrote:
>       >>>>    >
>       >>>>    >> JP,
>       >>>>    >> The idea of developing a network monitoring tool
>       that has a
>       >>>>
>       >>>>
>       >>> useful
>       >>>
>       >>>
>       >>>>    >> display certainly fits within the most useful SEAD
>       projects.
>       >>>>    The AD
>       >>>>    >> group has built ARNEOLD Academic Research Network
>       online Display
>       >>>>    >> platform.   This project can be an expansion of
>       the current
>       >>>>    simple GUI.
>       >>>>    >>
>       >>>>    >> Dan
>       >>>>    >>
>       >>>>    >>
>       >>>>    >> On 3/11/09 8:13 AM, "JP" <paul322@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>
>       >>>>
>       >>>>
>       >>>>
>       >>>
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu><http://
>       >>> us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu
>       <http://us.mc451.mail.yahoo.com/mc/compose?to=paul322@regis.edu>>>
>       >>>
>       >>>
>       >>>>    wrote:
>       >>>>    >> Has
>       >>>>    >>
>       >>>>    >>    Dan,
>       >>>>    >>
>       >>>>    >>    I have attached a project overview not sure if
>       it's right
>       >>>>    or who to
>       >>>>    >>    submit this to.
>       >>>>    >>
>       >>>>    >>    It would be easier to do the development at
>       home.  I can
>       >>>>    probably
>       >>>>    >>    find a
>       >>>>    >>    server to use/donate so I can get started
>       now.  Then just
>       >>>>    bring it to
>       >>>>    >>    one of the labs to integrate it into the network.
>       >>>>    >>
>       >>>>    >>    Thank you,
>       >>>>    >>    Jim Paul
```

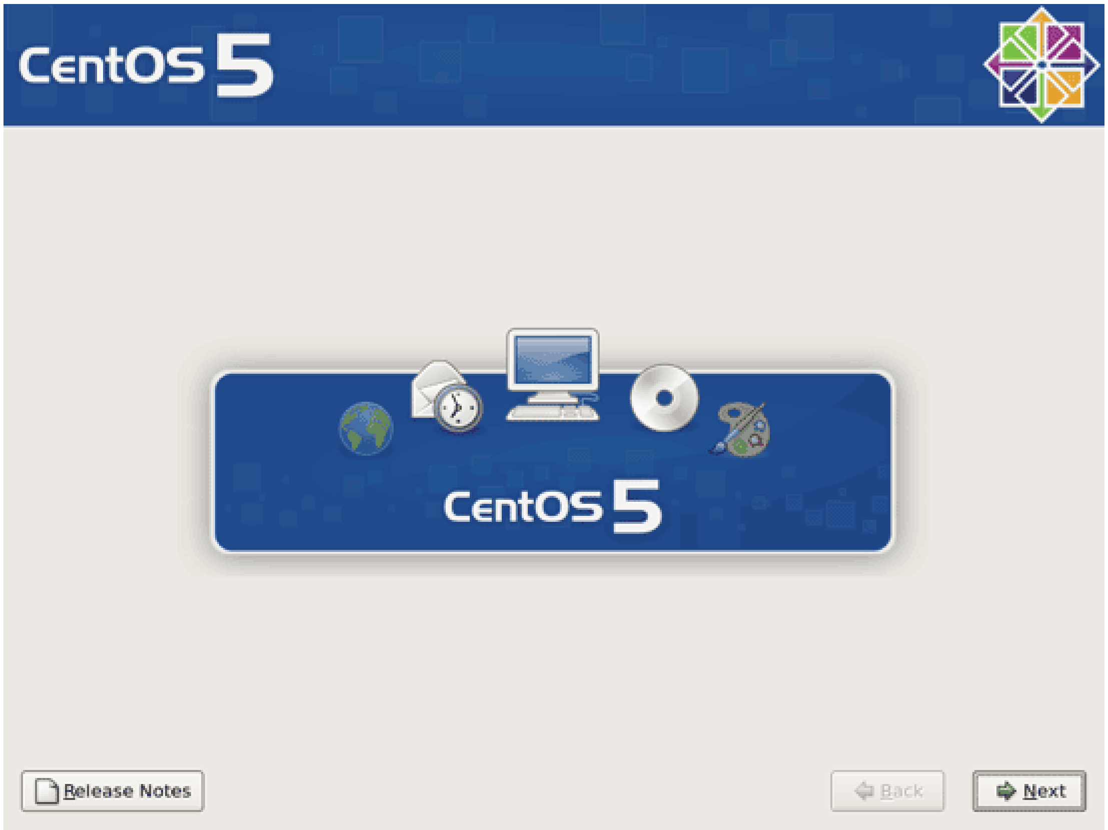
Appendix D

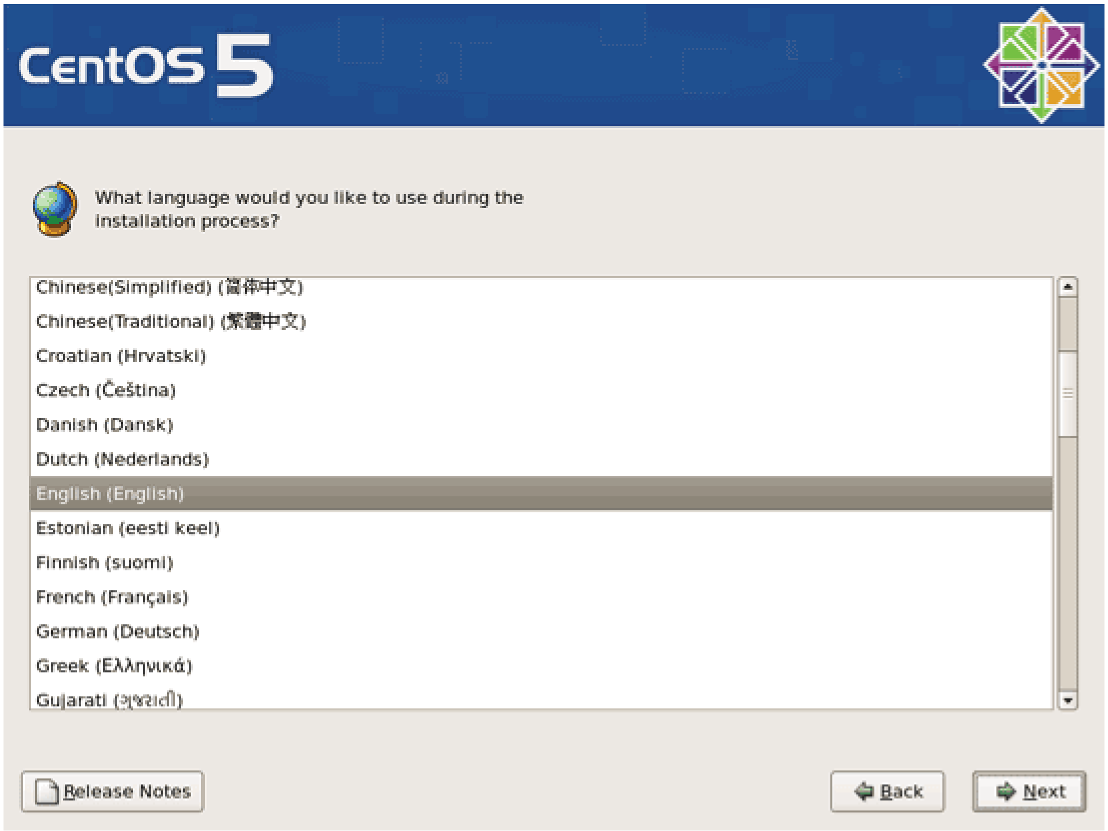


```
 -  To install or upgrade in graphical mode, press the <ENTER> key.

 -  To install or upgrade in text mode, type: linux text <ENTER>.

 -  Use the function keys listed below for more information.

[F1-Main] [F2-Options] [F3-General] [F4-Kernel] [F5-Rescue]
boot: _
```



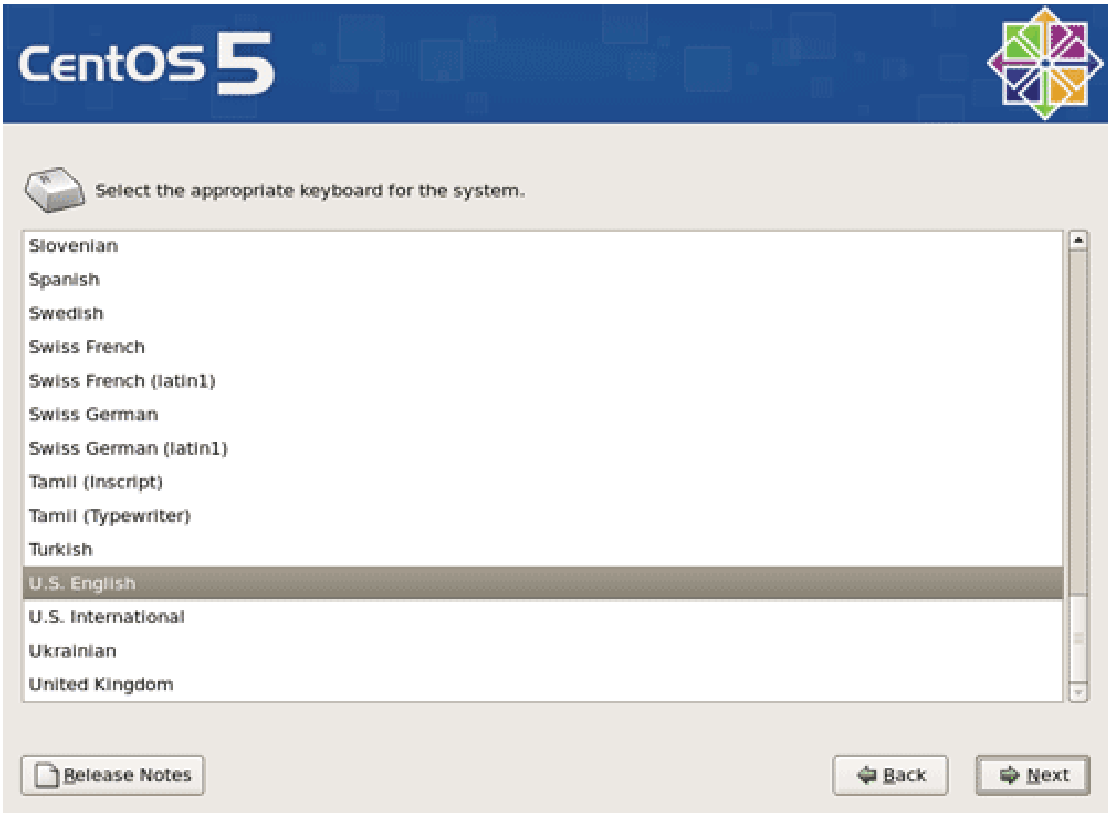
```
Welcome to CentOS

                    CD Found

     To begin testing the CD media before
     installation press OK.

     Choose Skip to skip the media test
     and start the installation.

     OK                    Skip

  <Tab>/<Alt-Tab> between elements  | <Space> selects | <F12> next screen
```





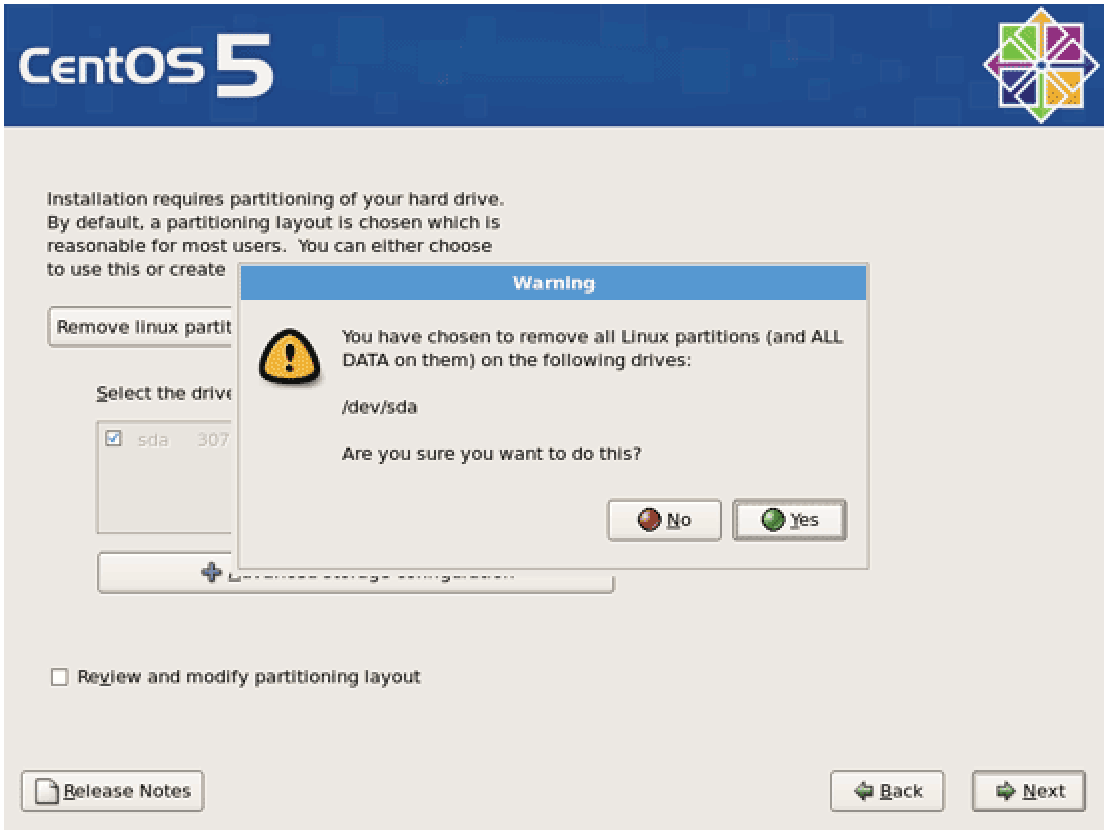
What language would you like to use during the installation process?

Chinese(Simplified) (简体中文)
Chinese(Traditional) (繁體中文)
Croatian (Hrvatski)
Czech (Čeština)
Danish (Dansk)
Dutch (Nederlands)
English (English)
Estonian (eesti keel)
Finnish (suomi)
French (Français)
German (Deutsch)
Greek (Ελληνικά)
Gujarati (ગુજરાતી)



Select the appropriate keyboard for the system.

- Slovenian
- Spanish
- Swedish
- Swiss French
- Swiss French (latin1)
- Swiss German
- Swiss German (latin1)
- Tamil (Inscript)
- Tamil (Typewriter)
- Turkish
- U.S. English
- U.S. International
- Ukrainian
- United Kingdom



Installation requires partitioning of your hard drive.
By default, a partitioning layout is chosen which is
reasonable for most users. You can either choose
to use this or create

Remove linux partit

Select the drive

☑ sda 307

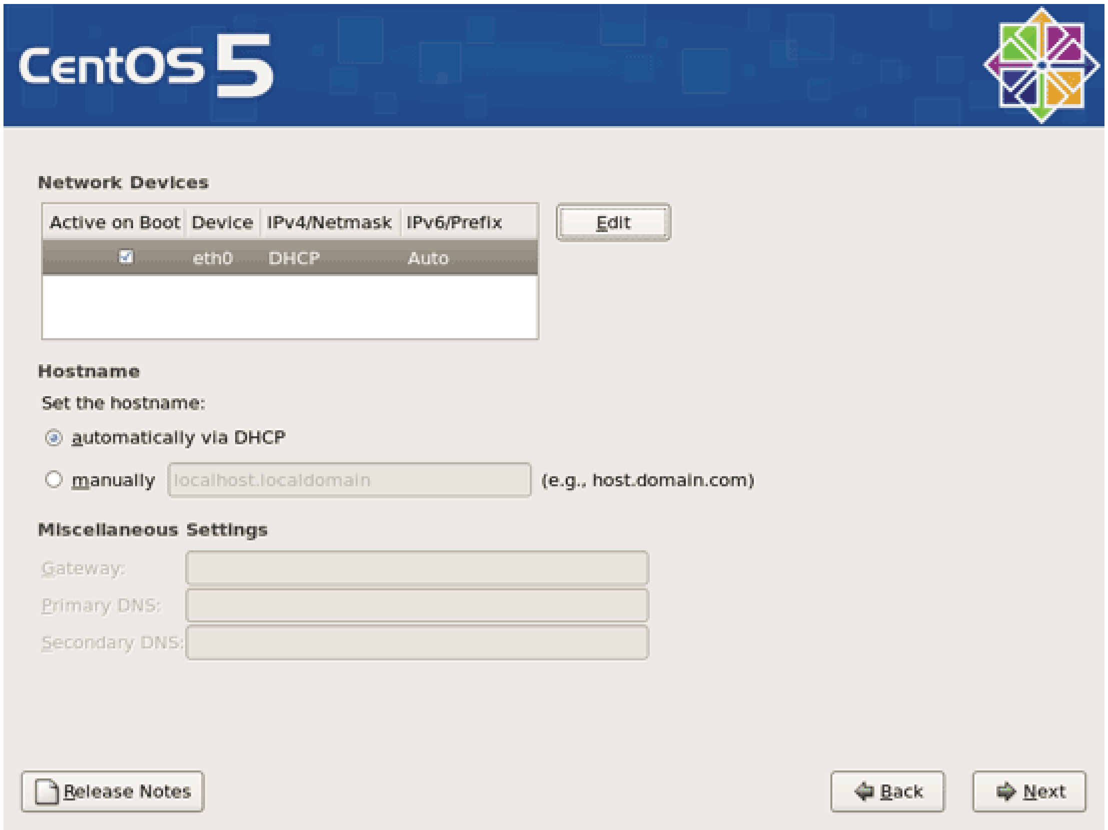
Warning

You have chosen to remove all Linux partitions (and ALL DATA on them) on the following drives:

/dev/sda

Are you sure you want to do this?

□ Review and modify partitioning layout



Network Devices

Active on Boot	Device	IPv4/Netmask	IPv6/Prefix
☑	eth0	DHCP	Auto

Hostname

Set the hostname:

● automatically via DHCP

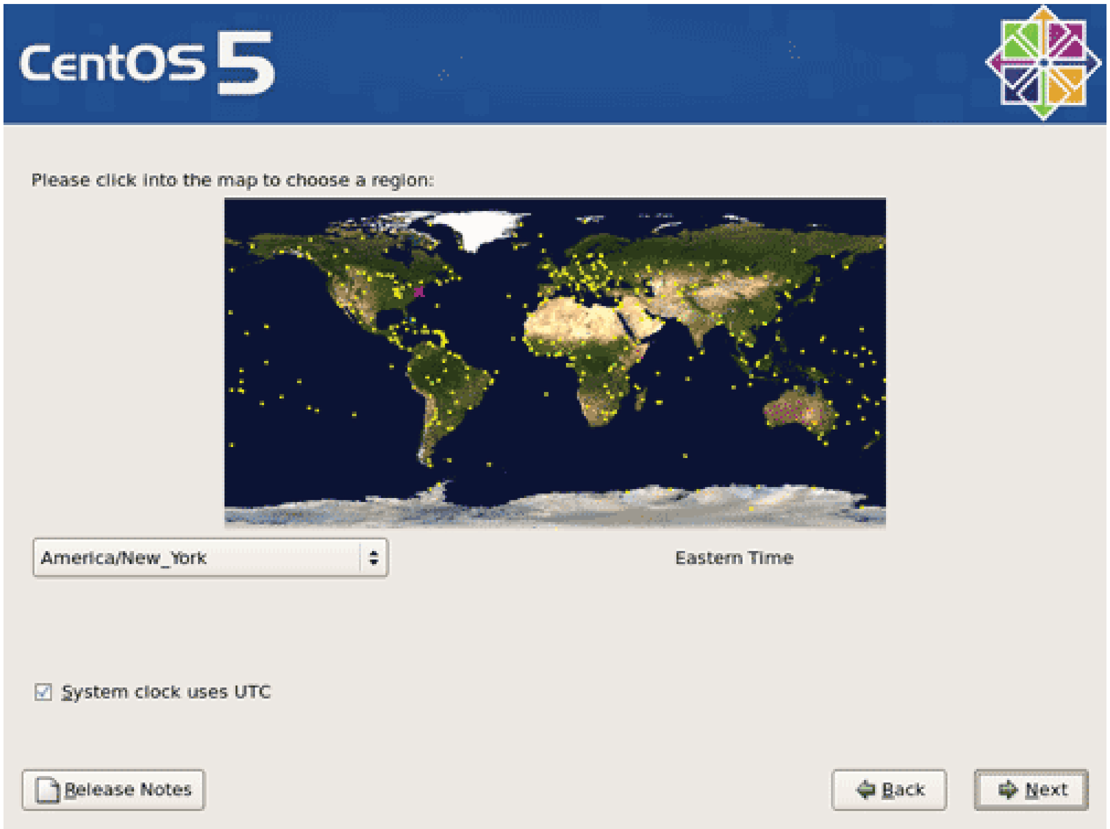
○ manually localhost.localdomain (e.g., host.domain.com)

Miscellaneous Settings

Gateway:

Primary DNS:

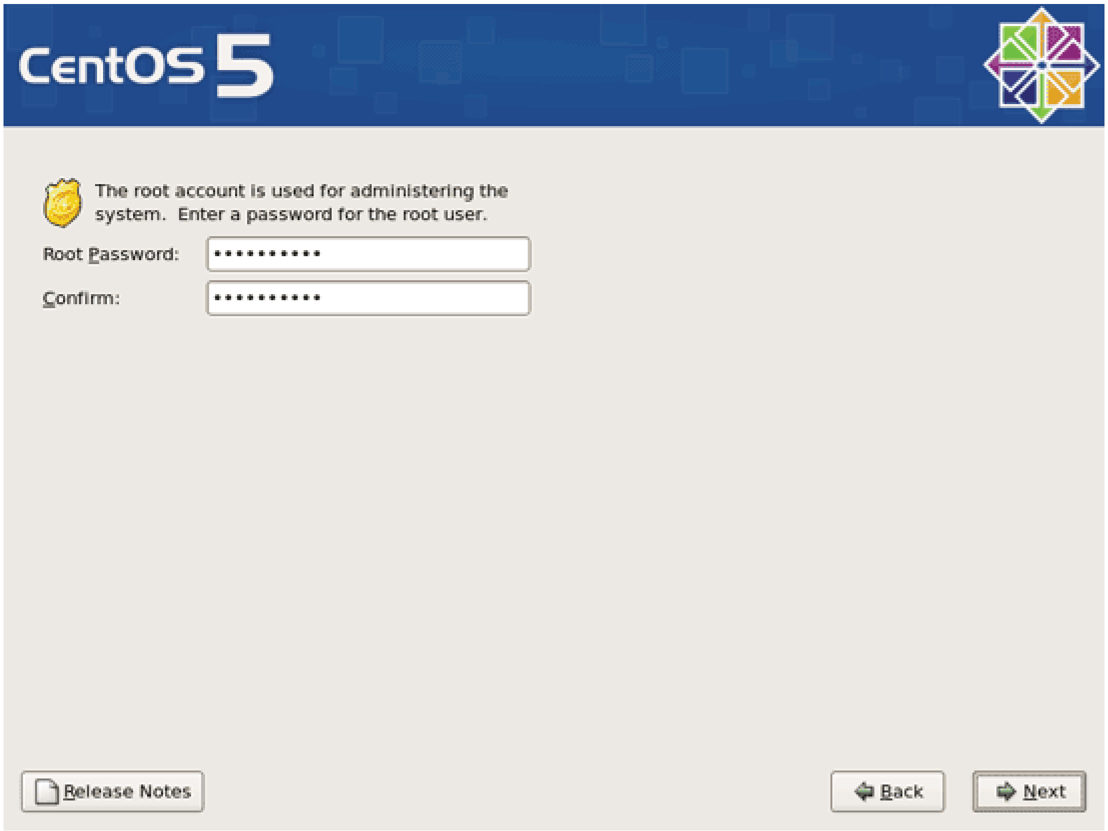
Secondary DNS:



Please click into the map to choose a region:

America/New_York Eastern Time

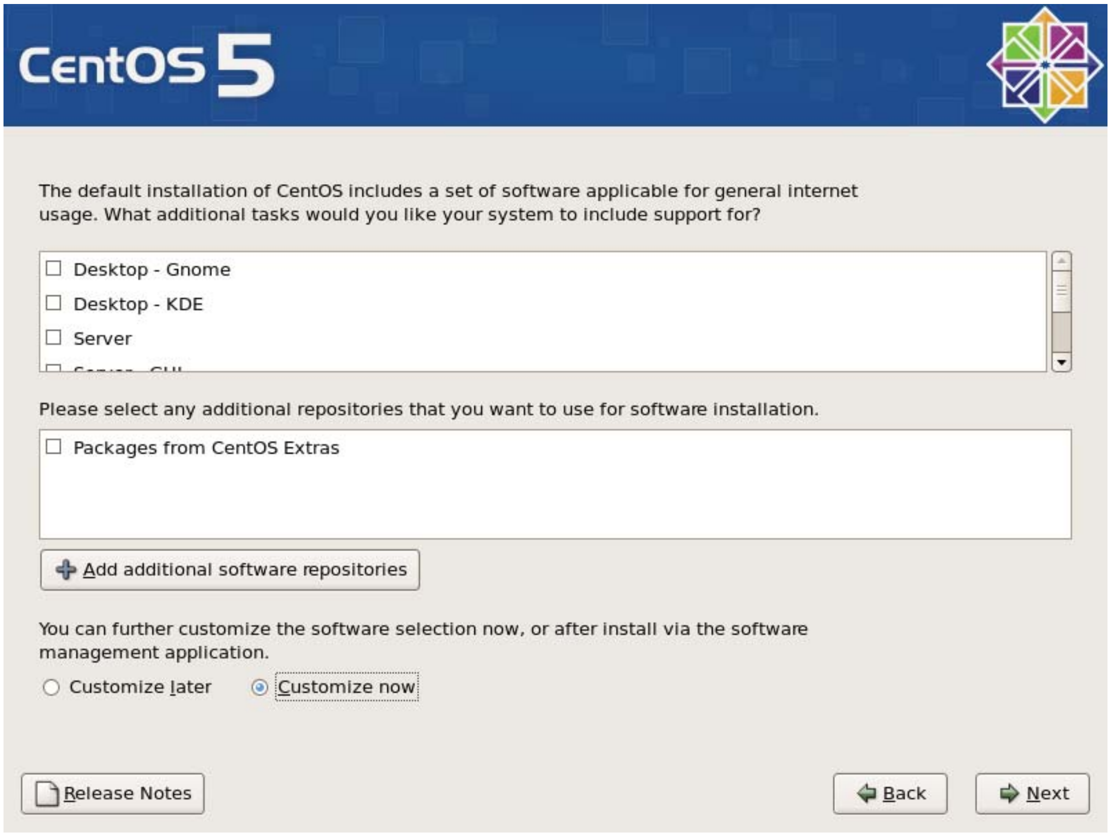
☑ System clock uses UTC



The root account is used for administering the system. Enter a password for the root user.

Root Password: ***********

Confirm: ***********



The default installation of CentOS includes a set of software applicable for general internet usage. What additional tasks would you like your system to include support for?

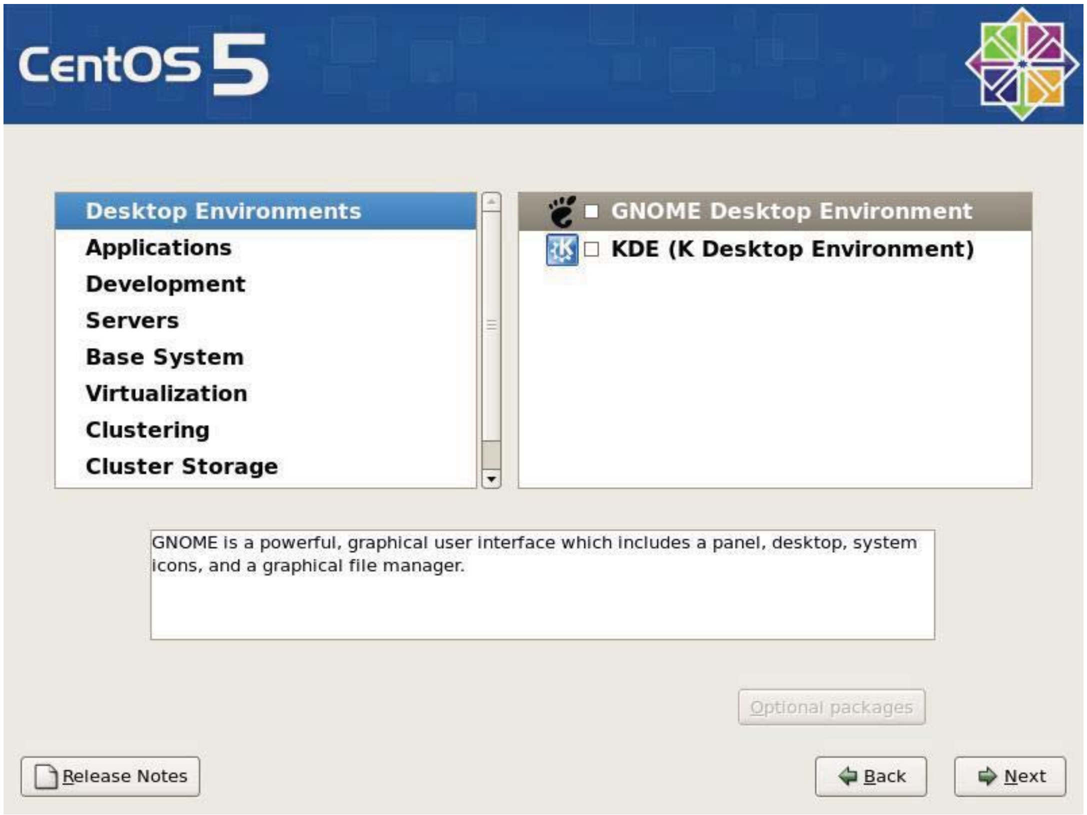
☐ Desktop - Gnome
☐ Desktop - KDE
☐ Server
☐ Server - GUI

Please select any additional repositories that you want to use for software installation.

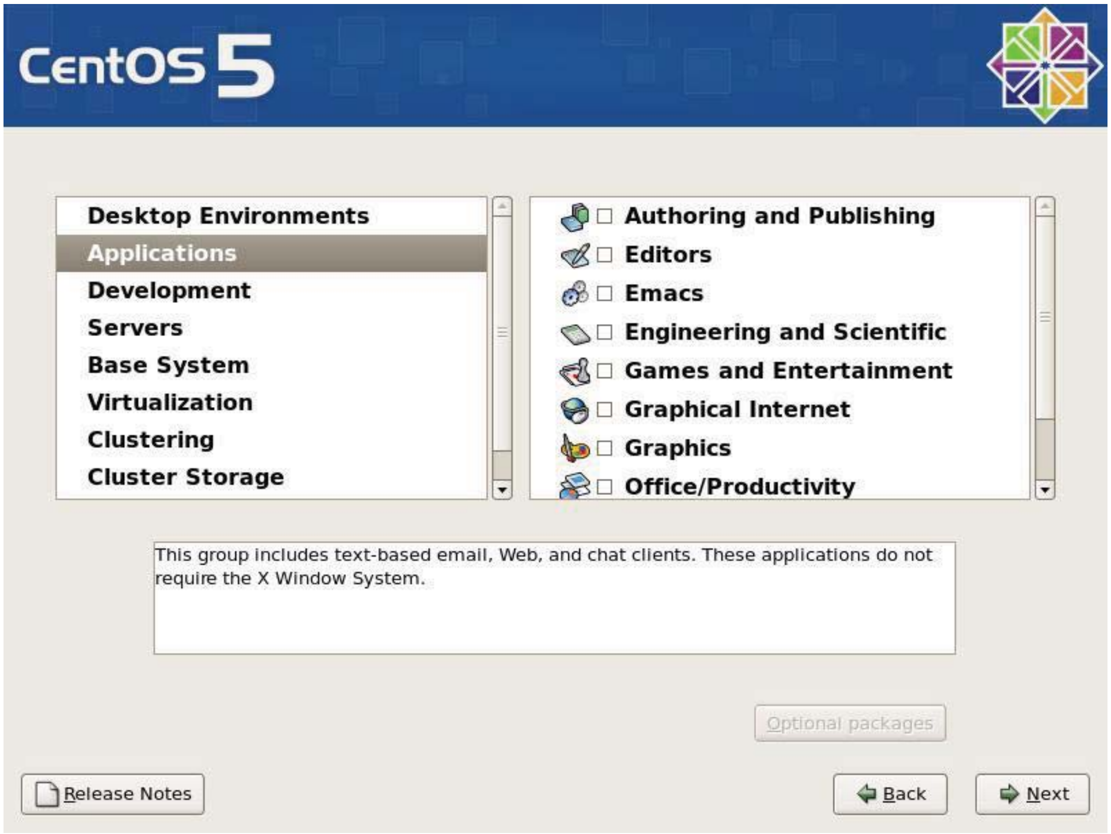
☐ Packages from CentOS Extras

You can further customize the software selection now, or after install via the software management application.

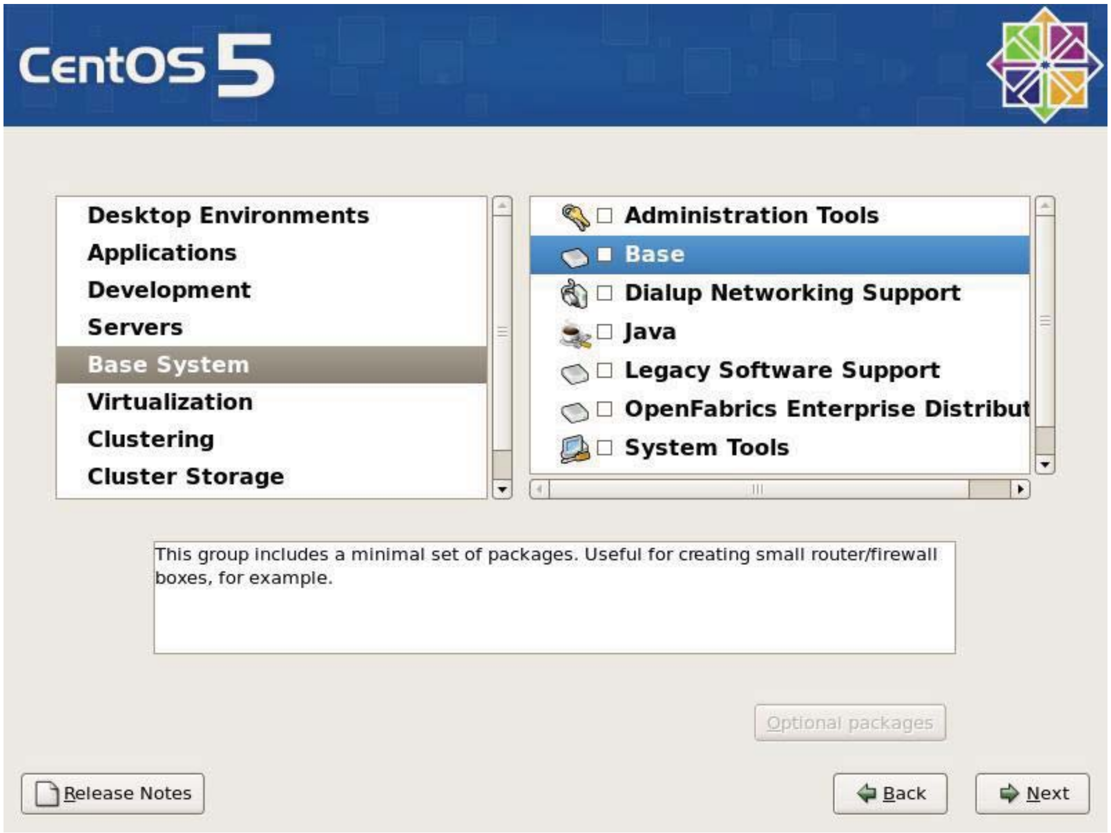
○ Customize later ● Customize now



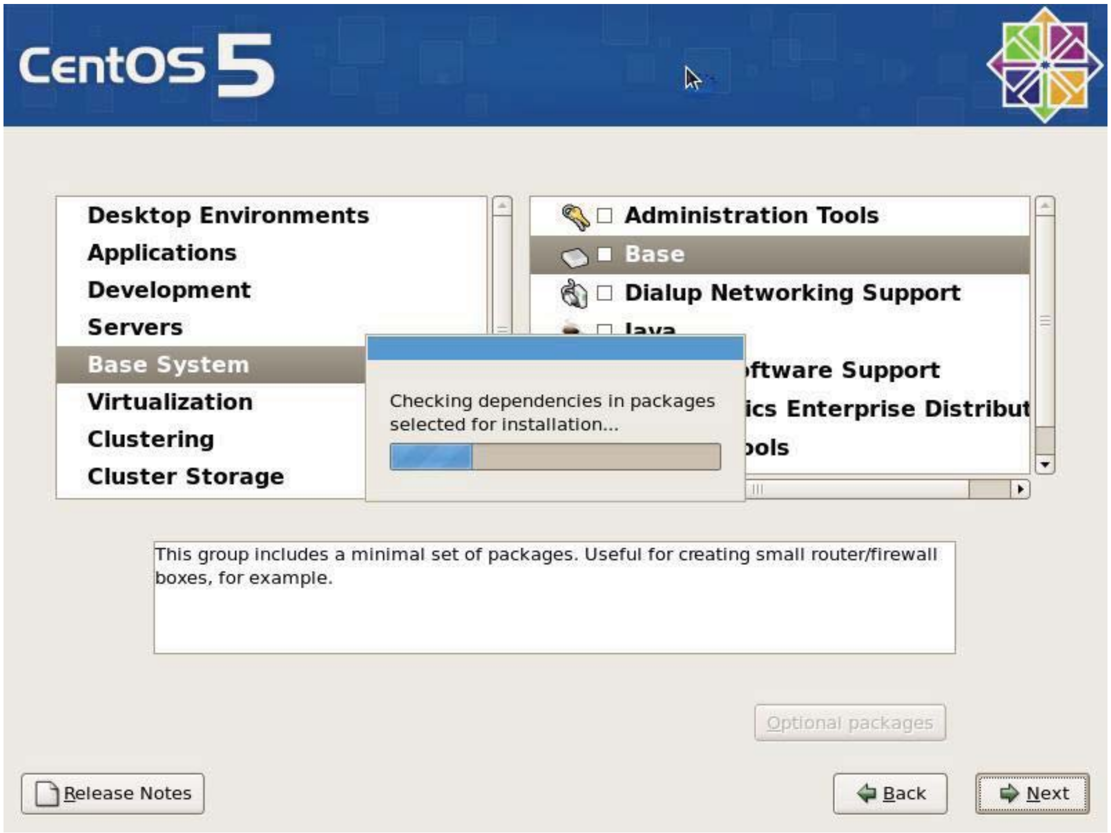
GNOME is a powerful, graphical user interface which includes a panel, desktop, system icons, and a graphical file manager.



This group includes text-based email, Web, and chat clients. These applications do not require the X Window System.

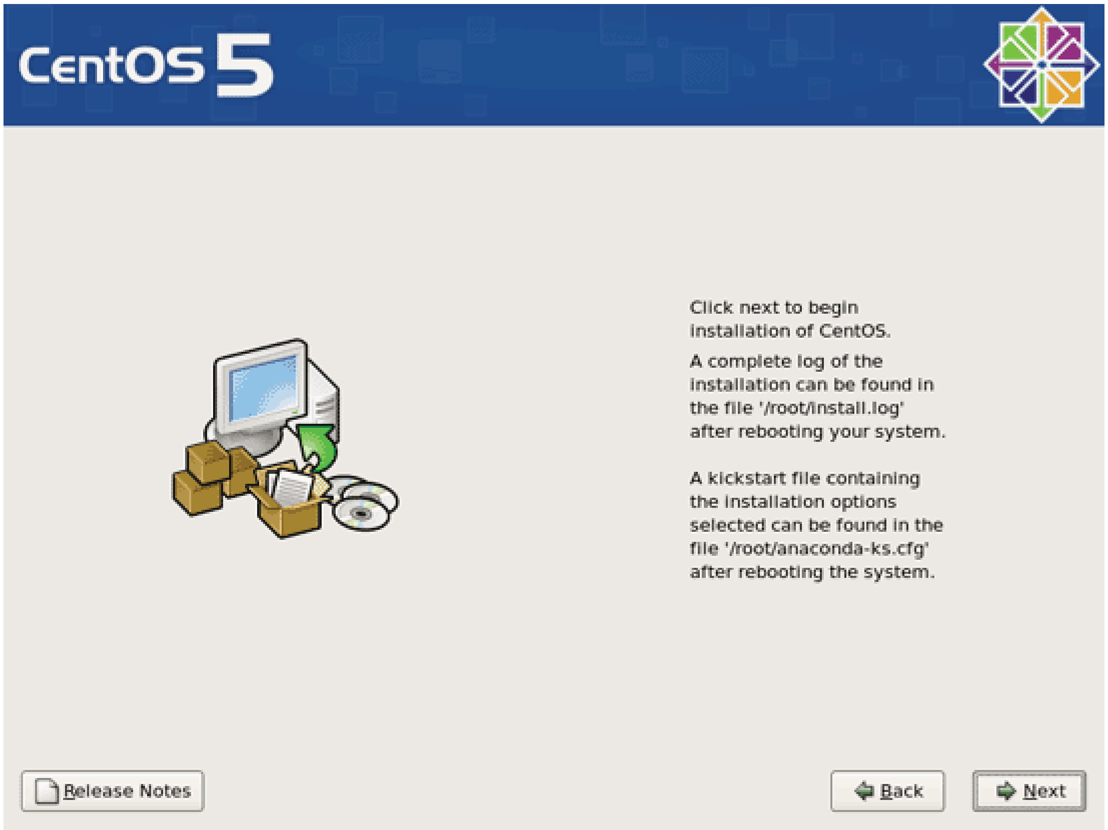


This group includes a minimal set of packages. Useful for creating small router/firewall boxes, for example.



Checking dependencies in packages selected for installation...

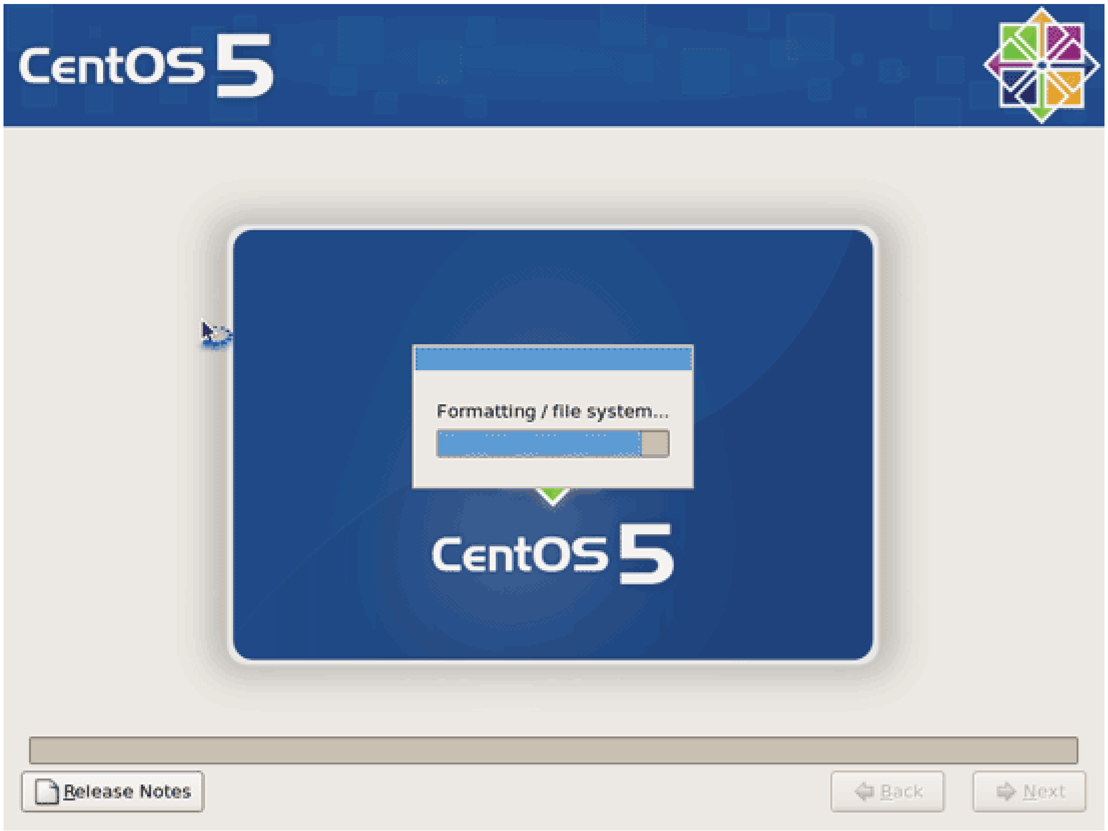
This group includes a minimal set of packages. Useful for creating small router/firewall boxes, for example.



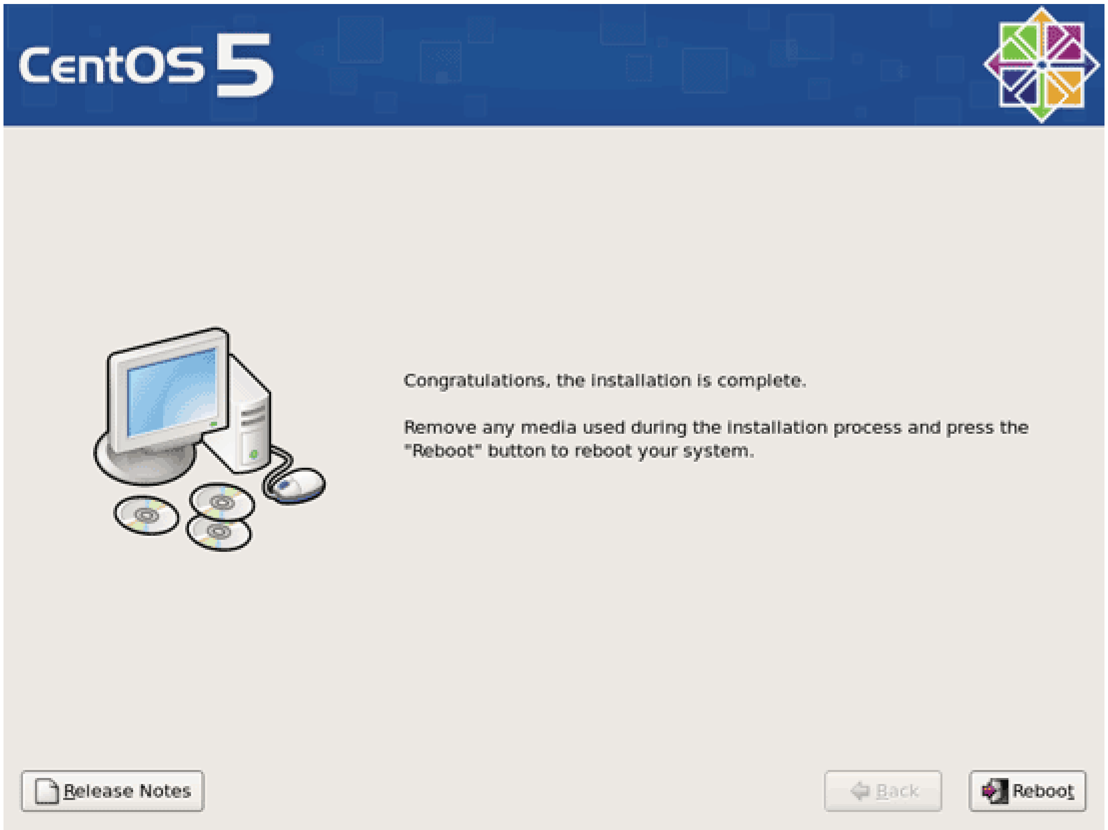
Click next to begin installation of CentOS.

A complete log of the installation can be found in the file '/root/install.log' after rebooting your system.

A kickstart file containing the installation options selected can be found in the file '/root/anaconda-ks.cfg' after rebooting the system.

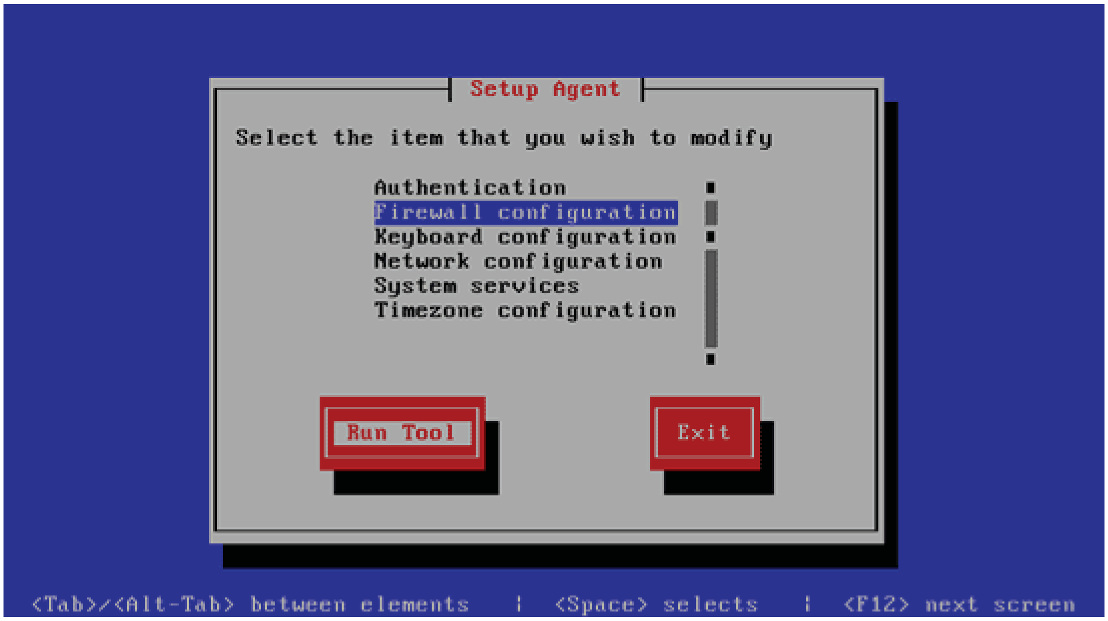


Formatting / file system...

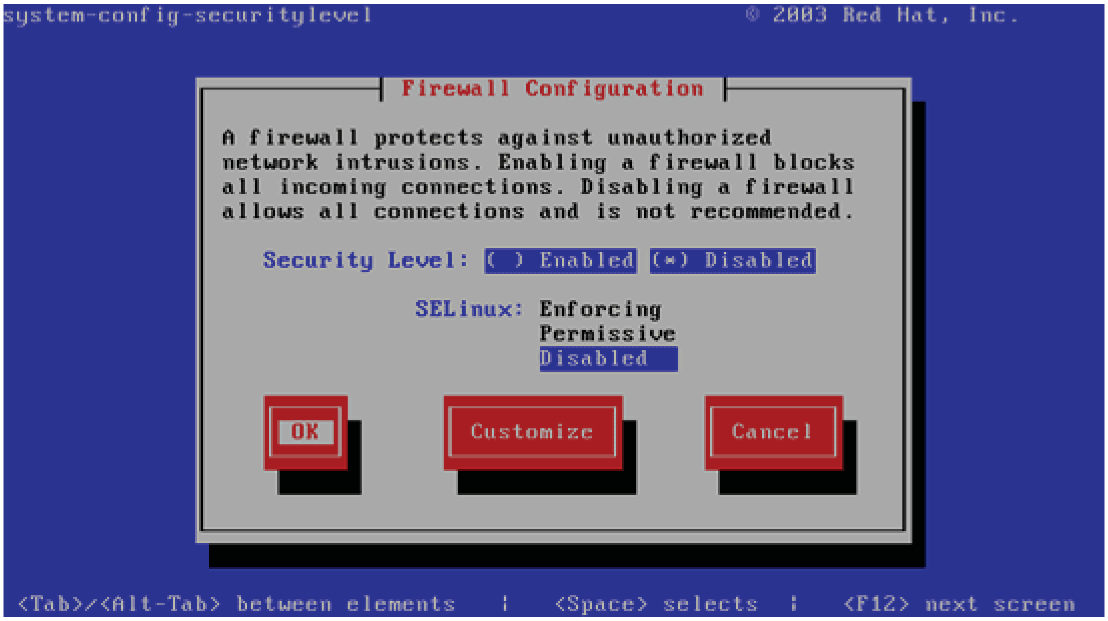


Congratulations, the installation is complete.

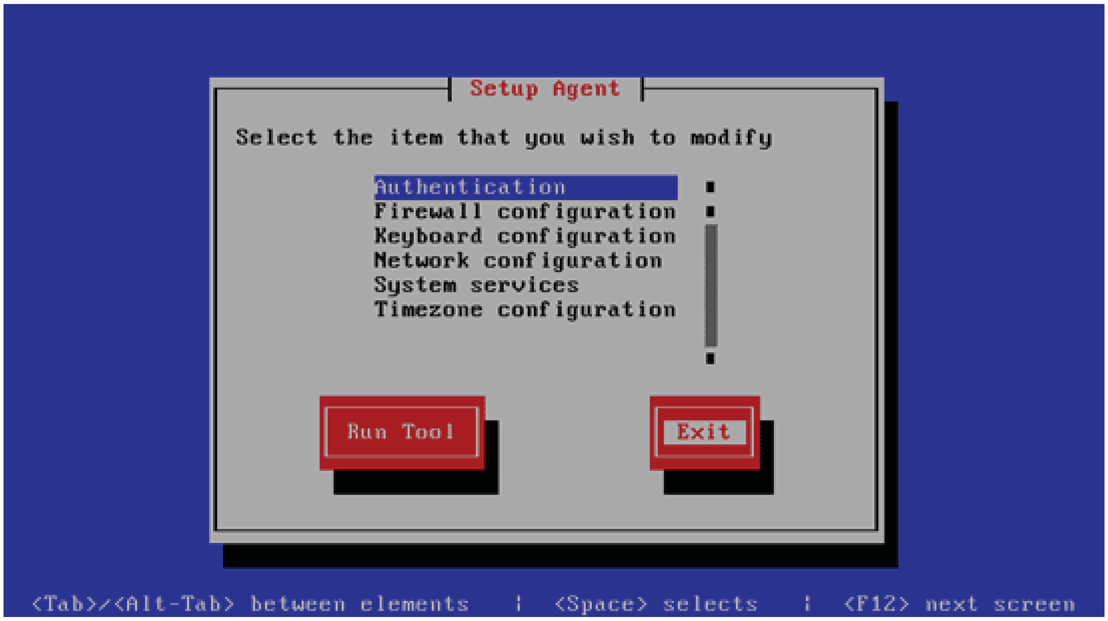
Remove any media used during the installation process and press the "Reboot" button to reboot your system.



```
Setup Agent

Select the item that you wish to modify

Authentication
Firewall configuration
Keyboard configuration
Network configuration
System services
Timezone configuration

Run Tool          Exit

<Tab>/<Alt-Tab> between elements  |  <Space> selects  |  <F12> next screen
```



```
system-config-securitylevel                          © 2003 Red Hat, Inc.

                    Firewall Configuration

        A firewall protects against unauthorized
        network intrusions. Enabling a firewall blocks
        all incoming connections. Disabling a firewall
        allows all connections and is not recommended.

           Security Level: ( ) Enabled (*) Disabled

                      SELinux: Enforcing
                               Permissive
                               Disabled

 <Tab>/<Alt-Tab> between elements   |   <Space> selects   |   <F12> next screen
```



```
                       Setup Agent

         Select the item that you wish to modify

                  Authentication
                  Firewall configuration
                  Keyboard configuration
                  Network configuration
                  System services
                  Timezone configuration

 <Tab>/<Alt-Tab> between elements   |  <Space> selects   |  <F12> next screen
```