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Network Monitoring System (Net-Mon)

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Abstract:

A network that is not monitored is a black hold and results in faults going unnoticed for extended periods of time. In most organizations and especially academic institutions, it is very difficult to impose technical restrictions on network traffic. In corporate networks 'acceptable' traffic can often be clearly defined. Almost any port might be required for some reasonable purpose (now or in the future), so simply banning traffic by port would be difficult. Restriction by type would be hard too – for example P2P software is used by research groups for ease of collaboration, as well as by users sharing copyright material. Assertions are confirmed in this paper that there are no technically enforced restrictions on what network traffic can go into or out of most networks. Set rules which users usually agree to abide by are broken therefore rendering the network prone to viruses and advanced hackers.

The Net-Mon Tool has been designed to be a modular tool, i.e. features can be implemented incrementally while maintaining a working system at each development stage. This is important because building a feature complete network monitoring system is outside the scope of this project due to technological and time constraints. Furthermore, this project aims to produce a system that we will call a Network Monitoring Tool, where the emphasis is on simplicity and dynamism, rather than statically, configured network models. Many key design decisions have been made with these goals in mind. Organizations that have the financial muscle are able to implement robust network monitoring systems that offer all of the features investigated and more. Some of the more popular systems are briefly examined in this paper.

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CHAPTER 1

PROBLEM SETTING

1.0 Introduction

Living and working in the technological era has brought about inter connections of computers of all kinds. Computers are used in both work and home settings. Data Networks have penetrated in our day-to-day life in a big way, such that we cannot think of any organization to run without on or the other form of it. Networks have evolved themselves into forms never thought of before with a large demand for tools and technical staff to man them. Companies have invested on their networks in a huge way and they are looking forward to achieve zero downtime for their network. One of the approaches that have gained popularity with this high demand is the concept of network monitoring; either active or passive to collect data and improve upon the networks. This has led to the development of numerous network performance monitoring tools and standards. The most common tools are network management system based on standardized network management protocols that give a comprehensive view of a network and all of its devices. Of course, there are other tools that are not as complex as a full network management system but are equally useful for monitoring certain aspects of network performance.

This research paper has covered the basics of network performance monitoring, standards for network management and different types of monitoring tools. It will conclude with a look at a number of different monitoring tools including commercial and open-source implementations. This project investigated how developments in network traffic management has evolved over the years and also looked at the attitudes of users of computer networked environments. It is only with continuous monitoring that a network administrator can maintain a high performance IT infrastructure for an organization. Modern computer networks are increasingly pervasive, complex, and ever-evolving due to factors like enormous growth in the number of network users, continuous appearance of network applications, increasing amount of data transferred, and diversity of user behaviors. Understanding and measuring such a network is a difficult yet vital task for network management and diagnosis. Network traffic monitoring, analysis, and anomaly detection provide useful tools for understanding network behavior and determining network performance and reliability so as to effectively and promptly troubleshoot and resolve various issues in practice.

Most small to medium sized businesses are unable to invest into robust network management software due to the huge capital investment that is required in such projects.

Systems and network administrators however require tools that are affordable to ease the management of computer networks. This research culminated into the development of a Network Monitoring Tool for network administrators. The tool has a light foot print and does not require the use of a database as at development stage. It instead monitors network traffic as well as available network adapters on a networked computer. These features are aimed at assisting systems and network administrators to identify problems as they occur in real time.

1.1 Background of the Problem

Networking and IT Professionals today have a tremendous responsibility when it comes to managing the network of a higher-education campus or organization. The massive growth of stored data (and the need to share it) is constantly placing pressure on an already over-stressed network. The unpredictable student user base is prone to network misuse and security breaches. Educators are looking to further leverage networked-based learning tools and streaming video. Campus administrators are adding new applications while demanding more and more remote accessibility; and campus legal departments are anxious to ensure that campus networks are meeting all government and other security and privacy regulations and compliancy—while constantly making requests for network usage reports and other network activity to assist in copyright protection efforts. The growing dependence on networks for everyday tasks has created the demand for high performance; reliable networks thereby making companies invest a lot on research on improving the networks and new designs. Part of achieving the goal of high performance is active monitoring of networks to help in the identification and prevention of network errors. Many tools have emerged to aid in performance monitoring of networks. The most common class of tools is based on the Simple Network Management Protocol (SNMP), a protocol for sending and transmitting network performance information on IP networks. Other types of network performance monitoring tools include packet sniffers, flow monitors and application monitors. (G.S. Nagaraja et-al, IJCSNS, VOL.7 No.7, July 2007)

1.2 Problem Statement

This research is aimed at confirming the assertions that there are no technically enforced restrictions on what network traffic can go into or out of most networks. There are rules and regulations which users agree to abide by, but if they choose to ignore these they are able to do so. This also makes the network more vulnerable to viruses and advanced hackers of the 21stcentaury. Inappropriate traffic can slow the network down, or even bring it to a complete shutdown, causing frustration to legitimate users of the network. Illegal traffic, such as pirated movies and music, can get both the Organisations and the individual users into serious litigation.

To an extent network abuse is inevitable. In most organisations and especially academic institutions, it is very difficult to impose technical restrictions on network traffic. In corporate networks ‘acceptable’ traffic can often be clearly defined. This is not the case in colleges or learning institutions. Almost any port might be required for some reasonable purpose so simply banning traffic by port would be difficult. Restriction by type would be hard too – for example peer to peer software is used by research groups for ease of collaboration, as well as by users sharing copyright material.

Systems and network administrators are burdened with fighting fires when something goes wrong on the network. They have no information of what may have caused a network failure. This is more so on computer networks that do not have any high grade network monitoring software installed. This scenario is common place in academic institutions because of the aforementioned reasons. This was the inertia for this research and project development.

1.3 Project Scope

The purpose of the project is to find the best network monitoring solution from a system administration point of view. One solution is to create some way of monitoring what is going on, so that if a problem arises, such as possible virus-generated traffic, movement of copyright material or high network load, it can be easily spotted, traced to its source and dealt with.

Usage of academic networks has changed dramatically in the last few years. A great many more students have their own computers, and the percentage rises every year. New viruses and file-sharing programs are constantly appearing, and vulnerabilities in software are being discovered all the time. This research, took into consideration attitudes of users and system administrators, looked at the changing attitudes of both towards security, legitimate network use and how they feel they use their network connection. The Net-Mon tool will monitor network traffic and bandwidth usage on a given computer and this data will then be co-related with the attitudes of users on the network. Both will provide invaluable information to system administrators of organisations and academic networks to help them devise a secure network for today's organisational and academic needs.

1.4 Project Objectives

This project has provided information about the fast-changing attitudes of users on computer networks (e.g. academic and organisational networks), the types of traffic seen on networks and the techniques system administrators must employ to keep control of today's networks. This has changed significantly, even over the last few years. Illegal file sharing is very common with many users seeing it as perfectly acceptable. Other users view such usage as a legitimate right because they claim they pay for such usage. The selection of these types of networks enabled the research to focus on two disparate network types as well as analyse the attitudes of two very different types of users of these networks. Both networks provide services for several hundred users and include university managed machines, organisational managed machines and those owned and managed by individuals.

The university network is predominantly for academic use whereas the organisational network is predominantly for work related use. Obviously having so many different machines and owners on the network is a cause for concern, and some users abuse their access. This project has investigated and implemented a system to allow the Computer Officers to protect and manage the network more efficiently, including monitoring network use, tracing and dealing with network faults, problems and

abuse. It has also provided extremely useful research into the constantly changing network usage patterns and the means that system administrators are employing to keep their networks open to legitimate use while tracking non-legitimate use.

More generally, traffic management of an organization or academic network is more complex, with new and more sophisticated viruses and hacking attempts to keep watch for. Computer ownership increases noticeably every year, allowing more and more people, often inexperienced, to gain Internet access through the networks that they use.

All of this means that system administrators must be able to be one step ahead of their users. This project will collect information from users and administrators of similar systems to provide a wealth of data that would not be otherwise available. It will also provide a practical monitoring tool developed from the perspective of network and systems administrators.

1.5 Limitations

During the study, the researcher faced a number of challenges including time. The time for the study was not enough to carry out intensive and extensive study because some of the information was not easily and quickly available. Considering that the researcher resides in Ndola and part of the research required gathering information from UNZA which is in Lusaka. Another major hindrance was the none disclosure of certain information by Network administrators and users citing security reasons.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Network Monitoring involves Using Software or hardware based Systems or a combination of both to constantly observe the status of network devices and hosts, and notifies the network administrator via email, SMS or other alarms in case of error or fail. Observing the status of network device and hosts is done when the Monitoring System speaks with the networking devices or hosts using different protocols within the protocols stack. Good monitoring tools give you both hard numbers and graphical aggregate representations of the state of the network. This helps you to visualize precisely what is happening, so you know where adjustments may be needed. (Computer Engineering and Intelligent Systems, Vol.5, No.8, 2014)
These tools can help you answer critical questions, such as:

1. What are the most popular services used on the network?
2. Who are the heaviest network users?
3. What other wireless channels are in use in my area?
4. Are users installing wireless access points on my private wired network?
5. At what time of the day is the network most utilized?
6. What sites do your users frequent?
7. Is the amount of inbound or outbound traffic close to the available network capacity?
8. Are there indications of an unusual network situation that is consuming bandwidth or causing other problems?
9. Is our Internet Service Provider (ISP) providing the level of service that we are paying for?
10. This should be answered in terms of available bandwidth, packet loss, latency, and overall availability.

2.1 Networks

Computer networks can be viewed as a series of devices that are interconnected and able to communicate with each other. Most networked environments connect computers via switches and routers. Switches provide the forwarding capability that allows logically neighbouring devices to communicate. Routers add the routing capability that provides the network with structure and allows communication between sub-networks. This project is interested mainly in the Internet Protocol (IP) networks (Information Sciences Institute, 1981). Computer networks vary significantly in size and importance. The larger and more important networks can cost organisations that are running them large sums of money for every minute that they are unavailable or malfunctioning.
. Many tools have emerged to aid in performance monitoring of networks. The most common class of tools is based on the Simple Network Management Protocol (SNMP), a protocol for sending and transmitting network performance information on IP networks. Other types of network performance monitoring tools include packet sniffers, flow monitors and application monitors

2.2 Network Monitoring Systems

Monitoring helps network and systems administrators identify possible issues before they affect business continuity and to find the root cause of problems when something goes wrong in the network. Be it a small business with less than 50 nodes or a large enterprise with more than 1000 nodes, continuous monitoring helps to develop and maintain a high performing network with little downtime.

For network monitoring to be a value addition to a network, the monitoring design should adopt basic principles. For one, a monitoring system should be comprehensive and cover every aspect of an enterprise, such as the network and connectivity, systems as well as security. It would also be preferable if the system provides a single-pane-of-glass view into everything about the network and includes reporting, problem detection, resolution, and network maintenance. Further, every monitoring system should provide reports that can cater to a different level of audiences—the network and systems admin, as well as to management. Most importantly, a monitoring system should not be too complex to understand and use, nor should it lack basic reporting and drill down functionalities. (SNMP, Monitoring tools, 2009)

When networks grow and become considerably large such as for the UNZA, it becomes infeasible for one person to maintain a mental model of the entire network. When this happens, the network is an unknown entity where faults could occur at any time and not be detected by network operators. A Network Monitoring System is a software package used to solve this debacle and diagnose faults on the network. It achieves this by storing an internal model of what the network is supposed to be and uses this model to evaluate the current state to the network. This enables the network monitoring system to provide insight into the otherwise unknown entity. The system also provides performance data on how well the network is utilized and answers questions regarding economics, i.e. is the network cost effective and meeting demand?

A network monitoring system should be able to monitor all these occurrences on the network without putting undue load on the devices being monitored. Not many network monitoring system are able to achieve this feature.

Different techniques can be used by network monitoring system to monitor a network. The rest of this section focuses on the features required in an ideal network monitoring system and those that should be provided to produce a general purpose network monitoring system.

2.2.1 Configuration System

Well-designed configuration systems are important for network monitoring systems. Networks change frequently which could lead to a network monitoring system network model being outdated, resulting in "black holes" that are not monitored. If the network monitoring system is easy to initiate and its configuration is easy to maintain, the model of the network should be more accurate.

2.2.2 Service Polling

Service polling is a type of network test where the network monitoring system regularly checks whether a device or a service is available and working within normal parameters. This allows for answering availability questions such as whether a server hosting our website on our network is reachable or not. More specific service polling tests may collect additional information about network state. One example of such additional information is verification of a web server's software; that it is running correctly, is responsive, and is serving the correct content without any errors.

2.2.3 Graphing

Time-series graphs depicting performance data drawn by a network monitoring system can be useful for identifying trends and anomalies. Where a large quantity of data values is given, such graphs are frequently used to identify changes in network state. Graphs need to be tailored to suite the network being monitored and some data is more useful to graph than others. A CPU time-series graph is useful as it indicates whether or not devices are being overworked and how close they are to operating at full capacity. Graphing bandwidth usage on network interfaces shows how close the network is to running at full capacity as well. This information is useful to systems administrators and can be used to plan network upgrades and identify likely bottlenecks.

2.2.4 Notifications and Events

Good or bad network changes should somehow reach someone especially those in charge of network monitoring. Network monitoring systems achieve this notification feature using event systems. Event systems can be very simple systems that check if some value is within a given threshold or has a certain value. If for example a host becomes unreachable, an event may be triggered. Complex event systems can also watch for undesirable trends or use anomaly detection to identify events that could impact the network. However, the notification system alone does not provide the full picture and some expertise may be required to determine what has caused an event to trigger.

2.2.5 Dashboard

A dashboard is a user interface that provides a visual display of information using a single screen such that all this information can be monitored at a glance (Stephen Few, 2006). This is useful for

network monitoring systems because it allows the whole network to be monitored from a large monitor in view of the system administrator and does not require actively searching through many pages of the network monitoring system to manually identify problems. Many dashboards include graphs that should be regularly checked for that network, for example performance graphs. It will also include summary statistics such as the current number of faults or a generalized network health measure. It should streamline the process of finding faults by ensuring that it is easy to discover the root cause of an event and by pointing the user in the direction of where they should start any further investigations.

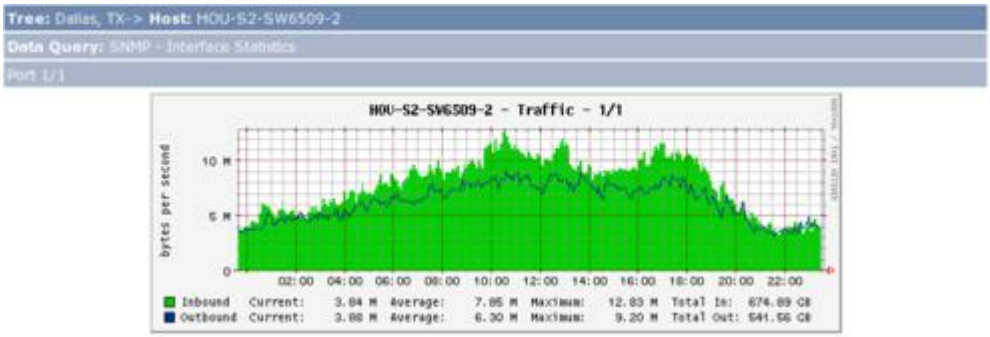
2.3 Popular Network Monitoring Systems

Organizations that have the financial muscle are able to implement robust network monitoring systems that offer all of the above features and more. Some of the more popular systems are briefly examined in this section.

2.3.1 Cacti

Cacti (cacti.net, 2015) is a network monitoring system designed for drawing time-series graphs of performance data on a monitored network. It typically draws a different graph for each monitored data source. A graph can be drawn from multiple data sources, but requires a suitable template created using the cacti format. The configuration system is entirely web based and there is no provided method for performing bulk configuration. The additional effort required to update the network model in Cacti often discourages the user from monitoring everything. Cacti also does not include an event detection system or a notification system and therefore is usually used to supplement another network monitoring system by providing historical graphs. These provide more visibility and insight as to why an event may have triggered in another monitoring system.

Figure 2.1: Traffic data graph from Cacti on network switch



Source: Cacti.net, 2015

Data to be graphed in Cacti is collected using SNMP (simple network management protocol) at a specified rate. This default's to five minutes but with some effort can be reduced to a faster rate.

2.3.2 Icinga

Icinga (Icinga, 2015) is a network monitoring system designed specifically for service polling, notifications and report generation. It is a fork of Nagios (Nagios, 2009-2015) and uses a large portion of Nagios code still in its core. Icinga service polling is modular: each service check is handled by a separate check script or process which is forked by the Icinga monitoring system. The check process will exit with an exit code that matches the severity of the problem (ok, warning or critical). Performance data from the test can be reported to Standard Output (stdout). Since Nagios has been an industry standard for the past ten years and is easy to script and modify, there are many different community maintained extensions that can extend Icinga and Nagios to support extra features. Data collection is handled by the check script and any protocol could be used to collect measurement data. SNMP is used exclusively for this purpose.

2.2.3 Wireshark

Wireshark (Wireshark, 2015) is a network packet analyzer. A network packet analyzer will try to capture network packets and tries to display that packet data as detailed as possible. It can be thought of as a measuring device used to examine what's going on inside a network cable.

Wireshark can capture traffic from many different network media types – and despite its name – including wireless LAN as well. Which media types are supported, depends on many things like the operating system in use. However Wireshark is not an intrusion detection system. It will not warn you when someone does strange things on your network that he/she is not allowed to do. You have to manually decipher what is going on from the packets that Wireshark captures. Wireshark will not manipulate things on the network, it will only "measure" things from it. It does not send packets on the network or do other active things (except for name resolutions, but even that can be disabled.)

2.4 Issues with Existing Solutions

In the previous section we examined some of the existing network monitoring systems that are used to monitor networks. This examination is not comprehensive but is an indicative guide on how the systems operate and some of their strengths and weaknesses. These systems use a number of tools and libraries to achieve the functionality that they deliver. In this section we will identify common problems in these systems that make them unsuited to being used as general purpose network monitoring systems. These issues are the reason that it is common to deploy multiple network monitoring systems, each with their own strengths and features, to provide full monitoring coverage for a network.

2.4.1 Data Collection

SNMP (Simple network management protocol) is the industry standard for data collection in a network monitoring system. SNMP is commonly configured in a centralized architecture, where a single SNMP collector collects data from every device on the network. A paper studying the behavior of SNMP collectors (Colin Pattinson, 2001) raised issues with the performance of the centralized design of SNMP when used for large-scale network monitoring. The paper suggests that a better design is a decentralized approach. Such an approach would use remote collector agents to monitor a subset of the network. Each remote collector would monitor a subset of the network. These collector agents periodically export data to a central system for storage. The benefit of this approach is that it works well when collecting data over the Internet. Moving the collector agent logically closer to where the devices are is also beneficial because often devices on a network are held in different geographical areas for redundancy. This is because a single expensive connection to a central storage server over the Internet is better than one expensive connection per monitored device.

SNMP is usually exclusively used in a polling configuration and this too is an issue. SNMP can be used to push data with the SNMP trap, which is built into the protocol for pushing data immediately to a collector. However, due to the difficulty of configuring traps correctly, the feature mostly goes unused. This leaves use relying on the poll interval of a SNMP collector being fast enough to detect important changes. However, monitoring a large network with a single SNMP collector will prevent a fast poll rate because of load and bandwidth constraints on the collector machine.

Network monitoring systems usually bundle a SNMP poller that they use to collect data. Once this is done it is either unchangeable or difficult to change. In a network where multiple network monitoring systems are deployed to provide the full suite of monitoring tools, this means we have to run multiple SNMP pollers as well. Some SNMP implementations do not perform caching of values so polling values on a device multiple times can be expensive to that device. This contradicts our requirement that monitoring should not greatly impact the services of the network.

2.4.2 Dashboard

The systems outlined in the previous sections all have useful dashboards. This is because the dashboard is the interface that most users of the system deal with day to day. A network monitoring system will not be used to monitor a network by a network or systems administrator if it has a bad interface.

The main issue with dashboards is that networks must be monitored by multiple network monitoring systems to have full testing coverage over the entire network. This means that multiple dashboards need to be used to track the status of the network. A user will be glancing at multiple dashboards to scan for faults which can be difficult and distracting. A solution that can unify this all to exist on one dashboard would better satisfy the requirements we are seeking.

2.4.3 Configuration

The common configuration systems that we have seen from the examined network monitoring systems are plain-text configuration files. These configuration files define the network model and how network monitoring systems should be monitoring the network.

Using plain-text files for configuration is usually a huge undertaking requiring a large amount of configuration. As an example, a small Icinga instance that monitors 34 devices investigated during this project used up to 3724 lines of configuration to define the network model. This magnitude of configuration is prone to human errors which if no attention is paid to detail can go unnoticed for extended periods of time. This has a negative impact on how well the network is monitored. Cacti has a limitation in its configuration because the configuration is locked in a custom relational database management system schema that is only accessible through a web interface. This interface does not provide bulk configuration options, which adds to the effort required to configure a whole network. These problems inhibit us from meeting the requirement of encouraging users to have high testing coverage by accurately setting up and maintaining the network model in the network monitoring system.

Running multiple network monitoring systems exacerbates the problem because the user must now maintain a number of different configuration systems. To make matters even worse, the configuration systems are usually incompatible. As a result, one change to the network model will mean updating this in multiple systems, further increasing the likelihood of mistakes.

2.5 Investigation

It has become apparent at this point that there are a number of issues with the most popular network monitoring systems used to monitor networks apart from implementation costs. Some of the newer systems investigated may be heading in the right direction but still remain targeted to specialized monitoring and are missing important features such as notification systems and decent dashboards. An example in question is Wireshark.

In this section we will investigate new techniques and updates to current techniques as well as the attitudes of computer network users. This investigation helps us to build a network monitoring tool suited for system administrators and which overcomes some of the limitations we have identified thus far. This section will also endeavor to introduce new methods that can be implemented in a network monitoring tool alongside current methods to improve the configuration and maintenance of the network monitoring tool.

2.5.1 Data Collection

This section defines a new set of requirements for a new data collector to replace SNMP. By replacing SNMP we seek to remove the limitations that it adds to the data collection section of a network monitoring system.

Most devices being monitored by a network monitoring system are powerful servers or switches. The requirement to have a very simple protocol that can work on low hardware requirements is therefore unnecessary. The efficient alternative is to use an efficient protocol built for transmitting large amounts of data points regularly without significant load impact on our collection server. A data collector with support for pushing data as a first class citizen allows important data to turn up instantly rather than on the next poll interval. A collector with a fast poll interval, to the point of being able to collect data at real-time without much overhead, will add another technique for a network or systems administrator to use to inspect active faults in greater depth. Using a decentralized system eliminates a single point of failure for our collector and improves scalability.

2.5.2 Automatic Configuration Discovery

One of the stated goals of this project is to ensure the configuration is easy to initialize and maintain. The best method of achieving this goal is to limit the amount of configuration required by our network monitoring tool by performing automatic configuration where possible. This section explores three different methods of automatically generating different parts of the configuration for a network monitoring tool.

However automatic configuration does not solve all our configuration issues. Automatic configuration must be maintained through some mechanism. This maintenance may prove to be too expensive to run with every interaction with the network monitoring tool. We need to have an update interval so that when the automatic configuration is performed changes are merged into the current network model. Our tool will keep this network model internally reducing on any storage requirements which may have a negative impact on the network.

2.5.2.1 Topology

Topology discovery is a method of scanning a local network or computer and determining the logical topology of that network. This is an important process because the network may have devices hidden in many different logical segments of it. By discovering all network segments and finding the entire network we can ensure that monitoring black holes are not introduced to our network monitoring by leaving out segments from our network model.

2.5.2.2 Devices

Once we have a network topology, the next stage of the automatic configuration system is device discovery. In the context of our network monitoring tool, devices refer to adapters on the computer

on which automatic configuration is being performed. Therefore this step is used to find adapters on the individual segments of the network that was revealed by the topology discovery. This results into a list of adapters that are to be monitored. There are a number of different techniques available for scanning adapters on a given network segment. We use an iteration technique through the available network adapters to discover all the available ones and list them as devices to be monitored.

2.5.2.3 Services

Service discovery is very similar to device discovery. When we have a list of adapters to monitor each adapter can then be independently probed to determine the services that it hosts. This can be as simple as doing a scan of open ports on the host machine and matching these against the well-known ports that common services use. Open ports can also be queried for a banner to see what service is listening on that port. In the test phase of the project Nessus (Jay Beale, etl, 2004) was used to verify that our network monitoring tool was scanning and identifying the services correctly.

CHAPTER THREE
RESEARCH METHODOLOGY

3.0 Introduction

Defined by Kothari, (2004), research refers to the structured enquiry which utilizes acceptable scientific methodology to solve problems and create new knowledge that is generally acceptable. Research methodology has been defined as a systematic way to solve research problem. Methodology consists of systematic observation, classification and interpretation of the study findings. This section discusses the methodology of the study, population of the study, sampling procedures and sample size, data collection methods and data analysis methods.

3.1 Research Design

Research design refers to the plan for undertaking the study especially obtaining a sample from a given population including techniques or the procedure that would be adopted (Patton, 1990). According to Panneerselvam (2007: 12), the research design provides complete guidelines for data collection. Selection of research approach, design of sampling plan, experiment and questionnaire are among the essence of research design. A research design is simply the framework or plan for a study used as a guide in collecting and analyzing data. It is the blueprint that is followed in completing the study (Churchill & Brown 2007). According to (Adam and Kamuzora, 2008), research design can be understood as a detailed work plan which is used to guide a research study to achieve specified objectives of the research. A guided interview research design was employed. This is because it was less expensive and most suited compared to other methods. It also allows the use of various data collection methods which were observation and documentation that was used in collecting data of this study (Kothari, 2002).

3.2 Network User Attitudes

In order to make the network monitoring tool relevant to the organizations under investigation it was deduced after having interviewed a random sample population of network users and systems administrators at UNZA and TAZAMA. Due to the nature of the interview questions and the responses, they could not be quantified but were taken as general views of the people interviewed. Key points were picked from the general views that were given. This section summarizes what their views are regarding network usage and monitoring.

3.3 Views and Attitudes of Computer Network Users at UNZA /TAZAMA

The continued growth of the cyber space era has brought with it a permanent change in the way students and workers in industry interact, socialize and do their research or work. A major part of this change is the advent of so called social networking sites on the internet, which have evolved to become virtual communities, where people communicate, share information and perhaps most important share their work or research ideas. The views of network users for both learning and corporate institutions are that network availability is priority number one. Connection speeds also are an issue that users expect to have reasonable enough for their use. Research is an area highlighted as number one for both learning and corporate institutions, therefore the demand for lesser restrictions

on the sites to access. Users feel the restrictions that are put in place by administrators are hindering them from achieving their intended goals. They therefore would like to be involved or consulted before restrictions to internet access are effected.

After having conducted random verbal interviews with a minimum number of about 50 (fifty) users from both institutions, the following views were listed as outstanding and noted:

i. Network Availability
ii. High connection speeds
iii. Demand for lesser restrictions on the sites to be accessed
iv. To be consulted before restrictions are effected.

3.4 Views of Network and Systems Administrators at UNZA/TAZAMA

Availability of Network is one of the most critical items an administrator looks at. This is for both corporate and learning institutions. Once the network is available, network security is the second most important issue to be considered. Network administrators always search for the best network monitoring tools, because a system administrator always needs to know about the status of their systems so that he can optimize performance and head off potential problems. Definitely, dealing with the networking system needs proper knowledge and good experience so that one can easily deal with the daily crashes, frequent errors and failures.

To be able to identify potential problems even before users start to complain, the administrator needs to be aware of what is normal in the network. Base lining network behaviour over a couple of weeks or even months will help the administrator understand what normal behaviour in the network is. Once normal or base line behaviour of the various elements and services in the network are understood, the information can be used by the administrator to set threshold values for alerts.

The network always has to be available because learners are always using it. The second most important thing as mentioned is security. Under an educational institution, such an organization is put under the scrutiny of software houses. Meaning that the software that is installed on the network needs to be correctly licensed and the network traffic always needs to be legitimate. Accessing unauthorized tasks should be monitored which brings us to the traffic the tool monitors in addition to the monitoring of availability that the tool conducts.

Learners are usually a notorious bunch and do not adhere to the regulations set out by the institution. It is therefore the province of network administrators to be on top of things in terms of monitoring the network traffic, usage, and availability. This also goes for corporate institutions like Tazama. Equally after having conducted verbal interviews with network administrators from both institutions, the following views were listed as outstanding and noted:

i. Network Availability
ii. Network Security
iii. The best network monitoring tool

3.5 Research Questions

As can be seen research results could not be quantified as they were taken down as views of both network administrators and network users. The most outstanding views or points were noted down and taken as key factors or features of the network monitoring tool.

The following are the questions for network administrators that yielded the above results.

1. What is your organization main activity?
2. How many machines are running on your network?
3. Are your machines “locked down” or can your users install programs?
4. Do you currently use a network monitoring tool?
5. If no to question no. 4, how often do you check your monitoring logs?
6. If you are currently using a monitoring tool, what other features would you like integrated?

The following are the questions for network users that yielded the above results.

1. Are you a member of staff or a student?
2. How often do you use the internet?
3. What sites do you frequent?
4. Are you satisfied with the current internet services being offered?
5. What don’t you like about the current services?
6. What would you want improved?

With the views given from the above questions, they were then summarized into four the four main views as given above under network users.

CHAPTER FOUR

PROJECT RESULTS

4.0 Introduction

The initial evaluation of existing network monitoring systems has demonstrated that no general purpose and light foot print network monitoring tool exists that meets all the requirements for this project. As a result, new methodologies and technologies are necessary to build a light foot print and refreshed network monitoring tool with systems and network administrators in mind.

Furthermore, this project aims to produce a system that we will call a Network Monitoring Tool, where the emphasis is on simplicity and dynamism, rather than statically, configured network models. Many key design decisions have been made with these goals in mind.

The Net-Mon Tool has been designed to be a modular tool for two reasons. First, features can be implemented incrementally while maintaining a working system at each development stage. This is important because building a feature complete network monitoring system is outside the scope of this project due to technological and time constraints. The second reason was to allow users to extend the feature set and tailor Net-Mon for their particular needs and to enable improved versions of modules, such as the data collector module, data storage, to be substituted without having to keep both loaded in the program at the same time. The modularity also helps reduce software bloat because the running version of the software only needs to enable the features required to monitor a particular host computer.

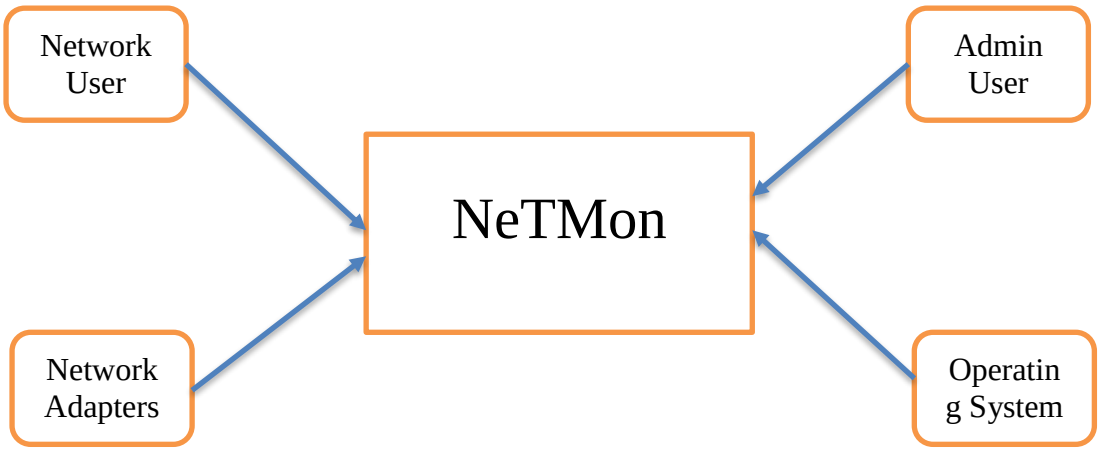
Another key design principal employed in the design of Net-Mon is to limit the amount of configuration that is required for the system to function. The minimum set of configuration required to monitor network adapters is stored in memory. Anything not required is considered non-essential. This is implemented by attempting automatic configuration where possible and having sensible defaults pre-configured for use if automatic configuration fails. This approach limits the amount of configuration that is required to run Net-Mon and reduces the likelihood of mistakes. Also because the configuration is easy to maintain, it is more likely to be up to date.

4.1 System Design

This section presents high level system diagrams of Net-Mon.

Context Diagram

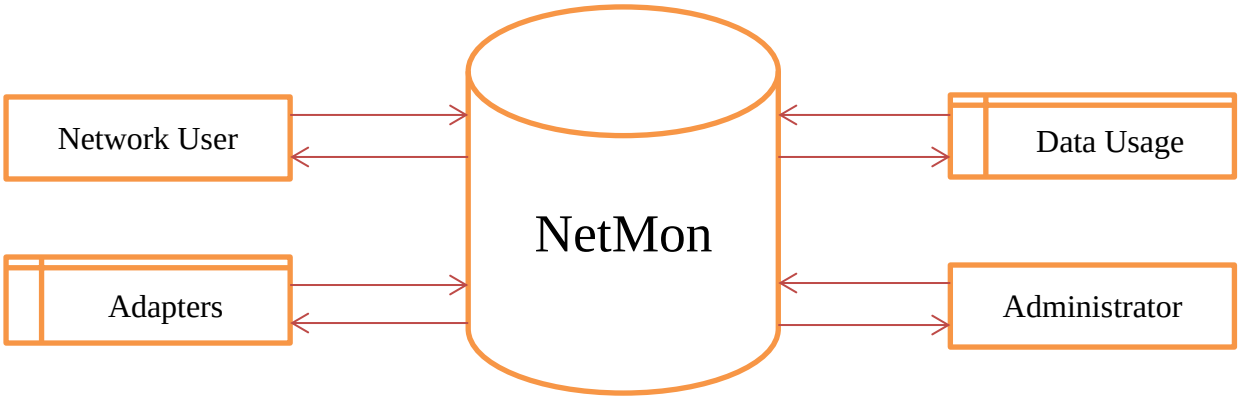
Figure 4.0



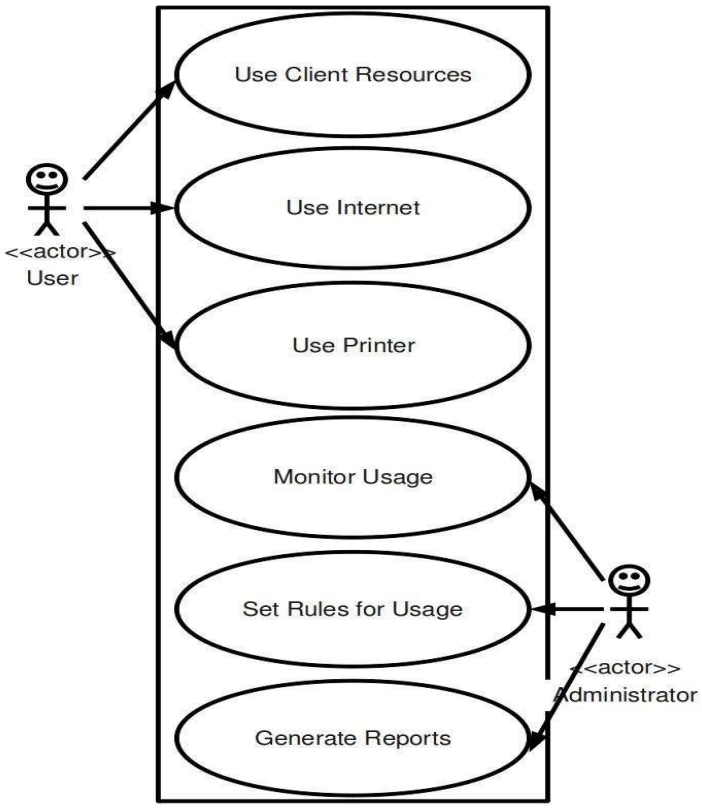
Source: Researcher, 2015

Data Flow Diagram

Figure 4.1



Source: Researcher, 2011



Use Case Diagram

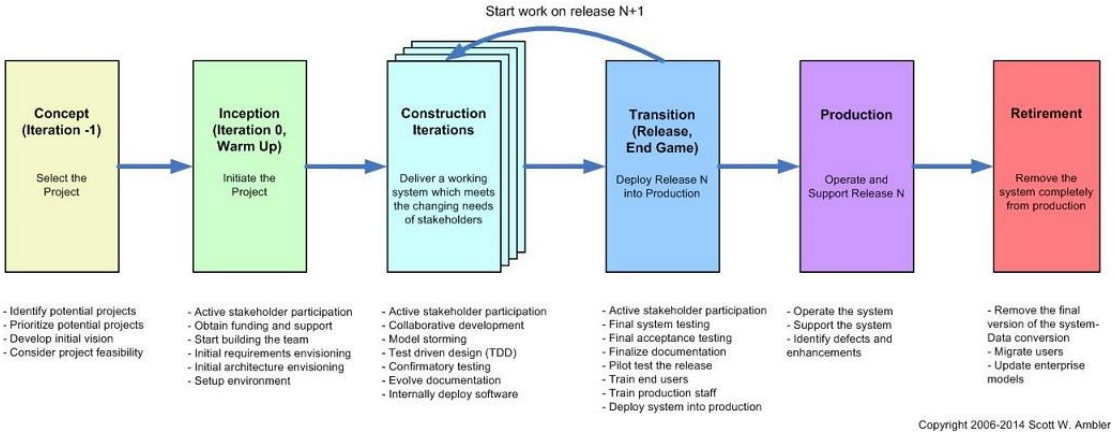
Figure 4.2

Source: Real time network monitoring system, slide share.

4.2 Development Methodology

This project followed an Agile development methodology with an emphasis on delivering iterative working system components to stakeholders. The users would then provide feedback on the modules that needed improvement and those would be worked on. The diagram below shows the stages that where followed in the development process.

Figure 4.3 The Agile SDLC (high-level)



Source: Scot W. Ambler, Agile Modelling (2002), The Agile system development life cycle (SDLC).

Agile software development is described as a group of software development methods in which requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It is said to promote adaptive planning, evolutionary development, early delivery, continuous improvement, and encourages rapid and flexible response to change. It also emphasizes just enough documentation as opposed to the traditional methods of software development especially for small projects. It is worth bearing in mind that in software development "no one size fits all" therefore the methodology is adapted to suite the project at hand. The high level stages of the Agile Software development Life Cycle are as follows:

- *Concept Phase*
- *Inception Phase*
- *Construction Iterations*
- *Transition (Release, End Game) Phase*
- *Production Phase*
- *Retirement Phase*

Technologies Used

This section outlines the technologies that were used to develop Net-Mon.

Visual Studio 2013

Visual Studio is Microsoft's proprietary Integrated Development environment. It has reach features for application development as well as development of web based applications. The rich libraries provide classes that are used to communicate with low level system hardware. This was one of the influencing factors in selecting this environment. Visual Studio supports C++, VB, C# and F# as the back end programming languages.

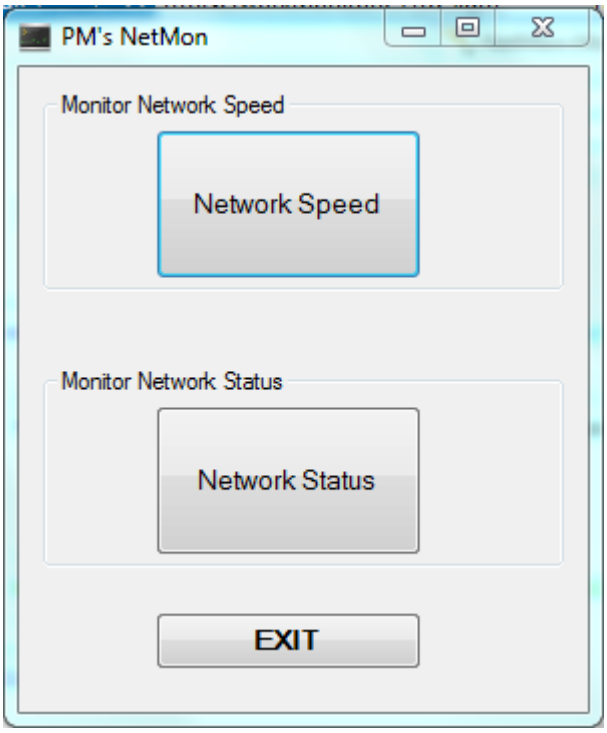
C-Sharp (C#)

C# was used as the programming language of choice for development of this project. It is an industry standard software development language with its roots in C++. It is however much simpler to learn than C++ and less prone to programming errors. C# offers a rich set of libraries that communicate with low level hardware such as network interface cards. These libraries were used in the implementation of NetMon.

Forms Application

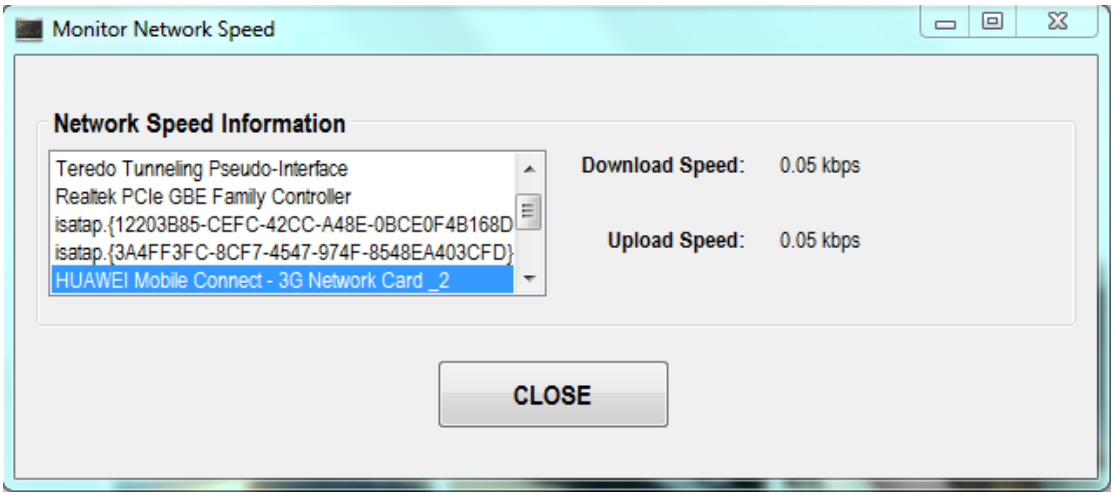
NetMon is developed as a desktop windows forms application. When packaged into an executable it is able to run on any Windows framework with any need for installation. It is has been developed with simplicity in mind and a very low foot print.

Net-Mon Screen Shots
Figure 4.4



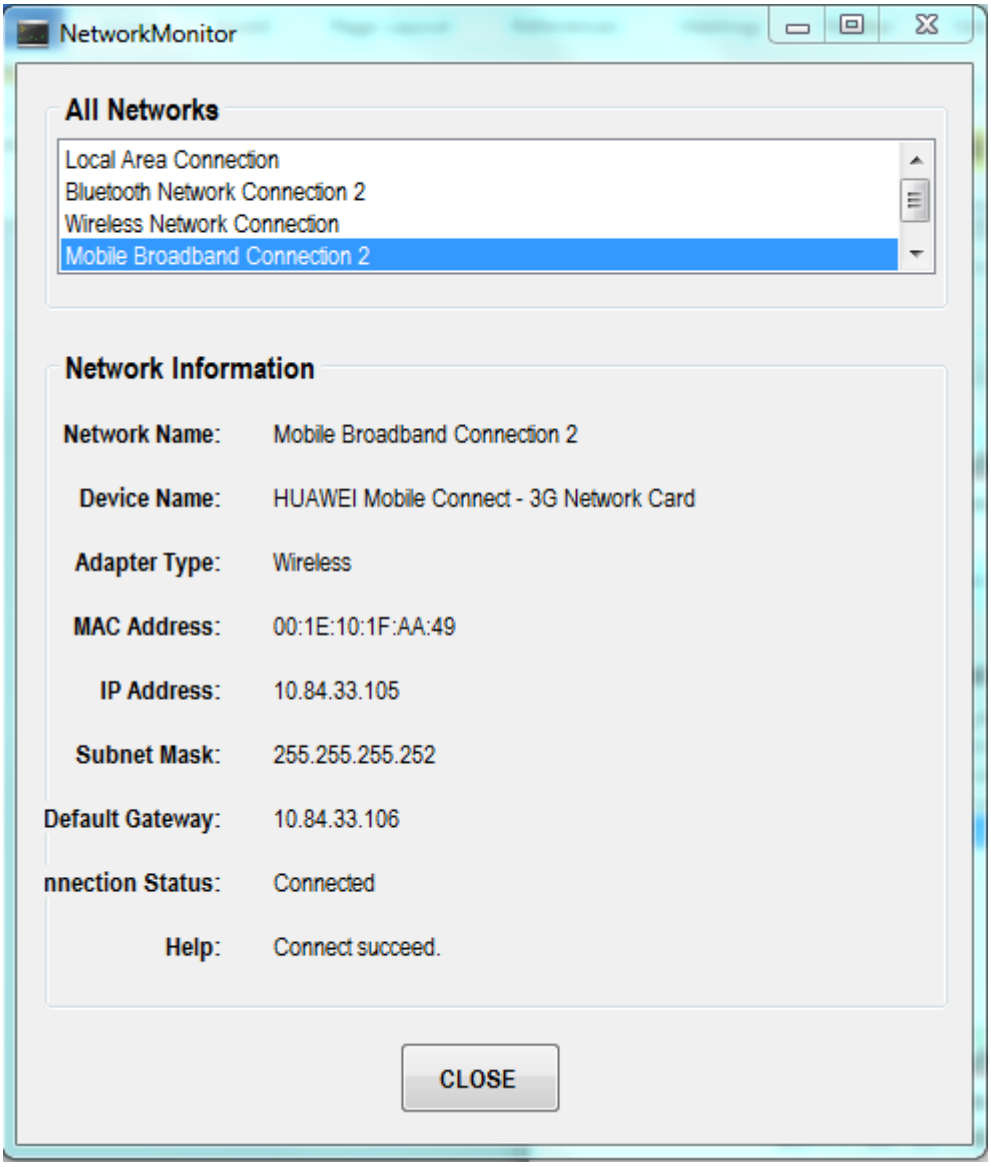
NetMon Launch Screen – the launch screen presents two options for monitoring network speed and network status on the host computer

Figure 4.5



NetMon Network Speed – the Network Speed monitor lists available network adapters that NetMon is monitoring. Selecting a network adapter from the list shows the download and upload speed of that adapter.

Figure 4.6



Network Monitor – the network monitor monitors the status of the network adapters on the host computer in real-time. Selecting an adapter from the list displays the status of that adapter.

CHAPTER FIVE
DISCUSSION OF RESEARCH FINDINGS

5.1 Introduction
Network monitoring systems are very large systems and to complete a fully featured network monitoring system is a mammoth task. The Net-Mon tool has been implemented as the framework to build a feature complete network monitoring system on top of. The core feature of a network monitoring system has been implemented in Net-Mon that of monitoring network devices these being network adapter monitoring in real-time.

5.2 Event Notification Module
A major feature that a network monitoring system should have is event notification. When something out of the ordinary occurs on the network, the network monitoring system should be able to send an event notification to the user so that the triggering event is investigated further. Additionally the event notification system should have the ability to send only event notifications that are solvable by the user. Sending event notification that the user is unable to solve would be unintelligent and a waste of resources. The event notification system should also be able to group similar triggering events and send only a single notification for such events as opposed to sending multiple notifications for a variation of the same base event trigger. This feature is an enhancement that would greatly improve Net-Mon. The notification system would also benefit from being modular and different notification modules could be turned on and off. For example notifications could be made over email, short message service (SMS), pager or Instant Message (IM).

5.3 Data Storage
Net-Mon currently stores all its configuration and monitoring data in memory. Once the tool is closed, this data is lost. Having a persistent data store allows network monitoring systems to be able to generate historical data and thereby generate reports based on that data. An ideal implementation of this data storage would be using SQL database with a Relational Database Management System (RDBMS) to store the data. Incorporating this feature in Net-Mon would mean one of two things: either re-implement the tool so that it is installable on a network server which has a RDBMS or incorporate a RDBMS in Net-Mon itself for data persistency. Both scenarios have added advantage as an enhancement.

5.4 Conclusions and Future Work
This project has shown the benefits and established how necessary network monitoring is on a network in academic and corporate organizations to properly administer and maintain it. Without monitoring, a network is a black hold and faults can go unnoticed for extended periods of time.

This project has shown that most popular network monitoring systems that are used today to monitor networks have a number of limitations and issues that prevent them from providing full testing

coverage and detecting every fault. We have shown the major issues can be solved by using technology available today that was not available when these systems were originally developed.

Improved techniques for building a better network monitoring system were devised and investigated. A new network monitoring tool was built from the ground up using new technologies. Some of the new techniques devised were integrated into the new network monitoring tool to improve usability and usefulness of a network monitoring tool from the perspective of network and systems administrators.

Lastly we also investigate the views and attitudes of network users and administrators and how these can be factored into developing network monitoring systems that address the today's network issues.

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