CHARACTERISTICS AND FUNCTIONALITY OF EMULATION NETWORK ANALYZER AND HARDWARE NETWORK ANALYZER

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ABSTRACT

This paper presents a development of an Emulation Network Analyzer for heterogeneous services in campus environment. We propose a framework and implementation named ENA that models the network behavior of heterogeneous environment. The purpose of this paper is to inform potential tool of analyzing the network in campus environment by providing an overview of the capabilities of ENA tool. For this purpose, we demonstrate our Emulation Network Analyzer (ENA) development is differ from others system such as application and hardware network analyzer (e.g. Fluke Optiview). This study focuses on the characteristics and functionality of two different systems (ENA and hardware network analyzer) and the study conclude that each system has their strength and functionality. With unique knowledge of this emulation available and a solid background in modeling and simulation, it is possible to utilize some of the campus problems dramatically shorten the time span involved in providing useful network architectural solutions, cost reduction and optimization of network resources during preparation, proposal and planning phases. Finally, ENA tool is a good emulation analyzer that can be used in small to medium size networks for campus environment purposes with minimum cost.

Keywords: *Emulation Network Analyzer, Hardware Network Analyzer, Campus, Heterogeneous*

1. INTRODUCTION

This study focuses on the characteristics and functionality of two different systems and the study conclude that each system has their strength and functionality. This study does not intend to perform a comprehensive test the functionality of all network analyzer features. According to M. Fleury et al, it is unfair to compare two models that are not coded identically [1]. The functionality and accuracy of the Emulation Network Analyzer (ENA) has proven in the lab and real network experiments. We have implemented this tool and based on our experiment results show that ENA tool has produced minimum relative error rate compare with hardware network analyzer [2][3][4][18][19]. Therefore, it contribute significant productivity to campus IT environment for managing their resources management without using any high cost hardware network analyzer or simulation tool.

The first major effort entails researching and determining a set of criteria to use in evaluating and comparing ENA tool. The second major effort involves using the criteria to identify and compare three network systems. The two network systems used in this study were ENA tool (our development tools) and hardware network analyzer (Fluke Optiview device). Each of these two network systems was evaluated their features and capabilities were compared. We have developed a new emulation network analyzer tool (ENA), while hardware network analyzer has originally been developed for real network environment with higher investment. This ENA tool provides efficiency and cost-effectiveness with respect to development, preparation and planning of heterogeneous network environment by removing their dependence on high cost hardware network analyzer and simulation tool.

The purpose of this study is to inform potential tool of analyzing the network in campus environment by providing an overview of the capabilities of ENA tool. With unique knowledge of this application available and a solid background in mathematical modeling and networking architecture, it is possible to utilize some of the campus problems dramatically shorten the time span involved in providing useful network architectural solutions, cost reduction and optimization of network resources during preparation, proposal and planning phases.

In addition, this study discusses several features comparison between hardware network analyzer and Emulation Network Analyzer (ENA). The ENA tool has capabilities similar to hardware network analyzer for network traffic and utilization module, and adds in some module: i) bandwidth requirement module; ii) delay; iii) and critical condition module (under constraint) such as upgrading network based on multi-medium interfaces, rescheduling network services, multi-links for LAN and WAN. Therefore, ENA tool is able to solve the current issues (in section 2.0) to achieve much of the flexibility on analyzing the network characteristics in heterogeneous environment.

2. RELATED WORKS: NETWORK ANALYZER, EMULATION AND SIMULATION

A network analyzer (also called a packet analyzer) is a combination of hardware and programming, or in some cases a stand-alone hardware device, that can be installed in a computer or network to enhance protection against malicious activity. Network analyzers can also analyze the packets in real time in order to alert the administrator about problems. A network analyzer also called a "packet analyzer," "traffic analyzer" and "protocol analyzer," [5] the network analyzer plugs into a port on a network hub or switch in real network and decodes one or more protocols into a human-readable format for the network administrator. Network analyzers functionality such as [6]: i) Provide detailed statistics for current and recent activity on the network; ii) Detect unusual levels of network traffic; iii) Detect unusual packet characteristics; iv) Identify packet sources or destinations; v) Configure alarms for defined threats; vi) Search for specific data strings in packets; and vii) Monitor bandwidth utilization as a function of time. Network emulation is a technique where the properties of an existing, planned and/or non-ideal network are simulated in order to assess performance, predict the impact of change, or otherwise optimize technology decision-making [22]. Network emulation has been widely used to aid in the development and evaluation of real time applications [20]. Network emulation has for a long time been an important tool for evaluating the performance of communication protocols. By emulating network characteristics, such as restricted bandwidth, delay and losses, knowledge about the behavior and performance of actual protocol implementations can be obtained [21].

The purpose of any model is to enable its users to draw conclusions about the real system by studying and analyzing the model. The major reasons for developing a model, as opposed to analyzing the real system, include economics and unavailability of a “real” system [7]. Discrete-event simulation is a very popular technique for the performance evaluation of systems, and in widespread use in network simulation tools [8], [9], [10]. When designing a network simulation environment intended specifically for modeling large-scale topologies, a number of issues must be addressed by the simulator designer. Memory requirements for network simulation engines can grow quadratically with the size of the simulated topology and can easily exceed available memory on modern workstations [11].

Current issues with hardware network analyzer are: i) High cost investment; ii) Limited input variables; iii) Easy fragile; iv) Only can operate after completed network implementation, operational and optimization. It is unable to predict under planning and preparing phases; v) Different hardware can support on different network interfaces; and vi) Limited functionality to conduct ‘What-If’ analysis. To overcome this limitation, we introduce a network analyzer concept for network emulation

3. METHODOLOGY AND FRAMEWORK

Figure 3.1 shows network life cycle approach for technologies and services implementation in the future [12]. We investigate how preparation and planning phases can be applied to heterogeneous environment in order to better utilize network resources. Figure 3.2 shows that ENA development concentrate more on preparation, planning and proposal areas. Hardware network analyzer are used to measure network traffic in real time activities and mostly cover under operational and optimization area (see Figure 3.2). The ENA development is differed from other applications such as application and hardware network analyzer.

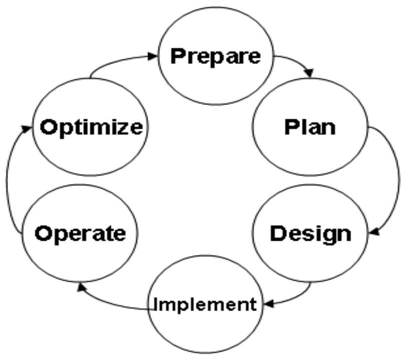

Figure 3.1: Network Life Cycle

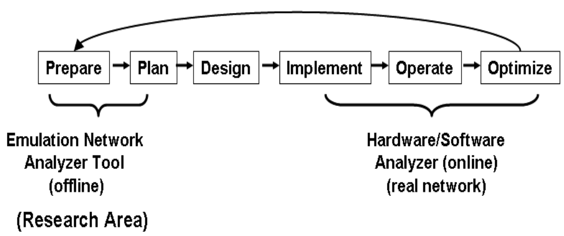

Figure 3.2: Comparison of ENA and Hardware Network Analyzer Coverage Area

ENA tool consists of two phases: with constraint (critical condition) and without constraint consideration (non- critical condition) (see Figure 3.3 and Figure 3.4). ENA tool was developed to measure and predict network activities based on offline condition. Figure 3.3 and Figure 3.4 show ENA tool architecture framework and divide into LAN and WAN performance measurement. ENA tool consists of seven categories: upgrading network, rescheduling network services, multi-links network, minimum bandwidth requirement, utilization, network traffic and delay.

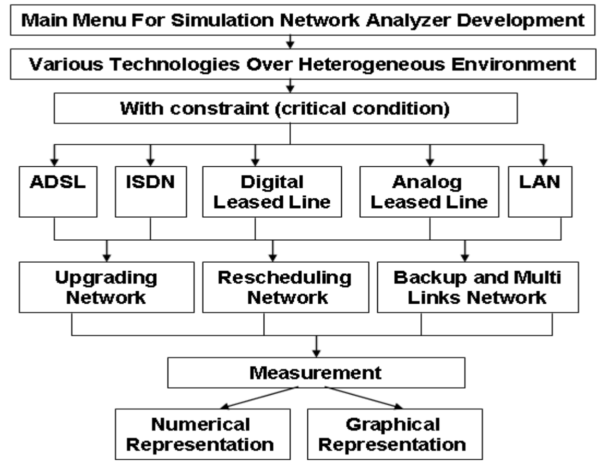

Figure 3.3: ENA Framework with Constraint Consideration (Critical Condition)

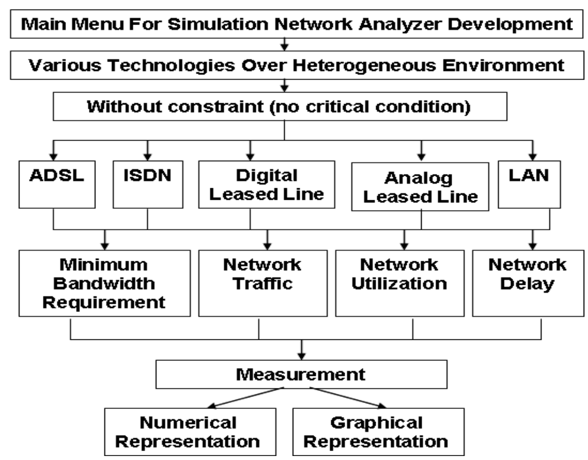

Figure 3.4: ENA Framework without Constraint Consideration (non- Critical Condition)

Figure 3.5 shows ENA tool development process. It also shows the mathematical model validation and verification process has conducted to ensure the accuracy of selected algorithms. After we satisfy and agree with real network experimental, code performance and accuracy of the model then we will develop and produce a complete ENA tool (see Figure 3.5).

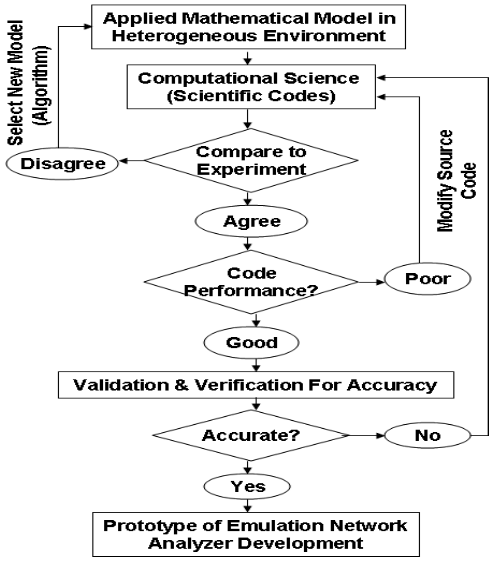

Figure 3.5: ENA Development Process

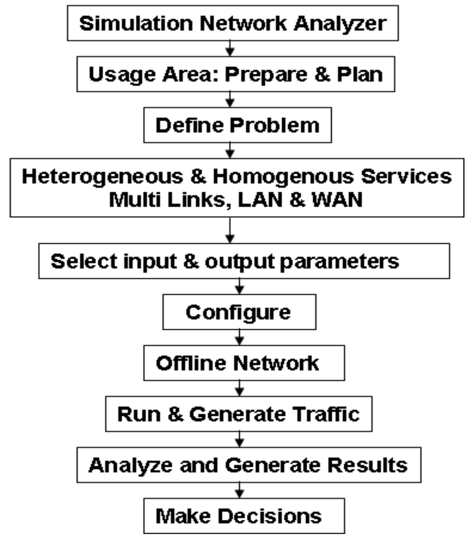

Figure 4.9: Functionality and Characteristics of ENA Architecture

4. ENA AND NETWORK ANALYZER FUNCTIONALITY COMPARISON

Emulation Network Analyzer (ENA) Tool: We developed an application tool to measure and predict network characteristics for heterogeneous services in campus environment. This application tool is a combination of simulation and analyzer. This application tool also called a 'Emulation Network Analyzer (ENA)'. Figure 4.9 shows the functionality and characteristics of ENA simulation tool. It shows the process of ENA operational. ENA is divided into two categories services: i) homogenous; and ii) heterogeneous.

Figure 4.10 and Figure 4.11 show the measurement of: i) new service menu (without constraint); and ii) new and current services menu (with constraint). The administrators are given an option to define which network medium should be analyzed the network behavior.

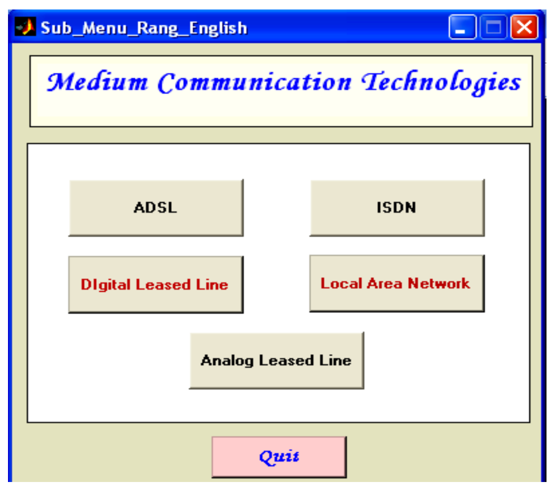

Figure 4.10: Measurement of New Service Menu (Without Constraint)

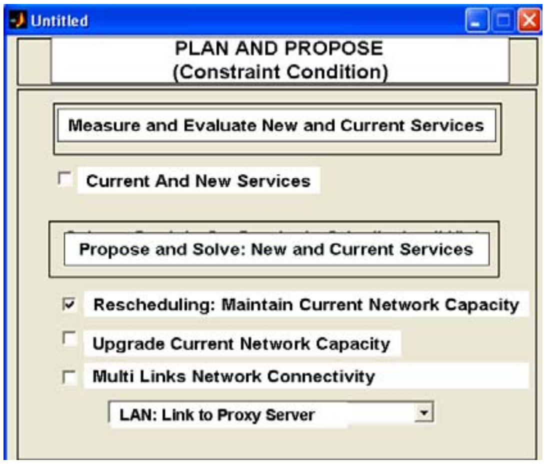

Figure 4.11: Measurement of New and Current Services Menu (With Constraint)

ENA tool consists of seven modules: upgrading network, rescheduling network services, multi-links network, minimum bandwidth requirement, utilization, network traffic and delay. In this case, we will discuss several modules such as: i) network utilization module (without constraint); ii) delay during transmission (without constraint); iii) rescheduling network services (with constraint); and iv) multi-links network (with constraint). ENA can provide network traffic behavior and trends. ENA also provides an in-depth view into which users and applications are consuming the most bandwidth, utilization and delay (see Figure 4.12 and Figure 4.13). Figure 4.12 shows sample of network utilization interface for heterogeneous services.

ENA converts that data into charts and tables providing network administrators with an easy way to identify and isolate the cause and source of network problems, as well as provide historical performance information to help plan for future growth. Pie charts show the distribution of bandwidth across different types of traffic (e.g., Video, Voice, Audio and Message) and across different medium of network. It is easy to use and has a user-friendly graphical and text interface, and it is useful for preparation and planning purposes (see Figure 4.12, Figure 4.13, Figure 4.14 and Figure 4.15).

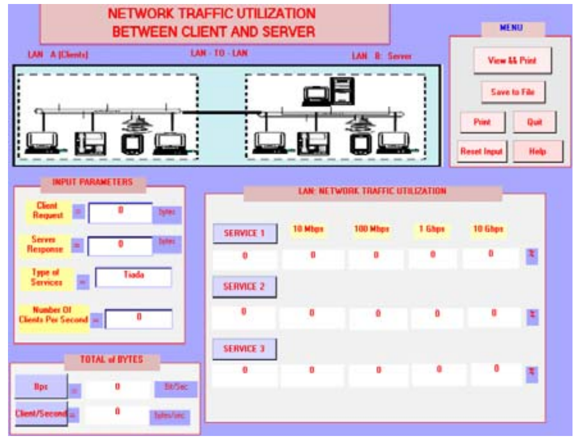

Figure 4.12: Sample of Network Utilization in Text Interface for Heterogeneous Services

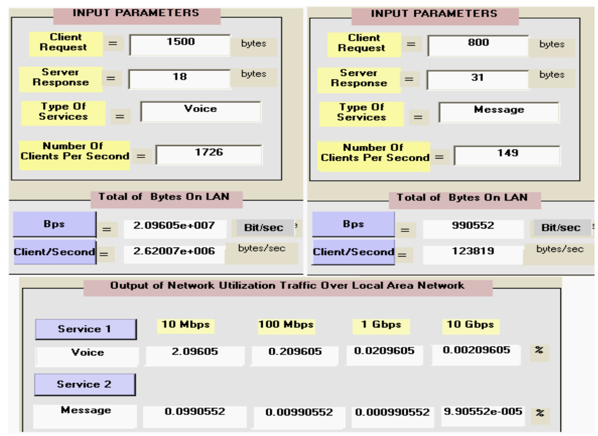

Figure 4.13: Input and Output Result for Network Utilization in Heterogeneous Services

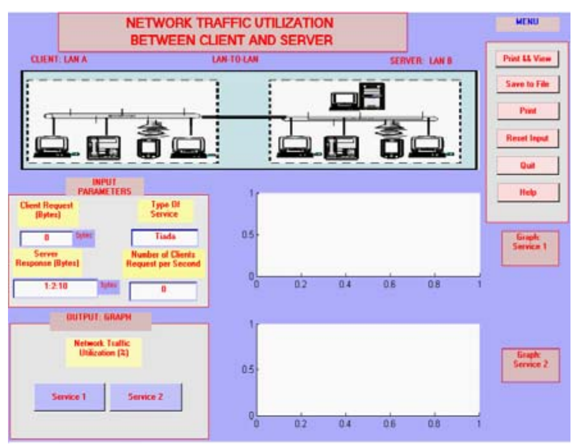

Figure 4.14: Sample of Network Utilization in Graphical Interface for Heterogeneous Services

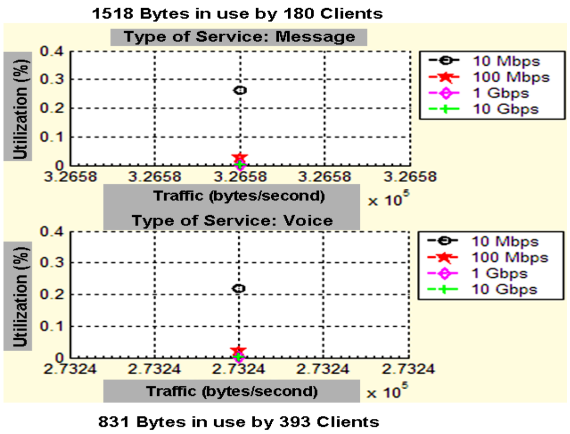

Figure 4.15: Sample of Graphical Interface Output

Output of network utilization and traffic that captured by simulation model is based on size of services and number of clients. In addition, this simulation model can also predict and estimate the variable parameters in graphical and text output interface. This graphical output interface can provide simulation model is easier to analyze and measure the network performance. Next we demonstrate how ENA tool can measure the network delay through heterogeneous environment. Figure 4.16 shows the network delay interface to measure delay occur during data transmission.

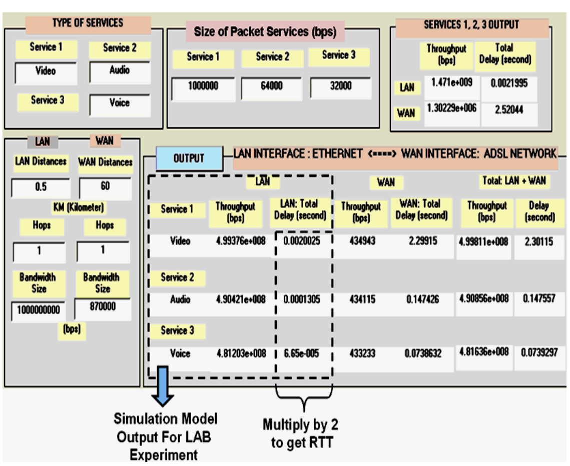

Figure 4.16: Estimation of Network Delay Over 1 Gbps Variables Using ENA

Several experiments have been conducted and we conclude based on our findings, Table 1 and Table 2 show the measurement of network delay and throughput using different type of services such as video, voice, audio and message are able to predict and estimate network delay. Low bandwidth link capacities via LAN and WAN interface can affect network delay for accessing the network.

Table 1: Remote Data Transfer Delay over WAN Using ENA

Number of Hops to Wan Interface = 4; LAN Bandwidth = 100 Mbps and 1 Gbps; WAN: 8.7 Mbps		
Data Transfer Over WAN	ENA Over LAN 100 Mbps	ENA Over LAN 1 Gbps
Simulation WAN Interface: 8.7 Mbps (ideal network)		
Video	540.38 ms	468.37 ms
Audio	35.15 ms	30.542 ms
Voice	17.87 ms	15.573 ms
Message	4.922 ms	4.347 ms

Table 2: Remote Data Transfer Delay over LAN Using ENA

LAN = 100 Mbps and 1 Gbps; Number of Hops = 3; Distances = 0.5 KM		
Type of Services	ENA on ideal environment (100Mbps)	ENA on ideal environment (1Gbps)
Video	80 ms	8 ms
Audio	5.125 ms	0.517 ms
Voice	2.656 ms	0.261 ms
Message	0.645 ms	0.069 ms

This ENA allows administrator to measure and predict multi-links and rescheduling network services to display network activities in a convenient readable format and multi-medium network. ENA application has a straightforward numerical and graphical interface through which administrator can measure network characteristics. Rescheduling network services module is b and size of services based on peak and non-peak hours during students are accessing network services in campus environment. ENA enable network administrators to evaluate and examine the results through multi-links and rescheduling network services by identifying network performance issues. ENA tool can use to help and understand network behavior and traffic patterns generated by multi-links and services (see Figure 4.17, Figure 4.19 and Figure 4.20).

When network utilization rate exceeds the threshold under normal condition, it may cause low transmission speed, intermittence and delay. This ENA tool will alert to administrator if network utilization rate exceeds 80% (see Figure 4.18). Through analyzing and monitoring network utilization rate, we will get an idea whether the network is idle, normal or busy. It also helps network administrator to set proper benchmark and troubleshoot network failures with the network utilization rate at preparation and planning phases.

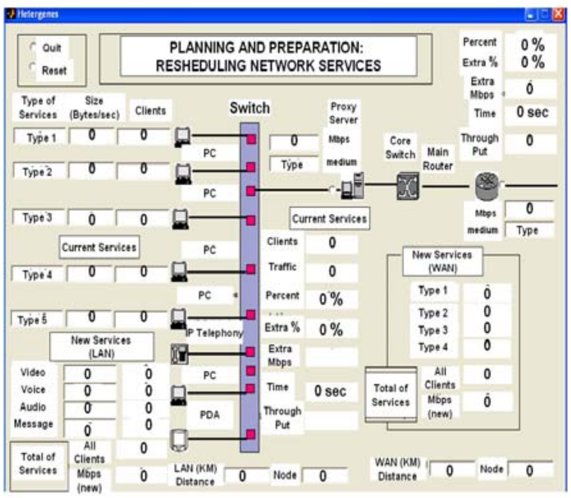

Figure 4.17: Sample of Rescheduling Network Services and Multi-Links in Text Interface for Heterogeneous Services

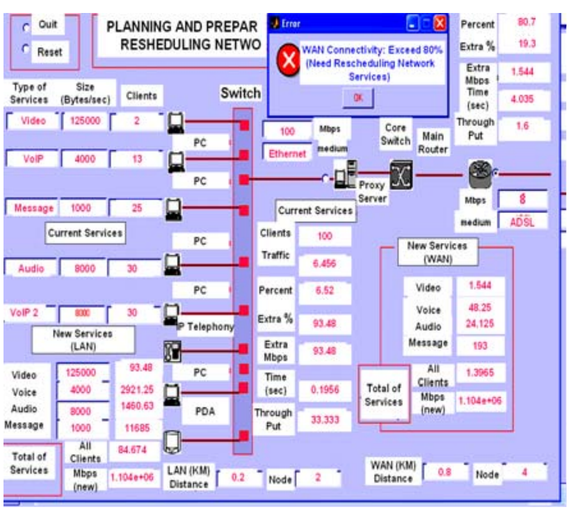

Figure 4.18: Sample of Rescheduling Network Services Output in Text Interface for Heterogeneous Services

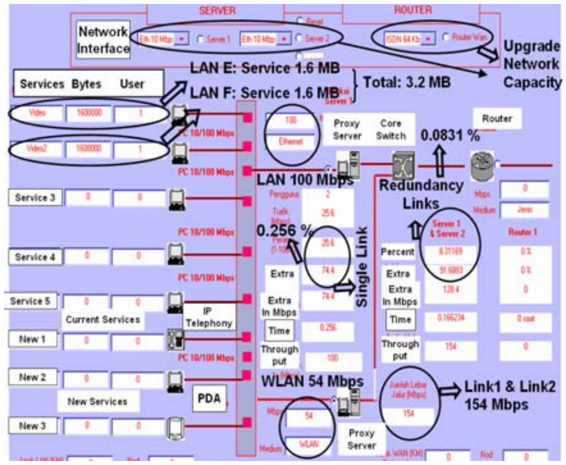

Figure 4.19: Sample of Multi-Links over Local Area Network via ENA

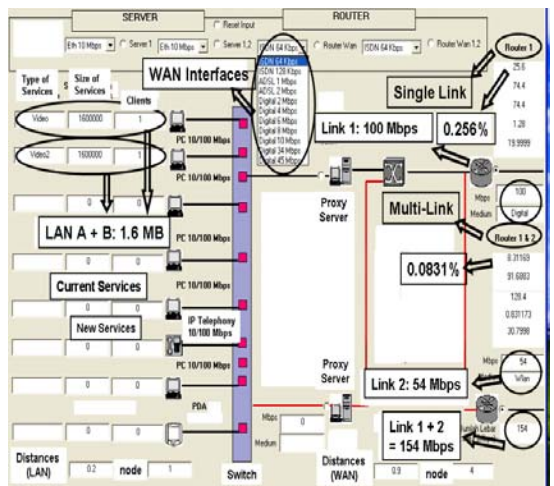

Figure 4.20: Sample of Multi-Links over LAN and WAN via ENA

Hardware Network Analyzer: In this section, we describe the characteristics and functionality of hardware network analyzer. The network analyzers operate on real time environment, without complete network infrastructure this network analyzers unable to predict and measure network characteristics. Figure 4.21 shows the functionality and characteristics of hardware network analyzer. It shows the process of hardware network analyzer operational. Figure 4.22 shows the front panel of network analyzer (e.g. Fluke Optiview), this network analyzer have two network interface ports such as i) 10/100 BASE TX and ii) 100 BASE-FX. In addition, all ports can configure as half duplex or full duplex. Figure 4.23 shows the sample of packet generate using hardware network analyzer that allows administrator to define i) frame size in bytes (maximum rate 1518); ii) frame rate in second (maximum rate 100K); and iii) network utilization in percentage. Some of the hardware network analyzer is also provide throughput testing feature. For example, with the throughput test, it can measure bidirectional data flow between two Fluke Networks' devices to validate LAN and WAN throughput capabilities. The throughput test requires a second device to communicate with on your network. That second device can either be an OptiView Integrated or Workgroup Analyzer, or an EtherScope or OneTouch Network Assistant (see Figure 4.24) [15].

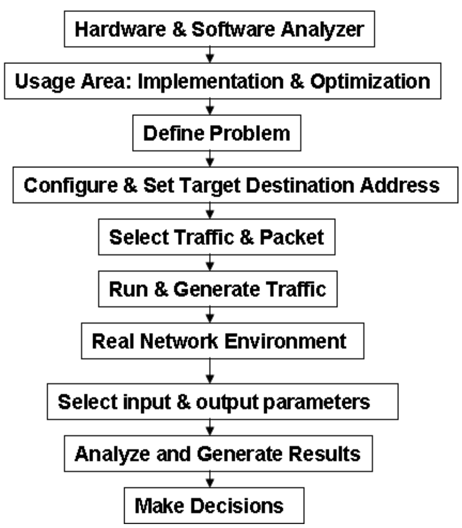

Figure 4.21: Hardware Network Analyzer Operation

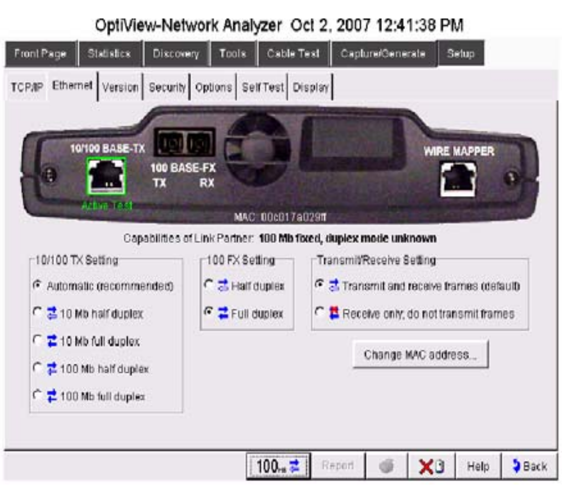

Figure 4.22: Optiview Network Analyzer to Generate Network Traffic

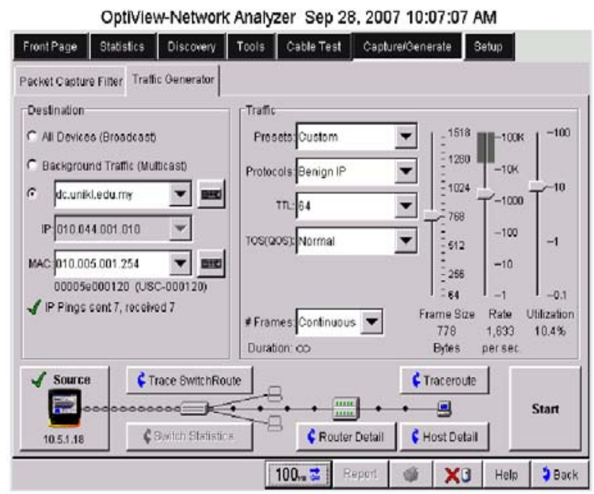

Figure 4.23: Fluke Optiview Engine Setting for Size of Packet Services and Clients

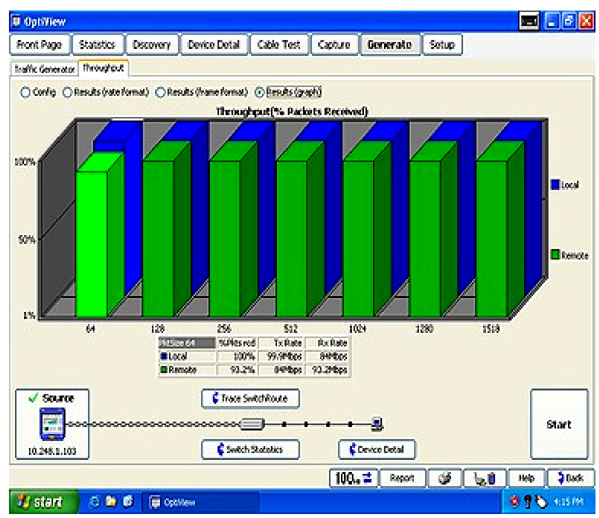

Figure 4.24: Optiview Network Analyzer to Generate Throughput

5. COMPARISON CRITERIA AND FEATURE

We describe why we did not choose to build on existing tools such as OPNET due to complexity; provide a high-level view of the architecture and core components and time to train a technical person [8][13][14]. Emulation Network Analyzer (ENA) is much simpler tool than OPNET and it can be managed by the administrators to measure the network traffic activity. The following features are use to compare two network systems such as ENA tool and hardware network analyzer as follows: i) platforms; ii) user interface; iii) utilities; iv) configuration; v) complexity; vi) costing and others. We conclude and summarize the comparison in Table 3.

Feature and Characteristics	Emulation Network Analyzer (ENA)	Hardware Network Analyzer (Fluke Optiview) [16], [17]
License	Open Source	Benchmark (manufacturer)
Cost	Minimum Cost Investment	High Cost Investment
Complexity	Simple and ease to use	Ease to use
Configuration	Simple and ease to configure	Medium Configuration
Who can use	Small and medium campus network due to low cost	Large campus and industrial network due to high cost
Input Variables	Unlimited	Limited
Functionality	Simulation + Network Analyzer (offline)	Network Analyzer for real environment
Strength	Planning and Preparation	Testing and Troubleshooting
Modeling and Development	Non object oriented approach, GUI interface and use Matlab source code programming.	GUI interface and Benchmark
Efficiently	Highly efficiently for analyzer based on simulation and can analyze virtually (offline) from real world network.	Highly efficiently for real network environment and limited to network interfaces. It needs to have different device for different network interface.
Design	ENA is designed for analyze traffic such as i) network utilization; ii) network traffic; iii) allocate and define minimum bandwidth requirement; iv) upgrading network capacity; v) rescheduling network services and vi) multi-links connectivity and multi-medium networks. The result is not based on run time environment.	Hardware network analyzer is designed for analyze traffic in real network environment. It does not support multi-medium networks interfaces and multi-links. The result is based on run time environment.
Future Enhancement	Extend to congestion, buffer, RAM, CPU and packet loss module.	Depend to manufacturer

6. CONCLUSION

Today's networking environment has become very complex. Networks have been growing in size rapidly and support complex applications. As result, troubleshooting and maintaining networks has become cumbersome and has created the need for new specialized tools. This study focuses on the characteristics and functionality of two different systems and the study conclude that each system has their strength and functionality. Even, our emulation network analyzer system cannot compete with OPNET simulation but it can determine and solve problems for homogenous and heterogeneous services in LAN and WAN such as: i) network utilization; ii) network traffic; iii) allocate and define minimum bandwidth requirement; iv) upgrading network capacity; v) rescheduling network services and vi) multi-links connectivity to LAN and WAN.

This emulation network analyzer is based on offline (non real time) and equivalent with the hardware network analyzer such as Fluke Optiview analyzer. Hardware network analyzer operates based on online (real time) platform and link to real network infrastructure. ENA still in preliminary phase and need further extend to other characteristics or functions. Hardware network analyzer only can be use after the network is under implementation, operation and optimization.

ENA can analyze and predict network behavior during preparation and planning phases. In addition, if we have captured data from network management system such as number of clients and type of services then we can predict the network trend for future planning. It can use to measure and analyze network traffic behavior for preparation and planning purposes. In addition, it is easy to use and provide a user-friendly graphical and text interface. Finally, ENA tool is a good emulation analyzer that can be used in small to medium size networks for campus environment purposes with minimum cost.

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