International Journal of Innovation, Management and Technology, Vol. 1, No. 1, April 2010
ISSN: 2010-0248

Network Analyzer Development: Independent Data, OPNET Simulation Tool and Real Network Comparison

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***Abstract*—This paper presents a complete network analyzer development for heterogeneous services in campus environment. The purpose of this study is to define the accuracy of network analyzer development with independent data, real network and OPNET simulation tool. This network analyzer software will test on traffic and utilization generated by the several services. The reliability of this network analyzer will test with email service, video conference service, VoIP service, and voice conference service. The results show that network analyzer software has accuracy and same trend with independent data, real network and OPNET simulation tool. Finally, this software is able to measure the network resources during preparation, proposal and planning phases.**

***Index Terms*—Accuracy, Traffic, Network Analyzer, OPNET.**

I. Introduction

This study focuses on the accuracy of network analyzer development using heterogeneous services. This study does not intend to perform a comprehensive test the functionality of all simulator and analyzer features. OPNET has originally been developed for network simulation and it is fully usable as a robust and reliability simulation tool with higher investment. This network analyzer development process has discussed detail in [1], [2], [3]. Table 1.1 shows service performance requirement for several services. Service performance requirement consists of delay, capacity (bandwidth) and reliability [4]. Reliability is a measure of the network/system ability to provide deterministic and accurate delivery of information [5], [6]. Table 1.2 shows example of bandwidth capacity requirement for single user [7].

TABLE1.1 Service Performance Requirements

Low= L High=H

Types of Services	Content				Sensitive			
	Teks	Audio	Video	Image	Delay	Jitter	Bandwidth	Reliable
Email	✓	✓	✓	X	L	L	L	H
LMS	✓	✓	✓	X	H	H	H	L
Video Conferencing	✓	✓	✓	✓	H	H	H	L
Online Discussion	✓	✓	X	X	L	L	L	H
Virtual Labs	✓	✓	✓	✓	H	H	H	L
WAP	✓	X	X	X	L	L	L	H
VoIP (IP Telefoni)	X	✓	X	X	H	H	L	L
Virtual Classroom	✓	✓	✓	✓	L	H	H	L

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TABLE1.2 Size of Services Requirement For Single User

Type of Services	Estimation	Size of Services
TV and VoD	HDTV (20 Mbps/ch) TV (5Mbps/ch)	50 Mbps
Video Conference	Less than 2 Mbps	2 Mbps
Web	Less than 10 Mbps	10 Mbps
IP Telephony	Less than 100Kbps	0.1 Mbps
Downloading Data	CD quality: 200 Kbps	0.2 Mbps
Size of Traffic or Bandwidth requirement		62.3 Mbps

II. Definition of Network Analyzer and Simulation

A network analyzer also called a "packet analyzer," "traffic analyzer" and "protocol analyzer," [8]. Network analyzers functionality such as [9]: 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) and vii) monitor bandwidth utilization.

Network Management: Network management consists of a variety of tasks, for example, monitoring, configuration, troubleshooting and planning that are performed by users and network administrators [10]. Network element is a component of the network that can be managed. This includes hosts, routers, switches, hubs and server that can be measured. Examples of end-to-end characteristics for network elements and network traffic are capacity (bandwidth), availability, delay, jitter, throughput, network utilization and error rates [11], [12], [13].

III. Network Analyzer Development Methodology

Figure 3.1 shows network life cycle approach for technologies and services implementation in the future [14]. Network life cycle approach consists of six phases such as prepare, plan, design, implement, operate and optimize. This network analyzer development concentrates more on preparation, planning and proposal areas.

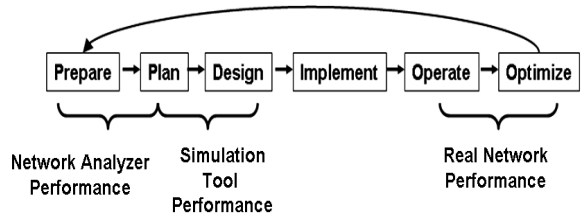

Figure 3.1: Comparison of Network Analyzer, OPNET and Real Network

Network analyzer development is based on mathematical model. We use queuing theory M/M/1 to build this software [15][16][17]. This software was developed to measure and plan network activities such as predict usage of network traffic and network utilization (refer to Figure 3.2).

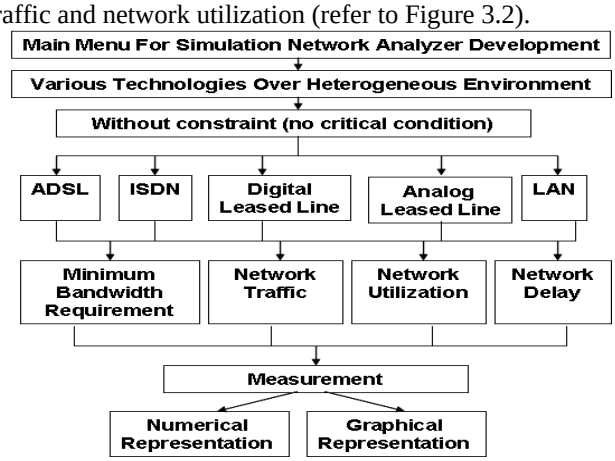

Figure 3.2: Network Analyzer Modules Development

Figure 3.3 shows network analyzer reliability test. The independent data output is generated based on number of users input, size of bandwidth input and size of services input. These inputs will use in OPNET, real network and network analyzer software (refer to Figure 3.4).

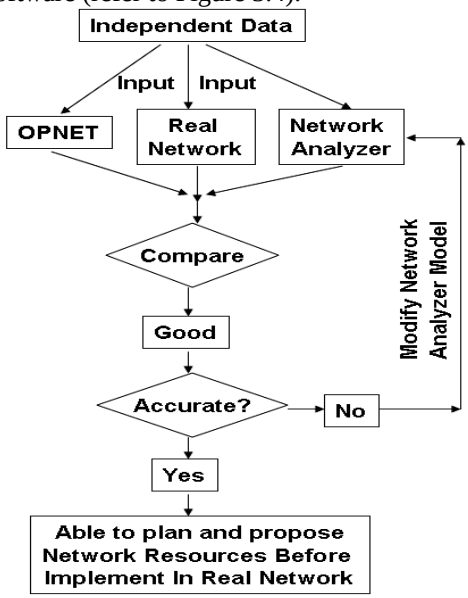

Figure 3.3: Network Analyzer Accuracy Testing Process

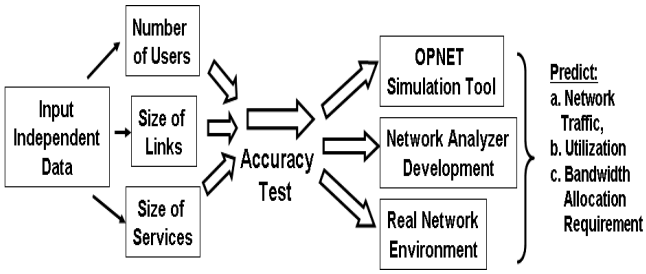

Figure 3.4: Input Parameters for Network Analyzer, OPNET and Real Network

IV. ANALYSIS AND RESULTS

We conduct three experiments to confirm the reliability of network analyzer development via independent data, OPNET application and real network. In our experiments, we will test e-mail service, voice conference service, VoIP service and video conference service. Figure 4.1 show the network traffic and utilization measurement performance via network analyzer software design, OPNET application design and real network design. Table 4.1 shows input for independent data for single user that will be used in network analyzer software, OPNET application and real network.

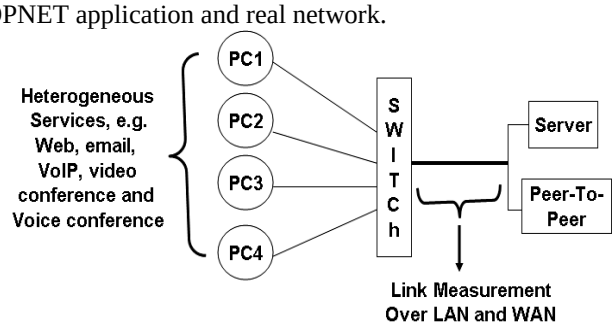

Figure 4.1: Network Design for Reliability Test

Table 4.1: Inputs for Independent Data Use by Single User

Types of Services	Size of Services Estimation
E-mail	50 Kbps
Voice Conference (heavy)	360 Kbps
Video Conference (low)	174 Kbps
VoIP	6 – 64 Kbps

A. Independent Data - Email Service

The first experiment is to test e-mail service with network analyzer development, OPNET application and independent data. Table 4.2 and Table 4.3 shows the amount of network traffic generated by each type of user in each e-mail client [19]. Bandwidth capacity 100 Mbps is used to link between client and server in real network design, OPNET application design and network analyzer design.

Table 4.2: Independent Data: Size of E-mail Service

Activity	Light	Heavy	Very heavy
Messages sent per day	5	20	30
Average message size	50 KB	50 KB	50 KB

Table 4.3: Independent Data: Number of Users and Traffics

Users	Size of Traffic	Total Traffic
	Independent Data	
1	50 Kbps	50 Kbps
2	100 Kbps	100 Kbps
3	150 Kbps	150 Kbps
4	200 Kbps	200 Kbps

Real Network – Email Service: Real network environment has setup to enable email service over LAN. The e-mail traffic will pump using fluke network analyzer to the server. Network management tool is used to capture email traffic and network utilization. Figure 4.2 show real network traffic for email service using by multiple users.

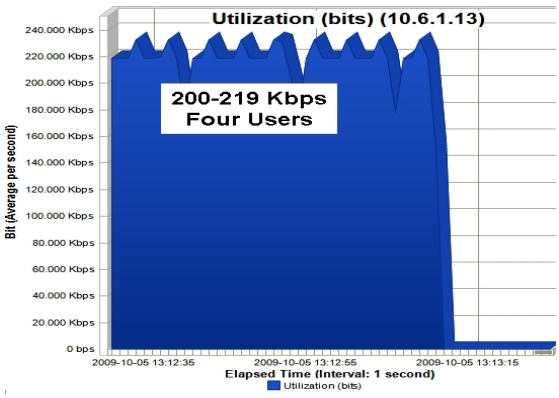

Figure 4.2: Real Network: Email Network Traffic for Four Users

OPNET Application - Email Service Design: OPNET application is used to design and configure email service (refer to Figure 4.3). The link measurement is focused between switch and email server. OPNET email table (refer to Figure 4.4) is used to configure size of email service (50 Kbps) (refer to Figure 4.4).

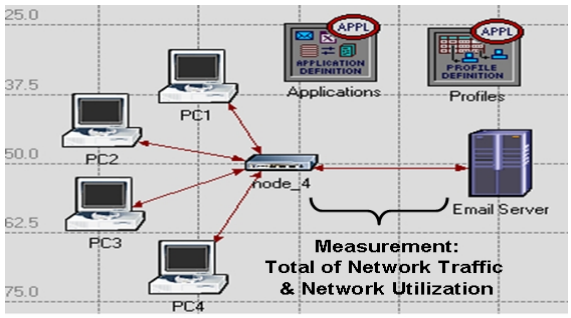

Figure 4.3: Email Service Design Using OPNET

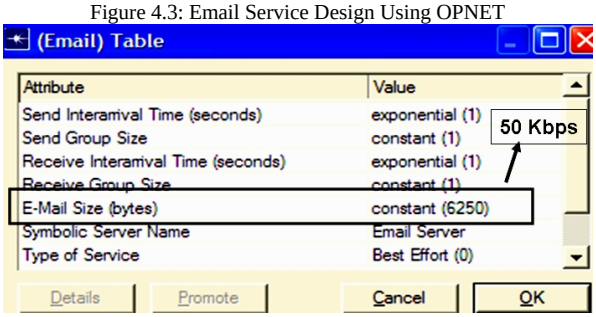

Figure 4.4: OPNET – Configuration of Email Service

Figure 4.5 show the output results generate by OPNET application to measure email network traffic and utilization for multiple users. OPNET application generates email traffic for single user. Then, OPNET will simulate for four users, the results generate by OPNET application shows email traffic and utilization will increase from single user to four users (refer to Figure 4.5). In addition, Figure 4.6 shows size of email service with 50Kbps will generate low network utilization.

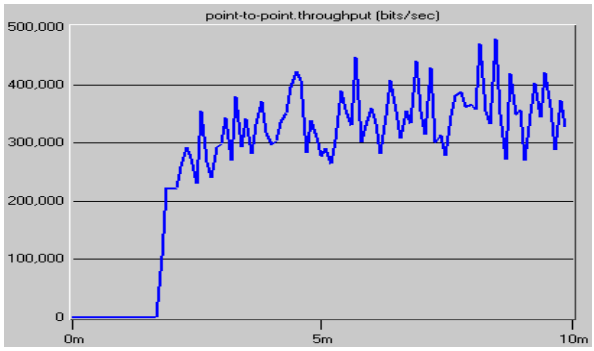

Figure 4.5: OPNET- Email Traffic for Four Users

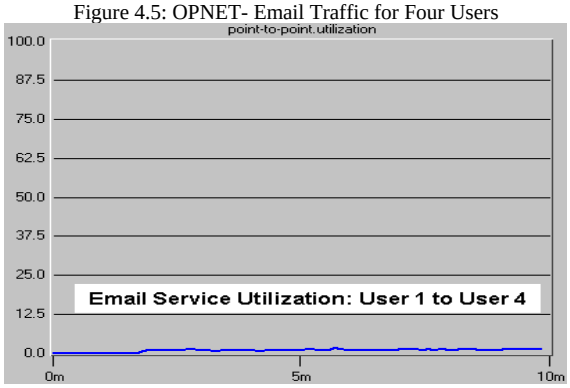

Figure 4.6: OPNET – Network Utilization

Network Analyzer Development – Email Service: Network analyzer is configure using bandwidth 100Mbps, it setup for single and multiple users. Then, network analyzer will execute and generate traffic and utilization. The results show that it generates 0.05 Mbps and 0.05% for single user. Then network analyzer will measure network traffic and utilization for four users (refer to Figure 4.7).

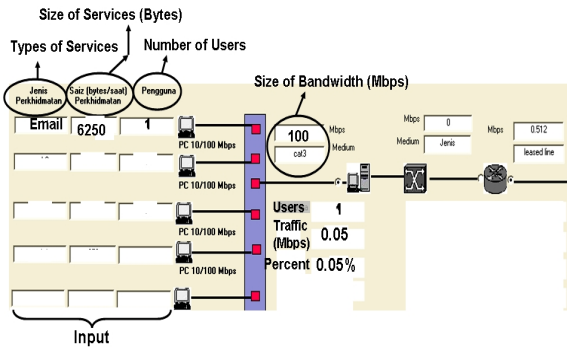

Figure 4.7: Network Analyzer – Email Traffic for Single User

We conclude all our findings in Table 4.4 and Table 4.5. The results generate from network analyzer is closely resemble with OPNET application, real network and independent data. Again, it is confirm and proof that network analyzer development is able to predict and plan network traffic and utilization usage for email service.

Table 4.4: Network Traffic - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	Size of Traffic	Total Traffic	Email (Kbps)	Email (Kbps)	Email (Kbps)
	Independent Data		Opnet	Network Analyzer	Real Network
1	50 Kbps	50	50-65	50	52-54
2	100 Kbps	100	75-100	100	97.152
3	150 Kbps	150	125-145	150	145.728
4	200 Kbps	200	200-300	200	200-219

Table 4.5: Network Utilization - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	Size of Traffic	Email (%)	Email (%)	Email (%)	Email (%)
	Independent Data		Opnet	Network Analyzer	Real Network
1	50 Kbps	0.05	0.05-0.065	0.05	0.052-0.054
2	100 Kbps	0.1	0.75-0.1	0.1	0.098
3	150 Kbps	0.15	0.125-0.145	0.15	0.148
4	200 Kbps	0.2	0.2-0.3	0.2	0.197

B. Independent Data - VoIP Service

This section discuss on VoIP design and configuration to measure the performance of network analyzer development. The most popular size of VoIP codec are G.723 (6 Kbps), G.729 (8 Kbps), and uncompressed G.711 (64 Kbps) [20], [23]. Table 4.6 shows size of VoIP traffic and number of users for independent data. Bandwidth capacity 100 Mbps is used to link between caller and destination in real network design, OPNET application design and network analyzer design.

Table 4.6: VoIP Service – Independent Data

User	Size of Traffic	Codec	Total Traffic
1	64 Kbps	G.711	64 Kbps
2	64 + 8 Kbps	G711 & 729	72 Kbps
3	64 + 8 + 6 Kbps	G711,729 & G723	78 Kbps
4	64 + 8 + 6 + 64 Kbps	G711,729 G723 & G711	142 Kbps

Real Network – VoIP Service: LAN real network environment has setup and configure to enable VoIP service. The voice traffic will pump using fluke network analyzer to the destination. Figure 4.8 shows real network traffic for VoIP service using by multiple users. In addition, Figure 4.9 shows size of voice service with 6 – 64 Kbps will generate low network utilization.

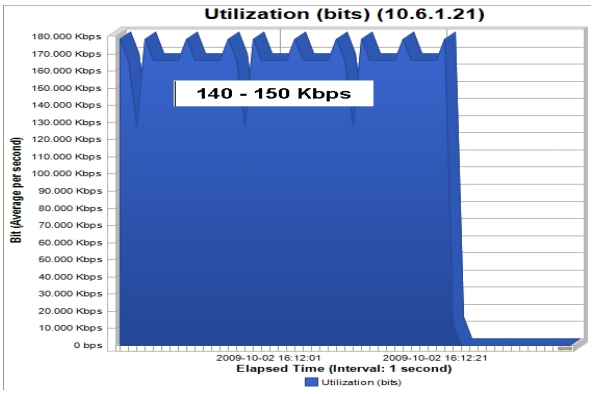

Figure 4.8: Real Network – VoIP Service for Codec G.711, G.729, G.723 and G.711

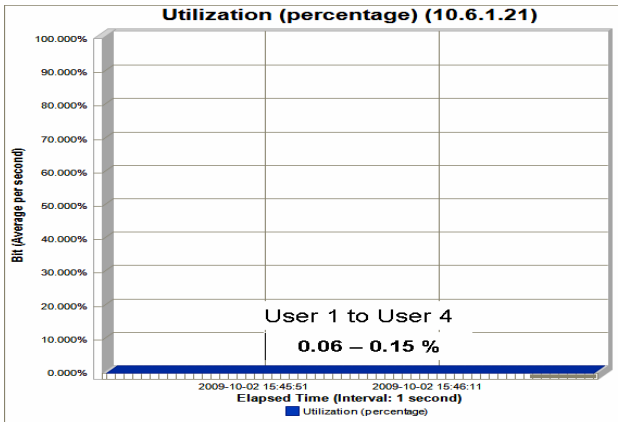

Figure 4.9: Real Network – VoIP Service Utilization

OPNET Application - VoIP Service: Figure 4.10 and Figure 4.11 show the output results generate by OPNET application to measure voice traffic and utilization for single and multiple users. OPNET application generates voice traffic for single user.

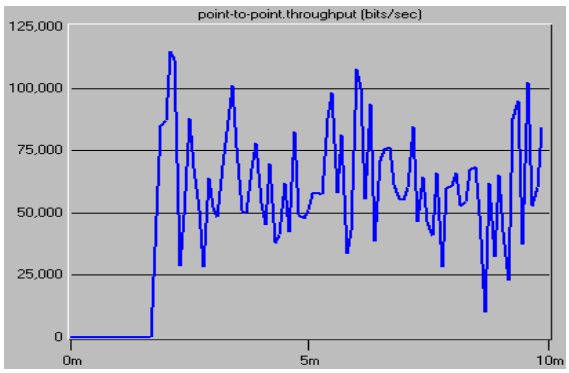

Figure 4.10: OPNET- Voice Traffic for Single User Using G.711

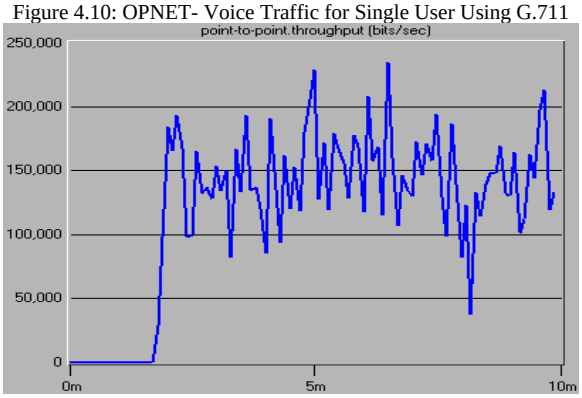

Figure 4.11: OPNET- Voice Traffic for Multiple User Using G.711, G723, G729

Network Analyzer Development – VoIP Service: Network analyzer is configure using bandwidth 100Mbps, it setup for single and multiple users VoIP. Then, network analyzer will execute and generate VoIP traffic and utilization. The results show that network analyzer generates 0.142 Mbps and 0.142% for four users (refer to 4.12).

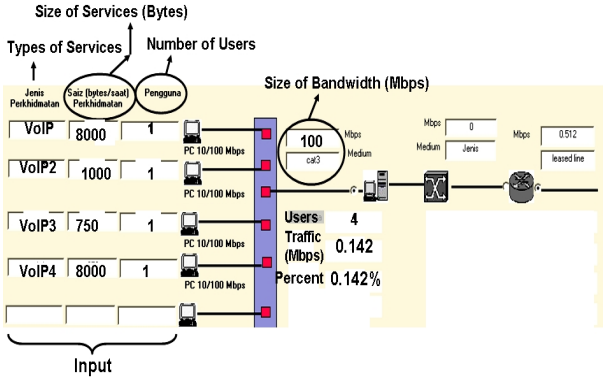

Figure 4.12: Network Analyzer- Voice Traffic and Utilization for Four Users Using G.711, G.723 and G.729

We conclude all our experiment findings in Table 4.7 and Table 4.8. The results generate from network analyzer is closely resemble with OPNET application, real network and independent data. Again, it is confirm and proof that network analyzer development is able to predict and plan VoIP traffic and utilization usage for voice service.

Table 4.7: Network Traffic VoIP- Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	VoIP: Size of Traffic		VoIP (Kbps)	VoIP (Kbps)	VoIP (Kbps)
	Independent Data		Opnet	Network Analyzer	Real Network
1	64 Kbps	64	50 - 75 Kbps	64 Kbps	62 - 68 Kbps
2	72 Kbps	72	50 - 75 Kbps	72 Kbps	73 - 78 Kbps
3	78 Kbps	78	75 - 90 Kbps	78 Kbps	78 - 80 Kbps
4	142 Kbps	142	120-150 Kbps	142 Kbps	140 - 150 Kbps

Table 4.8: Network Utilization VoIP - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	VoIP: Size of Traffic	VoIP (%)	VoIP (%)	VoIP (%)	VoIP (%)
	Independent Data		Opnet	Network Analyzer	Real Network
1	64 Kbps	0.064	0.05-0.075%	0.064	0.062-0.068%
2	72 Kbps	0.072	0.06-0.08%	0.072	0.073-0.078%
3	78 Kbps	0.078	0.07-0.09%	0.078	0.078-0.08%
4	142 Kbps	0.142	0.12-0.15%	0.142	0.14-0.15%

C. *Independent Data - Video Conference Service*

This section discuss on video conference configuration and design to measure the performance of network analyzer development. This independent data evaluates the network bandwidth required for videoconferencing clients. A simple point-to-point videoconference is shown in Figure 4.13. LiveLAN 3.0 uses approximately 174Kbps of bandwidth in each direction when using its 174K bandwidth option [21].

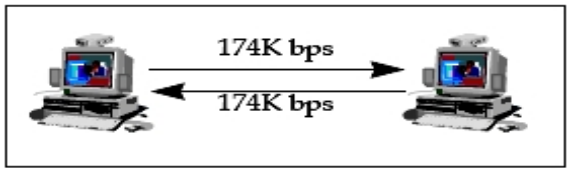

Figure 4.13 - Simple Videoconferencing Session

Table 4.9 indicates the independent data percentage of several link types consumed by a single LiveLAN or NetMeeting session. The real network experiment, OPNET application experiment and network analyzer development experiment only focus on: i) LiveLAN 174 Kbps for single and multiple users (Enet-100); and ii) LiveLAN 384 Kbps for single user (Enet-100).

Table 4.9 – Video conference – Utilization of Network Link

	Enet-10 Shared	Enet-10 FD	Enet-100 Shared	Enet-100 FD	T1 FD	T3 FD
NetMeeting	1.28%	0.64%	0.13%	0.06%	4.12%	0.14%
LiveLAN 174K	3.48%	1.74%	0.35%	0.17%	11.27%	0.39%
LiveLAN 384K	7.68%	3.84%	0.77%	0.38%	24.87%	0.86%
Intel Internet Video Phone	TBD	TBD	TBD	TBD	TBD	TBD

Real Network – Video Conference Service: Real video conference service has setup and configures to capture video traffic. The video conference traffic (180 Kbps with 1 frame) will pump using fluke network analyzer to the destination. Figure 4.14 shows real video conference traffic for multiple users (4 users - 700 Kbps). Second experiment shows real video conference with high traffic for single user is 390 Kbps. Video conference traffic utilization will increase depend on size of video conference and number of client's usage (refer to Figure 4.15).

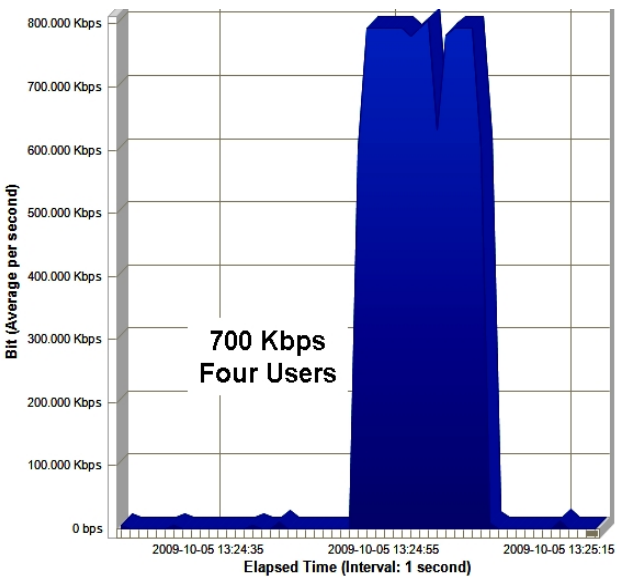

Figure 4.14: Real Network – Video Conference Traffic for Four Users

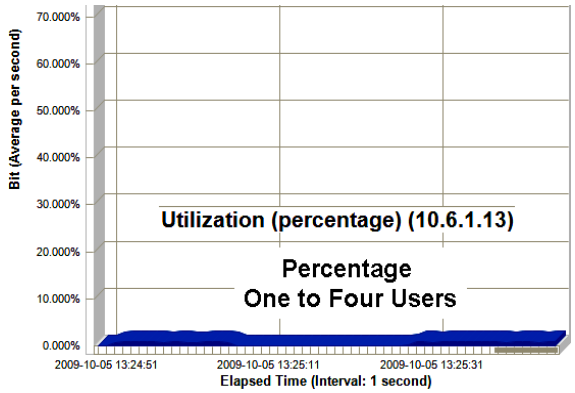

Figure 4.15: Real Network – Video Conference Traffic for Four Users

Network Analyzer Development – Video Conference Service: Network analyzer is configure using bandwidth 100Mbps, it setup for single and multiple video conference users. The results show that it generates 0.174 Mbps and 0.174% for single user. Then network analyzer will measure video conference traffic and utilization for four users (refer to Figure 4.16).

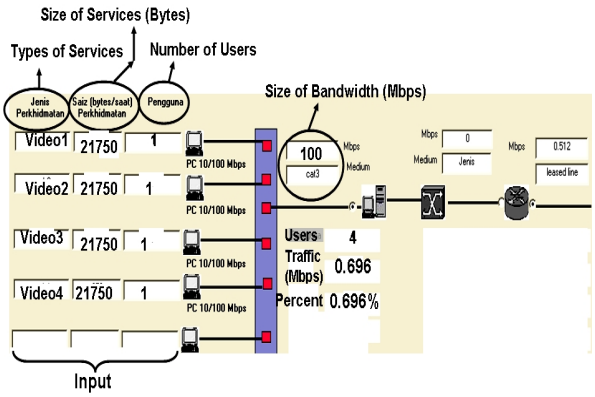

Figure 4.16: Network Analyzer- Video Traffic and Utilization for Four Users

OPNET Application – Video Conference Service: Figure 4.17 shows video conference network design using OPNET application with 100 Mbps link. OPNET application will configure 21800 bytes to support video conference service. By default OPNET application is set to transmit with 10 frames. Therefore, size of video conference traffic will generate 218000 bytes (21800 bytes x 10 frames) (refer to Figure 4.18). Real network experiment and network analyzer development is set to one frame only.

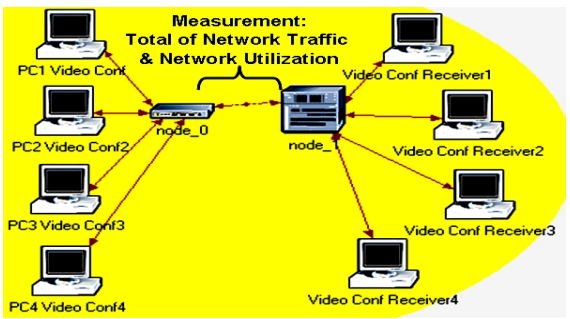

Figure 4.17: OPNET Application - Video Conference Network Design

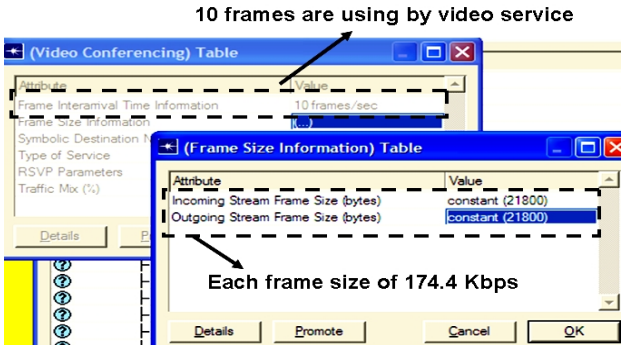

Figure 4.18: OPNET Application – Size of Video Conference Service

Figure 4.19 shows the output results generate by OPNET application to measure video conference traffic and utilization for multiple users. OPNET application generates video traffic for single user is 1.750 Mbps (10 frames) or 175 Kbps (one frame). Then, OPNET will simulate for four users is 5.5 Mbps (10 frames) or 550 Kbps (one frame), the results generate by OPNET application shows video traffic and utilization will increase from single user to four users (refer to Figure 4.20).

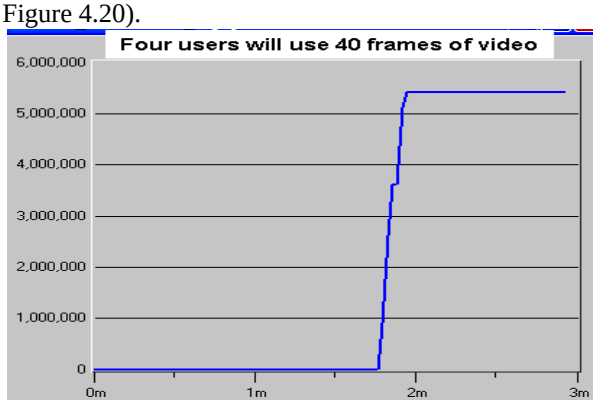

Figure 4.19: OPNET Application – Video Conference Traffic for Four Users

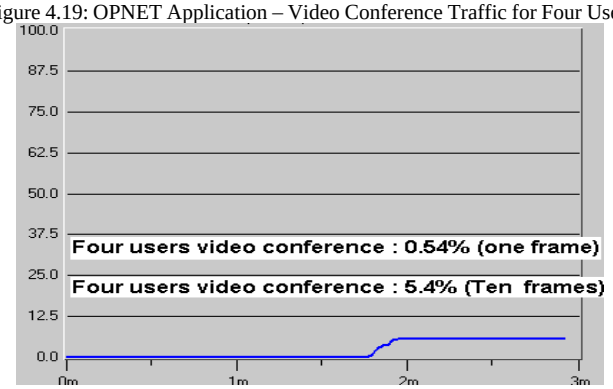

Figure 4.20: OPNET Application – Video Conference Utilization for Four Users

We conclude all our experiment findings in Table 4.10 and Table 4.11. The results generate from network analyzer is closely resemble with OPNET application, real network and independent data. Again, it is confirm and proof that network analyzer development is able to predict and plan video traffic and utilization usage for video conference service.

Table 4.10: Video Conference Traffic (One Frame) - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	Video Conference Size of Traffic	Total Traffic	Video (Kbps)	Video (Kbps)	Video (Kbps)
	Independent Data		Opnet	Network Analyzer	Real Network
1	174 Kbps x 1	174	180	174	180
1	384 Kbps x 1	384	397	384	390
2	174 Kbps x 2	348	190	348	340
3	174 Kbps x 3	522	522	522	534
4	174 Kbps x 4	696	541.4	696	700

Table 4.11: Video Conference Utilization (One Frame) - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	Video Conference Traffic	Video (%)	Video (%)	Video (%)	Video (%)
	Independent Data (Kbps)		Opnet	Network Analyzer	Real Network
1	174 x 1	0.174	0.1804	0.174	0.18%
1	384 x 1	0.384	0.397	0.384	0.39%
2	174 x 2	0.348	0.19	0.348	0.34%
3	174 x 3	0.522	0.522	0.522	0.53%
4	174 x 4	0.696	0.5426	0.696	.0.7%

D. Independent Data - Voice Conference Service

The next experiment is to test voice conference service using network analyzer development and to confirm this software able to measure heterogeneous service. Bridgit software is selected to use as *independent* data for voice conference. Table 4.12 shows the amount of voice conference traffic needs by each client [22]. Bandwidth capacity 100 Mbps is used to link between client and server in real network design, OPNET application design and network analyzer design.

Table 4.12: Independent Data – Bandwidth Requirement for Single and Multiple Voice Conference Users

One shared screen with a 1024 × 768 resolution	60 kbps
One open microphone using the standard quality setting	45 kbps × 4 = 180 kbps
One open webcam with moderate activity	30 kbps × 4 = 120 kbps
Total bandwidth required per user (180 kbps + 120 kbps + 60 kbps)	**360 kbps**
Total bandwidth required for all users (135 kbps × 4 users)	**1440 kbps or 1.4 Mbps (megabits per second)**

OPNET Application - Voice Conference Service Design: OPNET application is used to design and configure voice conference service (360 Kbps) (refer to Figure 4.21). The link measurement is focused between switch and voice conference destination. Figure 4.22 shows the output results generate by OPNET application to measure voice conference traffic and utilization for multiple users. OPNET application generates voice conference traffic for single user is 210 - 303 Kbps. Then, OPNET will simulate for four users voice conference, the results generate by OPNET application shows voice conference traffic is 1250 - 1480 Kbps.

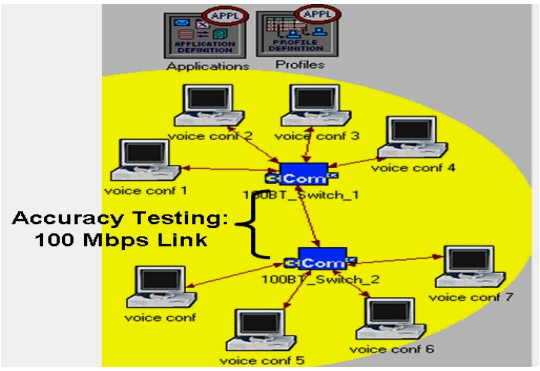

Figure 4.21: OPNET – Voice Conference Network Design

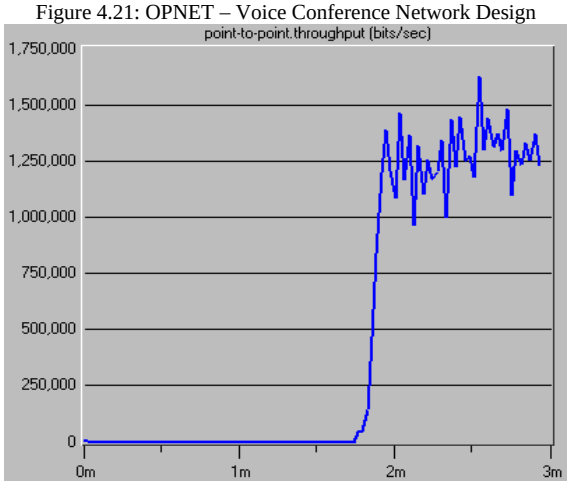

Figure 4.22: OPNET- Voice Conference Traffic for Multiple Users (4 Users)

Real Network – Voice Conference Service: Real voice conference service has setup and configures to capture network traffic. Figure 4.23 shows real voice conference traffic for multiple users (1440 Kbps). In addition, Figure 4.24 shows size of voice conference service with 360 Kbps will generate low network utilization.

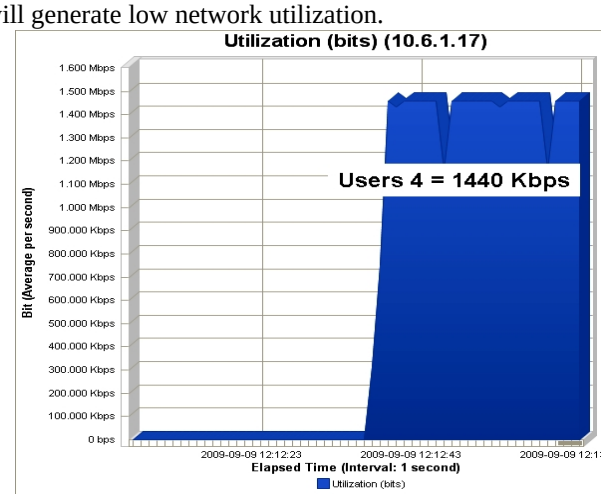

Figure 4.23: Real Network – Voice Conference Traffic for Four Users

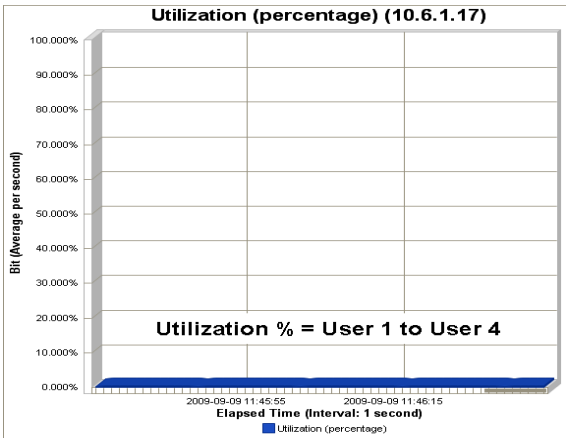

Figure 4.24: Real Network – Voice Conference Traffic Utilization

Network Analyzer Development – Voice Conference Service: Network analyzer is configure using bandwidth 100Mbps, it setup for single and multiple voice conference users. Then, network analyzer will execute and generate voice conference traffic and utilization. The results show that it generates 0.36 Mbps and 0.36% for single user. Then network analyzer will measure voice conference traffic and utilization for four users (refer to Figure 4.25). We conclude all our experiment findings in Table 4.13 and Table 4.14. Again, it is confirm and proof that network analyzer development is able to predict and plan voice conference traffic and utilization usage for single and multiple users.

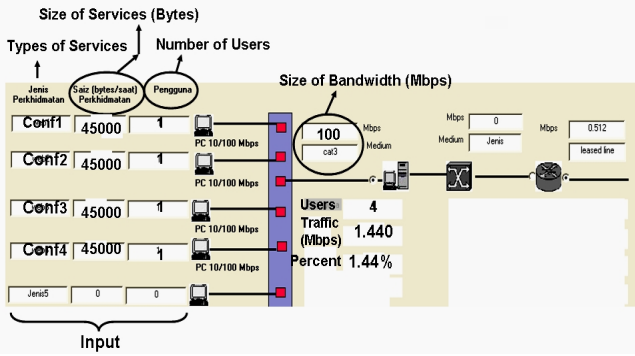

Figure 4.25: Network Analyzer Development – Voice Conference Traffic and Utilization for Four Users

Table 4.13: Voice Conference Traffic - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	Voice Conference Traffic	Total Traffic	Voice (Kbps)	Voice (Kbps)	Voice (Kbps)
	Independent Data (Kbps)		Opnet	Network Analyzer	Real Network
1	360 x 1	360	210 – 303	360	364.3
2	360 x 2	720	650 - 760	720	729
3	360 x 3	1080	850 - 1098	1080	1129
4	360 x 4	1440	1250 - 1480	1440	1457

Table 4.14: Voice Conference Utilization - Reliability of Network Analyzer Development between Opnet, Independent Data and Real Network Using 100 Mbps

User	Voice Conference Traffic	Voice (%)	Voice (%)	Voice (%)	Voice (%)
	Independent Data		Opnet	Network Analyzer	Real Network
1	360 Kbps	0.36	0.20-0.3%	0.36%	0.36%
2	720 Kbps	0.72	0.70-0.85%	0.72%	0.73%
3	1080 Kbps	1.1	0.85-0.99%	1.08%	1.12%
4	1440 Kbps	1.44	1.3-1.5 %	1.44%	1.46%

V. CONCLUSION

Today's networking environment has become very complex. Networks have been growing in size rapidly and support complex applications. Even, our network analyzer development can determine and solve problems for homogenous and heterogeneous services in LAN and WAN such as: i) network utilization; and ii) network traffic. The results show that network analyzer development is able to measure and analyze approximately same as OPNET simulation tool, independent data and real network. This network analyzer development 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.

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