Performance Analysis of Secured VoIP Local Area Network

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Abstract— Session Initiation Protocol (SIP) is one of the Voice over IP (VoIP) protocols. This paper outlines secured SIP based Local Area Networked (LAN) phone system at Melbourne Institute of Technology (MIT), one of the biggest private higher educational provider in Victoria, Australia. SIP is used as a Private Branch Exchange (PBX), which is central telephone system within organization. The LAN setup has been simulated using OPNET to measure jitter and packet loss. Performance analysis shows that jitter and packet loss are acceptable, even server load is high. Analysis of energy consumption is also presented in this paper.

Key-Words:- VoIP, SIP, VPN, Quality of Service, router, switch

1 Introduction

Melbourne Institute of Technology (MIT) [1] is a leading private higher educational provider in Victoria, Australia. MIT is planning to setup cost effective and an efficient Voice Over IP (VoIP) phone system. This paper explains plan, design and implementation of VoIP networking lab. The planned network consists of PCs, servers and other networking components.

The Network consists of wireless routers as well, which gives access to remote users via their laptops to access the server. The network also has necessary security measures such as Virtual Private Networks for remote users, access control lists, Syslog server, and Cisco IOS firewall. Session Initiation Protocol (SIP) based server and client VoIP service is used. Each workstation has a SIP client installed and SIP server is configured to enable voice calls.

Section 2 gives background of SIP and its performance factors. Section 3 outlines software and hardware setup. A cost effective and an efficient networking laboratory infrastructure for research and teaching purpose is presented in the section 4. Performance analysis of the network using OPNET is also explained in section 4. Section 5 concludes the paper.

2 Background

MIT has two campuses: Melbourne and Sydney. Melbourne is a main campus. The cost of phone calls between interstate campuses for medium scale company is huge. Voice Over IP (VoIP) is a new technology which can be used over internet with less expensive [2] [3]. There are four main VoIP protocols, namely H.323, Media Gateway Control Protocol (MGCP), Session Initiated Protocol (SIP) and Skinny Call Control Protocol (SCCP) [4]. Private Branch Exchange (PBX) is used in most of the business to transfer calls internally. There are 4 types of PBX phone system: PBX, virtual PBX, IP PBX and virtual IP PBX. SIP can be referred as a IP PBX, which is based on software based IP phone system. Therefore we have used SIP server for a VoIP service in this paper.

2. 1 Usability

This section outlines the usability of the system. There are different users such as students, lecturers, technical administrator, receptionist, service support who are using the system for different purposes. The Fig. 1 identifies the communication between entities and the VoIP system.

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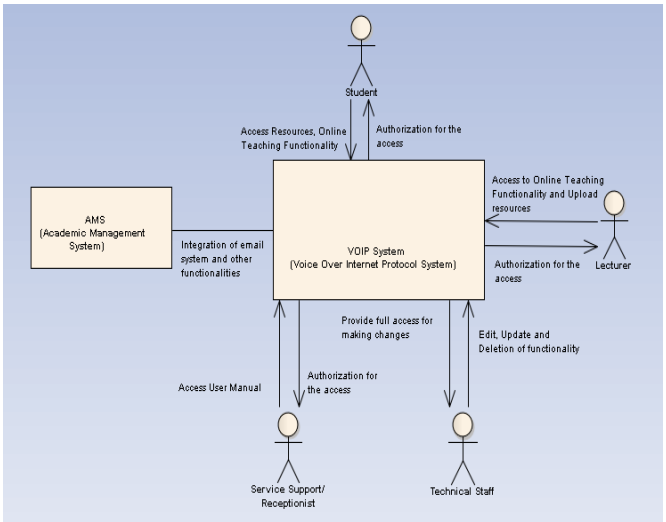

Fig. 1 VoIP system and external entities interaction

Initially the entities shown in the Fig. 1 are considered as external entities until they are verified with authentication process. The students of MIT are the main entities who will be most benefit from this VoIP system. There are different features available to the students in the VoIP system which includes their learning procedure such as online teaching, discussion forum, access to academic videos and post their comments on the course. They can access their course material, work on their exercises & questionnaires and submit their assessments. Using the online video teaching functionality, students and instructors can communicate online from anywhere in the world.

Instructors are classified as sessional and permanent, where permission level varies to access the resources and upload the contents of the courses to the students. Permanent lecturers have full access, whereas sessional lecturers can only access their respective subject folders.

Administrative staff also access VoIP system for effective communication. Technical staff will be responsible for the maintenance of the VoIP system, so they will have full privilege to update, delete and make any changes. Receptionist can access the calls and transfer them to the right person using the VoIP PBX. Service support is responsible to guide any user who requires any sort of help using the functions of the system as they will have access to the user manual.

The VoIP system also integrates with the Academic Management System (AMS) of MIT. The integration of email system or other functions of AMS with VoIP system help MIT to run system with cost reduction in an effective and efficient manner.

2.2 Performance factors

The performance of VoIP service can be measured in terms of the following performance factors:

- Delay or latency: It is a time taken for a voice packet to reach destination. The maximum one-way delay should not exceed 20 ms, or 40 ms round-trip time (RTT). Latency is depending on transmission medium. To reduce delay or latency increase bandwidth, choose a different codec type, or fragment data packets.
- Jitter: Packets arrive at destination with variable delay. Jitter depends on the congestion of the network. Jitter can be reduced by prioritizing voice packets.
- Packet loss and errors: Voice packets are very important and should not be lost. To reduce packet loss and errors, voice traffic should be priotised by using an appropriate codec and need sufficient bandwidth.
- Bandwidth: The general rule for sufficient bandwidth is to overprovision and under-subscribe. For bandwidth calculation include voice payload, packet overhead, and actual voice data.
- Quality of Service QoS is a mechanism of priotise voice traffic.

Another performance factor includes energy consumption. A fundamental step to improve energy consumption is through performing an energy audit [10]. An energy audit is a systematic gathering and analysis of information that is used to determine the energy efficiency of a specific process. There are three levels of audits as described by the Australian and New Zealand standard AS/NZS 3598:2000 [10]. A walk-through audit is one type of energy audit that is used to collect energy data, review energy bills, and compare the facility's unit energy consumption with facilities using similar processes. Equipment audits, such as lightning, heating, ventilating and air conditioning (HVAC) audits are performed by walk-through audit. As far as data center energy audit is concerned, a set of recommendations based on a balance of what produces the greatest savings and requires the least up-front investment.

The simplest tool that available in the current market is "Kill a Watt" device [10]. It has the ability measure followings such as: Voltage (volts), Current (amperes), Watt, Kilowatt-hours (kWh), Frequency (Hz), Volt-Amperes (VA), Power factor (PF) and Elapsed time.

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3 Software and Hardware Setup

This section gives requirements of software and hardware, including router and switch models.

Software includes: Server 2008, VMware, Linux, Windows XP, backtrack Linux, ADIOS, SIP server, application softwares: Opnet [5], Packet tracer, Network Simulator, GNS3, PhySim, NetSim.

Hardware includes: PC with Windows XP, Dell Server with 12GB RAM, 240GB hard disk, quad core CPU, routers (CISCO3825, CISCO2811, Cisco 1811W Wireless) and switches (Catalyst 3560 PoE, Catalyst 3750) [6]. Total cost of lab equipment is about AUD160K as shown in table 1.

Server's base operating system is Windows Server 2008. VMware workstation is installed on top of Server 2008. Various operating systems such as Linux, Windows XP, backtrack Linux, ADIOS, SIP server are installed on VMware. Application software's such as Opnet, Packet tracer, Network Simulator, GNS3 etc are installed on relevant operating system. Norton Ghost for Server 2008 is used to create PC operating system including the applications and made available to push the image to PCs whenever required. All router and switch images are stored on server, so that it can be restored or pushed on devices whenever needed.

4 Laboratory Setup and analysis

This section outlines an efficient space utilization and user friendly room setup for teaching and research purpose. As shown in Fig. 2, there are four tables, each table has 3 switches and 3 routers (including one wireless router), and 6 PCs. All devices on each table are interconnected each other through straight through cable from PCs to switch, fast ethernet cable between router and switch and serial cable between routers. One switch of each table is connected to a core switch (4503E), then to main server. Server has been configured with various applications such as SIP, packet tracer, GNS3, NetSim, PhySim etc. Security features such as VPN has been installed on server.

For simulation and analysis purpose, we have used audio data and professional version of OPNET Guru.

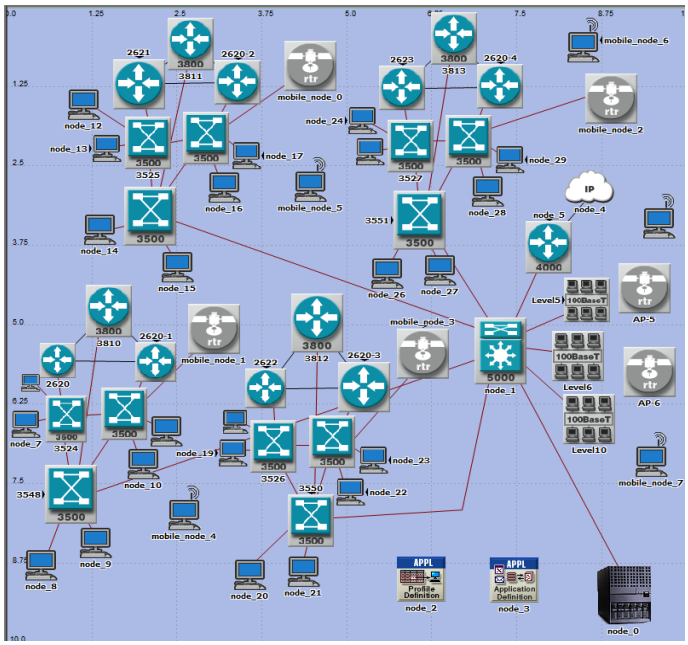

Fig. 2 Network Plan

The proposed network has been simulated using OPNET IT GURU [5]. OPNET is a software provides plan, design and solutions to application management. Perormance analysis of jitter, packet delay, bandwidth and server load have been explained in this section.

Fig. 3 shows the jitter values in seconds. The peak value is 0.008 seconds. Which is acceptable since it a small lab with few numbers of workstations [7].

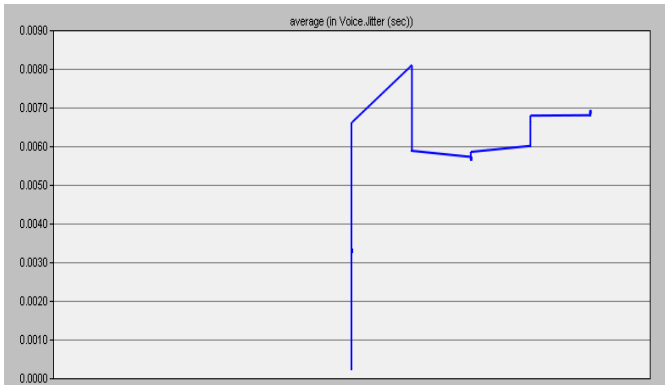

Fig. 3 Jitter in Seconds

The Fig. 4 shows voice packet delay in seconds. It varies between 0.15 to 0.40 seconds. These values are bit high because of wireless components, which add some more delay [8].

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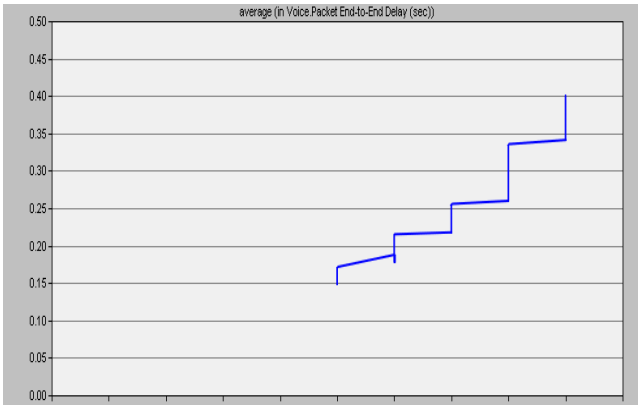

Fig. 4 Packet Delay in Seconds

The two graphs in Fig. 5 show bandwidth between server and clients in bits/sec. The peak value for uplink bandwidth is 4.5 Mbps and downlink bandwidth is 20 Mbps.

Server performance in requests/sec is represented in Fig. 6. The highest value goes up to 1.7 requests/sec. The network has more number of components such wireless routers and access points [9].

Energy Audit Analysis

For energy audit, all the necessary measurement data were collected. The equation is used to calculate total energy is [10]:

Watts * number of hours per day = watt-hours per day; * number of days per year = watt-hours per year; ÷ 1,000 = kWh per year.

Example of first room parameters which are taken for energy audition is given in the table 2.

TABLE 2
EXAMPLE OF FIRST ROOM ENERGY AUDIT PARAMETERS

Room	Server room 1
Quantity	1
Wall Colour	White
Entry Point	1
Windows	0

TABLE 3
ENERGY MEASUREMENTS OF ROOM 1

Items	Qty	Usage(W) Rating	Hour	Days	Total (kWh) Day	Total (kWh) Year
G	3	1200	24	7	86.4	31536
AC	2	200	24	7	9.6	3504
L1	10	75	8	7	6	2190
Ro	5	250	24	7	30	10990
Sw1	5	200	24	7	24	8760
Sw2	10	200	24	7	48	17520
RS1	10	37	24	7	43.2	15768
					Total	90268

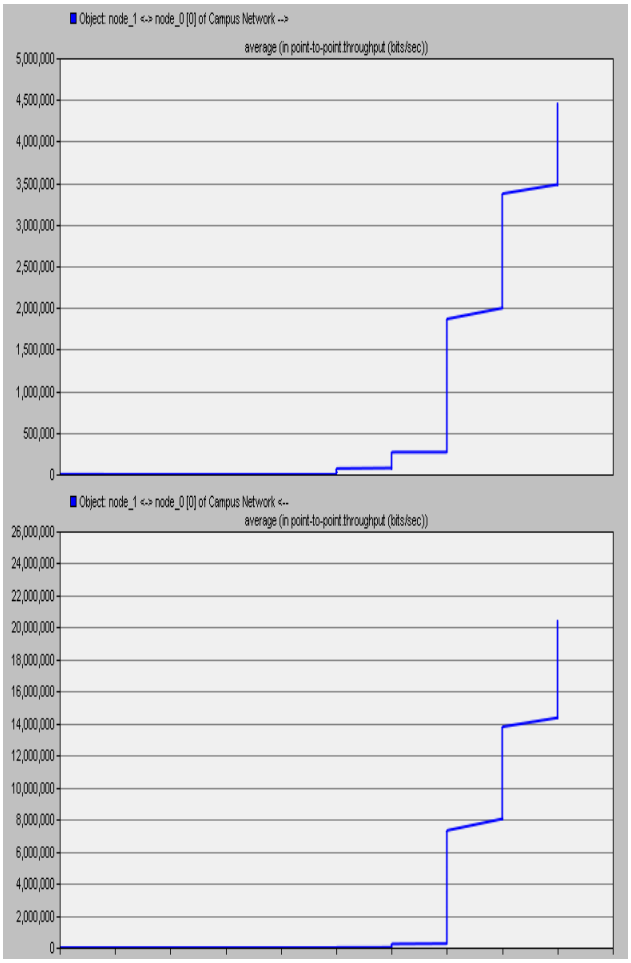

Fig. 5 Uplink and downlink bandwidth (bits/sec)

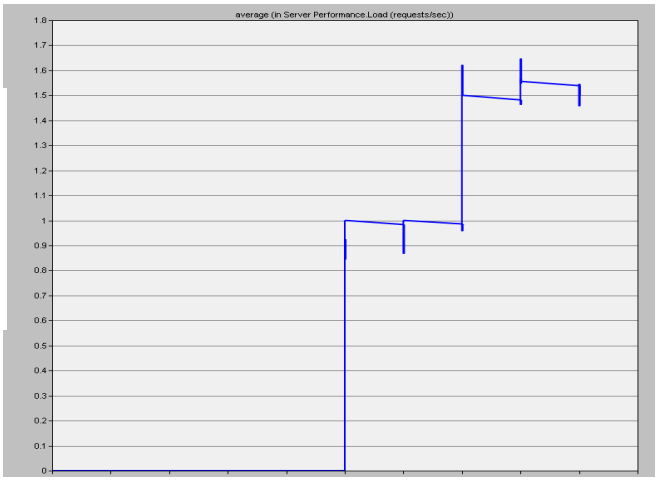

Fig. 6 Server Performace (request/sec)

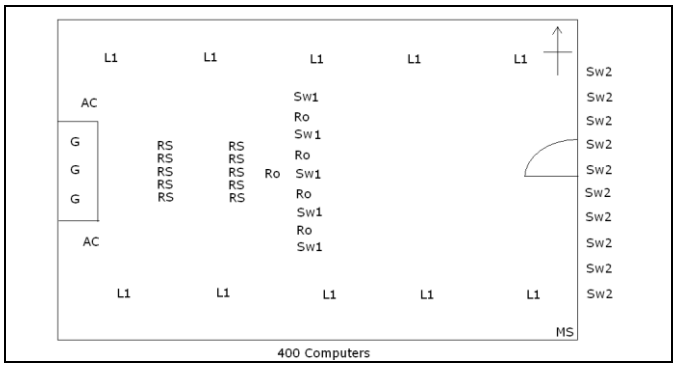

Fig. 7 Energy Audit Space Diagram

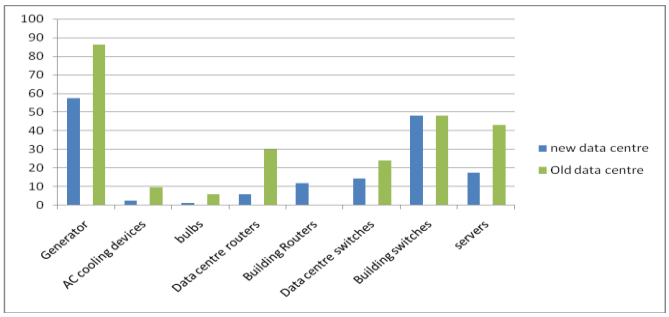

Fig. 8 Comparison of energy consumption per day in KWatt.

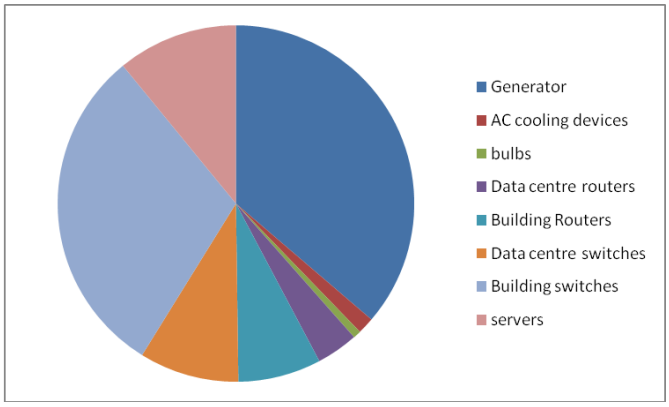

Fig. 9 New Data centre Energy consumption per day (KWH).

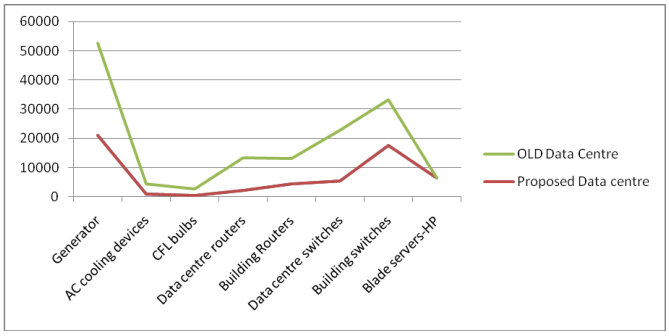

Fig. 10 Comparison between Old and Proposed data centre yearly energy consumption kWph .

Fig. 7 shows energy space diagram, where G: Generators, AC: AC cooling devices, L1: Normal bulbs, RS: Routers, SW: Switch, MS: Manual Switch, RS: Server. Collected data from room 1 is given in table 3. We have compared this table with old data centre room. Fig. 8, 9 and 10 show the comparison of these two data. Graphs 8 and 9 show energy consumption per day. These graphs show that our proposed laboratory set up is better than old lab setup, in terms of energy consumption as well.

5 Conclusion

This paper presents performance analysis of a secured local area networked Voice Over IP (VoIP) service. The simulated results show that the proposed network is efficient in terms of jitter, packet delay server load and energy consumption. Future plan is to work on the practical implementation of laboratory setup and test in a wireless environment as well.

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TABLE I
ESTIMATED COST OF NETWORKING LAB EQUIPMENTS

Item Description	Qty	Price / each	Total Price
Routers			
CISCO3825 including modules 2 port serial, 2 port FXS, 2 port E1, PVDM16	4	$6500.00	$ 26000
CISCO2811 including modules 2 port serial, 2 port FXS, 2 port E1, PVDM16	8	$3700.00	$ 29600
CISCO1811W Wireless Router	4	$1400.00	$ 5600
Switches			
Catalyst 3560 PoE, 24 port	4	$2200.00	$ 8800
Cisco Catalyst 3750 48 Port Switch	9	$3000.00	$ 27000
Cables			
Cat 6- 350m		$2/m	$ 700
Console cable	25	$15.00	$ 375
V.35 Serial	12	$50.00	$ 600
Phones			
Analog	24	$30.00	$ 720
IP Phones 7960	8	$180.00	$ 1440
Accessories			
Bluetooth dongle	4	$20.00	$80
RJ45 pieces- 200			$10
Cabinet	5	$200.00	$1000
Netgear WG111v2 Wireless	4	$30.00	$120
Tables, Chairs, power points			$4000
All-in-one modular crimp tool	5	$50.00	$200
Server	1	$2500.00	$2500
Computers	25	$2000.00	$50000
Softwares – VMWare, Windows 2008	1	$300.00	$300
		Total	$159045

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