Simulation Study of eLearning Classroom using iPads Based on Wireless LAN with IEEE 802.11b

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Abstract - *This paper presents a simulation study of eLearning classroom using iPads as mobile devices based on the wireless LAN with IEEE 802.11b protocol. Moreover, this paper presents a simulation study whether the IEEE 802.11b can support up to 25 iPads of the eLearning classroom without fairness problems on a shared Wireless LAN. The simulation is performed by OPNET IT Guru Academic Edition 9.1.*

Keywords: Wireless Lan(WLAN), OPNET 9.1, IEEE 802.11b, iPads

1 Introduction

The iPad was selected by Time Magazine as one of the 50 Best Inventions of the Year 2010.[2] while Popular Science chose it as the top gadget.[3] behind the overall "Best of What's New 2010" winner Groasis Waterboxx.[4] The iPad has already several uses in the classroom, and has been praised as a valuable tool by many teachers. When the iPad first came out, Duke University created an application that provided students with a campus map, contact numbers, and other helpful information.

How can a professor utilize the iPad in their classroom? Well, a professor can keep their lecture notes on the iPad. They do not need to carry a ton of books and notes from class to class. The iPad can also be plugged into a projector. The professor, instead of having the students find something, can project the image onto a screen for the whole class to see. If a professor becomes sick, they can go back to past class's lectures and post them on the application, so the class do not fall behind schedule.

Wireless local area networks(WLANs), which are based on the IEEE 802.11 standard, are now very popular and one of the fast growing wireless access technologies in the world today. We can easily find many places such as cafes, bookstores, airports, and campuses.[5] WLANs provide an effective means of achieving data connectivity without constraints of physical wires in public places, offices, and campuses. The rest of the paper includes brief review to the background work, design and the results of the performance simulation environment, simulations evaluation experiments. Lastly, section 6 summarizes the paper and describes ongoing work.

2 Background Work

2.1 Web/Protocol

Three communication protocols, which are IP, TCP, and HTTP, are dominant to the today's web. The Internet Protocol (IP) is the principal communications protocol used for relaying datagrams (packets) across an internetwork using the Internet Protocol Suite. Responsible for routing packets across network boundaries, it is the primary protocol that establishes the Internet. IP is the primary protocol in the internet layer of the Internet Protocol Suite and has the task of delivering datagrams from the source host to the destination host solely based on their addresses.[9] For this purpose, IP defines addressing methods and structures for datagram encapsulation.

The Transmission Protocol(TCP) is complementing the IP, and therefore the entire suite is commonly referred to as TCP/IP. TCP provides reliable, ordered delivery of a stream of bytes from a program on one computer to another program on another computer. TCP is the protocol that major internet applications rely on, applications such as the World Wide Web, e-mail, and file transfer. The FTP, HTTP, and Telnet are all examples of applications that require a reliable communication channel.[9] TCP is utilized extensively by many of the Internet's most popular applications, including the World Wide Web (WWW), E-mail, File Transfer Protocol, Secure Shell, peer-to-peer file sharing, and some streaming media applications. TCP is optimized for accurate delivery rather than timely delivery.

Lastly, the Hyper Text Transfer Protocol(HTTP) functions as a request-response protocol in the client-server computing model. In HTTP, a web browser, for example, acts as a client, while an application running on a computer hosting a web site functions as a server.[9] The HTTP protocol is designed to permit intermediate network elements to improve or enable communications between clients and servers. High-traffic websites often benefit from web cache servers that deliver content on behalf of the original, so-called origin server to improve response time. HTTP is an Application Layer protocol designed within the framework of the Internet Protocol Suite. The protocol definitions presume a reliable Transport Layer protocol for host-to-host data transfer.[2] The Transmission Control Protocol (TCP) is the dominant protocol in use for this purpose. In this simulation, HTTP is used to transfer web documents between eLearning server and iPads using HTTP/1.1.

2.2 IEEE 802.11b WLAN

IEEE 802.11b was proposed in 1999. It uses the 2.4GHz ISM band. There are several design objectives of IEEE 802.11b that make it more popular than IEEE 802.11a.[8] The main reason is that IEEE 802.11b is using the 2.4 GHz ISM band which is the same as that defined in IEEE 802.11. Together with the support of low data rate DSSS(1~2Mbps), backward compatibility is provided. This facilitates the interoperability of IEEE 802.11b and existing WLAN products on the market. [8] With relatively simpler modulation techniques, IEEE 802.11b devices are relatively cheaper. This technology provides low cost wireless Internet capability for end users, with up to 11 Mbps data transmission rate at the physical layer.

2.3 Wireless eLearning Performance

The wireless eLearning performance rely on the communication of the eLearning web clients(iPads) and eLearning web server. Sometimes, communication over the wireless network suffers from limited bandwidth, high error rates, and interference from another users in the shared wireless network channel.[10]

3 Simulation Environment

In this paper, I used OPNET IT Guru 9.1 Academic Edition for the simulations. OPNET IT Guru has certain advantages for the network design based on devices on the market, protocols, services and technology that is a trend in the telecommunications world.[1] OPNET IT Guru 9.1 assists with the testing and design of telecommunication protocols and networks by simulating network performance for wired or wireless network environments. The OPNET tool provides a hierarchical graphical user interface for the definition of network models as shown in Figure 1.a.[1] OPNET IT Guru comes with an extensive model library that includes the application traffic models(e.g HTTP, Email, Database, Video Conferencing) and protocol models(e.g IEEE 802.11b, TCP/IP, Ethernet).[1] Types of simulated services vary, be it the Internet(WEB), VoIP, file transfer, video conferencing, video streaming and others that can be set based on the needs of the user simulation. In general, OPNET IT Guru is sufficient as a reliable packet-based simulator.

The IEEE 802.11 WLAN architecture is built around a Basic Service Set(BSS). A BSS is all the devices associated with a local or enterprise IEEE 802. Wireless local area network(WLAN). With 802.11 it is possible to create an ad-hoc network of client devices without a controlling access point called an independent basic service set(IBSS).[6] In this mode, all mobile devices in the WLAN communicate with the server based WLAN.

4 Simulation Design

In this work, I used OPNET IT Guru Academic Edition 9.1 to simulate an eLearning classroom simulation scenario in Fig. 1.a. The network consisted of an iPad as a mobile client and eLearning Web Server as a WLAN server. The mobile client accessed web contents from the eLearning server using the IEEE 802.11b protocol(2.4GHz band). Node was represented an iPad. The WLAN connection operated at 1 Mbps, 2 Mbps, 5.5 Mbps, 11 Mbps automatically in the IEEE 802.11b, but I used only 11 Mbps in this simulation. The Wireless LAN parameters of the iPad were that the data rate(bps) was fixed with 11 Mbps. The Physical characteristic was the direct sequence, which represented each bit in the frame by multiple bits in the transmitted signal, instead of the frequency hopping and Infra Red.[7] It also had the channel settings with the 1,000 khz bandwidth and the 2.4Ghz minimum frequency. Lastly, the BSS identifier was fixed as 1.

The simulation factors had number of iPads(mobile clients) and web object size(light browsing, medium browsing, and heavy browsing) summarized in Table below.

Factors	Values
Number of iPads	1, 10, 25
HTTP web object size	16KB, 32KB, 64KB

5 Simulation Results

5.1 Experiment 1

The first simulation model was the single iPad scenario shown in Figure 1.(a). The simulation results were shown from the OPNET simulations of the network in Figure 1. Moreover, these simulations were performed using the HTTP/1.1.

5.2 Experiment 2

I performed the ten iPads scenario to see whether each iPad got fair connections between the WLAN workstations(mobile clients) on a shared Wireless LAN. I also tested different size of objects(16KB, 32KB, and 64KB) in the experiment. Figure 2 showed the simulation results from this experiment of the ten iPads scenario.

Figure 2.(a) showed the ten clients infrastructure WLAN. Figure 2.(d) showed the wireless delay for the iPad client which was simulated for 12 minutes with time average. For high load condition of the high browsing(64KB), the delay was reaching over 0.01 sec.

Basically, this experiment was performed under the HTTP/1.1 instead of the HTTP/1.0, so this got more advantages of the TCP acknowledgement packet. Figure 2.(e) showed the WLAN throughput(bits/sec) in the network level. Figure 2.(f) showed the average eLearning server response time at the node iPad1. With the 64KB load, the response time was almost 0.35 sec which was very close to the response time at the node iPad5(Fig 2.(g)) and iPad8(Fig 2.(h)). This indicated that there were no fairness problems between ten iPads on a shared Wireless LAN. That was the ten iPads shared the channel very fairly in the high load case(64KB).

5.3 Experiment 3

My primary question was whether the large numbers of iPads like twenty-five here can be supported in the 802.11b Wireless LAN. This was about the ability of a network to increase total throughput under an increased load when more iPads were added. Figure 3.(a) showed a large classroom simulation scenario with the same loads of the previous experiment 2. Figure 3.(e) showed the network level throughput results. Even with high load condition(64KB), the throughput was stable at about 210,000 bits/sec. Figure 3.(f), (g), (h), and (i) showed the HTTP response time at each node iPads, and they did not have fairness problems between twenty-five iPads on a shared WLAN. The network level throughput is higher than the application layer throughput because of protocol overhead such as TCP, IP, headers and retransmissions.[9]

6 Conclusions

In this experiment, I simulated the performance of three different modeling scenarios with using 1, 10, and 25 iPads in the eLearning classroom. The simulation results showed that the IEEE 802.11b Wirelss LAN could successfully support up to twenty-five iPads no matter of conditions of light, medium and heavy web browsing without the fairness problem. For the next steps, I am going to simulate larger models of the eLearning classroom over 50. Furthermore, ongoing work is focused on the more realistic workloads such as video conferencing and video streaming.

7 References

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[2] Harry McCracken. "The 50 Best Inventions of 2010: iPad". Time Magazine, Nov 2010.
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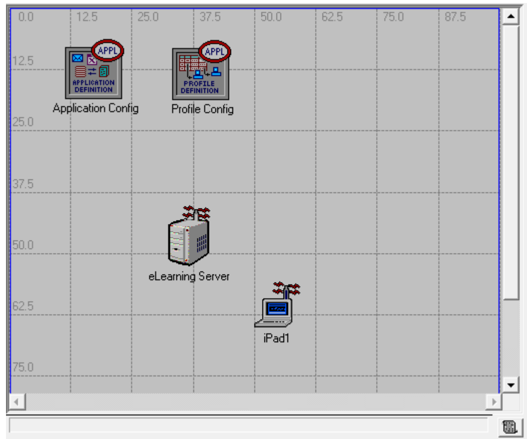
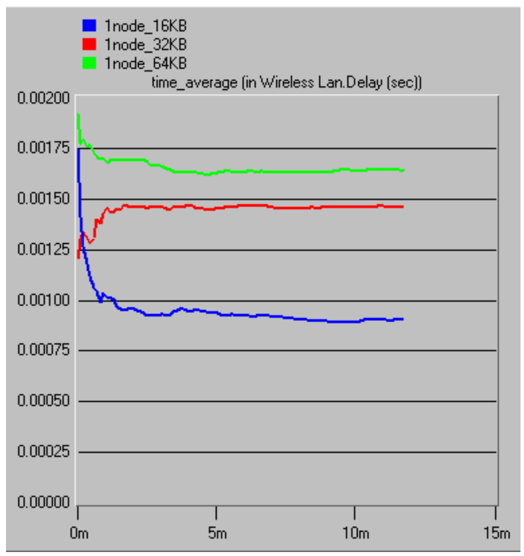
[10] D. Kotz and K. Essein, "Analysis of a Campus-Wide Wireless Network", Proceedings of ACM MOBICOM, Atlanta, GA, Sep 2002.

8 Appendix

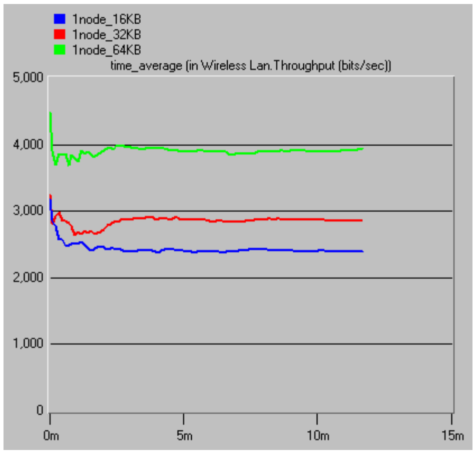
8.1 Experiment 1: 1 iPad client



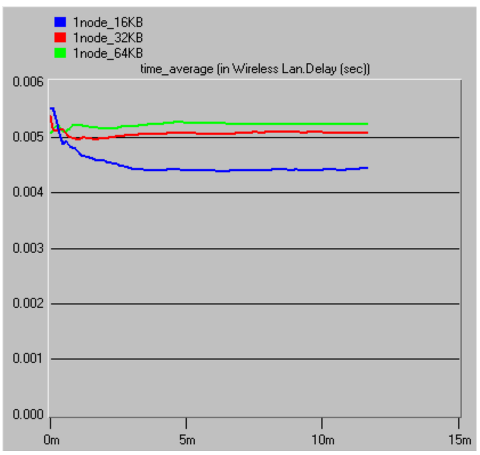
<**Fig 1.a** iPad classroom simulation scenario>



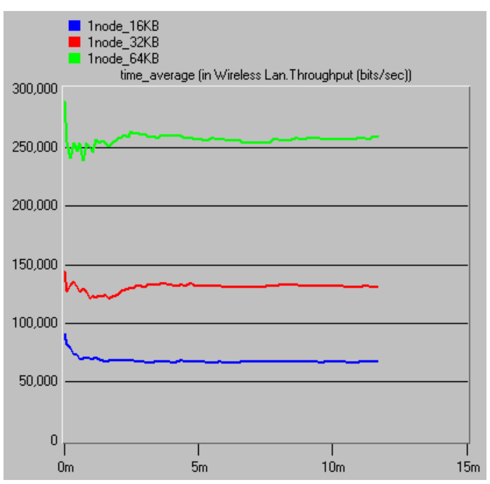
<**Fig 1.b** eLearning Server; WLAN delay(sec)>



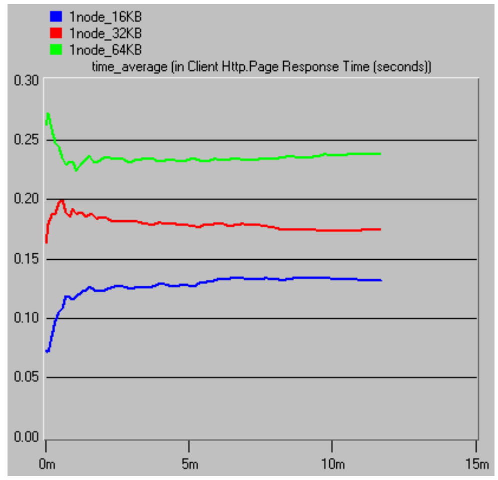
<**Fig 1.c** eLearning Server; WLAN throughput>



<**Fig 1.d** Average of iPad; WLAN delay(sec)>

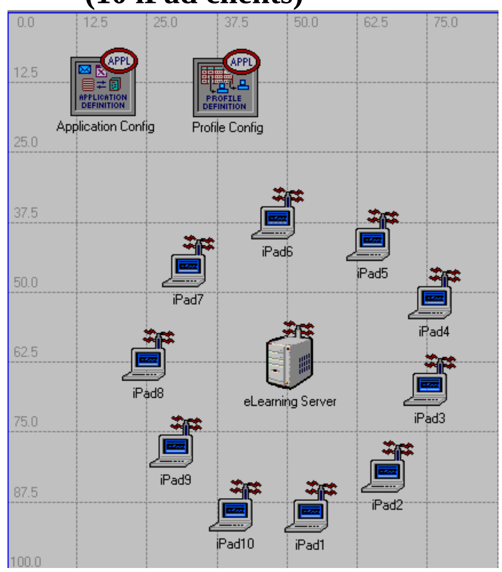


<**Fig 1.e** Average of iPad; WLAN throughput>

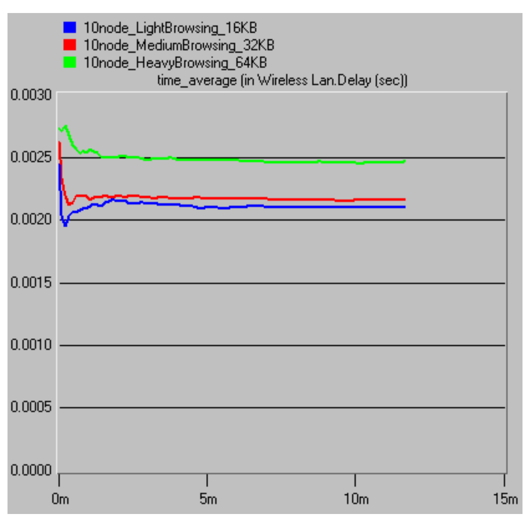


<**Fig 1.f** eLearning HTTP server response time>

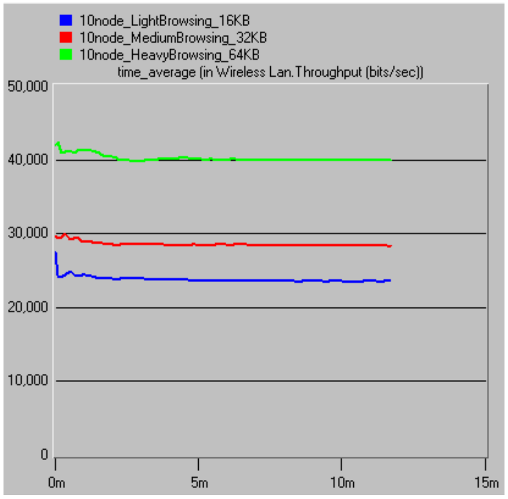
8.2 Experiment 2: Small Classroom (10 iPad clients)



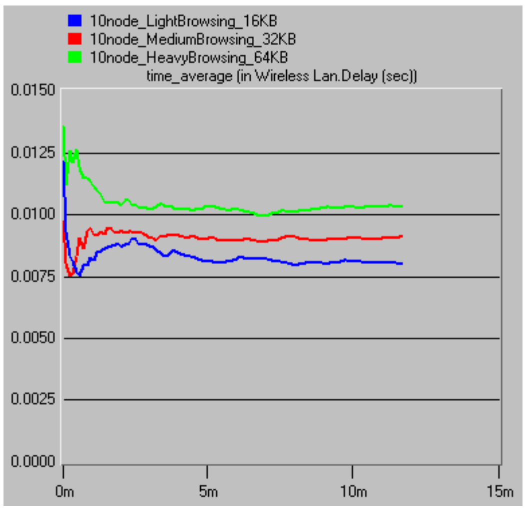
<**Fig 2.a** Small classroom simulation scenario>



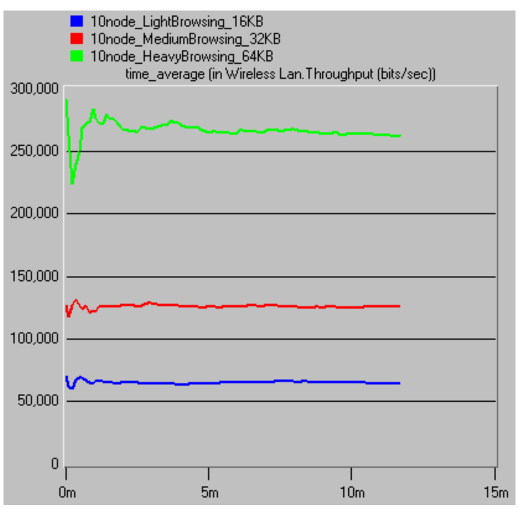
<**Fig 2.b** eLearning Server; WLAN delay(sec)>



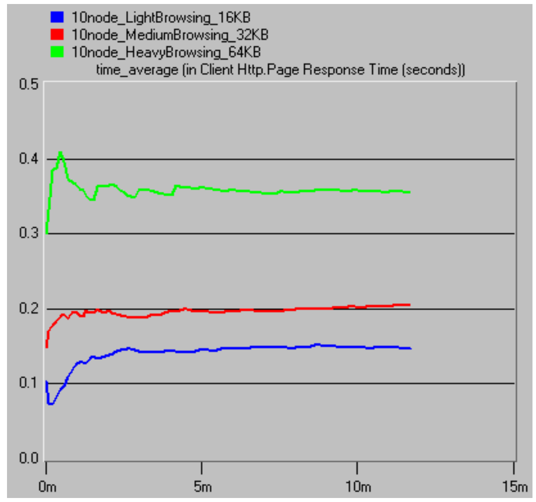
<**Fig 2.c** eLearning Server; WLAN throughput>



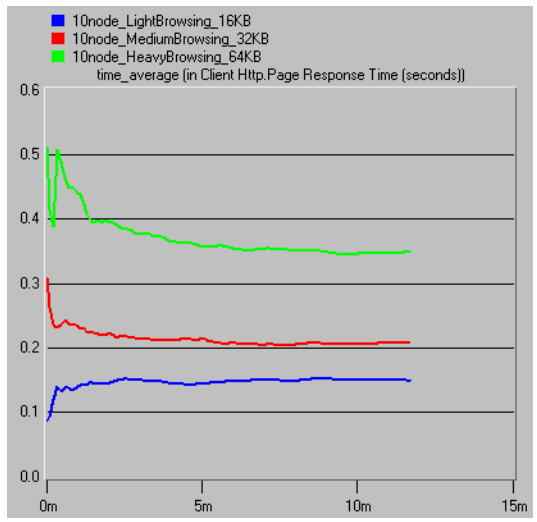
<**Fig 2.d** Average of iPad; WLAN delay(sec)>



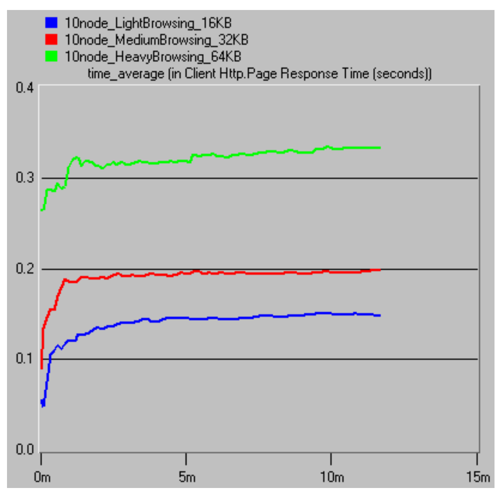
<**Fig 2.e** Average of iPad; WLAN throughput>



<**Fig 2.f** eLearning HTTP server response time(sec) at iPad1>

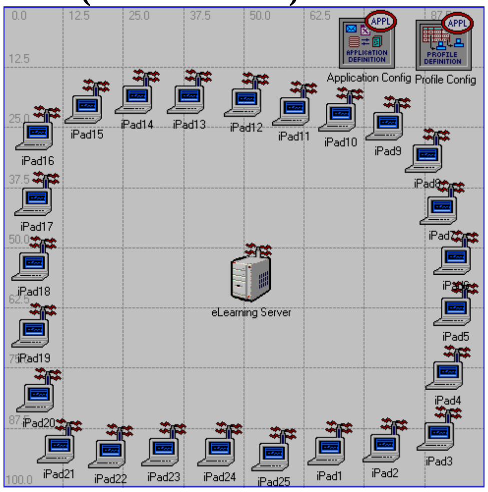


<**Fig 2.g** eLearning HTTP server response time(sec) at iPad5>

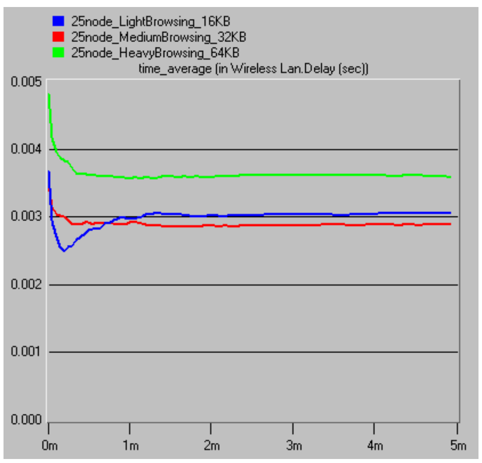


<**Fig 2.h** eLearning HTTP server response time(sec) at iPad8>

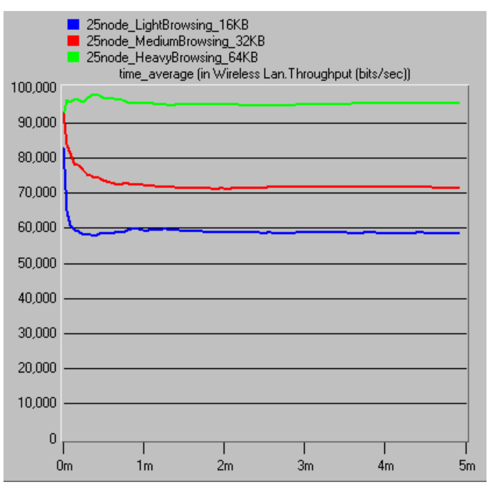
8.3 Experiment 3: Large Classroom (25 iPad clients)



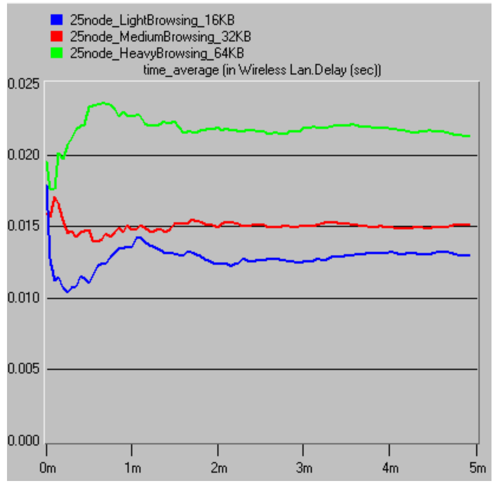
<Fig 3.a Large classroom simulation scenario>



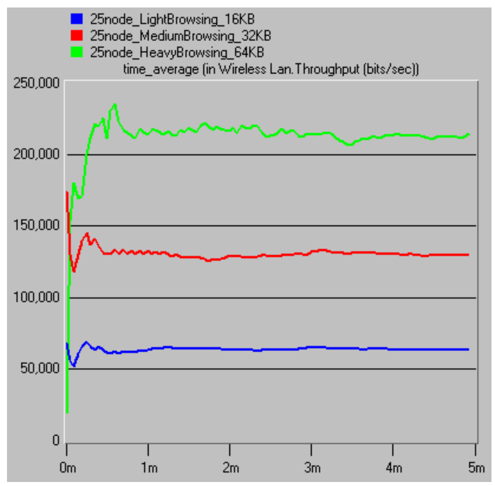
<Fig 3.b eLearning Server; WLAN delay(sec)>



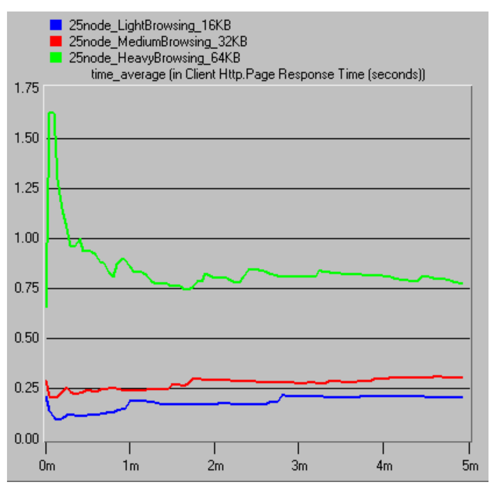
<Fig 3.c eLearning Server; WLAN throughput(bits/sec)>



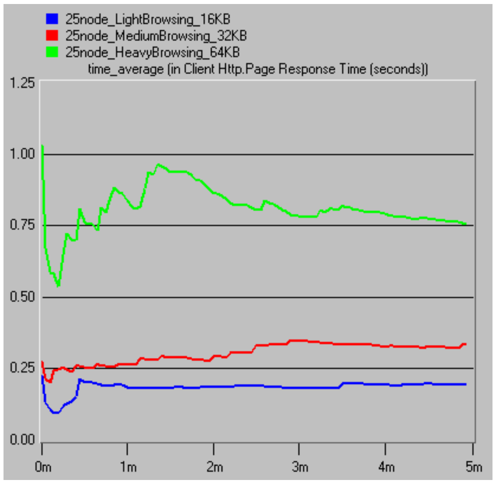
<Fig 3.d Average of iPad; WLAN delay(sec)>



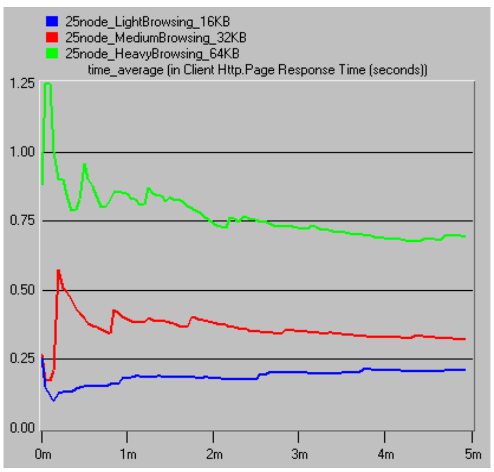
<Fig 3.e Average of iPad; WLAN throughput(bits/sec)>



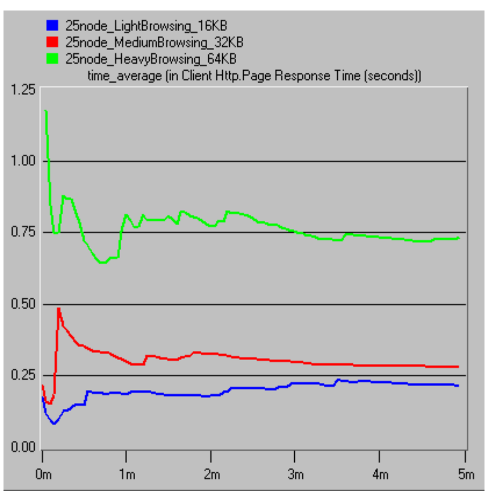
<Fig 3.f eLearning HTTP server response time(sec) at iPad5>



<**Fig 3.g** eLearning HTTP server response time(sec) at iPad12>



<**Fig 3.h** eLearning HTTP server response time(sec) at iPad18>



<**Fig 3.i** eLearning HTTP server response time(sec) at iPad24>