# PERFORMANCE EVALUATION OF IEEE 802.11B WIRELESS LOCAL AREA NETWORKS FOR E-LEARNING CLASSROOM NETWORK

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## ABSTRACT

*This paper presents the modeling and implementation of a wireless LAN (WLAN) applied in E-learning classroom based on OPNET. Further, this paper presents a simulation study to estimate the appropriate number of E-learning clients that can be supported in the WLAN as well as the user-perceived Web response time as a function of network load. The simulation results show that an IEEE 802.11b WLAN can support up to 50 clients with modest E-learning and Web browsing activities. The Web server is located on a 100 Mbps Ethernet LAN segment. The mobile client accesses content from the E-learning and Web server via the AP1, using the IEEE 802.11b protocol.*

***Keywords:*** *WLAN Throughput, HTTP (Hyper Text Transfer Protocol) Page Response Time, E-Learning.*

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## I. Introduction

Wireless local area networks (WLANs) are in a period of great expansion and there is a strong need for them to support multimedia applications. Wireless networks are becoming more and more popular in recent years, ranging from digital cellular telephony up to satellite broadcasting. With the increasing demand and penetration of wireless services, users of wireless networks now expect Quality of Service (QoS) and performance comparable to what is available from fixed networks. Wireless access points are now commonplace on many areas such as: homes, airports, university campuses. Technologies such as IEEE 802.11b wireless LANs (WLANs) have changed the way people think about networks, by offering users freedom from the constraints of physical wires [1-4]. A natural step in the wireless Internet evolution is the convergence of technologies to form the "wireless Web": the wireless E-learning classroom, the wireless campus, the wireless office, and the wireless home. Educators can embrace wireless Internet access to enhance the learning experience in the classroom for students with wireless laptops through on-line access to lecture: notes, demo, examples, quizzes, assignments and supplementary reading material [5]. In this paper, we explore wireless Web performance in the context of E-learning classroom area networks. This work is based on measurements of a small-s wireless classroom experiment, where in an Ethernet web server was used in an environment to deliver selected course content to a graduate class with 25 students. We parameterize the simulation model based on our E-learning classroom measurements and validate the model against empirical measurements using simple E- learning and Web workload models. We then build a model of browsing behavior for E- learning and Web client and use this model in a simulation study addressing the scalability of the E- learning classroom area network [6-9]]. This work is focus on the HTTP transaction rate, wireless delay, end-to-end throughput achievable in the wireless network environment, Wireless Access point delay, and the impacts of factors such as number of clients, and E- learning Web object size. The simulation results of this paper show that an IEEE 802.11b WLAN can easily support up to 50 clients with modest E- leaning and Web browsing behavior. The remainder of this paper is organized as follows. Section II describes the simulator used for creating WLAN scenarios. Section III describes the simulation setup for proposed scenarios. Section IV presents the simulation results and analyses. Finally, Section V concludes the paper and followed by the future work.

## II. SIMULATOR

Proposed WLAN scenarios are designed in OPNET environment. OPNET IT Guru is a powerful communication system simulator developed by OPNET Technologies. OPNET IT Guru 9.1 assists with the testing and design of communications protocols and networks by simulating network performance for wired and/or wireless environments [10]. The OPNET tool provides a hierarchical graphical user interface for the definition of network models. A network is constructed by graphically connecting network nodes via communications links. OPNET IT Guru comes with an extensive model library, including application traffic models (e.g., HTTP, FTP, E-mail, Database), protocol models (e.g., TCP/IP IEEE 802.11b, Ethernet), and a broad set of distributions for random variant generation. There are also adequate facilities for simulation instrumentation, report generation, and statistical analysis of results.

## III. PROPOSED SCENARIO DESIGN

The IEEE 802.11 standard defines a set of wireless LAN protocols that deliver services similar to those found in wired Ethernet LAN environments. The IEEE instrumentation, report generation, and statistical analysis of results. The IEEE 802.11 standard defines a set of wireless LAN protocols that deliver services similar to those found in wired Ethernet LAN environments. The IEEE 802.11 WLAN architecture is built around a Basic Service Set (BSS). A BSS is a set of stations that communicate with one another. When all the stations in the BSS can communicate directly with each other (without a connection to a wired network), the BSS is known as an ad hoc WLAN. When a BSS includes a wireless access point (AP) connected to a wired network, the BSS is called an infrastructure network. Infrastructure WLAN consists of wireless stations and access points. Access Points are connected with a distribution system [4] (such as Ethernet). Different access points create different cells having different locations and a confined communication radius. The mobile unit can move geographically while it is communicating. In this mode, all mobile stations in the WLAN communicate via the AP providing access to stations on wired LANs and the world-wide Internet. In this work, we use OPNET IT Guru to model a simple infrastructure WLAN as shown in Fig.1. The network consists of a mobile client, a wireless Access Point (AP), an Ethernet-based E-learning Web server, and an Ethernet Switch. The Web server is located on a 100 Mbps Ethernet LAN segment. The mobile client accesses content from the E-learning and Web server via the AP1, using the IEEE 802.11b protocol. (Additional clients are considered in later experiments.) The mobile client node represents a laptop with client-server applications running over TCP/IP. These applications make use of the WLAN connection, which can operate at 1 Mbps, 2 Mbps, 5.5 Mbps, or 11 Mbps, as defined in IEEE 802.11b. We use only the 11 Mbps setting in our work. The Ethernet-based E-Learning Web server node represents an E-Learning and HTTP server running over TCP/IP. The operational speed is determined by the wired link's data rate.

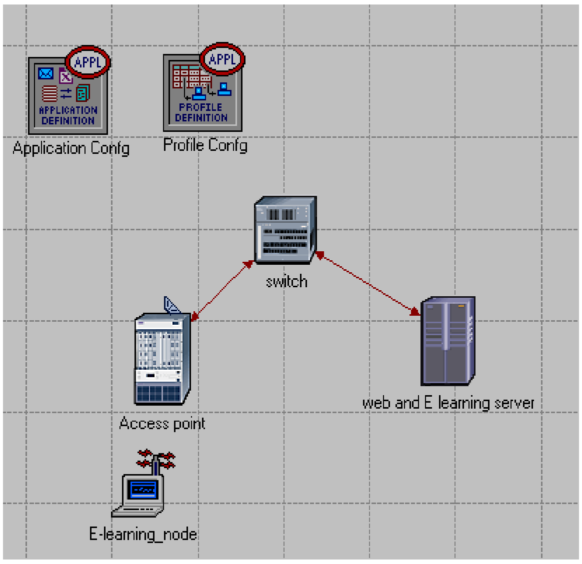



**Fig. 1 Single Client Simulation Scenario**

A one-factor-at-a-time simulation design is used to study the impacts of many factors on wireless LAN performance and user-level Web performance. These factors include number of clients, Web object size, and HTTP/TCP protocol features. The simulation factors are summarized in Table 1.

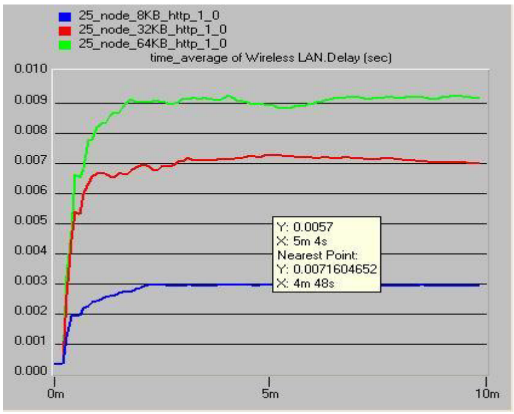
Table 1. Simulation factors and levels for wireless E-Learning Classroom area network study

| Factors | Levels |
|---|---|
| Number of Clients | 1, 25, 50 |
| E-Learning and HTTP Transfer Size (KB) | 1, 8, 32, 64 |
| HTTP Protocol | /1.0, /1.1 |

## III. SIMULATION RESULTS

This section presents selected results from our OPNET simulations of the network shown in Fig.1.

**Scenario 1: 25 Clients:** The first scenario studies 25-client , to see if there are fairness problems between 25 clients on a shared WLAN. We consider different loads in experiment; Figure 2 shows the results from the 25-client scenario using HTTP/1.0. In the high load case with E-learning and HTTP transfer size are (8, 32, 64 KB), the 25-clients share the channel fairly, and experience similar user-level Web performance, and similar numbers of TCP resets.




**Simulation Time**

**Fig. 2 (a) Average of wireless Delay (sec)**

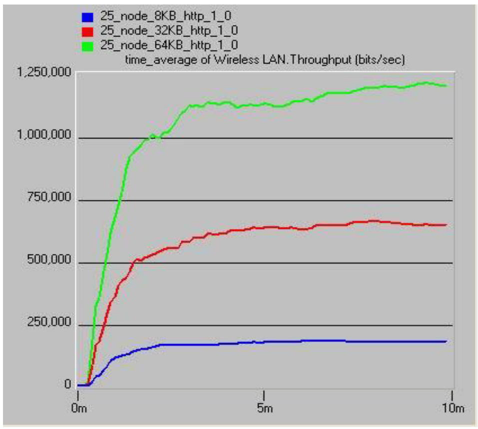



**Fig. 2 (b) Average of wireless throughput (bits/sec)**

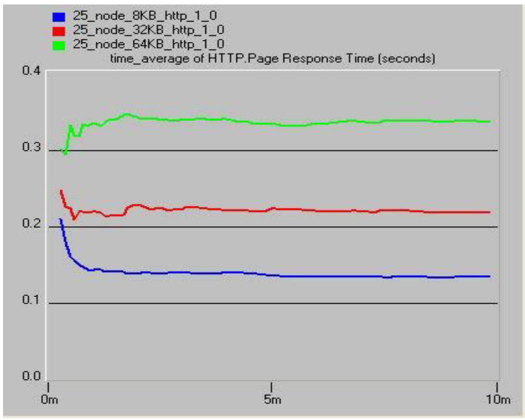



**Fig. 2 (c) E-Learning HTTP Page response time (s)**

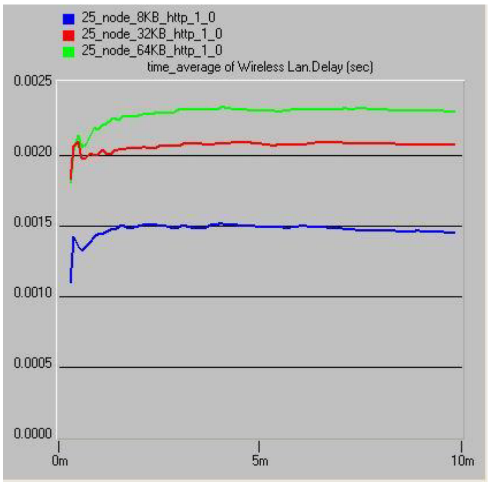



**Fig. 2 (d) Wireless Access Point (AP1) Delay (sec)**

**Scenario 2: Large Classroom Network:**

Our main interest is in the scalability of classroom area networks (i.e., how many clients can be supported in the WLAN, and how does user-perceived browsing performance degrade with network load). Figure 3 shows the simulation results from these experiments. Figure 3(a) shows the wireless delay for the Web clients, averaged over the simulated 10 minutes period. This delay is sprimarily a function of the number of clients, reaching almost 0.0125 (sec.) with 50 clients. HTTP/1.1 has a small advantage over HTTP/1.0; this advantage would increase significantly with more efficient TCP DATA/ACK packetization. Figure 3(b) shows the network-level throughput results. The network throughput is higher than the application-layer throughput because of protocol overhead (e.g., TCP, IP, headers, retransmissions). Again, this load is a direct function of the number of clients. Figure 3(c) shows the mean HTTP transfer time, averaged across all transfers by all clients. The mean HTTP transfer time increases slightly with the number of simulated clients, because of contention for use of the shared WLAN, and perhaps queuing delay at the server. Finally, Figure 3(d) plots the mean channel access delay for the shared WLAN channel. This graph shows an increase in channel access delay with the number of competing clients, as expected.

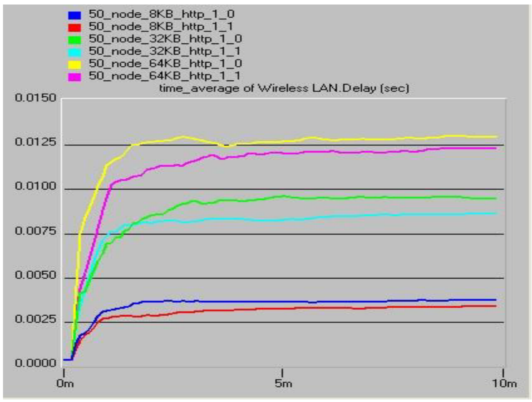



**Fig. 3 (a) Average of wireless Delay (sec)**

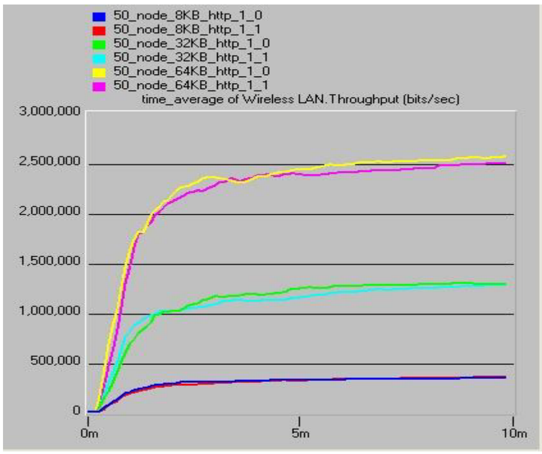



**Fig. 3 (b) Average of wireless throughput (bits/sec)**

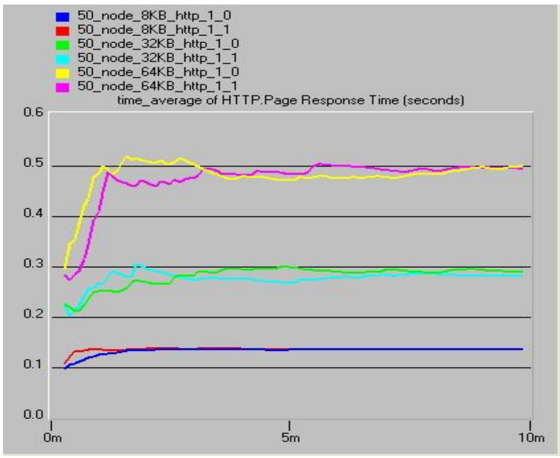



**Fig.3 (c) E-Learning HTTP Page response time (sec)**

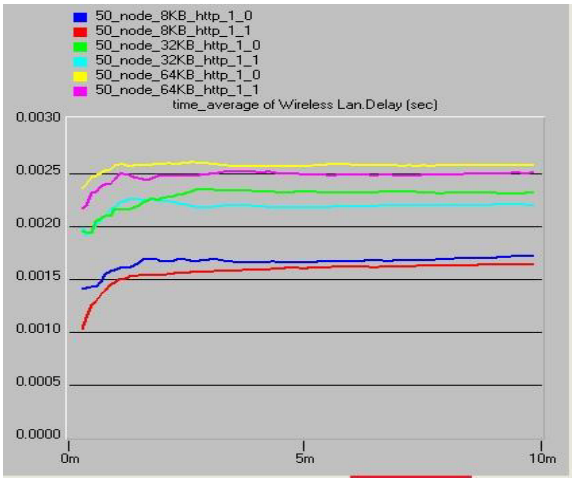



**Fig. 3 (d) Wireless Access Point (AP1) Delay (sec)**

## IV. CONCLUSION

Last years WLANs have become one of the first actors in wireless technologies, copi ng a lot of attention from different points of view, which comprise users, business people, researchers, etc., who see in that technology a new opportunity to offer / receive mobile services without the participation of the established bigger mobile operators. Moreover, this broadband mobile access combined with the change on the Internet traffic profiles, such as the VoIP, P2P and other multimedia services will be one of the fundamentals axes of an advanced Internet. This paper presented a simulation study of an IEEE 802.11b wireless LAN in an E-Learning classroom network scenario. The simulations, conducted using OPNET IT Guru 9.1. The simulation results show that an IEEE 802.11b WLAN can easily support up to 50 clients doing modest E-learning and Web browsing. The results also show that persistent HTTP connections can provide a significant performance advantage in a WLAN environment. Ongoing work focuses on extending our E-Learning and Web browsing model to represent more realistic Web workloads and simulating larger network models.

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