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Performance Evaluation of IEEE 802.11b WLANs

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Abstract: *This paper presents a simulation study of an IEEE802.11b WLANs used to model a WLAN sub network deployed within an enterprise WAN framework. Current trends towards a ubiquitous network (the Internet) capable of supporting different applications with varying traffic loads: data, voice, video and images, has made it necessary to improve WLAN performance to support applications requiring more bandwidth. Here performance optimization has been shown with the help of few simulation tests with different parameters such as data rate, and the physical characteristics [3]. The different quality of service parameters are chosen to be overall WLAN load data, Packet Delay and Medium Access Delay, and the overall throughput of the WLAN.*

Keywords: *Wireless LAN, IEEE802.11b, OPNET IT GURU, Load*

1. Introduction

The field of wireless local area networks (WLANs) is being widely studied and used in various emerging research domains such as mobile and pervasive computing, where WLANs provide high-speed wireless connection and support accessing information from anywhere and anytime.[2] WLANs support a wide range of applications, which may include simple applications such as web browsing (HTTP), file transferring(FTP), email, etc. and the other ones, for instance, real-time multimedia applications (e.g., video streaming and video conferencing). IEEE 802.11is a vital standard for wireless LAN, which adopts the standard 802 logical link control (LLC) protocol that is further divided into two sub layers: physical layer (PHY) and medium access control (MAC) layer. Initially 802.11 had two physical layers: Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS) and later, the physical layer have been categorized into three types with different physical characteristics and frequency spectrum [2]. The physical characteristic of 802.11a and 802.11g are identical – both are based on OFDM and support data rate of 54 Mbps but they differ in operating frequency spectrum– 802.11a operates on 5 GHz band, while 802.11g on 2.4 GHz. 802.11b is based on DSSS and operates at 2.4 GHz band width. Transmission rate from 1 to 11 Mbps. 802.11a has significant advantage due to the wide range spectrum of 5 GHz, having more number of independent channels. Both 802.11b and 802.11g are compatible with each other as both of them operates on 2.4 GHz spectrum, but this may cause degradation in system performance as 2.4 GHz is a small band spectrum with a lesser number of independent channels[2]. The main objective of the work presented in this paper is to evaluate the performance of wireless local area network especially end-to-end delay, media access delay, load, traffic received and traffic sent, traffic dropped, throughput. The network setup has been simulated using OPNET IT GURU.A typical WLAN is connected via the wired LAN as shown in Figure 1

2. WLAN Techniques

Commercial wireless LANs employ spread-spectrum technology to achieve reliable and secure transmission in the ISM bands although bandwidth efficiency is compromised for reliability. Newer WLAN technologies such as the IEEE 802.11(a) and (g) are employing

Orthogonal Frequency Division Multiplexing (OFDM) schemes. The basic access method in the IEEE 802.11 MAC protocol is the Distributed Coordination Function (DCF), which is a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) MAC protocol.

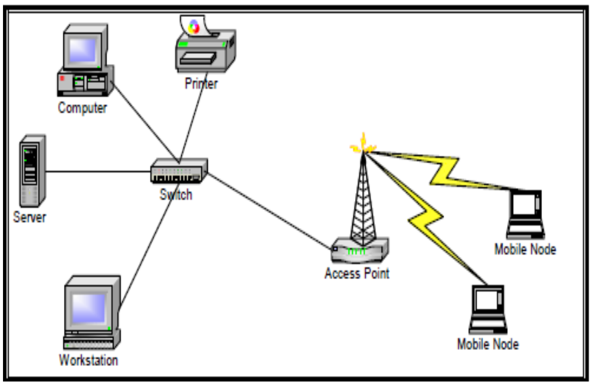

Fig1. *Wireless Local Area Network [3]*

The IEEE 802.11 standard defines a Basic Service Set (BSS) of two or more fixed, portable, and/or moving nodes or stations that can communicate with each other over the air in a geographically limited area[3]. Two configurations are specified in the standard: ad-hoc and infrastructure. The ad-hoc mode is also referred to as the peer-to-peer mode or an Independent Basic Service Set (IBSS) as illustrated in Fig. 2(a). This ad-hoc mode enables mobile stations to interconnect with each other directly without the use of an access point (AP). All stations are usually independent and equivalent in the ad-hoc network. Stations may broadcast and flood packets in the wireless coverage area without accessing the Internet. The ad-hoc configuration can be deployed easily and promptly when the users involved cannot access or do not need a network infrastructure. However, in many instances, the infrastructure network configuration is adopted. As shown in Fig. 2(b) in the infrastructure mode above, the wireless network consists of at least one AP (access point) connected to the wired infrastructure. All the wireless stations are connected to the AP. An AP controls encryption on the network and also can router the wireless traffic to a wired network (same as a router)[1]. BSSs can be connected by a distributed system that normally is a LAN. The coverage areas of BSSs usually overlap. Handover will happen when a station moves from the coverage area of one AP to another AP.

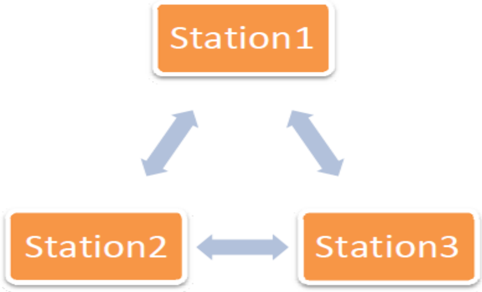

Fig2a. *Ad hoc network [1]*

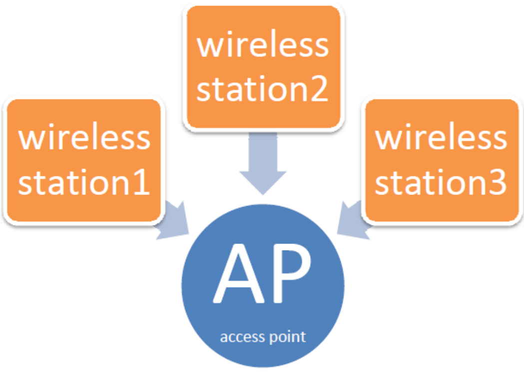

Fig2b. *Infrastructure [1]*

Three physical media are defined in the original 802.11 standard:

2.1. Direct Sequence Spread Spectrum (DSSS)

Operating in the 2.4-GHz ISM band, at data rates of 1 Mbps and 2 Mbps. In the United States, the FCC (Federal Communications Commission) requires no licensing for the use of this band. The number of channels available depends on the bandwidth allocated by the various national regulatory agencies. This ranges from 13 in most European countries to just one available channel in Japan.

2.2. Frequency-Hopping Spread Spectrum (FHSS)

Operating in the 2.4-GHz ISM band, at data rates of 1 Mbps and 2 Mbps. The number of channels available ranges from 23 in Japan to 70 in the United States.

2.3. Infrared

At 1 Mbps and 2 Mbps operating at a wavelength between 850 and 950 nm.

OPNET IT GURU provides a Virtual Network Environment that models the behavior of your entire network, including its routers, switches, protocols, servers, and individual applications 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 variable generation. There are also adequate facilities for simulation instrumentation, report generation, and statistical analysis of results.

Table1.*Summary of Key WLAN standards*

IEEE Standards	**RF Band**	**Max. Data rate**	**Physical Layer**	**Range**
IEEE802.11	2.4 GHz	2 Mbps	FHSS, DSSS, IR	50-100 m
IEEE802.11b	2.4 GHz	11 Mbps	DSSS	50-100 m
IEEE802.11a	5 GHz	54 Mbps	OFDM	50-100 m
IEEE802.11b	2.4 GHz	54 Mbps	OFDM	50-100 m

3. OPNET IMPLEMENTATION

3.1. Simulation Network Model /Baseline Scenario

The 802.11b baseline model was created using a variation of the OPNET 802.11 standard models wlan_deployment scenario. In this scenario, the behavior of a single infrastructure 802.11b WLAN is examined within the framework of a deployed WAN to better emulate the configuration of an actual network. An effective and efficient way of increasing the capacity and coverage of WLANs is to place one or more access points at a central location and distribute the wireless signals from the access points to various antenna locations [9] The subnet_0 represents the remote branch office consist of an *office_LAN* having 20 workstations and an 802.11b WLAN BSS sub network connected by a 100BaseT link. Within that sub network are the mobile nodes and the Access Point that contain the WLAN as shown in fig.4

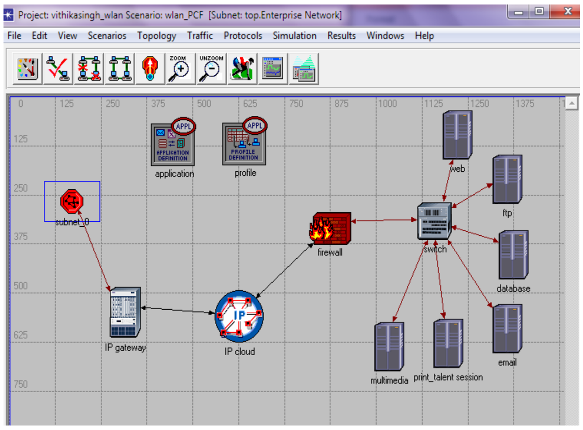

Fig3. *Simulated WAN Framework*

Distribute the wireless signals from the access points to various antenna locations. The WLAN is connected via its AP to an office LAN connected through a central switch using 100BaseT (100Mbps) Ethernet wiring emulating a real life office environment with a standard Fast Ethernet LAN. An IP gateway (i.e., an enterprise router) connects the LAN to an IP cloud used to represent the backbone Internet.[3] The gateway connects to the office LAN using 100BaseT Ethernet wiring while the connection between the gateway and the IP cloud is done with a Point-to-Point T1 (1.544Mbps) serial link depicted in Figure 4. The network's traffic servers are located on the other side of this IP cloud via a firewall connected by a T1 link denoting the Headquarters of the hypothetical corporation. These servers connect to the firewall using 100BaseT Ethernet wiring and are used as the source and destination of all services: Hyper Text Transfer Protocol (HTTP), File Transfer protocol (FTP), Electronic Mail (E-mail) , Database, multimedia (voice & video) and talent session, running on the entire network representing traffic that is exchanged with the mobile nodes in the 802.11b WLAN during the simulation. A single fixed Access Point and six mobile nodes were chosen as the WLAN configuration for the model. All mobile nodes are the same distance from the AP.

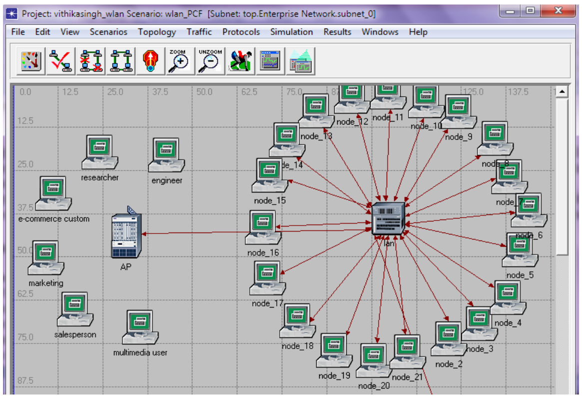

Fig4. *802.11b WLAN BSS*

This small WLAN was selected both to limit the scope of the simulation and to approach accepted emulation durations. The WLAN 802.11g baseline network model is configured to generate six types of application traffic: Web Browsing, File Transfer, Email, Database, print, talent session and video conference. However, all the applications defined in OPNET IT GURU are enabled for future use.

3.2. Important Attributes Changed for each Node

3.2.1. Access Point

Node Model: wlan_ethernet_slip4_adv [1]

Wireless LAN Parameters: BSS Identifier: same level number as the associated Workstations

Access Point Functionality: Enabled

Operation Mode: 802.11b

Physical Characteristic: Direct Sequence

Data Rate: 11Mbps

3.2.2. Mobile Stations

Node Model: wlan_station_adv

BSS Identifier: same level number as the associated AP

Access Point Functionality: Disabled

Operation Mode: 802.11b

Physical Characteristic: Direct Sequence

Data Rate: 11Mbps

3.2.3. Switch

Node Model: ethernet16_switch

Application Supported Services: All

3.2.4. Application

Node Model: Application Config

Application Definitions: Default (It includes 8 applications with high load and low load for each. Email, File Transfer, Web Browsing, File Print with high load are used for this project)

3.2.5. Profile

Node Model: Profile Config

Profile Configuration: choose the applications using for correspond to different scenarios

3.2.6. IP Cloud

Node Model: ip32_cloud_adv

3.2.7. Firewall

Node Model: ethernet2_slip8_firewall

3.2.8. IP Gateway

Node Model: ethernet4_slip8_gtwy

3.2.9. Server

Node Model: ethernet_server

Workstations

Node Model: ethernet_station_adv

3.3. Application and Profile configuration

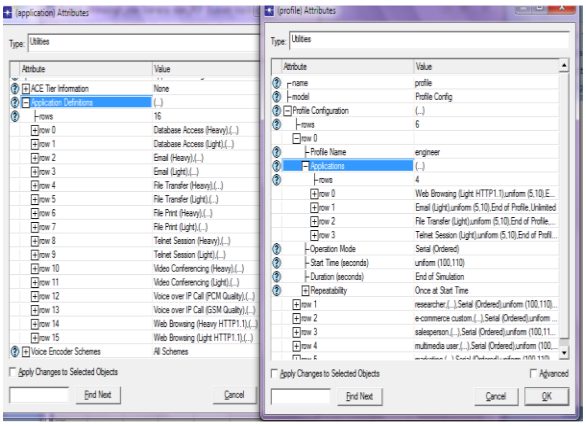

Table2. *User Profiles and Applications*

Profile /Dept.	Applications							
	Web Browsing	**FTP**	**Database**	**Email**	**Telnet**	**Video Conf.**	**Print**	**Voice**
Engineer	Light	Light	Light	-	Light	-	-	-
Researcher	Heavy	-	Light	-	-	-	-	-
Ecommerce customer	Heavy	-	-	-	-	-	-	-
Sales Person	Light	Light	Light	Light	-	-	-	-
Multimedia User	-	-	-	-	-	Light	-	PCM
Marketing	Heavy	Light	Heavy	Light	-	-	-	-

3.4. Application supported services for servers

Web server: Web browsing (heavy HTTP1.1), Web Browsing (light HTTP1.1), Telnet session (light), Email (heavy), Email (light)

FTP: File Transfer (light), File Transfer (heavy), File print (light)

Database: Database Access (heavy), Database Access (light)

Email: Email (light), Email (heavy)

Print_telnet session: Telnet session (heavy), Telnet session (light)

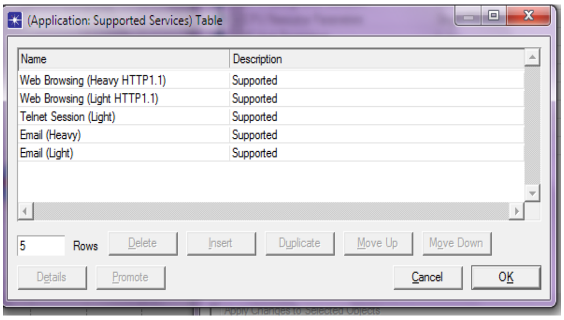

Fig5. *Application Supported Services*

3.5. Attributes of mobile station

The BSS identifier of all the mobile stations is kept the same as access point. All the mobile stations are assigned different wireless MAC address.

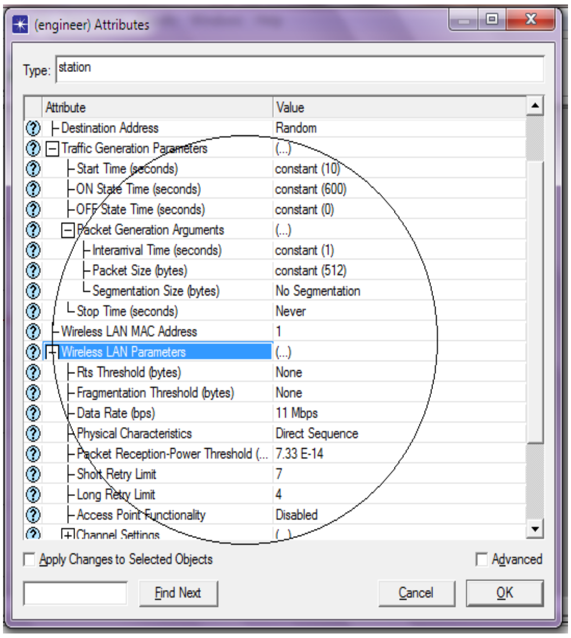

Fig6. Attributes of engineer

4. Simulation Results

4.1. Load

The final load on the WLAN as a specific function of time as the simulation progressed is one of the important results.

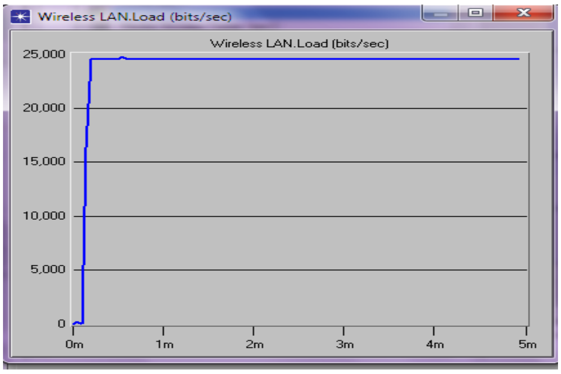

Fig7. *Overall WLAN load*

4.2. Traffic Received, Traffic Sent, Data Dropped, Throughput

The figure given below shows the traffic sent by different mobile stations, office workstation, LAN, access point. It tells how much data is sent by the node. The traffic received tells the data received after few packets are dropped. Throughput tells the net traffic sent by the system which is successfully received.

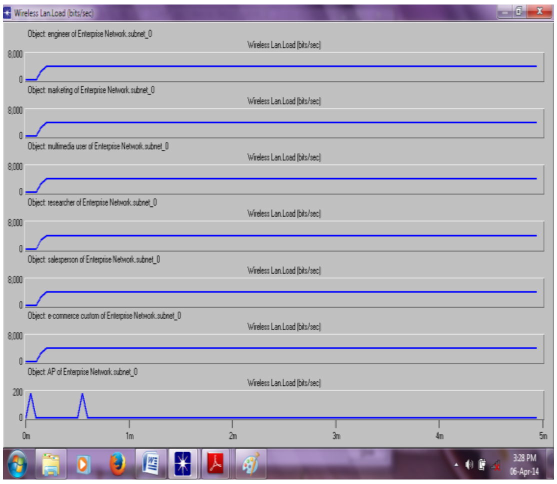

Fig8. *Load graph for different nodes*

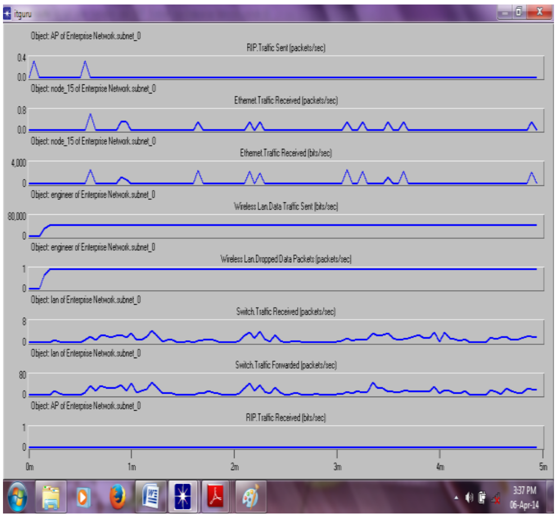

Fig9. *Graph for traffic received, sent and dropped*

4.3. Media Access Delay

Media access delay represents the global statistic for the total of queuing and contention delays of the data, management, delayed Block-ACK and Block-ACK Request frames transmitted by all WLAN MACs in the network. For each frame, this delay is calculated as the duration from the time when it is inserted into the transmission queue, which is arrival time for higher layer data packets and creation time for all other frames types, until the time when the frame is sent to the physical layer for the first time. Hence, it also includes the period for the successful RTS (Request To Send)/CTS (Clear To Send) exchange, if this exchange is used prior to the transmission of that frame. Similarly, it may also include multiple numbers of backoff periods, if the MAC is 802.11e-capable and the initial transmission of the frame is delayed due to one or more internal collisions.

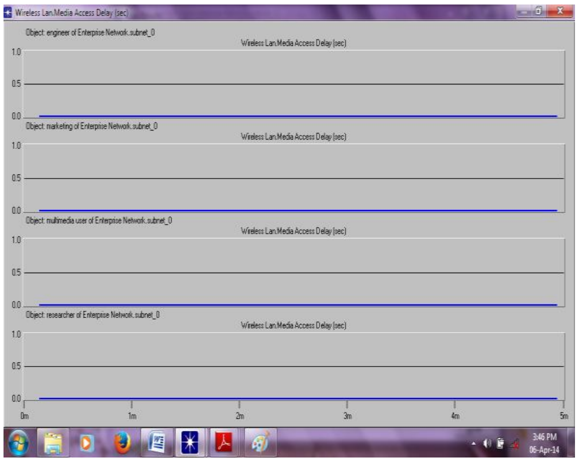

Fig10. *Graph for Media Access Delay*

5. Conclusion

The overall performance of the IEEE 802.11b Wireless Local area networks has been analyzed in detail with the help of OPNET IT GURU. The performance has been analyzed with the help of the parameters like throughput, medium access delay, and the overall WLAN load data. These different parameters reveal the different methods to optimize the performance of wireless local area networks through a limited time, the performance can be optimized in terms of throughput, media access delay. Results obtained show that the WLAN sub network operates within normal limits of the IEEE 802.11b standard.

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Priya Jayaswal has completed her 12th from St. Xavier jr/sr school from Muzaffarpur. She is currently pursuing BE in electronics and communication department from BIT Mesra, Patna Campus. Her current passion is wireless communication. She has done project in wireless communication on OPNET IT GURU.