American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-12, pp-09-15
www.ajer.org

Research Paper Open Access

# Performance Evaluation ofIEEE802.11g WLANsUsing OPNET Modeler

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***Abstract:*** **-**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 imperative to improve WLAN performance to support 'bandwidth-greedy' applications [1,2]. In this paper the performance optimization methods have been presented using an advanced network simulator, OPNET Modeler to model a WLAN subnetwork deployed within an enterprise WAN framework.. Here performance optimization has been shown via a series of simulation tests with different parameters such as Data rate, and the physical characteristics. 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. Then finally the results are compiled to improve the performance of wireless local area networks.

***Keywords:***- *Wireless LAN, IEEE 802.11g, OPNET*

## I. INTRODUCTION

A WLAN is a versatile data communications system deployed either as an extension, or as an alternative to a conventional wired LAN. Majority of WLAN systems use Radio Frequency (RF) transmission technology with a few commercial installations employing the Infrared (IR) spectrum[3]. A typical WLAN is connected via the wired LAN as shown in Figure 1 below.

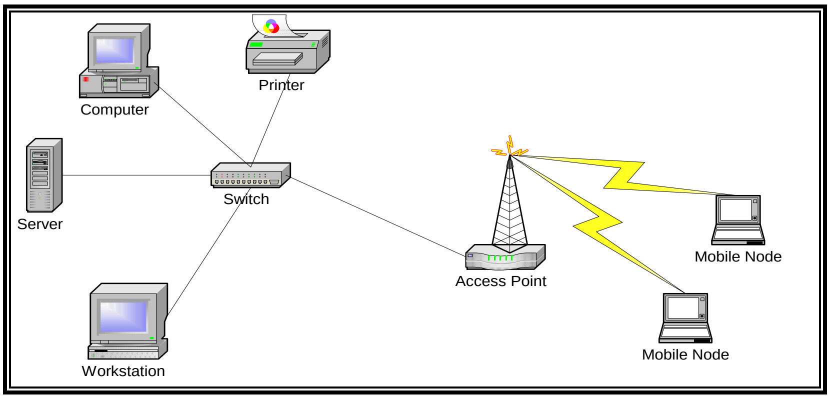



Fig. 1: Wireless Local Area Network

## II. WLAN TECHNIQUES

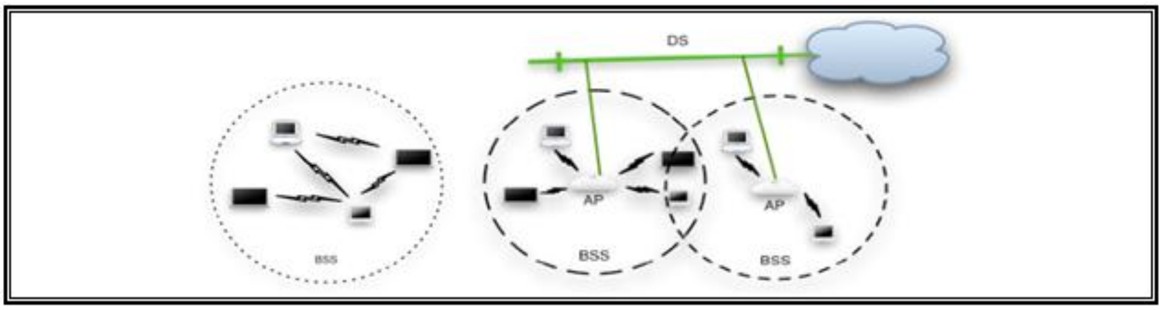
Commercial wireless LANs employ spread-spectrum technology to achieve reliable and secure transmission in the ISM bands although bandwidth efficiency is compromised for reliability. Newer WLAN technologies such as the IEEE 802.11(a) and (g) are employing Orthogonal Frequency Division Multiplexing (OFDM) schemes[4,5].

The IEEE 802.11 WLAN standard specifies a Media Access Control (MAC) layer and a physical layer for wireless LANs. The MAC layer provides to its users both contention-based and contention-free access control on a variety of physical layers.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 [6].

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 [6]. 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, there are APs, which bridge mobile stations and the wired network. 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[7].



**(a)** **(b)**

**Fig. 2(a): Ad Hoc network architecturesand (b): Infrastructure [6]**

Due to the need for high-speed data rates, many standards IEEE 802.11a and the European Telecommunications Standards Institute (ETSI)'s High Performance Local Area Network type 2, (HIPERLAN/2) are in place[8]. A summary of the key WLAN standards is given in Table 1 below:

**Table 1: Summary of Key WLAN Standards[8]**

| | RF Band | Max. Data Rate | Physical Layer | Range |
|---|---|---|---|---|
| **IEEE 802.11** | 2.4GHz | 2Mbps | FHSS,DSSS, IR | 50 – 100m |
| **IEEE 802.11b** | 2.4GHz | 11Mbps | DSSS | 50 – 100m |
| **IEEE 802.11a** | 5GHz | 54Mbps | OFDM | 50 – 100m |
| **IEEE 802.11g** | 2.4GHz | 54Mbps | OFDM | 50 – 100m |
| **HIPERLAN/2** | 5GHz | 54Mbps | OFDM | 50m indoor<br>300m outdoor |

## III. SIMULATION ENVIRONMENT

OPNET Modeler v14.5 is used for all network simulations. OPNET Modeler is a powerful communication system discrete event simulator (DES) developed by OPNET Technologies. OPNET Modeler 14.5 assists with the design and testing of communications protocols and networks, by simulating network performance for wired and/or wireless environments[9].

OPNET Modeler 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 .

The OPNET tool provides a hierarchical graphical user interface for the definition of network models. OPNET provides a comprehensive development environment for modeling and performance-evaluation of communication networks and distributed systems. Thepackage consists of a number of tools, each one focusing on particular aspects of the modeling task. These tools fall into three major categories that correspond to the

three phases of modeling and simulation projects: Specification,Data Collection and Simulation , and Analysis[10].
These phases are necessarily performed in sequence. They generally form a cycle, with a return to Specification following Analysis. Specification is actually divided into two parts: initial specification and re-specification, with only the latter belonging to the cycle, as illustrated in the following figure(3).

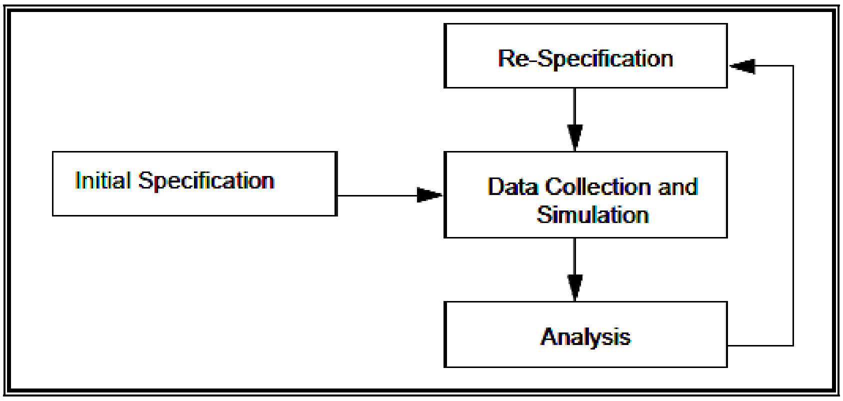



Fig. 3 Opnet tools

### 3.1 Simulation Network Model /Baseline Scenario

The 802.11g baseline model was created using a variation of the OPNET 802.11 standard models wlan_deployment scenario. In this scenario, the behaviour of a single infrastructure 802.11g 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[11].

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. 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: HyperText 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 802.11g WLAN during the simulation.

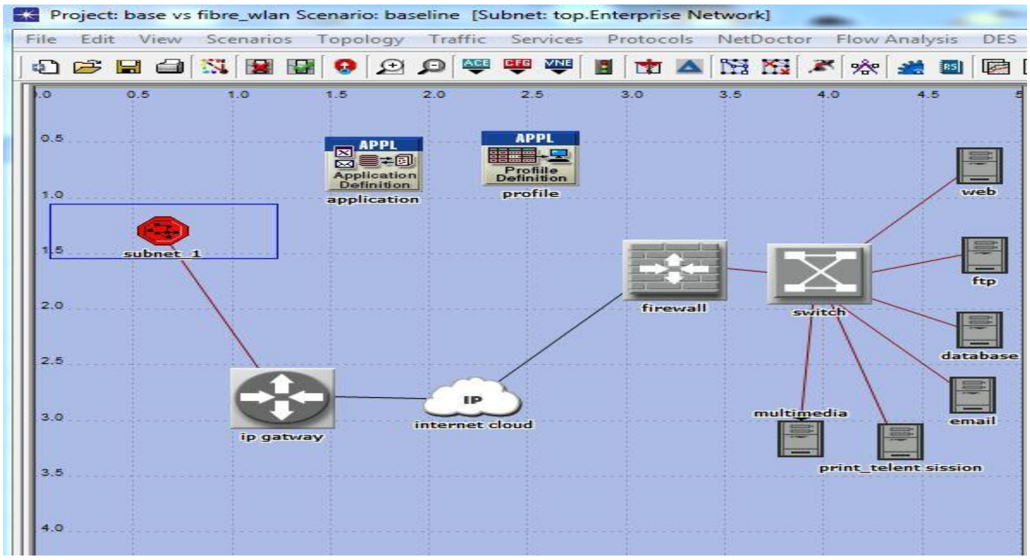



Figure 4: Simulated WAN Framework

The red octagon in Figure 4 titled *subnet_1* represents the remote branch office consist of an *office_LAN* having 20 workstations and an 802.11g WLAN BSS subnetwork connected by a 100BaseT link. Within that subnetwork are the mobile nodes and the Access Point that contain the WLAN, as seen in Figure 5.

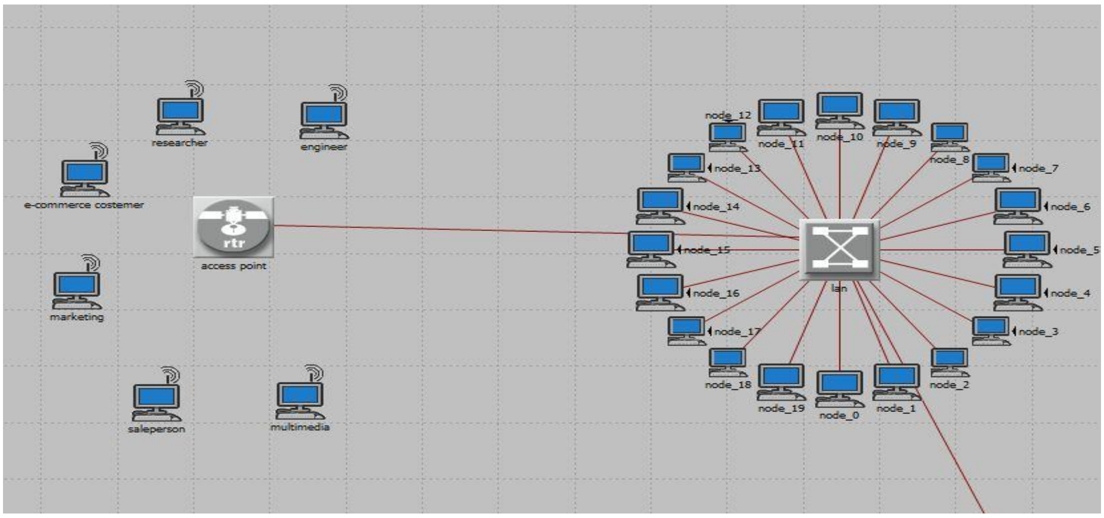


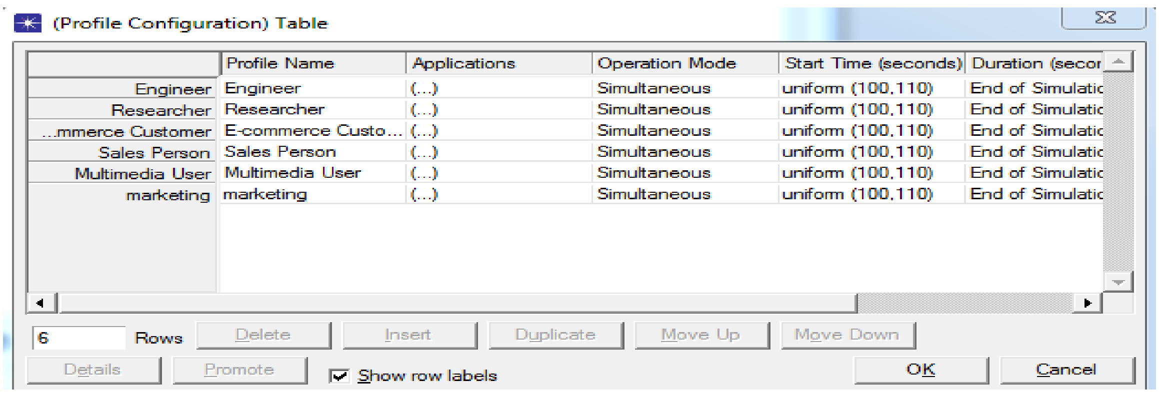

Figure 5: 802.11g WLAN BSS

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. 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 Modeler are enabled for future use. Table 2 details the departments and the applications commonly used. Figure 6 shows the profile configuration, which defines how the applications are run at the OPNETnetwork level. Every profile contains many number of applications, configured as shown in Table 2, which runs throughout the simulation.

**Table 2: User Profiles and Applications**

| PROFILE/ DEPARTMENT | APPLICATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Web Browsing | FTP | Email | Database | Talent session | Video confergence | print | voice |
| Engineer | Light | Light | Light | ____ | Light | ____ | ____ | ____ |
| Researcher | Heavy | ____ | Light | ____ | ____ | ____ | ___ | ____ |
| E-commerce Customer | Heavy | ____ | ____ | ____ | ____ | ____ | ____ | ____ |
| Sales Person | Light | Light | Light | Light | ____ | ____ | ___ | ____ |
| Multimedia User | ____ | ____ | ____ | ____ | ----- | Light | ___ | PCM |
| Marketing | Heavy | Light | Heavy | light | ____ | ____ | __ | ____ |




| | Profile Name | Applications | Operation Mode | Start Time (seconds) | Duration (secor |
|---|---|---|---|---|---|
| Engineer | Engineer | (...) | Simultaneous | uniform (100,110) | End of Simulatic |
| Researcher | Researcher | (...) | Simultaneous | uniform (100,110) | End of Simulatic |
| ...mmerce Customer | E-commerce Custo... | (...) | Simultaneous | uniform (100,110) | End of Simulatic |
| Sales Person | Sales Person | (...) | Simultaneous | uniform (100,110) | End of Simulatic |
| Multimedia User | Multimedia User | (...) | Simultaneous | uniform (100,110) | End of Simulatic |
| marketing | marketing | (...) | Simultaneous | uniform (100,110) | End of Simulatic |

Figure 6: Profile Configuration

### 3.2 Baseline IEEE 802.11g WLAN Deployment Scenario

The 802.11g baseline model was used in an OPNET to test and illustrate its performance. The goal of the emulation was to ensure proper operation of the model using the analysis of a particular aspect of a protocol's behaviour or examining a specific network performance characteristic.

#### 3.2.1 LOAD

The final load on the WLAN as a specific function of time as the simulation progressed is one of the important results. The overall WLAN load data is displayed in Figure 4.1 showing an average value of 325Kbps on the 15 minute mark.

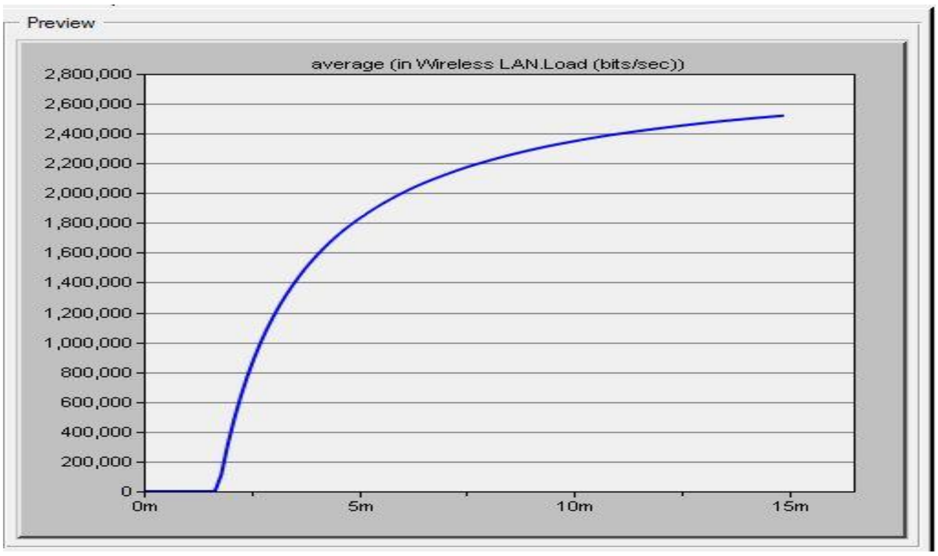



Figure 7.1 Total load of WLAN

The loads on each station and the AP are shown in Figure 7.2, and approximate average peak values on the 15 minute mark are shown in Table 3 below.

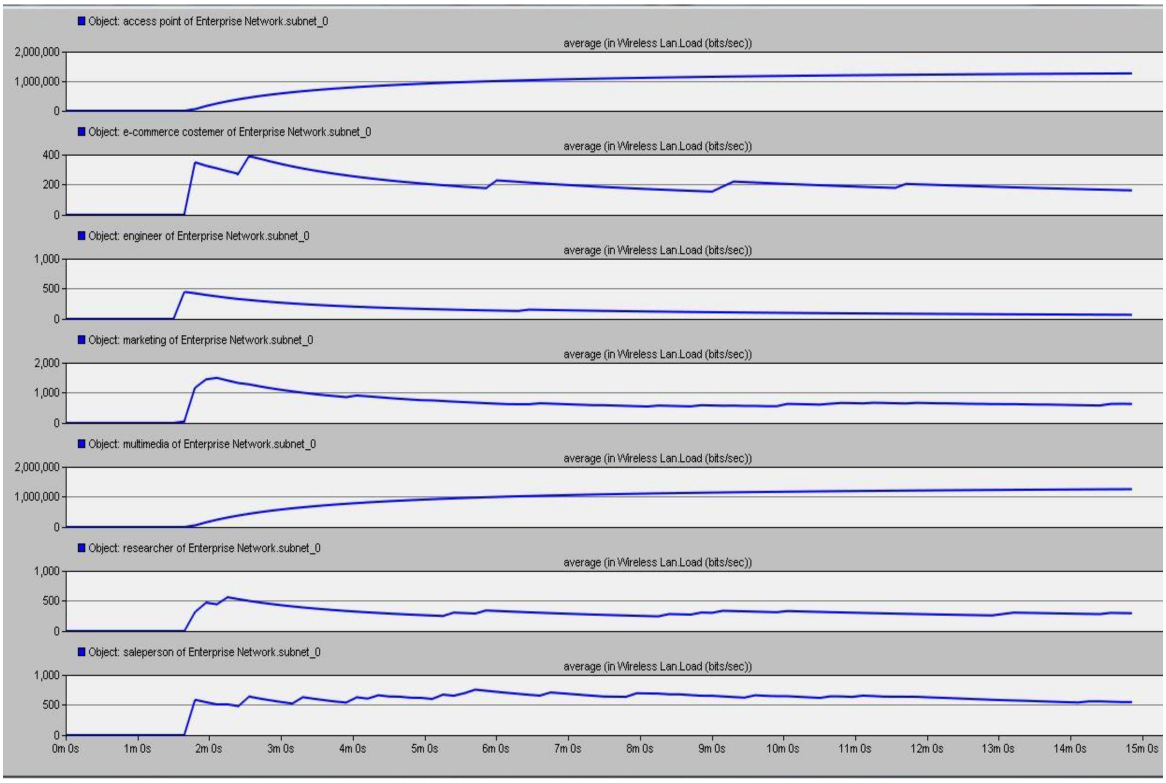



Figure 7.2: the Load Values for the access point and stations

Table 3: the load values for the AP and stations

| Node | Load (Kbps) |
|---|---|
| *AP* | 162.5 |
| *e-commerce costemer* | 0.0485 |
| *engineer* | 0.061 |
| *marketing* | 0.186875 |
| *multimedia* | 156.8625 |
| researcher | 0.07 |
| saleperson | 0.095 |
| **total** | **320** |

The total summation of the average loads of the access point and the stations show a value approximately equal to the overall WLAN load.

### 3.2.2- Delay

An important parameter in determining the successful operation of the MAC layer, its timing operations, and the RTS/CTS mechanism are the medium access delay and overall packet transmission delay statistics. Those results are shown in Figure 8. Average overall WLAN delay reach to 6ms while the average WLAN medium access delay reach to 5ms.

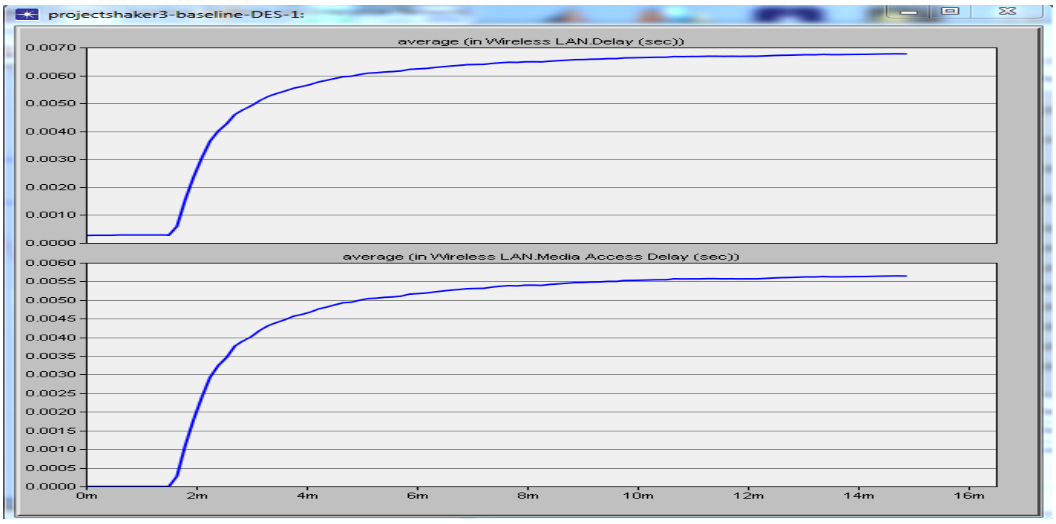



Figure 8: Packet Delay and Medium Access Delay

### 3.2.3-Throughput

A result of that no data was dropped is that the total load on the WLAN must be closely matched to the overall throughput of the WLAN which is the case here as is shown in Figure 9.

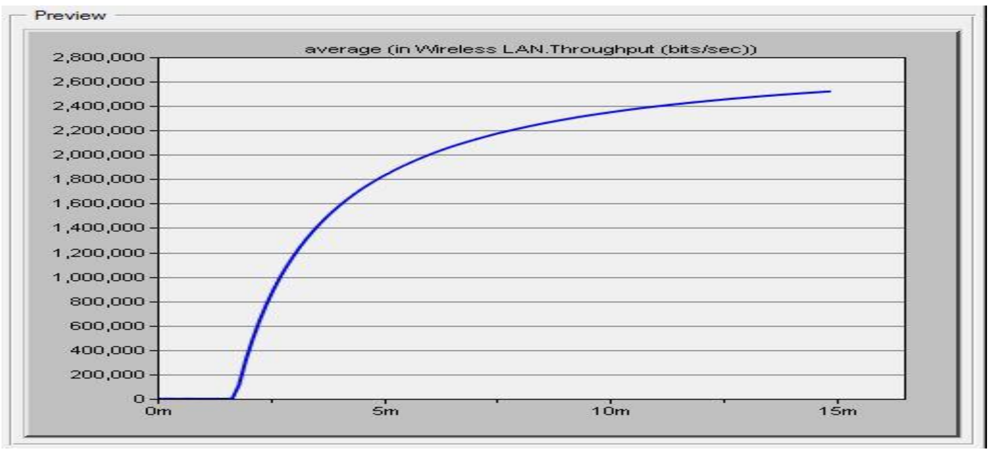



Figure 9 the overall throughput of the WLAN

## IV. CONCLUSION

The overall performance of the IEEE 802.11g Wireless Local area networks has been analyzed in detail with the help of OPNET Modeler. The performance has been analyzed with the help of the parameters like throughput, access delay, and theoverall 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 subnetwork operates within normal limits of the IEEE 802.11g standard.

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