

# Evaluating the Performance of Wireless Network using OPNET Modeler

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## ABSTRACT

Wireless networks have biggest constraint of limited bandwidth in comparison to wired networks but in spite of this constraint wireless networks are becoming popular day by day on account of their flexibility, mobility as well as inexpensive physical medium (air). This paper aims to simulate wireless local area network. The performance of the network is evaluated using optimized network engineering tool, OPNET 14.5 modeler, over four major physical layer technologies Infra-Red, Direct Sequence Spread Spectrum DSSS, Frequency Hopping Spread Spectrum FHSS and Orthogonal Frequency Division Multiplexing OFDM at multiple transmission rates, 1Mbps, 2Mbps, 5.5Mbps, 6Mbps, 9Mbps, 11Mbps, 36Mbps, 48Mbps, 54Mbps. DSSS can use 1, 2, 5.5, 11 Mbps rates. FHSS and IR are able to operate at 1 or 2 Mbps rates, while OFDM is capable to operate at 6, 9, 11, 36, 48 or 54 Mbps rate. A trade-off exists between the selected data rate and the physical technology. It is founded that at some transmission rate, the OFDM technology delay is better than in DSSS. FHSS delay is less than DSSS delay. IR delay is better than FHSS and DSSS delay. In addition, for one physical layer technology the delay can be reduced by increasing the transmission rate of the channel.

## General Terms

Throughput, delay, loads.

## Keywords

Wireless LAN, IEEE 802.11 OPNET.

## 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. WLANs [1-3] support a wide range of applications, which may include simple applications such as web browsing, file transferring, etc. and the other ones, for instance, real-time multimedia applications (e.g., video streaming and video conferencing). IEEE 802.11 is 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. This configuration provides optimized functionality for wireless communication. 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. The physical characteristic of 802.11a and 802.11g are identical – both are based on OFDM and support data rate of 54 Mbps.

However 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 with 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 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. 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. Infra-Red, Direct sequence, frequency hopping and OFDM has been utilized with different setting for comparison between them. The network setup have been simulated using OPNET 14.5 modeler. The simulation consists of sixteen scenarios. One scenario differs from the other scenario either in the physical layer technology or (and) transmission rate or (and) in data generation rate.

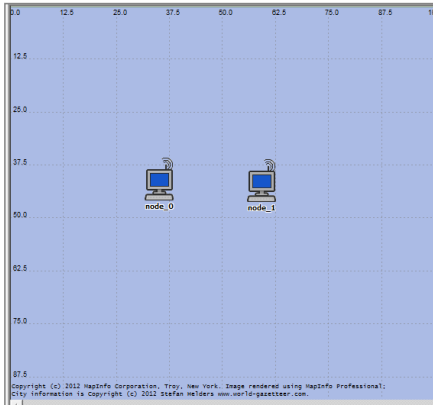
## 2. RELATED WORK

There exists a large body of research on wireless network, such as [4, 5, 6, and 7]. In [4], performance analysis of the Wireless and Wired computer networks through simulation has been attempted using OPNET as simulating tool.

The authors [5] simulated wireless LAN standard through the delivery of video traffic. The authors [6] suggest that Wireless LAN performance can be improved by fine tuning parameters such as fragmentation threshold, and buffer size. In [7], performance of 802.11 WLAN scenarios have been evaluated in OPNET Modeler 14.5. Throughput of the WLAN is evaluated in the presence of high priority traffic as well as low priority traffic, generating data simultaneously

## 3. EXPERIMENTAL SETUP

In order to study the performance of wireless networks, the network setup have been simulated using OPNET-14.5 simulator and various tests on it have been conducted. Performance of the proposed system is evaluated with different scenarios. The proposed network is an ad hoc network (Fig.1) consists of two independent wireless workstations (mobile).



**Fig.1: The Proposed Network**

Table 1 includes the traffic generation parameters and Table 2 includes WLAN parameters for this work. The traffic generation parameters are selected such that the generation rate of data is 1Mbps. The results are shown in figures (2-19)

**Table 1. Traffic Generation Parameters.**

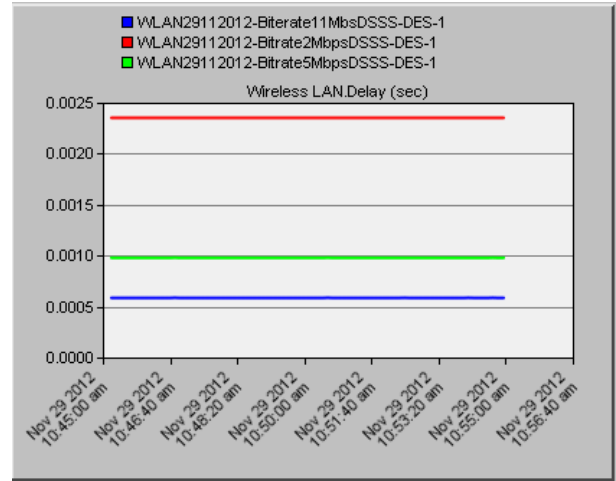
Attribute	Value
Start Time (seconds)	Constant (10)
On State Time (seconds)	Constant (600)
Off State Time (seconds)	Constant (0)
Interval Time (seconds)	0.004
Packet Size (bytes)	512
Stop Time (seconds)	Never

**Table 2. WLAN Parameters**

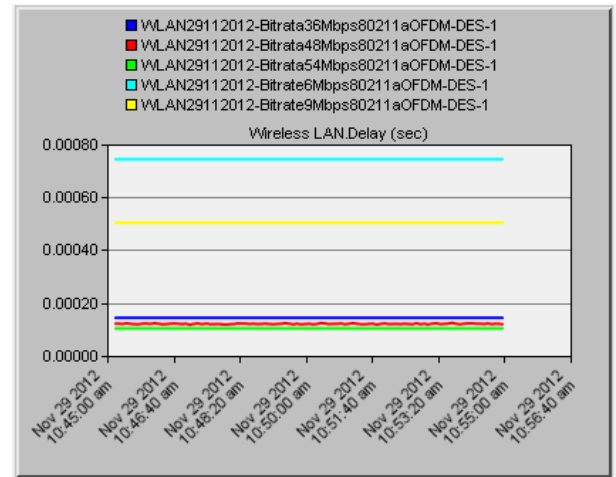
Attribute	Value
BSS Identifier	Auto Assigned
Access Point Functionality	Disabled
Physical Characteristics	Infra-Red, Direct Sequence, Frequency Hopping, OFDM
Data Rate	1Mbps, 2Mbps, 5.5 Mbps, 6Mbps, 9Mbps, 11Mbps, 36Mbps, 48Mbps, 54Mbps
Channel Setting	Auto Assigned
Buffer Size (bits)	2560000

### 3.1 WLAN Delay

Global statistics of WLAN delay is gathered for ten minutes of simulation time and can be observed in the following figures. WLAN delay represents the end to end delay of all the packets received by the wireless LAN MACs of all WLAN nodes in the network and forwarded to the higher layer. This delay includes medium access delay at the source MAC, reception of all the fragments individually, and transfers of the frames via AP (Access Point), if access point functionality is enabled. In this system the AP functionality is disabled as shown in table 2. WLAN end to end delay can be shown in figures (2-7).

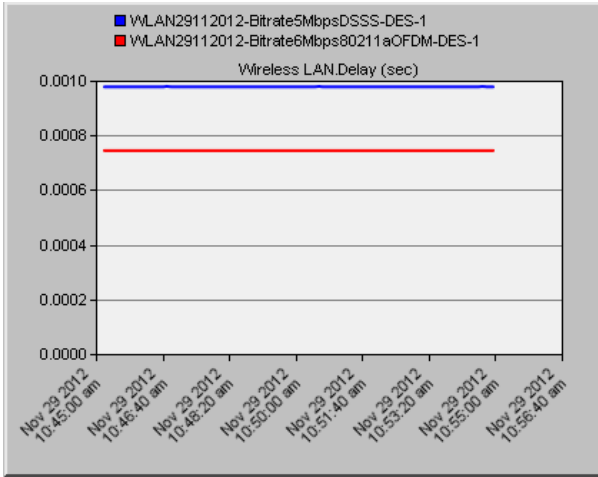


**Fig.2: WLAN End to End Delay with DSSS Physical Layer Technology.**

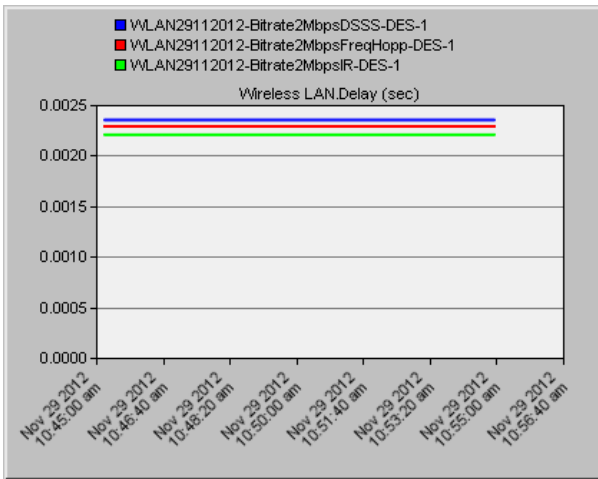


**Fig 3: WLAN End to End Delay with OFDM Physical Layer Technology.**

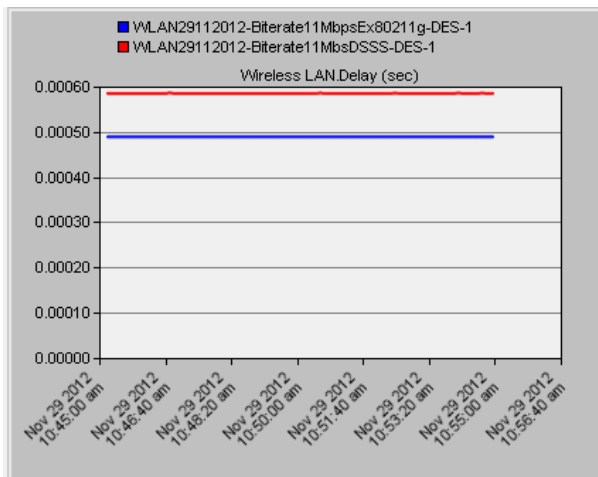
As expected, the end to end delay is reduced with increasing the bit rate (fig. 2,3). A comparison between the end to end delays of different physical layer technologies at the same bit rate can be shown in figures (4,5,6). Figure 6 shows the WLAN end to end delay for most scenarios presented in this paper. From these figures, it can be concluded that, at the same bit rate, the end to end delay in DSSS physical layer technology is greater than in OFDM and frequency hopping technologies. In addition, the figures show that the delay for IR is lower than delays for DSSS and FHSS. The best delay can be obtained when the OFDM physical layer technology at 54 Mbps is utilized.



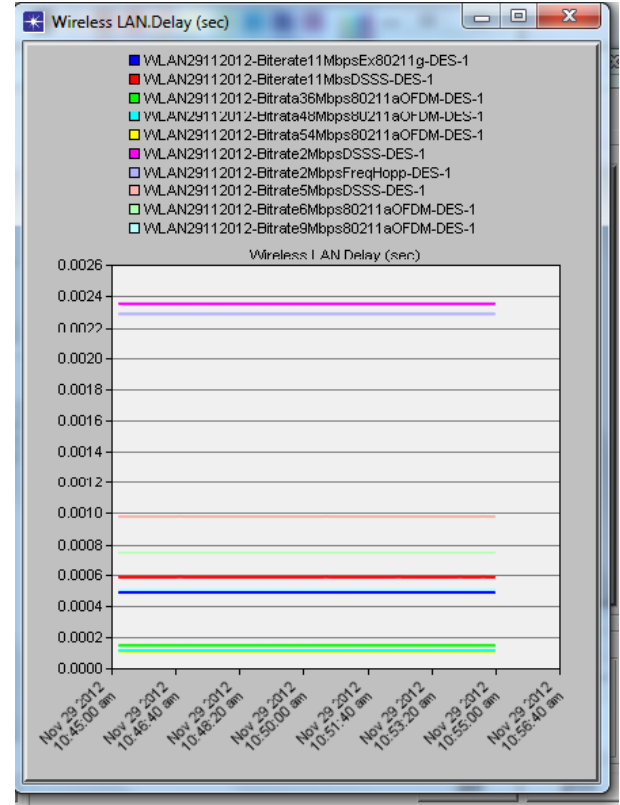
**Fig.4: WLAN End to End Delay (DSSS at 5.5Mbps, OFDM at 6Mbps)**



**Fig.5: WLAN End to End Delay (DSSS at 2Mbps, Frequency Hopping at 2Mbps, IR at 2Mbps)**



**Fig.6: WLAN End to End Delay (DSSS at 11Mbps, Ex802.11g at 11Mbps)**



**Fig 7: WLAN End to End Delay for the Proposed Scenarios**

### 3.2 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. This delay can be compared with the WLAN end to end delay. As shown in fig. (8-10) the media access delay can be neglected in compared with the end to end delay.

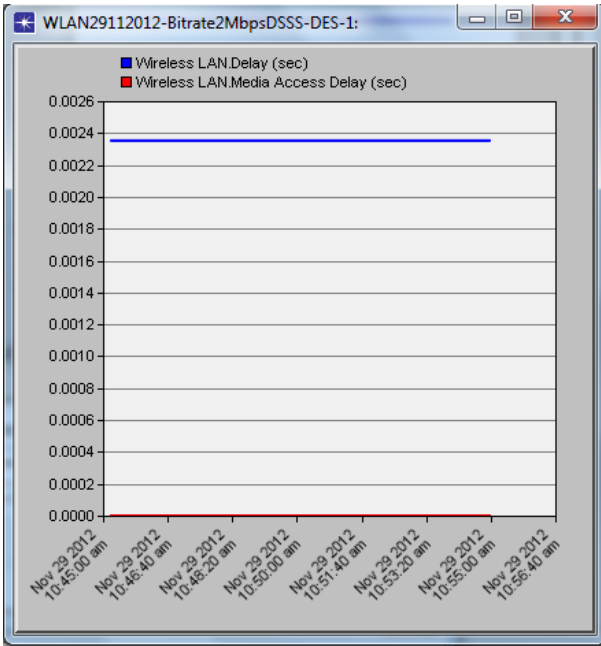


Fig.8: Media Access Delay and End to End Delay with DSSS Physical Layer Technology.

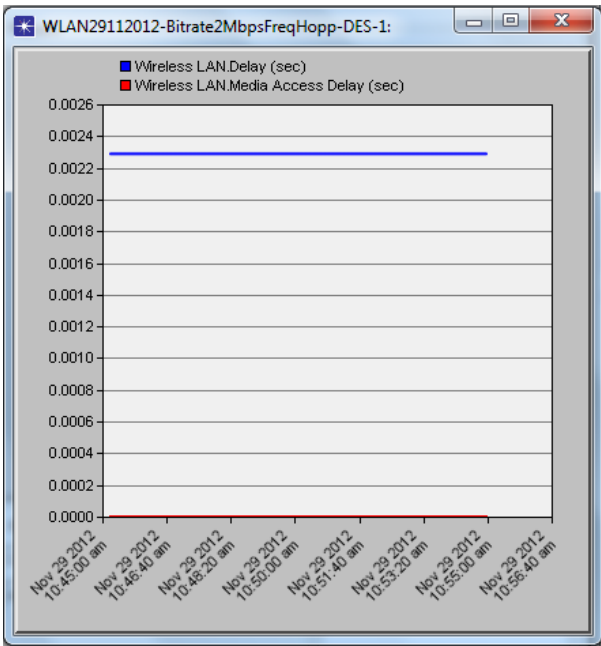


Fig.9: Media Access Delay and End to End Delay with Frequency Hopping Physical Layer Technology.

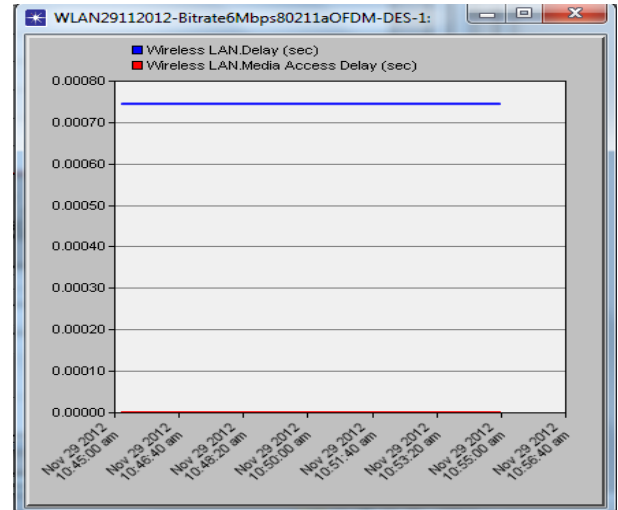


Fig.10: Media Access Delay and End to End Delay with OFDM Physical Layer Technology

### 3.3 Traffic Received, Traffic Sent, Data Dropped, Throughput and Load

The traffic received, traffic sent, data dropped, throughput and load are shown in figures (11-19).

The traffic generation parameters for the proposed system are selected in a way such that the generation rate of data is 1Mbps. So the throughput, load, traffic received and traffic sent are 1Mbps for the proposed system and no dropped data as shown in figures (11-13). In the network with 1Mbps bite rate (fig.15), there is dropping in the data. The load on the network equal to 1Mbps but the throughput is less than this value (fig.14). The traffic received can be improved (fig.16) by tuning the traffic generation parameters.

The load on the network is fixed for the proposed scenarios. So to improve the throughput of the system, the traffic generation parameters are tuned (fig.17&18). The WLAN delay has been increased as shown in fig.19.

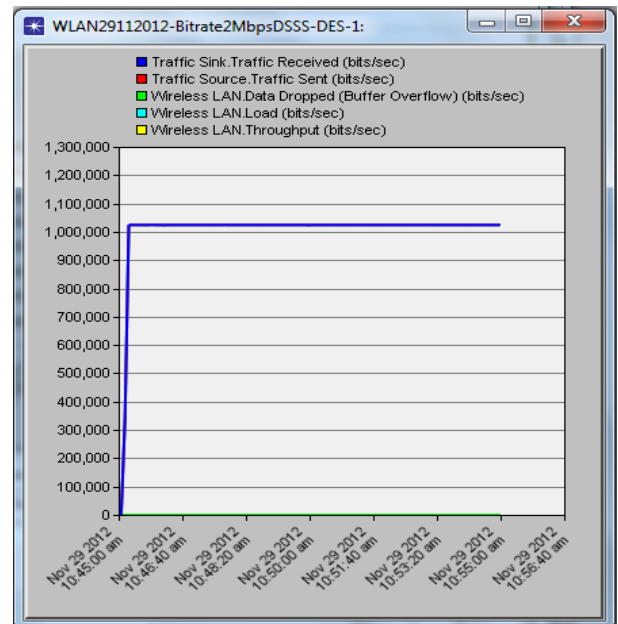


Fig.11: Traffic, Load, Throughput, Data Dropped for DSSS physical layer technology at 2 Mbps

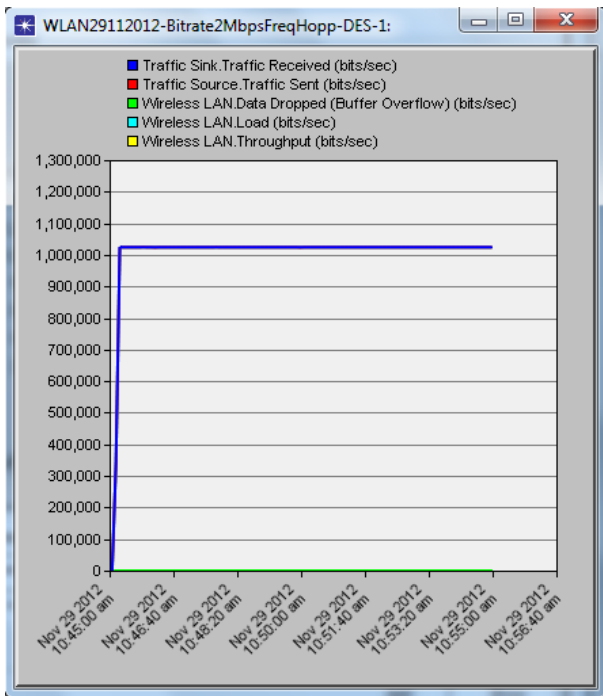


Fig.12: Traffic, Load, Throughput, Data Dropped for Frequency Hopping physical layer technology at 2 Mbps

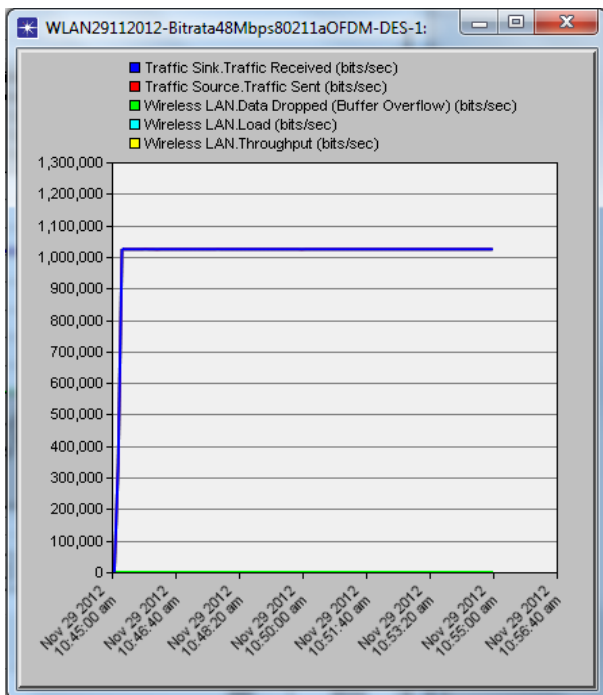


Fig.13: Traffic, Load, Throughput, Data Dropped for OFDM physical layer technology at 48Mbps

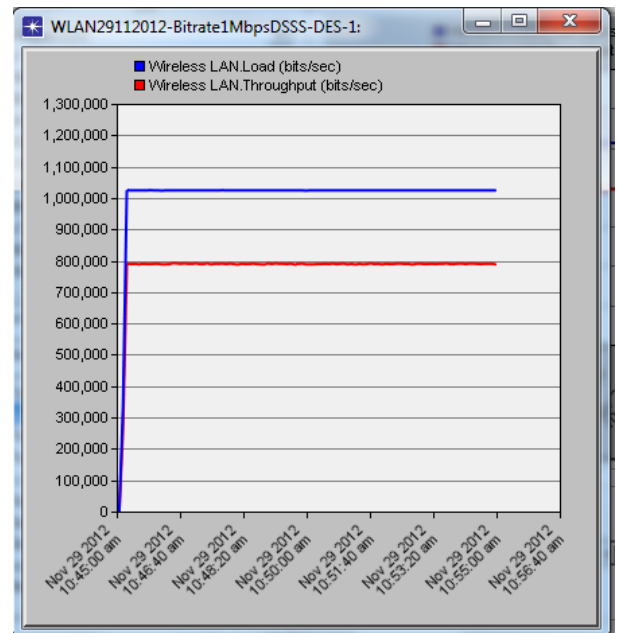


Fig.14: Load, Throughput for DSSS physical layer technology at 1 Mbps

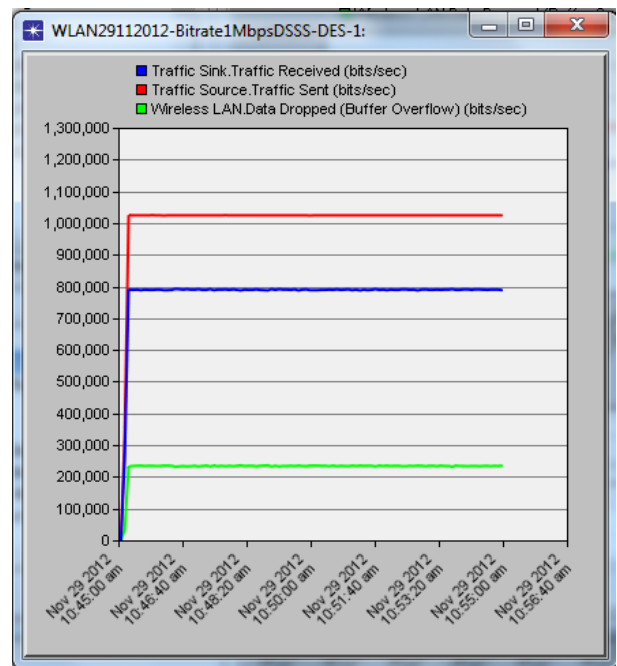
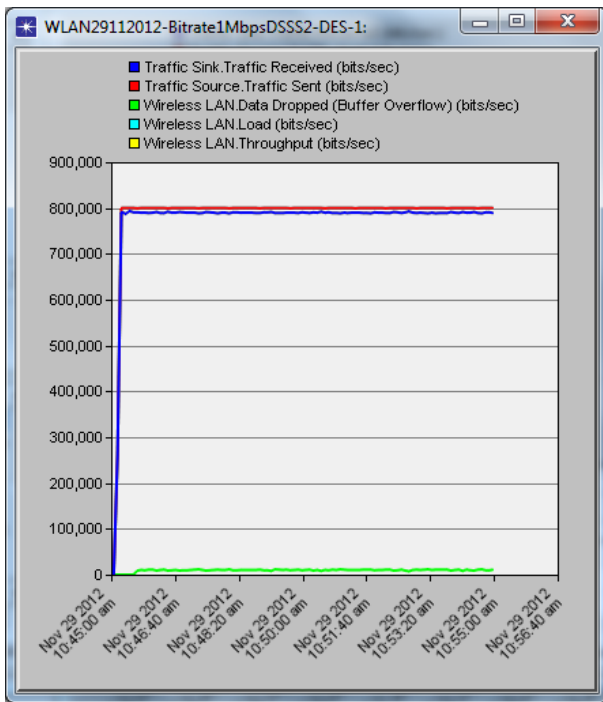
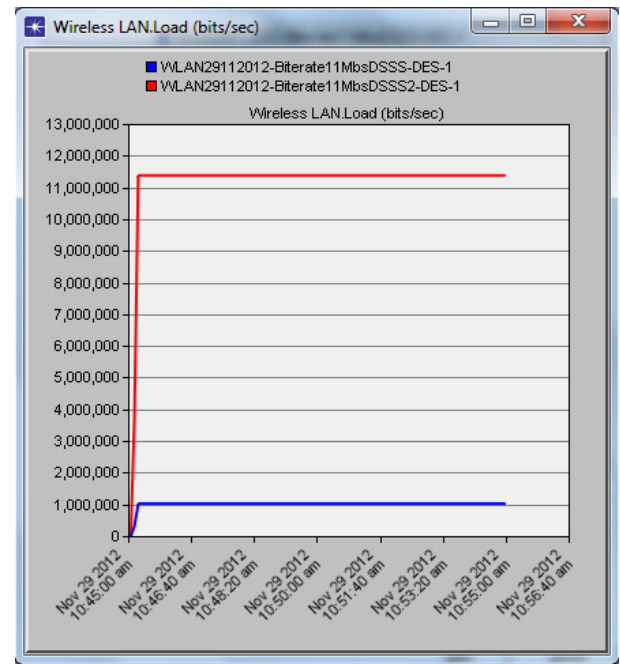


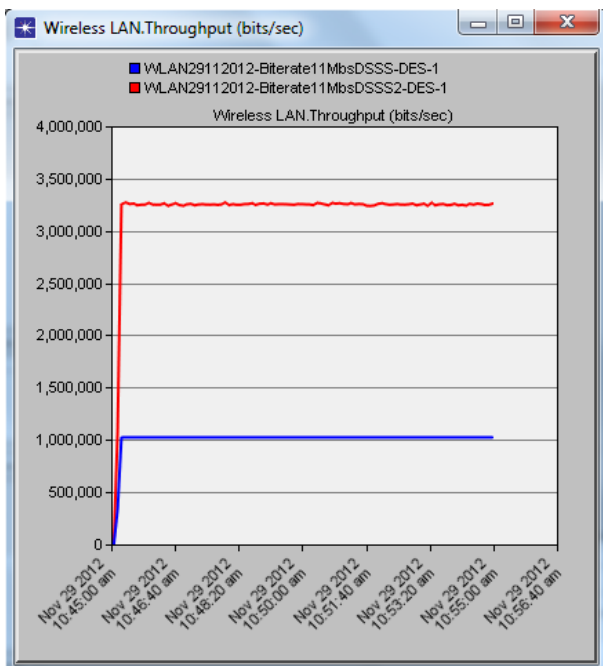
Fig.15: Traffic Received, Traffic Sent, Data Dropped for DSSS physical layer technology at 1 Mbps



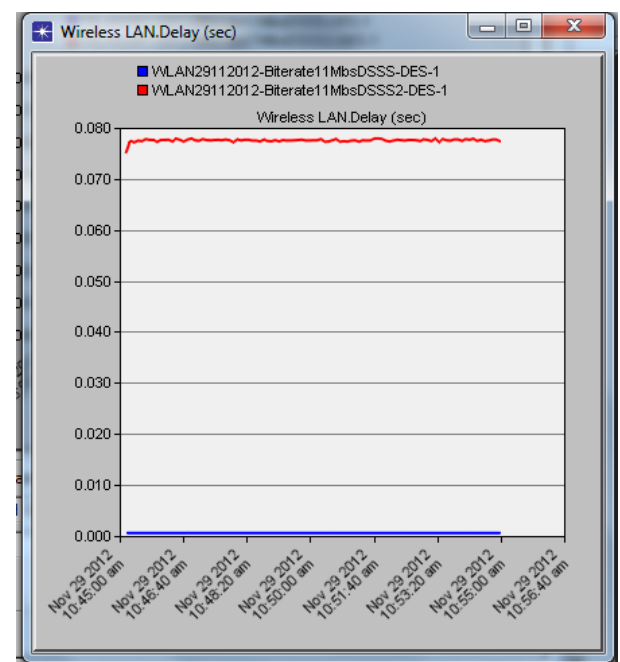
**Fig.16: Traffic Received, Traffic Sent, Data Dropped, Throughput, Load for DSSS physical layer technology at 1Mbps after tuning traffic generation parameters**



**Fig.18: Load for DSSS physical layer technology at 1Mbps before (DSSS) and after (DSSS2) tuning the traffic generation parameters**



**Fig.17: Throughputfor DSSS physical layer technology at 1Mbps before (DSSS) and after (DSSS2) tuning the traffic generation parameters**



**Fig.19: WLAN end to end delay for DSSS physical layer technology at 1Mbps before (DSSS) and after (DSSS2) tuning the traffic generation parameters**

## **CONCLUSIONS**

In the proposed system, the performance of wireless network scenarios (sixteen scenarios) in OPNET Modeler 14.5 is evaluated. End to end delay, media access delay, throughput, load, traffic received and traffic sent is evaluated for the physical layer technologies IR, DSSS, FHSS and OFDM at multiple transmission rates. In terms of delay, at some physical layer technology, the delay can be improved (decreased) with increasing the transmission rate. Delay at the same transmission rate, OFDM is better than DSSS and FHSS physical layer technology. In addition, IR is better than DSSS and FHSS. To obtain better throughput, the generation of data is tuned.

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