Throughput and Delay Analysis of Access Point in IEEE802.11b Wireless LAN Using Opnet Simulator

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Abstract : In this paper, we analyze the throughput and Delay performance of IEEE 802.11b Wireless Local Area Network (WLAN) with one access point. The IEEE 802.11b is a wireless protocol standard. In this paper, a wireless network was established which has one access point. OPNET IT Guru Simulator (Academic edition) was used to simulate the entire network. In this paper we considered the effects of varying the data-rate were observed on the throughput and Delay performance metric. Several simulation graphs were obtained and used to analyze of wireless network with good throughput and minimum access delay.

IndexTerms - Access Point (AP), Medium Access Control (MAC), OPNET, Wireless local area networks (WLANs), Data-rate, buffer size, fragmentation threshold, throughput.

I. INTRODUCTION

As the technology is improving so are the demands of end users and their applications increasing. Wireless Local Area Networks (WLANs) has become one of the most promising and successful technology in recent years. WLANs provide free wireless connectivity to end users, offering an easy and viable access to the network and its services. Wireless networks are superior to wired networks with regard to aspects such as ease of installation and flexibility. They do, however, suffer from lower bandwidth, higher delays, higher bit-error rates, and higher costs than wired networks. With the advent of Wireless Local Area Networks (WLANs), bandwidth has increased and prices have decreased on Wireless networking solutions. These factors have made WLANs a very popular Wireless networking solution [1].

Wireless network has some attributes or parameters such as data-rates, buffer sizes, fragmentation threshold (FTS), etc. It also has some qualities of service or metrics like the Throughput, Delay, Media access delay, Data dropped Retransmission attempts, etc. But analysis here is only for throughput and Delay performance.

Physical Architecture of WLAN

There are two kinds of WLAN architectures:

1. Ad-hoc (Infrastructure less) architecture
2. Infrastructure architecture

***Ad-hoc (Infrastructure less) Architecture*:**

It is the simplest WLAN configuration. It is an independent (or peer-to-peer) WLAN and is also known as an Ad-hoc network. It is a group of computers each equipped with a wireless LAN client adapter. In this configuration, no access point is necessary and the devices in the LAN configure themselves at the same radio channel to enable peer-to-peer communication. Independent network can be set up whenever two or more wireless adapters are within range of each other [2].

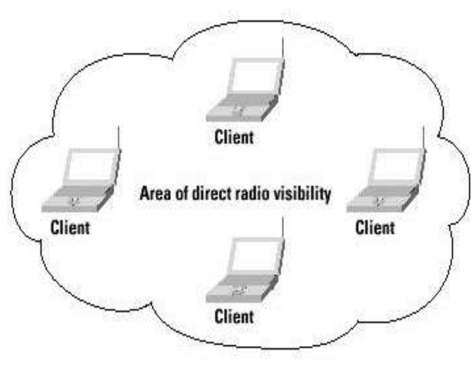

Figure1. Infrastructure less Wireless Network

Infrastructure Architecture:

Infrastructure WLAN consists of wireless stations and access points. Access Points are connected with a distribution system (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. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called "handoff" [2].

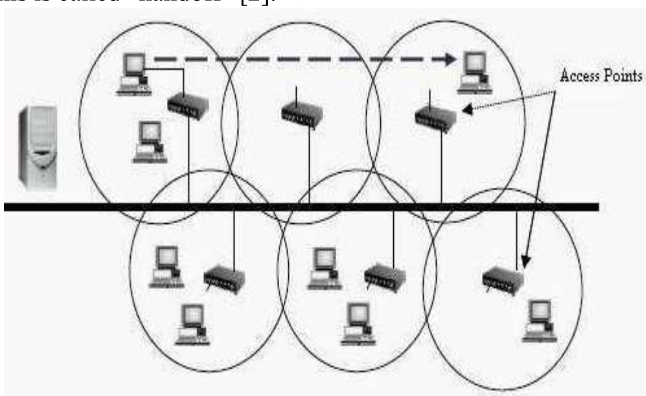

Figure2. Infrastructure Wireless Networks

II. SELECTING FIGURE OF ACCESS POINT

2.1 Throughput Analysis

In a wireless network, system throughput is defined as the fraction of time that a channel is used to successfully transmit payload bits. Throughput can be obtained by analyzing the possible events that may happen on a shared medium in a randomly chosen slot time [3].

Let P_{idle}, P_{col} and P_{succ} be the probabilities that a randomly chosen slot corresponds to an idle slot, a collision, and a successful transmission, respectively. Moreover, let δ, T_{col}, and T_{succ} be the duration of the slot corresponding to an idle slot, a collision, and a successful transmission, respectively.

We can obtain the average duration represented by T_{avg} that a generic slot lasts as follows:

$$T_{avg} = P_{idle}\delta + P_{succ}T_{succ} + P_{col}T_{col} \ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Now, the throughput S can be calculated as

$$S = E\ [\text{Payload information transmitted in a slot time}] \ldots(2)$$

$$S= \frac{P_{succ}*E[P]}{T_{avg}} = \frac{P_{succ}*E[P]}{P_{idle}\delta + P_{succ}T_{succ} + P_{col}T_{col}} \ldots\ldots \ldots\ldots\ldots\ldots(3)$$

Where E[P] is the average payload size (in terms of time unit), and thus is the average amount of payload information successfully transmitted in a generic slot time.

By dividing the numerator and denominator of equation (3) by ($P_{succ}T_{succ}$), the throughput can be expressed as follows:

$$S= \frac{E[P]/T_{succ}}{1+\frac{P_{col}}{P_{succ}}*\frac{T_{col}}{T_{succ}}+\frac{P_{idle}}{P_{succ}}*\frac{\delta}{T_{succ}}}\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Accordingly, the above analysis applies to both two-way and four way handshakes transmission. To specifically compute the throughput for a given handshake, we only need to specify the corresponding values of T_{col} and T_{succ}. Note that the idle slot time, δ, is specific to the physical layer [4].

2.1 Delay Analysis

The packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network. This time is expressed in sec. Hence all the delays in the network are called packet end-to-end delay, like buffer queues and transmission time. Some time this delay can be called as latency; it has the same meaning as delay. There are different kinds of activities because of which network delay is increased. We have several kinds of delays which are processing delay (PD), queuing delay (QD), transmission delay (TD) and propagation delay (PD). The queuing delay (QD) is not included, as the network delay has no concern with it [5].

Mathematically it can be shown as equation (5).

$$d_{end\text{-}end} = N\,[d_{trans} + d_{prop} + d_{proc}] \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where,
$d_{end\text{-}end}$ = End to end delay
d_{trans} = Transmission delay
d_{prop} = Propagating delay
d_{proc} = Processing delay
Suppose if there are N number of nodes, then the total delay can be calculated by taking the average of all the packets, source destination pairs and network configuration.

III. NETWORK DESIGN AND SIMULATION RESULTS

A network which has one access point and five nodes was set up as shown in fig. below. Simulations were carried out using OPNET IT Guru simulator (Academic edition). The effects of varying data rate on the throughput and delay as a performance metric were analyzed.

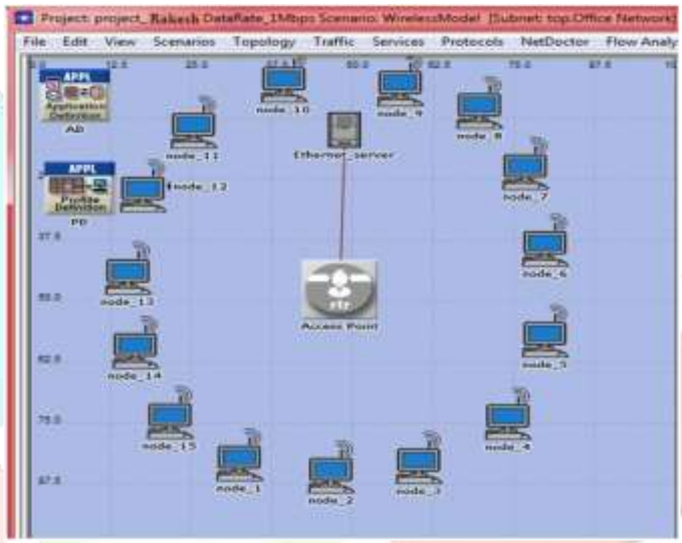

Figure3. Infrastructure Wireless Model Design

3.1. The Data-Rates (Mbps)

This signifies the speed of the nodes connected within a network. The WLAN model in OPNET IT Guru 14.1 supports data transfer at 1, 2, 5.5 and 11Mbs. These data rates are modelled as the speed of transmitters and receivers connected to WLAN MAC process. Each data rate is associated with a separate channel stream, from the MAC process to the transmitter and from the receiver to the MAC process.

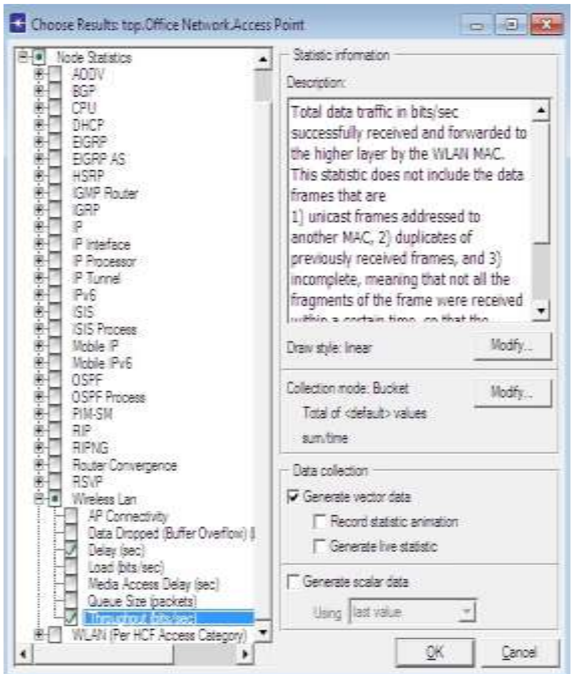

Figure4. Selection of Access Point statistics

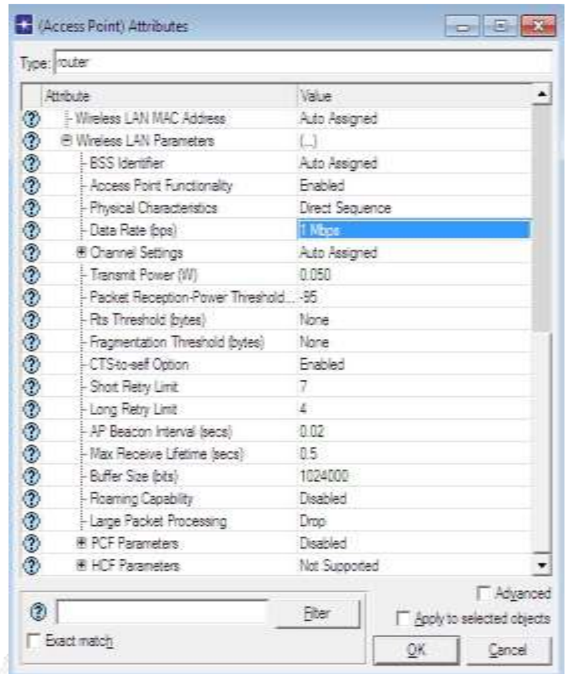

Figure5. Selection of attributes for 1Mbps

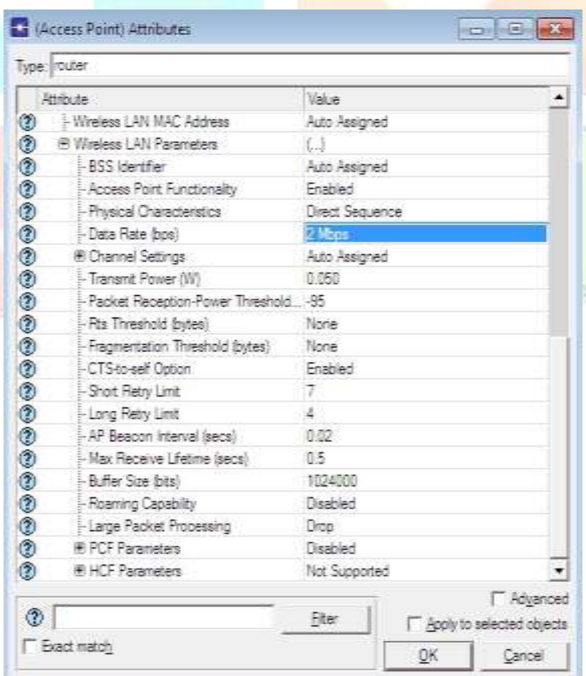

Figure6. Selection of attributes for 2Mbps

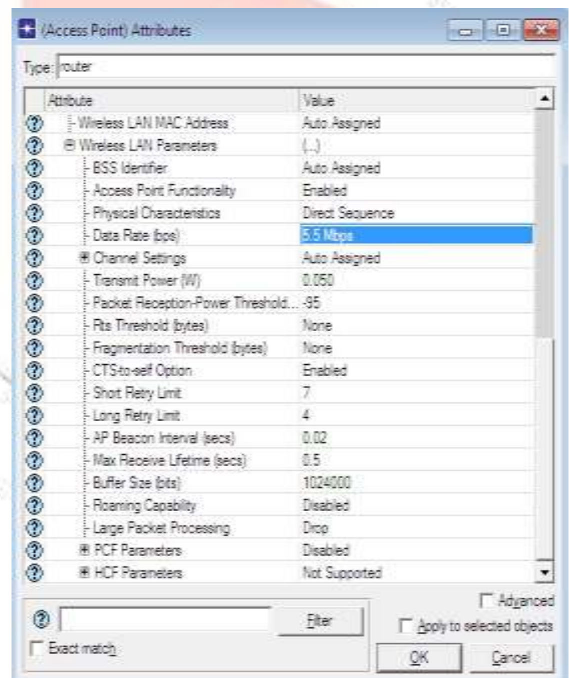

Figure7. Selection of attributes for 5.5Mbps

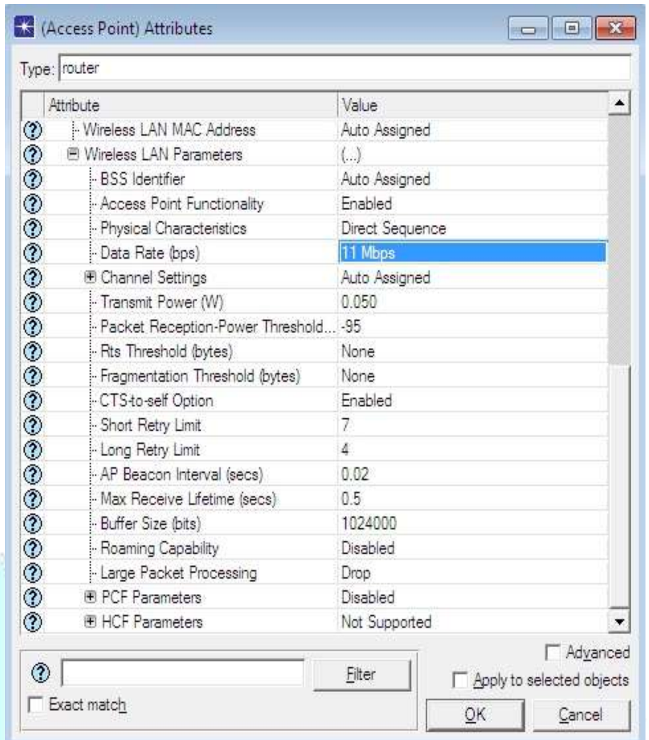

Figure8. Selection of attributes for 11Mbps

IV. ANALYSIS AND SIMULATION RESULT

Figure 9 shows the wireless LAN Delay and Throughput for data rate 1 Mbps, according the simulation result in fig 9 we find maximum delay 0.32sec and Throughput 3000000 bit/sec.

Figure 10shows the wireless LAN Delay and Throughput for data rate 2 Mbps, according the simulation result in fig 10 we find maximum delay 0.25sec and Throughput 3700000 bit/sec.

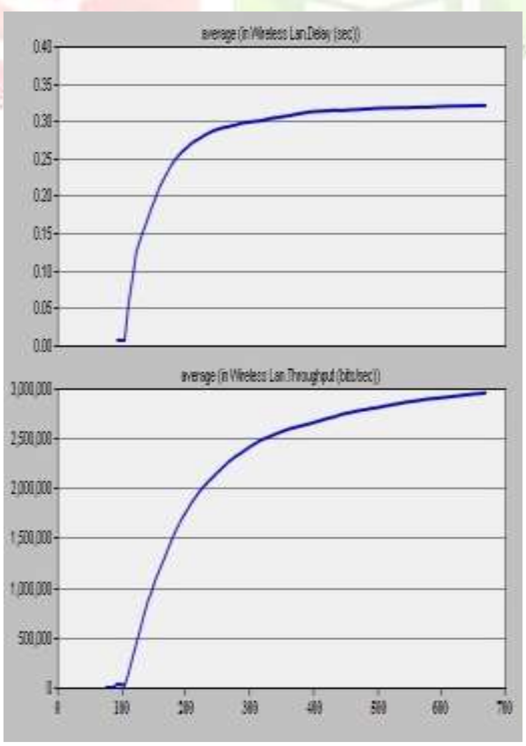

Figure9: Delay and Throughput for 1Mbps

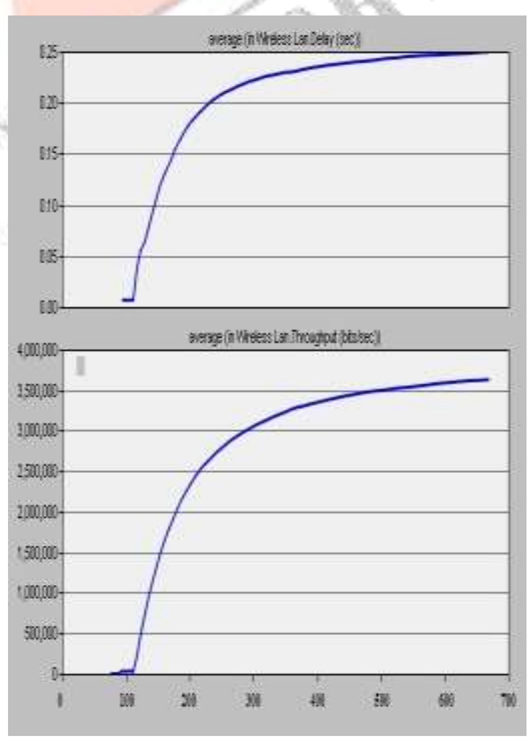

Figure10: Delay and Throughput for 2Mbps

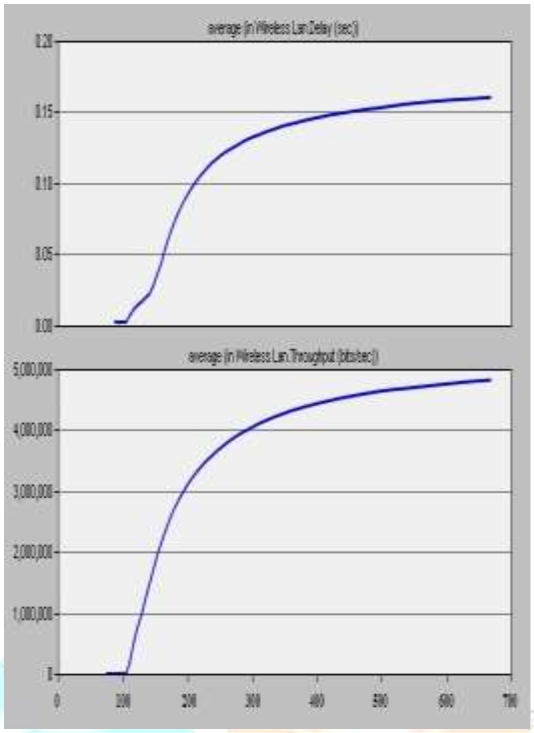

Figure11: Delay and Throughput for 5.5Mbps

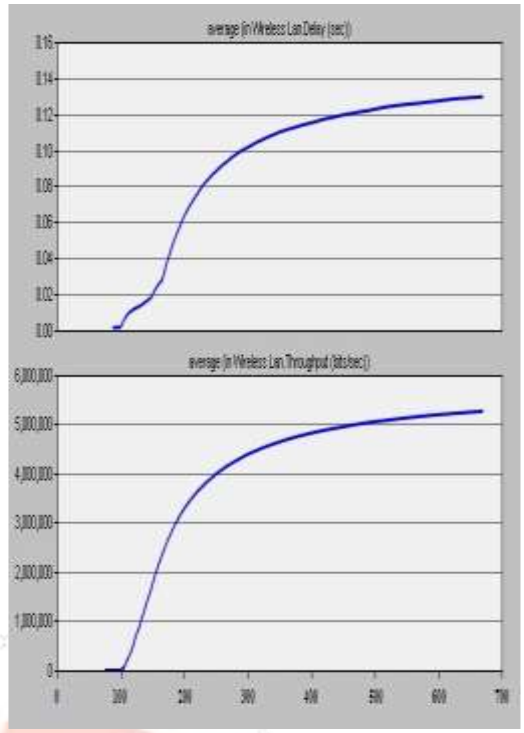

Figure12: Delay and Throughput for 11Mbps

Figure 11 shows the wireless LAN Delay and Throughput for data rate 5.5 Mbps, according the simulation result in fig 11 we find maximum delay 0.16sec and Throughput 4900000 bit/sec.

Figure 12 shows the wireless LAN Delay and Throughput for data rate 11 Mbps, according the simulation result in fig 12 we find maximum delay 0.13sec and Throughput 5200000 bit/sec.

Based on the simulation of the four scenarios for the data-rates, the graphs in figure 13 were obtained. It is found that when the data-rate was increased from 1Mbps to 11Mbps, the delay decreased. Thus based on the graphical result above, it can be said that when data-rate increases in a network, the Delay decreases.

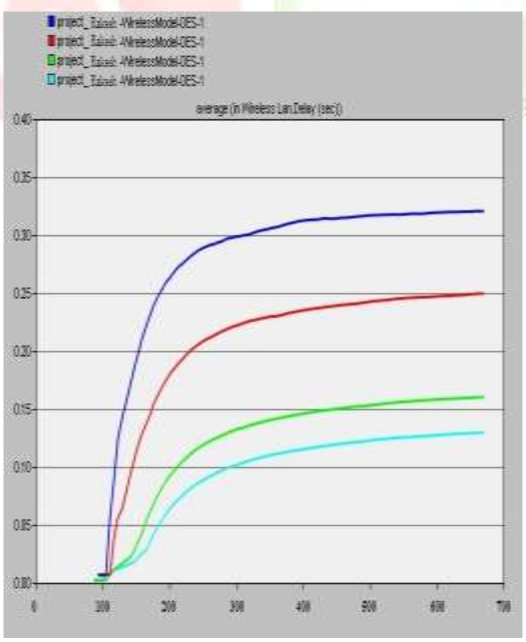

Figure13. Delay comparison result

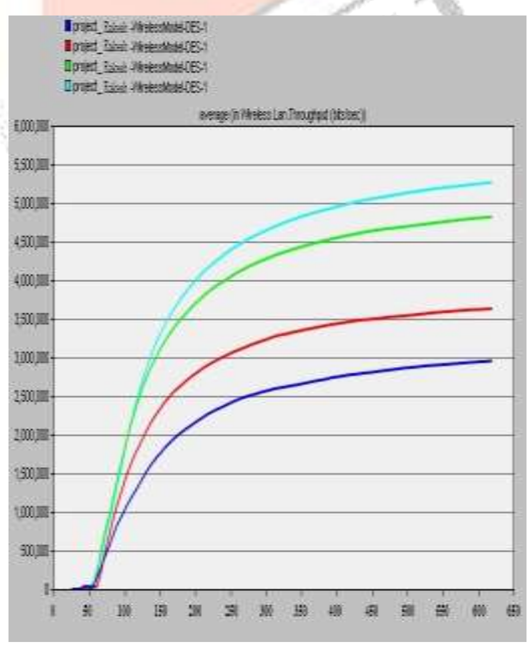

Figure14. Throughput comparison result

Based on the simulation of the four scenarios for the data-rates, the graphs in figure 14 were obtained. It is found that when the data-rate was increased from 1Mbps to 11Mbps, the throughput increased. This is predictable from the theoretical view point that as data-rate increases, the number of bits received increases [6]. Thus based on the graphical result above, it can be said that when data-rate increases in a network, the throughput increase; but when the network is overloaded with several stations, that same throughput decreases, since throughput is the number of bits successfully transmitted per second.

The 11Mbps is good for the network, and that is why the graphs first rose sharply before they became stable. Stability of a network is what matters in any network design, and that is why this simulation was performed using long duration of 650 seconds in order to get a good performance study.

V. ACKNOWLEDGMENT

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