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Performance Optimization of IEEE 802.11B WLAN Using Discrete Event Simulation

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***Abstract* - Wireless communication always attracts extensive research interest, as it is a core part of modern communication technology. IEEE 802.11b has become common in recent years largely due to the advantage of User mobility, relatively low acquisition cost, and ease of implementation, thus becoming common for both residential and business places for Internet access. However, the end-user experience has often been less satisfactory than what the technology can offer. IEEE 802.11b WLAN is known to achieve relatively small throughput performance compared to other standards. The focus of this work is on IEEE 802.11b network performance. The quaternary key shifting modulation technique was used for the dissertation while discrete event simulation was the simulation technique used on the Riverbed Modeller software. Results showed that when the data rate was increased from 1Mbps to 11 Mbps which is the optimum value, throughput increased, there was an 80% reduction in delay, and retransmission attempts also decreased to approximately zero, results also showed that when buffer size was increased from 1000bits to 12800bits which is also at optimum value, throughput increased by approximately 90% no data dropped since it will take a longer time for the buffer to be filled up and about zero retransmission attempts was achieved.**

Keywords: IEEE 802.11b, network performance, Riverbed Modeller, Quaternary Modulation.

I. INTRODUCTION

Wireless networks have become the norm for users accessing online services on the Internet [1]. The amount of data flowing through these networks is growing rapidly due to new applications and connected devices, leading to an increasing need for higher bandwidth [2]. Currently, most wireless local area networks (WLANs) use the IEEE 802.11 distributed coordination function (DCF) standard, which employs a probabilistic medium access control (MAC) layer[3], [4]. WLANs are mainly deployed in the infrastructure mode, where all nodes, typically in close proximity, communicate through an access point, which serves as a link between the wireless and wired networks [5].

The IEEE 802.11b standard extended the original IEEE 802.11 by introducing Direct Sequence Spread Spectrum (DSSS) [6] with complementary code keying (CCK) modulation [7], enabling data rates of up to 11 Mbps in the 2.4 GHz unlicensed spectrum. This standard is commonly used in point-to-multi-point configurations, where an access point communicates through an omni directional antenna with mobile clients within its range and direct line of sight [8]. The range of 802.11b networks depends on factors such as output power, audio frequency environment, and receiver sensitivity [9].

During the development of 802.11b, another extension called 802.11a was created, which operates at a higher frequency (around 5 GHz) and supports bandwidth up to 54 Mbps [10]. However, the higher frequency of 802.11a results in shorter range and more difficulty in signal penetration through obstacles like walls. Due to compatibility issues and cost, 802.11a is typically found in business networks, while 802.11b is more prevalent in-home environments [11].

802.11b became widely adopted as a definitive wireless LAN technology due to significant price reductions. However, a major disadvantage of this standard is the common frequency band it shares with other technologies like cordless phones, Bluetooth devices, microwave ovens, and baby monitors, leading to interference and user density problems. Other standards like 802.11g, 802.11n, and 802.11ac offer faster maximum speeds than 802.11b, but their higher deployment costs make 802.11b remain popular and attractive [12]. Quality of service (QoS) is crucial in assessing network performance, considering aspects such as throughput, packet loss, bit rate, and transmission delay.

Wireless technologies, such as WLANs based on the IEEE 802.11 standard, WiMAX, and LTE, have revolutionized Internet access, providing connectivity anywhere and anytime. WLANs with Access Points have proven successful in offering infrastructure access and cost-efficient alternatives to wired connections [13]. However,

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wireless resources are limited, and the standard lacks QoS guarantees. Efficient resource management is essential to ensure QoS for real-time services while enhancing overall throughput and fair resource sharing among best-effort users. The IEEE 802.11 working group has ratified wireless communication standards for systems operating in the license-free 2.4 GHz ISM band.

IEEE 802.11b as compared to other standards has the slowest maximum speed and supports bandwidth of just 5.5 – 11Mbps data rates (in addition to the already specified and 2 Mbps). There is therefore need to analyze, throughput, fragmentation threshold, delay, retransmission attempts, media access delay, buffer size in order to achieve the maximum yield from this standard (as it is probably the most widely implemented wireless technology) under noisy channel conditions with real time traffic.

II. LITERATURE REVIEW

In their research work, [14] described a Wireless Local Area Network (WLAN) as a wireless computer network that links two or more devices using a wireless distribution method (Often Spread-Spectrum or Orthogonal frequency-division multiplexing (OFDM) radio) within a limited area such as a home, school, computer laboratory or office building. In their calculation for IEEE 802.11b and 802.11g in an office area shows that IEEE 802.11b and 802.11g operate at 2.4GHz. Assuming that transmitter and receiver antenna gains are I, the path loss in 1m is

$$L_0 = 10\text{Log}_{10}\, G_1 G_r\left(\frac{f/c}{4\pi}\right)^2 = 10\text{Log}_{10}\left(\frac{3\times10^8/2.4\times10^9}{4\pi}\right)^2 = 40.04\text{Db}$$

The maximum transmitted power is 100mW (20dBm) and the minimum sensitivity of the receiver is around -90dBm, which allows a maximum path loss of 20dBm – (-90dBm) = 110dBm. In an office area with a distance power gradient of 3, coverage of the system can be determined from the equation;

$$L_0 = 10\text{Log}_{10}\, P_r - 10\text{Log}_{10}\, P_0 = 10\text{Log}_{10}\frac{pt}{po} = -10\log_{10} G_a G_r\left(\frac{\pi}{4\pi}\right)^2$$

Therefore110=40.04+10x3Log$_{10}$d. That leads to d = $10^{69.96/30}$ = 215m. What this result means is that gives users the ability to move around within a local coverage area and still be connected to the network, and can provide a connection to the wider Internet.

A relay-enabled Point Coordination Function (PCF) protocol to improve the performance of IEEE 802.11b WLAN was prposed by [15]. He simulated and compared the performance of proposed protocol and Auto Rate Fallback (ARF) protocol, which had been implemented in products. Using the Friis free space propagation model and the 2-ray ground propagation model as the large-scale propagation model to simulate the situation when the wireless channel condition is stable. The Friis free space propagation model is defined as follows:

$$Pr(d)\text{Friis} = \underline{PtGtGr\lambda}(4\pi)^2 d^2 L \qquad (1)$$

Where *d* is the distance between the sender and the receiver, *P*t and *P*r represent the transmit power and the receive power (in Watts), *G*t and *G*r are the transmit and receive antenna gains, *λ* is the carrier wavelength (in meters), and *L* is the system loss factor. In this paper, *P*r is equal to 15 dBm, *G*t, *G*r, *L* are set to be 1.0 and *λ* is equal to 3×108⁄2.4×109 = 0.125m (note that 802.11b operates on 2.4 GHz). The Friis model works well only when the sender and receiver have a clear, unobstructed line-of-sight propagation path between them, and hence the Friis model cannot work accurately alone. The 2-way ground model is based on geometric optics, and it considers both the direct path and the ground reflected propagation path between the sender and the receiver. Under 2-way ground model, given a distance *d* from the sender, the received power can be expressed as:

$$Pr(d)\text{2-way} = \underline{PtGtGrh^2th^2}rd^4 \qquad (2)$$

Where *h*t and *h*r are the transmitted and received antenna heights, and equal to 1.0 meters in this paper. During simulation, they combined these two models by using the Friis model at short distance and the 2-way ground model at long distance. In particular, a crossover distance *d* cross is defined as:

$$d\ \text{cross} = \underline{4\pi hrht}\lambda \qquad (3)$$

If *d* >*d*cross, *Pr(d)* is calculated by equation (2); otherwise, *Pr(d)* is obtained through equation (1). When there is multi-path fading or relative movement between the sender and receiver, the channel condition between them may change frequently. Simulation results showed that the proposed relay-enabled PCF protocol could improve the network performance in terms of throughput and delay compared to ARF.

Their report [16] indicated that setting Maximum Transmission Unit (MTU) was helpful to address fairness issues of 802.11b WLAN. It did not require any change to MAC layer rather it involved a simple configuration of the Access Point. To this end when all clients are transmitting at the same data rate the access point allows them all to use the maximum MTU.

Although there was slight variance measured data, to a first approximation, they assumed that $o_1 = o_2 = o_{5:5} = o_{11}$ – in other words, they assumed the overheads for message transmission are the same. Likewise, without introducing

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major error, they assumed that the different time per-byte times are proportional to the transmission rates – in other words, we can estimate that an 11 mb/s rate actually is actually 11 times faster than a 1mb/s rate. Our measurements from the previous section indicate this is an acceptable assumption, since the per-byte transmission rate for the 1Mb/s connection was measured as 0.00736 millisecond per byte and that of the11Mb/s connection was 0.0000756 milliseconds per byte, or 9.7 times less. This implied that the access point can simply estimate the time needed by each station as:

$T_k^{!}(s_k) = o + tr_k \sim s_k / s_k{=}r_k$, where r_k is the transmission rate (*i.e.* 1, 2, 5.5 or 11).

At this point, a circular argument was made and they proposed the need to know s_k and to set s_k such that $T_1^{!}(S_1) = T_2^{!}(S_2) = \ldots\ldots = T_n^{!}(S_n)$

The solution adopted was to assume that stations would always like to transmit the maximum sized packet; an alternate solution would be to assume that we could estimate future packet sizes. Using our simplified timing model, the access point simply finds the highest transmission rate, r_{max}, and then sets the maximum message size for each station to be 1500 * r_k / r_{max}. They implemented an adaptive MTU control mechanism, which added overhead to each package.

They [17] found that in addition to the network state, different encoding parameters also affected the performance of streaming video, as the number of contending stations increases from 3 to 7 to 10, the mean delay increases to 30ms, to 100ms to 400ms respectively. As the number of contending stations is increased from 3 to 7 to 10 stations with a Dc of 500ms, the mean loss rate including packets dropped due excessive delay is increased from 1% to 15% to 41% respectively. They suggested the main limitation was in the MAC layer and QoS in later 802.11 protocols would help to enhance the performance.

The researchers [18] analysed the problem of WLAN when user requires high quality, real time media transmission. The protocol used in their experiment was 802.11b. It was found that the reliability of data transmission would limit the network performance and that wireless connection was not as reliable as cable connection.

Researchers in [19] studied about energy saving technology in 802.11 WLANs based on Distributed Coordination Function (DCF), and developed an energy-efficient technique called Energy-efficient Distributed Access (EDA). The study used NS2 simulator to test the performance of EDA. We use Jain's index to calculate throughput fairness $(\sum_{i=1}^{n_u} x_i)^2/(n_u \sum_{i=1}^{n_u} x_i^2)$

Results showed that when EDA was enabled, energy saving improvement was up to 80% compared to when DCF was enabled.

The work in [20] studied the relationship between resource utilization in the wireless LAN and the quality of VoIP calls transmitted over the wireless medium. Using 802.11b WLAN, one AP (router) with 16 clients as the test bed. Results indicated that load of network would affect the performance of on-going call. Heavy load caused poor voice quality. It was suggested that QoS was necessary for real-time applications.

In their work, [21] tried to find out the maximum throughput that 802.11 multi-hop network could deliver. Both simulation and real-network experiments were carried out in the research. The simulation platform used for the research was NS-2. In both simulation and experiments, the choice was 802.11b as the wireless network protocol. It was found that if greedy sources were uncontrolled, they would cause high packet-loss rate and unstable throughput. The study involved both single-flow and multi-flow in the network and it was found that throughput of single flow was influenced by the hidden-node effect and that there were mutual interferences between different traffic flows.

Researchers in [22] introduced a tool to study performance of 802.11 WLANs in different environments. They designed and implemented the tool called WiMed. The design was an 802.11 WLAN test tool. Results suggested that the tool was able to detect non-802.11 interference source and provide information to help user understanding of 802.11 performances while [23] did a comparative study between results generated by a real 802.11 test bed in different outdoor and indoor environments and 3 usual network simulators (NS2,QualNet and OPNT). The wireless network protocol used in the work was IEEE 802.11b. Comparison of experimental results and simulation results suggested that choice of the physical layer characteristics was very important for simulators. Based on proper configuration, simulation results could be quite close to experimental results in some scenarios.

[23] Analysed a cross-layer optimization problem in multi-cell WLANs inter-AP interference problem. The results indicated that association control alone was not enough for the problem and hence proposed a cross layer association control (combined with other rate control and contention control) to address the problem. Experiments were performed to test the performance of the proposed algorithm and also used NS2 to simulate the conditions. Results showed that the algorithm helped to optimize network performance. In [24], two ARQ mechanisms to improve the network performance of 802.11

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WLANs were proposed. One of the proposed mechanisms was called aggregated selective repeat Automatic Repeat Request (ARQ), the other was the aggregated hybrid ARQ. To test the performance of the proposed ARQ schemes, they used a system C/C++ network simulation model to simulate a WLAN with one AP. Results showed that both proposed ARQ mechanisms could improve mean service time and throughput.

In [26], a new scheme to enhance the saturation performance of IEEE 802.11 MAC protocol was proposed. This scheme allows a station to transmit a burst of packets after winning the transmission opportunity instead of sending only one packet. This model reduces the idle time slots between consecutive packet transmissions and in turn reduces the packet collision probability. This scheme also concentrates on the fairness issue among the stations by assigning the maximum length of the burst size to be transmitted in each transmission attempt.

III. METHODOLOGY

The methodology used to achieve the results of the research is shown in the block representation in Fig 1. RIVERBED MODELLER was used to create the network model based on local area network considerations. The major consideration is the nodal distance, because the area of LAN network should not be more than 2km. In this research, it is assumed that the premise of the LAN is within an area of 100m x 100m.So in implementing this, the terminals or nodes are placed within this area of 100m x 100m and the nodal distance was 62.5m x 62.5m.

In the network model, four terminals or nodes were used, while the statistics selected were the parameters and the performance metrics of the WLAN. The selected parameters are the data-rate, buffer size, fragmentation threshold (FTS) and physical characteristics. The performance metrics are the throughput, delay, media access delay, retransmission attempts and data dropped. After selecting the statistics, the simulation is run and results are obtained in the form of graphs. These results are viewed and analysed.

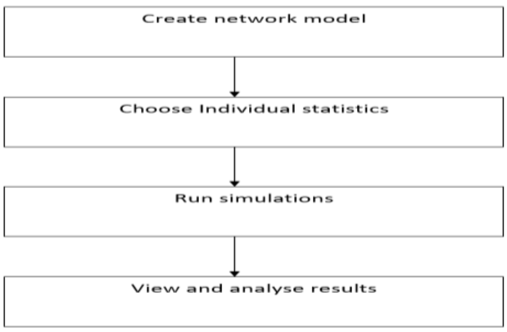

Figure 1: Block representation of the Methodology for the research

The area for the test-bed is going to cover a space of office floor and consist of 13Aps, 22 wireless workstations and 10 wired servers. The transmission power is going to be at the maximum.

3.1 Characterization of Test-bed for Generic WLAN

WLAN = Wireless network of APs and workstations as shown in Fig 2.

- Each workstation associates itself with one AP for Internet access.
- Cell = AP + all workstations associated with that AP.
- Each cell uses one channel.
- Most traffic is downlink.

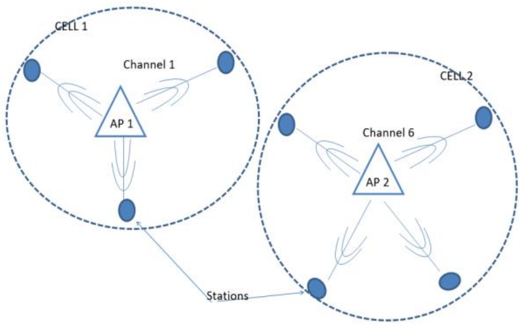

Figure 2: Illustration of a generic WLAN communication link

3.2 System Design

In the system design, five patterns are followed namely; Network performance metrics, throughput analysis, delay analysis, packet inter arrival time analysis and packet drop probability

3.2.1 Network Performance Metrics

Wireless LAN using IEEE 802.11b standard was used and simulated with RIVERBED MODELLER simulator to carry out the performance evaluation of the network.

With simulation, the effects of varying some network attributes or parameters such as the data rates, buffer sizes, fragmentation threshold (FTS) can be seen on physical characteristics on several metrics or qualities of service such as throughput, delay, media access delay, retransmission attempts and data dropped can be determined.

3.2.2 Throughput Analysis

The system throughput is defined as the fraction of time that the channel is used to successfully transmit payload bits. Throughput can be obtained by analysing the possible events that may happen on the shared medium in a randomly chosen slot time.

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Let P_{idle}, P_{col} and P_{succ} be the probabilities that a randomly chosen slot corresponds to an idle slot, a collision, or 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, or a successful transmission, respectively.

The average duration represented by T_{avg}, the generic slot lasts as follows, (Achinkole 2010):

$$T_{avg} = P_{idle}\delta + P_{succ}T_{succ} + P_{col} + T_{col} \quad (3.2)$$

Now, the throughput S can be calculated as

S = E [Payload information transmitted in a slot time] *(3.2)*

E [Length of a slot time]

$$S = \frac{P_{succ} x E[P]}{T_{avg}} = \frac{P_{succ} x E[P]}{P_{idle}\sigma + P_{succ}T_{succ} + P_{col}T_{col}} \quad (3.3)$$

Where E [P] is the average payload size (in terms of time units), and thus $P_{succ} x E[P]$ is the average amount of payload information successfully transmitted in a generic slot time.

By dividing the numerator and denominator of equation (3.3) by $(P_{succ}T_{succ})$, the throughput can be expressed as follows (Makta 2008):

$$S = \frac{E[P]/T_{succ}}{1 + \frac{P_{col}}{P_{succ}} x \frac{T_{col}}{T_{succ}} + \frac{P_{idle}}{P_{succ}} x \frac{\sigma}{T_{succ}}} \quad (3.4)$$

Accordingly, the foregoing analysis applies to both the 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; which is specific to the physical layer.

3.2.3 Delay Analysis

In IEEE 802.11b standard, there is no queue at the MAC layer itself, and thus IEEE 802.11b standard has no specified queuing mechanism. However, normally there should be a queue on the top of the MAC layer. Therefore, in general, the delay that a packet experiences should include two parts; the delay experienced in the queue and the delay experienced at the MAC layer. Let us focus on the MAC layer delay.

Since there are many stations contending for the shared medium and IEEE 802.11b DCF is a random access protocol, the MAC layer delay is a random value, which requires a detailed analysis. Five types of delay at the MAC layer are relevant to this analysis, and these will be discussed in this work.

As we know, in IEEE 802.11b, if a packet is handed to the MAC layer from the upper layer, it may be transmitted successfully in one or several trials, or it will be dropped if the retrial limit is reached. In both cases, the MAC layer will notify the upper layer about the final status of the packet (i.e. whether successfully transmitted or dropped).

Therefore, the MAC layer delay should be defined to be the time interval from the instant that the packet is headed to the MAC layer to the instant that the upper layer gets a notification from the MAC layer regarding the final status of the packet. We can define the following four kinds of delays namely;

D_{succ}, D_{drop}, D_{notify} and $D_{intersucc}$.

D_{succ}: This is the delay experienced at the MAC layer when a packet is successfully transmitted.

D_{drop}: This is the delay experienced at the MAC layer when a packet is dropped.

D_{notify}: This is the total delay (D_{succ}+ D_{drop}) before the upper layer will get a notification from the MAC layer about the final status (transmitted or dropped) of the packet.

$D_{intersucc}$: From the view point of an upper layer at a given station, this is the delay between two successful packet transmissions. Note that in the definition of $D_{intersucc}$, the successful transmissions must belong to a single station only.

But if we assume that a packet will always be retransmitted (i.e. indefinite retrials) until it is transmitted successfully, and then the delay, called $D_{infinite}$ is the delay experienced at the MAC layer.

The D_{succ} which is defined to be the time interval from the time a packet is at the head of its MAC queue ready for transmission, until acknowledgement for this packet is received. This can be analytically represented as, Wu et al; (2002):

$$D_{succ}(j,b) = (b \ x \ T_{avg}) + (j \ x \ T_{col}) + T_{succ} \quad (3.5)$$

Where:

$D_{succ}(j,b)$ = represents the delay of a packet that is successfully transmitted at stage j.

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B = the sum of the back-off slots generated up to stage j.

$(b \times T_{avg})$ = represents the duration of the b number of back-off slots.

T_{succ} = duration of successful transmission.

T_{col} = duration of collision

The average packet delay E [D] is given as:

$$E[D] = E[X]E[slot] \qquad (3.6)$$

Where:

E[X] = average number of slot times required for a successful packet transmission.

E[slot] = Duration of time slot.

3.2.4 Packet Inter-arrival time Analysis

The packet inter-arrival time is defined as the time interval between two successful packet receptions at the receiver and can be simply obtained from throughput. The inter-arrival time is given as:

$$E[D_{inter}] = \left(\sum_{j=0}^{\infty} p^{j(m+1)} \sum_{i=0}^{m} p^{i} \frac{W+1_i}{2} \right) E[D_{slot}] \qquad (3.7)$$

The average packet delay, inter-arrival time, and drop time are related by the expression:

$$E[D] = E[D_{inter}] - \frac{P_{drop}}{1-P_{drop}} E[D_{drop}] \qquad (3.8)$$

However, the expression: $Pdrop/(1-pdrop) = p^{m+1}/(1-p^{m+1})$ represents the average number of dropped packets needed for a successful transmission. The expression in equation (3.8) is of key importance since it gives insights of the delay characteristics of the IEEE 802.11b back-off mechanism and relates the average packet delay with the packet inter-arrival time, the packet drop probability, and the average time to drop a packet.

3.2.5 Packet Drop Probability

The packet drop probability is defined as the probability that a packet is dropped when the retry limit is reached. A packet is found in the last back-off stage m if it encounters m collisions in the previous stages and it will be discarded if it experiences another collision. Therefore packet drop probability can be expressed as a function of the last back-off stage and the collision probability P as

$$P_{drop} = P^{m+1} \qquad (3.9)$$

Where,

m is the last back-off reached by the packet.

P is the collision probability

3.2.6 Average Jitter

Jitter is characterized as variety in delay after some time from point-to-point. It is ordinarily utilized as an indicator of consistency and stability of a network.

Jitter is a standout amongst the most essential components to determine the execution of a system and the QoS of the system. The measure of jitter tolerable on the network is influenced by the depth of the jitter buffer on the system equipment.

The more jitter buffer available, the more the system can lessen the impacts of jitter. Equation 3.3 characterizes the steps to figure average jitter. It is the average of the absolute difference in the time it took for successive packets to achieve the destination.

$$Average\ Jitter = \frac{\Sigma\, i\, [(Packet\ Arrival\ i+1 - Packet\ Start\ i+1) - (Packet\ Arrival\ i - Packet\ Start\ i)]}{n-1} \qquad (3.10)$$

Packet $Start_0$indicate the period when first packet is transmitted, and Packet Arrival is the period when last packet arrived at the destination.

3.2.7 Packet Loss

Packet Loss Ratio (PLR) means the quantity of packets lost amid the transmission from source to destination in a transmission channel. A few reasons for packet loss or corruption would be bit errors in an incorrect wireless network or inadequate buffers because of network congestion when the channel becomes overloaded.

Some of the packets are lost because of network congestion or due to noise. The estimation of PLR ought to be kept to least minimum as indicated by ITU standards since packet loss influences the apparent nature of the application.

The lower estimation of the packet lost the better execution of the protocol

$$Packet\ Loss\ Ratio = \frac{\Sigma i\ Packet\ Loss}{iPackets\ Sent} \qquad (3.11)$$

Equation 3.11 demonstrates the procedure to figure out the packet loss, which is characterized as the aggregate of all the packets that do not reach the destination over the total of the packets that leave the destination.

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IV. RESULTS AND DISCUSSION

This is limited to the General Statistics of the network which includes wireless LAN Delay (sec), packet End-to-End delay (sec), wireless LAN Media Access Delay (sec), Data Dropped (bits/sec), Traffic Received (Packets/sec), Traffic sent (Packets/sec), and Objects Statistics such as wireless LAN Delay (Sec), throughput (bits/sec) graphs and description of the network are presented in the following sub-section.

4.1 Wireless LAN Implementation

Here, the network parameters such as data-rate, buffer size, fragmentation threshold and physical characteristics were tuned or varied to different scenarios in order to get the result of different qualities of service or metrics. Table 4.1 shows the varied parameters.

Table 4.1: Varied WLAN Network Parameters

Attributes (parameters)	**Scenario-1**	**Scenario-2**	**Scenario-3**
Data rates	1 Mbps	5.5 Mbps	11 Mbps(Optimized)
Buffer Sizes	1000 bits	6400 bits	12800 bits(Optimized)
Fragmentation Threshold	None	16 bytes	256bytes (Optimized)
Physical characteristics	DSSS	FHSS	Infrared

These attributes or parameters were varied to different scenarios as shown in Table 4.1, using the OPNET IT Guru Simulator Software.

When any WLAN network parameter is tuned to a different scenario, there is a change in some qualities of service or metrics; and these metrics are usually considered for network improvement. Below is the list of some of these parameters with the metrics are analysed in Table 4.2

Table 4.2: Wireless LAN parameters and metrics studied

S/N	Parameters	Metrics
1	Data rates (for 1 Mbps, 5.5 Mbps and 11 Mbps)	Throughput Delay Delay Access Media Retransmission attempts
2	Buffer sizes (for 1000 bits, 6400 bits and 12800 bits)	Throughput Data dropped
3	Fragmentation threshold (for none, 16 bytes and 256 bytes)	Throughput Delay Media Access Delay Data dropped Retransmission Attempts
4	Physical characteristics (for DSSS, FHSS and Infra-red	Throughput Delay Retransmission attempts

4.2 Implementation using OPNET IT Guru Simulator for the Wireless LAN

The network was set up and represented as shown in Fig 4.1. It is assumed that the premise of the LAN is within an area of 100M x 100M. So in implementing this, the four terminals or nodes are placed within this area.

In this thesis, the four terminals were placed within 62.5M x 62.5M. See Fig 3.

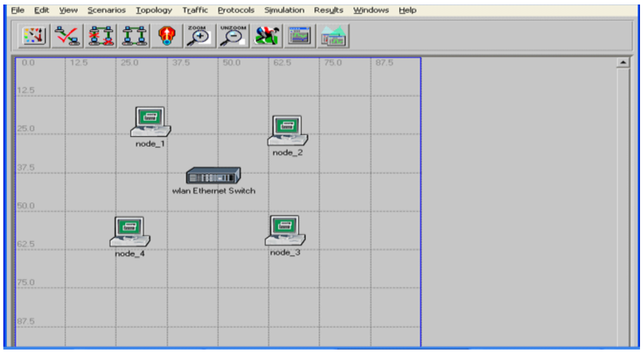

Figure 3: Wireless LAN implementation with 4 nodes using OPNET IT Guru Simulator

4.3 Wireless LAN Simulation Results and Analysis

As earlier stated, four network parameters were used in this research thesis. They are: data-rate, buffer size, fragmentation threshold (FTS) and physical characteristics.

Appendix one shows the Excel sheets of the Wireless LAN simulation results.

4.3.1 Data-Rates (Mbps)

The values for the simulation result of the data-rates used are shown in Table 4.3.

The graphs of the simulation Figs 4-9 show the effects of data-rates on the performance of the wireless LAN. The metrics or qualities of service to be analyzed are: the throughput, delay, media Access delay and retransmission attempts.

1) Throughput

Based on the simulation of the three scenarios, the graph of Fig 4.1 was obtained. It was 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 we increase the data-rate, the number of bits received increases. Thus based on the graphical result below, it can be said that when the data-rate increases in a network, the throughput increases, but when the network is overloaded with several

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stations, that same throughput decreases, since throughput is the number of bits successfully transmitted per second.

Table 4.3: Table showing the data-rates used for different scenarios

Attributes (Parameters)	Scenario_1	Scenario_2	Scenario_3
Data-rates	1Mbps	5.5Mbps	11Mbps (Optimized)
Buffer Sizes	12800bits	12800bits	12800bits
Fragmentation Threshold	None	None	None
Physical characteristics	DSSS	DSSS	DSSS

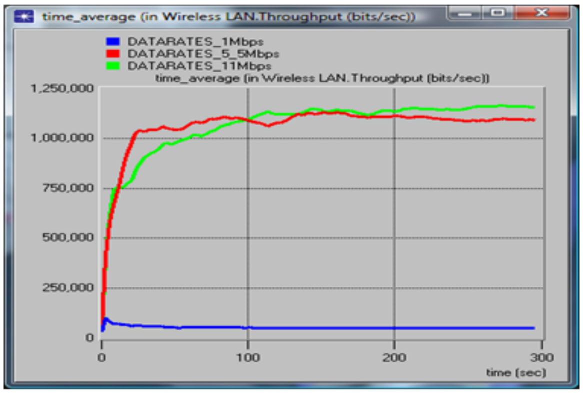

Figure 4: Graph of Throughput study for data-rates of 1Mbps, 5.5Mbps and 11Mbps

2) Delay

The simulation graph for the delay is shown in Fig 4.2. When the data-rate was increased from 1Mbps to 11 Mbps, the delay decreased. The graph below is a good result because it means that data would stay for less time in the media (buffer) for higher data-rates.

It can however be stated that the delay in a wireless LAN can be minimized by increasing the data-rate or increasing the rate at which each of the nodes transmits or receives.

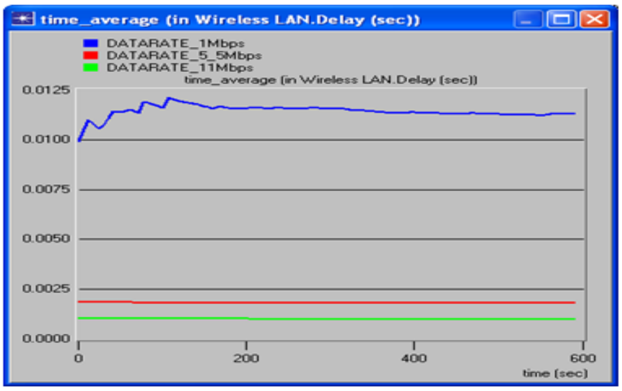

Figure 5: Graph of Delay Study for Data-rates of 1Mbps, 5.5Mbps and 11Mbps

3) Media Access Delay

The analysis of the result of the media access delay is the same with that of the Delay above. When the data-rate was increased, the media access delay decreased. This is shown in the graph of Fig 6.

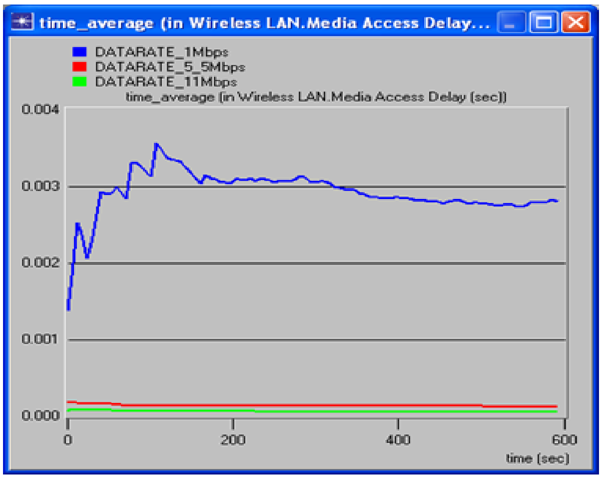

Figure 6: Graph of Media Access Delay for data-rates of 1Mbps, 5.5Mbps and 11Mbps

4) Retransmission Attempts

When the data-rate was increased from 1Mbps to 11 Mbps, the number of retransmission attempts was decreased to approximately zero. This is so because if data-rate is increased, packets are delivered more accurately; hence less requirement for retransmission. The simulation graphs of Figs 4.4 and 4.5 show the analysis for nodes 1 and 2 respectively.

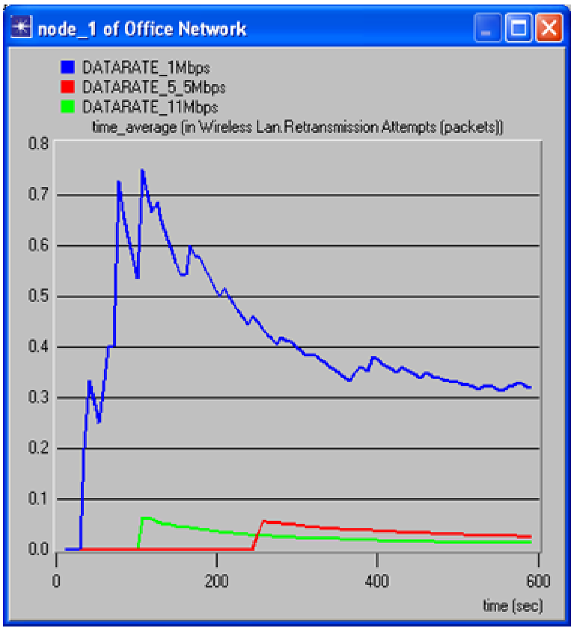

Figure 7: Graph of Retransmission attempts occurring at node 1 for data-rates of 1Mbps, 5.5Mbps, and 11Mbps

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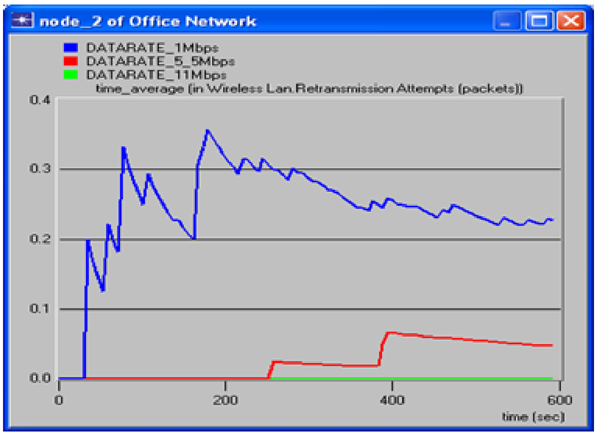

Figure 8: Graph of Retransmission Attempts occurring at node 2 for data-rates of 1Mbps, 5.5Mbps and 11Mbps

V. CONCLUSION

This work has presented a simulation study and evaluated the performance of IEEE802.11b Wireless LAN in an infrastructure network, with four nodes and one access point. The research was carried out using RIVERBED MODELER using network performance metrics such as; throughput, media access delay, delay, number of retransmission attempts and data dropped; for parameters such as Data-rates, Buffer sizes, Fragmentation Threshold (FTS) and Physical (PHY) characteristics.

The results of the research show that proper tuning (adjustment) of the WLAN parameters, such as:

i. Increasing the data-rate improves the performance of the WLAN (in terms of the metrics above, e.g. throughput).
ii. Increasing the buffer size reduces the number of dropped data packets.
iii. Implementing fragmentation for heavy load traffic condition (for a network with high error probability i.e. high bit error rate for longer frame), reduces the duration the channel is occupied when frames collide; and also in case of failed transmission, the error is detected earlier and there is less data to retransmit.
iv. In using Direct Sequence Spread Spectrum, Frequency Hooping Spread Spectrum and Infra-Red data encoding methods, the Direct Sequence Spread Spectrum framing format gave the best performance in terms of throughput, while the Frequency Hooping Spread Spectrum gave better performance for retransmission attempts.

5.1 Contribution

This paper offers contribution to knowledge since it helps to show that proper tuning and appropriate adjustment of the wireless LAN parameters will enhance network performance and would also improve the services that the IEEE 802.11b protocol provides to various communications. Communication companies such as MTN, 9mobile, Global Com, Airtel, Swift, and Spaternet can use this RIVERBED MODELER to design and simulate their networks before deployment as this would enable them get better performance. It will also assist to eliminate unforeseen bottlenecks usually associated with WLAN network designs.

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