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Effects of Adjusting Data-Rate and physical Characteristics on the Delay Metric in Ieee802.11b Wireless Local Area Network

Isizoh A. N.[1] Okide S. O.[2] Asogwa T.C.[3] Nwokeke A. O.[4]

[1]Dept. of Electronic and Computer Engineering, NnamdiAzikiwe University, Awka, Nigeria.
[2]Dept. of Computer Engineering, NnamdiAzikiwe University, Awka, Nigeria.
[3]Dept. of Computer Engineering, Enugu State University of Sci. and Tech., Enugu, Nigeria.
[4]Dept. of Computer Engineering,Federal Polytechnic, Oko, Anambra State, Nigeria.

Abstract
The IEEE802.11b is one of the protocol standards used in Wireless Local Area Network (WLAN). There are several parameterswhich must be considered when handling IEEE802.11b. Theseparameters are tuned or adjusted to a certain level for proper enhancement of qualities of service or metrics.Some of theseparameters are the data-rate, buffer Size, fragmentation threshold (FTS), Receive to Send/Clear to Send (RTS/CTS) threshold, physical characteristics, etc. Those qualities of service or metrics are the throughput, data dropped, delay, load,media access delay, retransmission attempts, etc. However, this paper analyzes the effects of adjusting the data-rate and physical characteristicsparameters on the delay metric in IEEE802.11b WLAN network. The simulation study was carried out using OPNET IT Guru 9.1simulator; with the result being satisfactory and was used to validate the theoretical concepts of delay metric in Wireless LAN network.

Keywords: Physical characteristics, data-rate, WLAN,Media Access Control (MAC), Delay metric.

Introduction

TheIEEE 802.11b is one of theprotocolstandardsused in wireless local area network. The major differences between all the protocol standards used in WLAN are: the modulation technique used and the data rate.

Some of the protocol standards are enumerated below:

IEEE 802.11a: This uses the modulation technique of Orthogonal Frequency Division Multiplexing (OFDM), and has a maximum data-rate of 54 mbps [1]. The disadvantage of using this OFDM is noise.

IEEE 802.11b: It uses the modulation technique of Direct Sequence Spread Spectrum (DSSS), with the data-rates of 1 Mbps, 5.5 Mbps, and 11 Mbps. Thus the maximum data-rate for this standard is 11mbps.

In this paper, the wireless protocol standard used was this IEEE 802.11b; because it is cheap, common in market, less noise, etc.

IEEE 802.11g: One big mistake made in the above two standards is having a difference in the modulation techniques used; as this brought about no compatibility of their equipments. There came IEEE 802.11g, which uses the combination of OFDM and DSSS modulation techniques. This standard solved the problem of incompatibility. Using this IEEE 802.11g, all equipments (i.e. in IEEE 802.11a and IEEE 802.11b) can communicate among themselves. The data-rate is now double, i.e. 108 mbps, 54 mbps, 27 mbps, 11 mbps, 5.5 mbps, and 1 mbps. The maximum data-rate is 108 mbps.

IEEE 802.11n: All the above standards have no adequate security. To achieve security features, there was an introduction of IEEE 802.11n standard, which has many security features in it. It uses such security technology as: Wired Equivalent Privacy (WEP), Wireless Private Access (WPA 1), WPA 2, 802.1x, etc.

IEEE802.11b Network Parameters and qualities of service.

There are several parameterswhich must be considered when handling IEEE802.11b WLAN Network. Theseparameters are tuned or adjusted to a certain level for proper enhancement of qualities of service [2].Some of the parameters are the Data rate, Buffer Size,Fragmentation threshold (FTS), RTS/CTS threshold, Physical characteristics, etc. Those qualities of service or metrics are the Throughput, Data dropped, Delay, Load,Media access delay, Retransmission attempts, etc.

However, this paper explains the effects of adjusting the data-rate and physical characteristicsparameters on the delay metric in IEEE802.11b WLAN network. Let us look at the data-rate and physical characteristicsparameters, andalso the delay metric or quality of service.

Data Rate

This signifies the speed of the nodes connected in the network. The WLAN model in OPNET IT Guru 9.1 supports data transfer at 1, 2, 5.5 and 11Mbs. These data rates are modeled as the speed of transmitters and receivers connected to the 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 [3]. A station can transmit data packet only at the configured data rate. However, it can receive data at any data-rate (1, 2, 5.5 and 11Mbs). Finally, all control packets are transmitted at a data-rate of 1Mbps as specified by the standard.

Physical (Phy) Characteristics (DSSS, FHSS and Infra Red)

In Physical Characteristics, three data encoding methods are usually used. They are theDirect Sequence Spread Spectrum(DSSS), Frequency Hopping Spread Spectrum (FHSS) and Infra Red data encoding methods.

Delay Analysis

This represents the end to end delay of all packets received by the nodes in a wireless LAN MAC and forwarded to the higher layer [4]. This delay includes Media access delay at the source MAC reception of all the fragments individually and transfers of the frames via Access Point (AP), if AP functionality is enabled.In IEEE 802.11b standard, there is no queue at the MAC layer itself, and thus IEEE 802.11b standard has not specified any queuing mechanism. However, normally there should be a queue on the top of the MAC layer. In general, the delay that a packet experiences should include two parts, i.e. the delay experienced in the queue and the delay experienced at the MAC layer [5]. 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 [6]. 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 [7]. We can define the following four kinds of delays:

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

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

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

$\mathbf{D_{notify}}$: 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.

$\mathbf{D_{intersucc}}$: 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, 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:

$D_{succ}(j,b) = (b \text{ x } T_{avg}) + (j \text{ x } T_{col}) + T_{succ}$……………………. (1)

Where:
$D_{succ}(j,b)$ represents the delay of a packet that is successfully transmitted at stage j.
bis the sum of the back-off slots generated up to stage j.
$(b \text{ x } T_{avg})$ represents the duration of the b number of back-off slots.
T_{succ} is the duration of successful transmission.
T_{col} is duration of collision
The average packet delay E[D] is given as:

$E[D] = E[X] \text{ x } E[slot]$ …………………………………… (2)

Where:
E[X] is the average number of slot times required for a successful packet transmission.
E[slot] is the duration of time slot.

Wireless LAN Implementation

When any WLAN network parameter is tuned to a different scenario, there is always a change in some qualities of service or metricsand these changes are usually considered when using the network [8]. So when network parameters such as Data rates, Buffer sizes, Fragmentation Threshold (FTs) and Physical (Phy) characteristics are tuned or varied to different scenarios,different results are obtained for different metrics. Table 1 shows the parameters used and scenarios.

Table1: Varied WLAN network parameters

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

Implementation using OPNET IT GURU for a Wireless LAN

The WLAN network was set up and represented as shown in figure 1 using OPNET software. Since the network is a LAN, let us assume that the premise is within an area of 100metres x 100metres. So in implementing this, the four terminals or nodes are placed within this area of 100m x 100m.
In this paper, one access point with four terminals or nodes were used, and the nodes wereplaced within 62.5metres x 62.5metres.

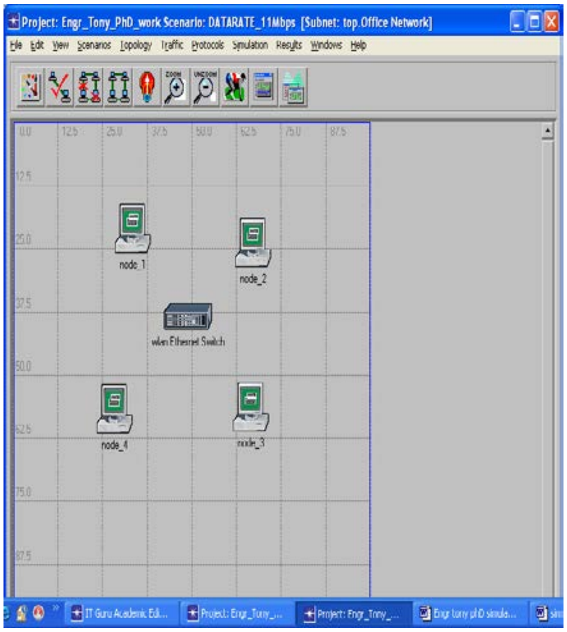

Fig. 1: Wireless LAN implementation with 4 nodes using OPNET IT GURU for Data-rates

Simulation Results and Discussions

As earlier stated, four network parameters (Data-rate, Buffer size, Fragmentation Threshold and Physical Characteristics)were considered in this

paper but only the data-rate and physical characteristics were tuned or varied. At first, the data-rate was varied from 1Mbps to 5.5Mbps and then to 11Mbps, keeping other parameters constant or unvaried. The effect of the variation on the delay metric was examined.
During the second simulation, the data encoding methods of the Physical Characteristicswere varied leaving other parameters unvaried. These encoding methods are DSSS, FHSS and Infra Red. The effect on the delay was also examined.
The table for the simulation result of the Data-rates used is shown in table 2; while the table showing different physical characteristics encoding methods for different scenarios is shown in table 3.

Table 2: Table showing the variation of data-rates used for different scenarios

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

The simulation graph for the delay is shown in figure 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. This validates the theoretical result.
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.

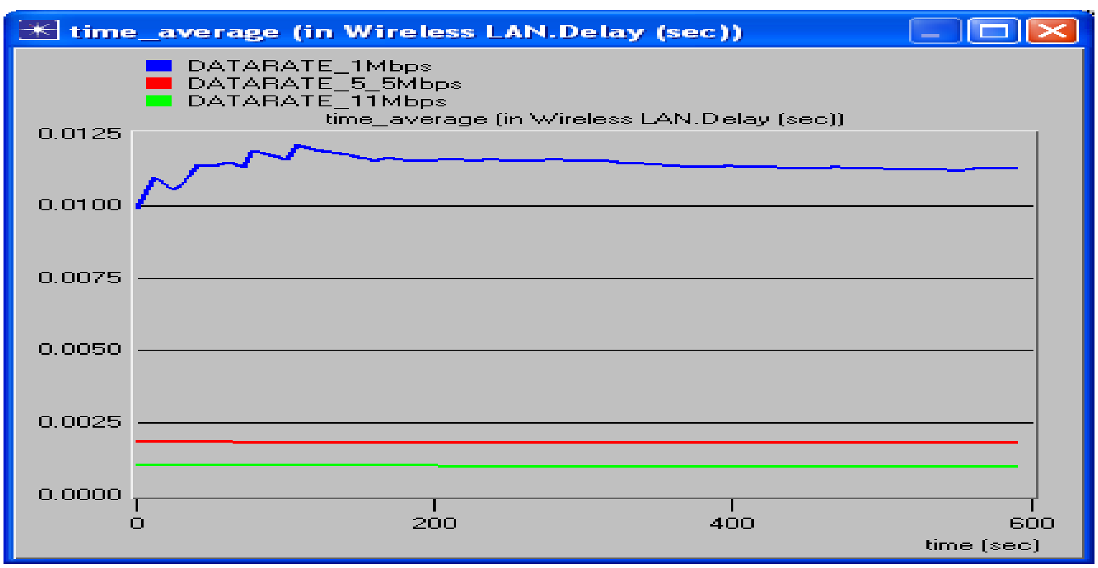

Fig 2: Delay Study for Data-rates of 1Mbps, 5.5Mbps and 11Mbps

Table 3: Table showing different physical characteristics encoding methods for different scenarios

Attributes (Parameters)	Scenario-1	Scenario-2	Scenario-3
Data-rates	11 Mbps	11 Mbps	11Mbps
Buffer Sizes	12800bits	12800bits	12800bits

Fragmentation Threshold	None	None	None
Physical characteristics	DSSS	FHSS	Infra Red

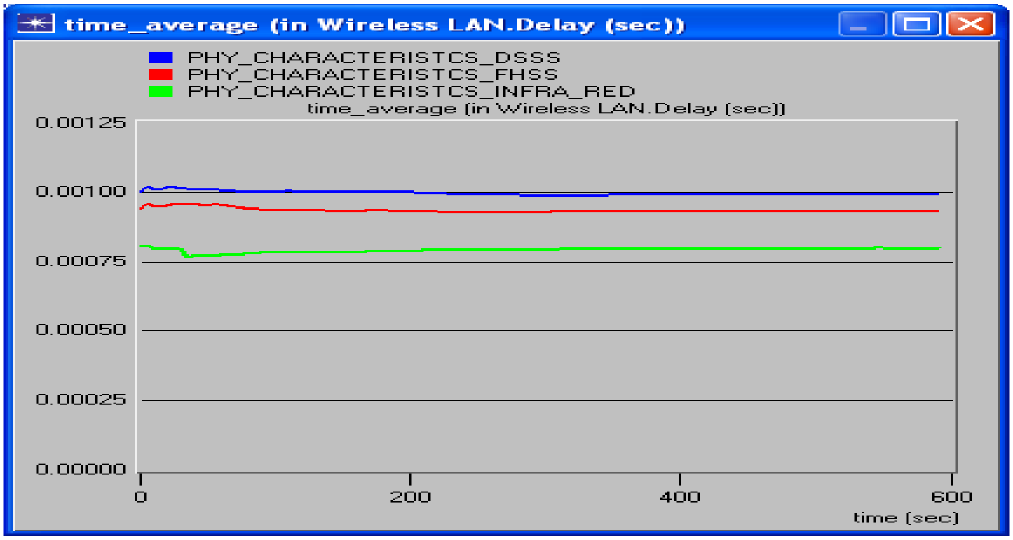

Fig. 3: Delay analysis for different physical characteristics

The simulation graph shows that the Infrared framing format gave the lowest delay followed by the FHSS framing format and finally the DSSS encoding method. It shows that the infrared gave the best performance for this quality of service.

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