EFFECTS OF DATA FRAME SIZE DISTRIBUTION ON WIRELESS LANS

By

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ABSTRACT

The continuous need to replace cables and deploy mobile devices in the communications industry has led to very active research on the utilization of wireless networks. IEEE 802.11 WLAN is known to achieve relatively small throughput performance compared to the underlying physical layer's transmission rate and this is as a result of large overhead information composed of medium access control header, physical layer preamble information back-off duration control frames (ACK) transmissions and even inter-frame spaces. This paper provides an overview of frame size distribution using the dual fixed frame size as a case in point and subsequently a performance evaluation in a multi-user transmission channel condition is carried out. The distribution of frame size and its effect on the throughput is also investigated. This is done through comparison of various scenarios such as fixed frame size distribution and dual-fixed frame size distribution. The dual- fixed frame size distribution case has both equality and inequality cases and both are investigated. The case of equal frames was found to have improved marginal throughput compared to the other cases. The analysis and measurement results from OPNET simulation has shown that an equal fixed frame size distribution can be efficient in optimizing useful data.

Keywords: WLAN, Dual fixed frame, Performance analysis.

1.0 Introduction

Networks are collections of computers, software and hardware that are all connected to help their users work together. The most common networks are Local Area Networks or LANs for short. A LAN connects computers within a single geographical location, such as one office building, office suite, or home. A Wireless LAN or WLAN is the linking of two or more computers without using wires. WLAN utilizes spread-spectrum technology based on radio waves to enable communication between devices in a limited area, also known as the basic service set [1]. This gives users the mobility to move around within a broad coverage area and still be connected to the network.

IEEE 802.11 Wireless Local Area Networks (WLANs) has become very popular among portable mobile device users for the Internet access in the last decade. Although the WLAN supports relatively lower data transmission rate than wired networks which, no doubt, have much higher speed, today, support for mobility and lower overhead cost are jointly ensuring an astonishing growth in the number of mobile users worldwide.

There are four main chronological specifications so far in terms of the development of the 802.11 protocol. These are the 802.11a, 802.11b, 802.11g, and 802.11n. The IEEE 802.11 specification was first approved in 1997, and in 1999 the second revision was published [2]. The initial IEEE 802.11 specification provides for a single Medium Access Control (MAC) and three Physical Layers (PHY), which provided physical rates of 1 and 2 Mbps. In 1999, two new high-speed PHY specifications were additionally defined, namely, IEEE 802.11a [3] and IEEE 802.11b [4]. The IEEE 802.11a standard provides from 6 to 54 Mbps raw

PHY transmission rates using the 5 GHz bands and using the Orthogonal Frequency Division Multiplexing (OFDM) method of modulation, while the IEEE 802.11b standard provides from among the following: 1, 2, 5.5 and 11 Mbps raw PRY transmission rates at the 2.4 GHz bands. The more recent IEEE 802.11g, which also has the 2.4 GHz PHY but slightly better developed, also supports up to 54 Mbps [5].

2.0 Literature Review

The IEEE 802.11 WLAN is a very large research field and there are several related works done in the Past in the area of performance analysis, even for the DCF in the MAC layer. The MAC layer and access is introduced in [6]. The MAC layer defines two different access methods, the Distributed Coordinated Function and the Point Coordinated Function. The basic access mechanism, called the Distributed Coordinated Function, is basically a carrier sense Multiple with collision Avoidance mechanism (usually known as CSMA/CA) .

The position of a station relative to other stations is the basis for analYsis in [7] and [8]. The research paper [9] recognizes that MAC brings with it a lot of overhead including the RTS/CTS scenario and proposes the ADCA which uses batch (back-to-back) transmission and block acknowledgement. A method of relay is also used to increase effective data rates in a saturated network [10]. In other researches the idea was to implement service differentiation (DiffServ) by prioritizing the traffic based on contention window size and length of payload [11]. A wide study of Frame-Burst-based Medium Access Control Protocols under Imperfect Wireless Channels has also been done in [12]. The research paper [13] illustrates the case of stations operating under unsaturated condition. DCF Provides only best effort service but not a good quality of service (QoS), this was the main discussions proved in [14]. Qiang [15] proposes a simpler cycle time in enhancing the DCF’s performance. It describes an adaptive service differentiation scheme for QoS enhancement in IEEE 802.11 wireless ad-hoc networks. The approach, called Adaptive Enhanced Distributed Coordination Function (AEDCF), is derived from the EDCF (Enhanced Distributed Coordinated Function). Inan et at [16] presents various adjustments to protocol parameters in order to improve behavior of large networks while not seriously affecting that of small networks. A Hybrid coordination function (HCF) in place of the DCF to enhance QoS was introduced and illustrated in [17]. Chatzimisios et al. [18] suggests a possible minimum communication range and a good contention window size to be used by MAC in vehicles. Bianchi et al. [19] takes into account bit transmission errors due to imperfect channels. An analytical model using the discrete-time Markov chain was developed in [20] and [21] based its own model on elementary conditional probability. Puthal et al. [22] Takes into account several transmission modes, forward error correction rates and modulation types and tries to algorithmically select the best. But the area of frame size distribution has not been addressed and looked into as a focus.

3.0 Overview of WLAN MAC Architecture

The goal of the MAC layer is that it should support PHYs using electromagnetic waves through the air. These could be radio waves, infra-red waves or visible light. The rules of obtaining access to the medium are described in two functions - the DCF for distributed systems and asynchronous data transfer, and PCF for contention free frame transfer. PCF is an optional operating mode for quality of service (QoS) support [23]. The wireless MAC supports both connectionless service and a service supporting packetized voice. The MAC protocol is based on time division multiplexing and prioritization on medium access is achieved by the use of different timings known as Inter-Frame Spaces (IFS). Also a single MAC is capable of supporting multiple PHYs. The MAC and PHY layer are shown below in a block diagram. The PHY layer is subdivided into the PLCP and the PMD layers [24].

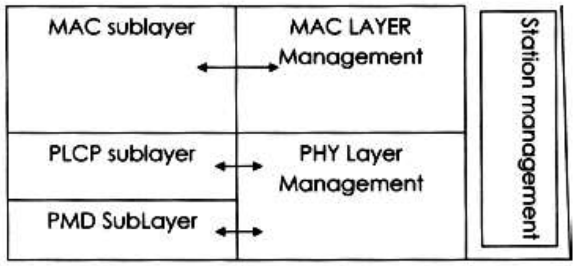

Figure 1: OSI model for IEEE 802.11 (MAC layer is the Data link layer)

Distributed Coordination Function

Under DCF operation, Mobile stations apply Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), unlike the Ethernet's collision detection CSMA/CD scheme. The CSMA/CD is a non-persistent CSMA technique as a channel access procedure. A STN ready to transmit monitors or senses the channel for the time duration DIFS in order to determine whether it is free or not. In networks using OFDM in the PHY layer, channel sensing is equal to measurements of the channel's signal strength level. If the detected level does not exceed the threshold of -88dBm for the duration of DIFS, the channel is deemed by a STN to be idle. The STN initiates the Collision Avoidance (CA) procedure. In order for two or more Mobile stations, to avoid a collision, a STN is not allowed to start a transmission immediately after the medium is detected idle, but after randomly chosen time duration, called backoff time. If the medium is detected as busy, the STN has to wait until the channel becomes idle and available again.

Collision Avoidance

The collision avoidance procedure is based on the so called backoff procedure. After detecting the medium as idle, the STN defers for a random backoff interval. The duration of this interval is calculated by the product of a random integer number and the slot duration, which is set to 9µsec. The random number is drawn from the interval between 0 and CW where CW is the Contention Window (CW) size, maintained at each STN separately. The starting value of CW is CWmin = 7. After every collision, the value of CW is increased. Its values increase in powers of 2, with maximum value of CWmax = 1023. After a collision resolution, CW is set again to CWmin. If during the backoff countdown, carried out in steps of 9µsec, of STN 1 another STN 2 starts a transmission, then the countdown at STN 1 is interrupted. STN 1 defers until the end of any other transmissions and after detecting the medium idle again, continues its countdown for the remaining backoff interval [26].

Acknowledgement and Collisions

A received data frame is acknowledged in case of correct reception by an Acknowledgement (ACK) frame, sent from the receiver with a delay SIFS after reception's end. Even if a STN doesn't have any other data packets in the queue waiting for transmission, after the reception of ACK it initiates a backoff procedure. This backoff is referred to as "post-backoff" and guarantees that any frame, with the only exception of the first data packet of a burst arriving in a STN in idle state, will be transmitted after a backoff procedure. "Post-backoff" enhances the system's fairness, and improves the service time in networks with lower load. Should two or more stations access the same frequency channel at the same time, a collision occurs. A retransmission attempt in each collided STN is started after back off. Depending on the frame size, the number of retransmission attempts is limited. For data frames, shorter than an implementation dependent threshold, the Short Retry Counter (SRC) is used to denote the number of unsuccessful transmissions for the same data frame, including the unsuccessful transmissions of Ready To Send (RTS) frames (SRC maximum value is 7). For long data frames respectively, the Long retry Counter (LRC) with maximum value 4 is applied.

After a successful transmission both these counters are reset.

The RTS/CTS Handshake

The DCF allows optionally the use of a handshake between transmitter and receiver, before the transmission of the actual data frame. If the data frame is larger than a certain threshold, which is not defined in the standard and is therefore implementation dependent, the transmitting STN transmits a RTS frame when backoff reaches zero. This frame informs both, the intended receiver and Mobile stations in the neighborhood of the transmitter about the coming data frame. Upon receiving a RTS, Mobile stations which are not the intended receivers, interrupt their backoff countdowns and set their Network Allocation Vector (NAV) (Fig.2) according to the duration encoded in the RTS frame. The NAV denotes the time a STN must defer from the medium in order not to interfere with an ongoing transmission. The intended receiver, if idle i.e. able to receive data, responds to the RTS frame with a Clear To Send (CTS) frame, after time SIFS. The CTS frame informs the neighboring Mobile stations to the receiver about the pending data transmission, which set their NAV as well. With the successful reception of the CTS frame at the transmitter the handshake is finished. The data frame is then transmitted after SIFS.

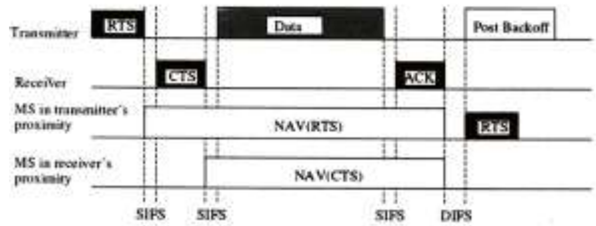

Figure 2: RTS/CTS Operation and Setting NAV

A trace me of captured real live wireless traffic from two case studies (UNN wireless Network (LIONET) and Afrihub Nsukka) was used in the analysis. Wireshark Network Analyzer was used on the various servers and the traffic data collected. Each captured information included frame number, number of bytes on channel, number of bytes captured and some prism monitor header information which included whether the frame were a wireless LAN management frame or not. A total of 100,000 frames were used for analysis by progressively analyzing the first 10 frames, first 100 frames, first 1,000 frames, first 10,000 frames as well as all the frames together. The trends of individual frame size types as well as the trend of management and non-management (mostly data) frames were discerned.

The Captured traffic of 100000 frames was subsequently analyzed on a Per-frame basis to produce the distribution shown in Table below.

Frame size captured	Occurrence in first 10 frames	Occurrence in first 100 frames	Occurrence in first 1000 frames	Occurrence in first 10000 frames	Occurrence in first 100000 frames
175	5	55	780	6031	35394
90	2	17	67	723	19314
117	4	6	30	228	13958
342	0	2	13	678	9077
66	0	0	0	817	6054
175	0	0	31	386	3936
42	0	15	54	351	3507
Total (% age)	10(100%)	100(100%)	975(97.5%)	9214(92.1%)	91240(91.2%)
Other frames	0	0	25	786(7.9%)	8760(8.8%)

In terms of management and non-management traffic, approximately 49% of the frames were management frames consisting mainly of the 175-byte frame type which by itself occupied 35.4 %. Non management frames therefore accounted for about 51% of frames with leading data frame types consisting of the 90-byte frame type (19.3%), the 117-byte frame type (14%) and a host of other frame types numbering up to forty.

4.1 Frame Size Distribution

Data frames are messages that deliver user-specified data. The Data frames format specifies message boundaries and sequencing. Each message is identified by a **message id** and each part of the message is identified by a sequence number. Each unique instance of a piece of a message is uniquely identified by a serial number. Message serial numbers help statistics-gathering mechanisms to differentiate between original instances of a message fragment and their retries [28].

Due to the variance in the frame size types, for the purpose of simplifying the analysis and in view of the principle of self-similarity the most frequently occurring data frames were isolated and used. These were the 90-byte frame and the 117-byte frames.

4.1.1 Dual Fixed Frame Size Distribution

In dual fixed frame size distribution, the frames types (9O-byte and 117 byte) are fed into the network in different combinations of either fifty percent each or a quarter of one and three quarters of the other. The most important relationship between fixed frame size and dual fixed frame size is that its variance is more than that of the fixed frame size distribution but less than, say the geometric distribution or hyper-geometric distribution.

Network Design

The network used for this simulation is a continuously changing one.

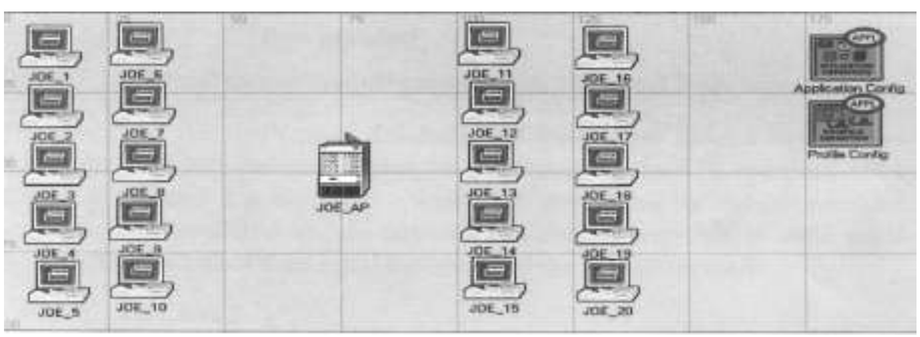

Figure 3: A view of the network in a scenario with 20 stations and one ac cess point

4.2 Simulation Results

The simulation was run accordingly and the statistics were collected and displayed on a graph. Results of the three cases are shown below.

DUAL FIXED CASE 1

This is the case in which the proportion of 90-byte frames and 117-byte frames were equal i.e. fifty percent each (50% 90 bytes and 50% 117 bytes).

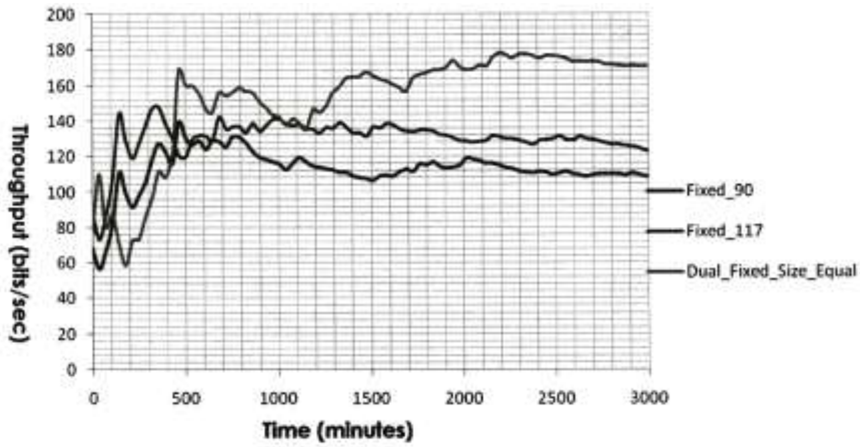

Figure 5: Dual fixed case with equal proportion of 90 and 117 bytes frames

The dual fixed case with equal distribution of frame sizes gives a higher emergent throughput. Though there is no basis for comparing the fixed 90 and fixed 117 bytes since it is expected that the 117 byte frame will give higher throughput provided the environmental conditions are the same. It can also be seen that at some point the throughput for the dual fixed equal frame crossed the 175 bits/see mark.

DUAL FIXED CASE 2

This is the case where 25% of the frames are 117 byte frames and 75% are 90 byte frames.

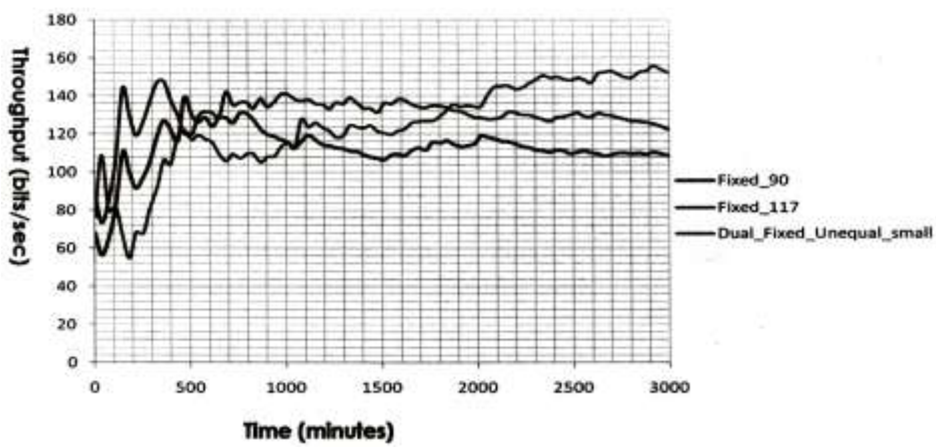

Figure 6: Dual fixed Case with majority of 90 byte Frame

As in case 1, the unequal distribution of the frames as described above still gives rise to higher throughput than the case of the individual fixed frame sizes. However, the throughput is always less than 175 bits/sec. The dual fixed distribution experiences an early rise in the curve, fall and slope, but the slope is smaller than that of the fixed frames sizes. This could be explained by a possible trade-off between media access delay and throughput. This eventually builds up after ten minutes to give a higher average value compared to the fixed frame sizes.

DUAL FIXED CASE 3

This is the scenario in which the distribution of frames is still unequal but in the opposite direction, i.e. 25% of the frames are 90byte types while 75% are 117byte types.

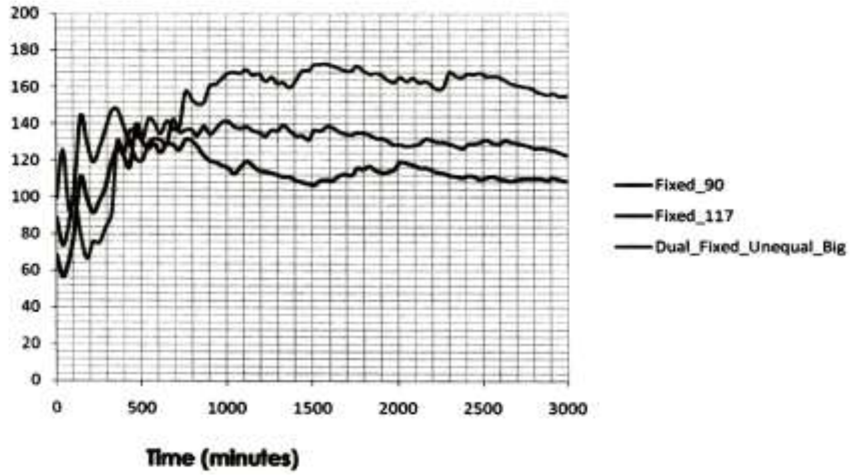

Figure 7: Dual Fixed case with majority of 117 byte frame

In this case, we still have more throughput delivery than in the individual fixed frame cases. Again the throughput value for the dual fixed unequal distribution has an early rise but less steep curve than the two single fixed cases. However, it eventually does improve in activity and maintained average throughput larger than the other two. Also, the throughput was further below the 175bits/sec mark.

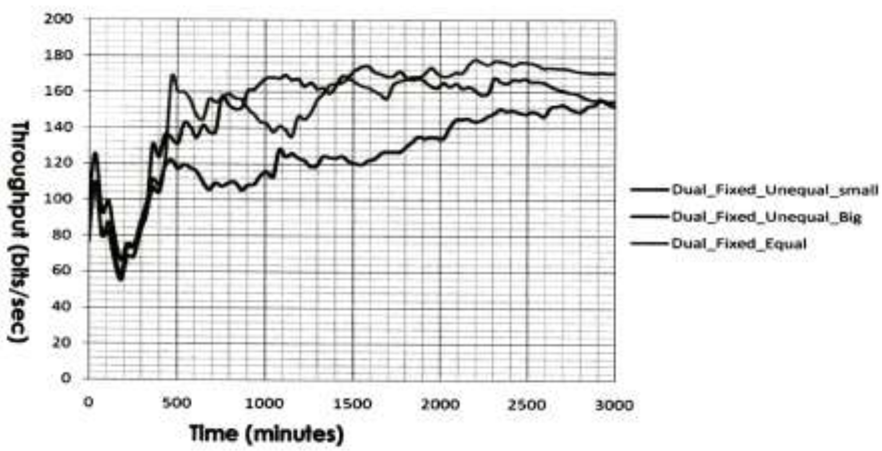

Figure 8: The three dual fixed case scenarios at a glance

However, the load was maintained at the same level throughout the simulation. The reason is to ensure an equal basis for comparing the results of throughput. The collected result showing the average value of load throughout the simulation time of 60 minutes for the case of 20 stations is shown below in Fig 9.

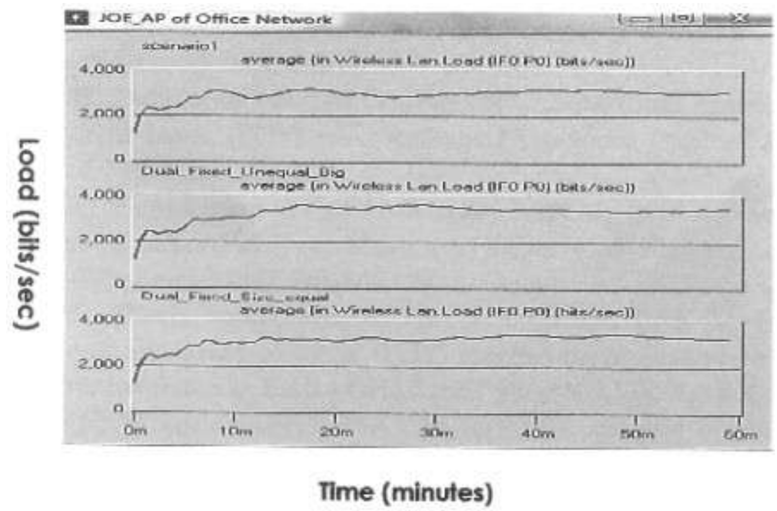

Figure 9: The Load reading for the Three Scenarios

The average load made a fast rise within the first four minutes as depicted by the very steep curve at the beginning. Afterwards it maintains a steady rate of at least 3000 bits/sec. Therefore a difference in the values of throughput in the face of equa1load per time makes the dual fixed size with equal proportions a better choice for frame size distribution.

5.0 Conclusions

The objective of this research is to carry out a performance analysis of WLAN MAC by investigating the effect of Frame size distribution on Wireless LAN. This research has presented a frame size distribution scheme which can be expanded. The work investigates and shows how frame size distribution in moderate and saturated load modes affects the main parameters of measure of performance in WLAN MAC Layer namely: Throughput. The analysis and measurement results from OPNET simulation has shown that an equal fixed frame size distribution can be efficient in optimizing useful data. These results are irrespective of the number of stations in the wireless LAN subject to a limit of 30 stations because that was the focus of this research. The frame size distribution could be implemented at the Mac level or at the PHY level.

Although some of these results are characteristic of the designed network, it is concluded that the network performance is mainly based on the simplification of the traffic in addition to mobility and number of hops for the frames.

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