Throughput Analysis of IEEE 802.11b

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***Abstract*— this paper provides information about saturation throughput analysis of IEEE 802.11b. Here we are taking the results from the bit error rate analysis. Those results will fed to throughput techniques. To calculate the saturation throughput of the IEEE 802.11b it is necessary to analyze the MAC layer of the IEEE 802.11b system.**

Keywords-IEEE 802.11b, MAC

1. INTRODUCTION

In present days most of the Communication products using WLANs technology. In these WLANs we are using IEEE 802.11b. In the IEEE 802.11b technology the transmitter section is designed using DSS PSK modulator. The IEEE 802.11b maximum data rate is 11 Mbps with the frequency range is around 2.4GHz band. The IEEE 802.11b using various modulation techniques for each and every data transmission rate such as Differential BPSK for 1 Mbps data rate, Differential QPSK for 2 Mbps data rate, and CCK for 5.5Mbps and 11 Mbps. Here we are calculating the preamble and the header is 192us.

For calculate the throughput of the system is compulsory to analyze the MAC layer of the corresponding IEEE 802.11b system. Here we are using Stop and Wait Protocol for calculating the throughput. And here we are calculating the throughput is also considering the data packets, it consists of Preamble and also Header. The transmitted time to this data packet is

$$t_T = DIFS + OVERHEAD + \frac{Data(Bits)}{Rate(Bit/Sec)} + SIFS + ACK$$

Frame Control 2 bytes	Duration And ID2 bytes	Address 1,2,3,4 6 +6+6+6 bytes	Sequence Control 2 bytes	Frame body 0 - 2312 bytes	Frame check sequence 4 bytes

SIFS, DIFS and ACK frame are considered here because they are necessary to ensure a correct reception of packet. Using Stop-And-Wait protocol, the data packets are transmitted, if any of the data packets is received in error the receiver section, it does not send an ACK back to the sender and it has to waits until the packet is retransmitted.

Rate	1Mbps	2Mbps	3Mbps	4Mbps
t_T	8.4msec	4.2msec	1.6msec	0.9msec

Then, the average time for an accurate data transmission to be received in the receiver section is given by

$$T_w = t_T + (1-p).\sum_{i=1}^{\infty} i.\, p^i \cdot t_T$$

The above equation,
the ith retry the packet must have been delivered in error i times.The probability of receiving it correctly on the ith retry is just (1-p).

$$(1-p)\sum_{i=1}^{\infty} i.\,p^{i}\cdot t_T = t_T\cdot p.(1-p)\sum_{i=1}^{\infty} i.\,p^{i-1}$$

$$= t_T\cdot p.(1-p).\frac{1}{(1-p)^2} = \frac{t_T\cdot p}{(1-p)}$$

$$T_w = t_T + (1-p)\sum_{i=1}^{\infty} i.\,p^{i}\cdot t_T$$

$$= t_T + \frac{t_T\cdot p}{(1-p)} = \frac{t_T}{1-p}$$

After calculating the average time for the accurate data transmission, the throughput can be calculated as

$$Throughput\left(Bits/_{\sec}\right) = \frac{Data}{T_w} = \frac{Data}{t_T}.(1-PER)$$

The basic structure of packets passed to the PHY layer from the MAC layer is shown in figure 1 Note that this is the basic format for all packets sent by the MAC layer. Some actual packets do not actually contain all of the fields. However, all fields are present in all data packets.

Figure1:The structure of packet created at the MAC Layer.

II. THROUGHPUT MODEL & ANALYSIS

When a MSDU (MAC Service Data Unit) is available at the MAC sub-layer, it is encapsulated into a MPDU (MAC Protocol Data Unit) by adding a 24 byte MAC header and 4 byte FCS (Frame Check Sequence) field. The MSDU comprises available length frame payload whose maximum size is limited to 2304 bytes. The MPDU is then passed to the physical (PHY) layer where the PLCP (Physical Layer Convergence Protocol) preamble and header is attached [1], [2].This is illustrated in Figure2. In 802.11b two types of the PLCP preamble are available such as: long (mandatory) and short (optional). In this analysis we consider only the short preamble type, because it has to improves efficiency on the network and is currently widely supported by 802.11bSTAs. It makes up of 9bytelong PLCP preamble (that is shorter compared to the long preamble by 7bytes) sent at1 Mbps and the PLCP header comprising 6bytes transmittedat2 Mbps (compared to the long preamble it contains the same number of bytes but it's transmitted at lower1 Mbps rate). The MPDU may be transmitted at one off our predefined PHY ratesof1, 2, 5.5, and 11 Mbps.

PLCP Preamble 9bytes	PLCP Header 6bytes	MAC Header 24bytes	Frame payload (MSDU) <2304	FCS 4bytes

MPDU PPDU

Figure 2: Frame format of IEEE 802.11b

The IEEE 802.11b supports two different modes which allow all the stations to access the medium such as PCF and DCF.
In the DCF mode all stations start with sensing the medium. If medium is idle they defer for a period of DIFS (DCF Inter frame Space) and then execute a back-off procedure. The back-off procedure is based on drawing a random slot from the interval [0, CWmin] where CW stands for Contention Window.
A frame transmission is considered to have failed if an error is introduced into the PPDU or the ACK. Failure to receive an ACK will also constitute a failed transmission where a timeout for the reception of an ACK frame has been defined as

ACK timeout = SIFS+ ACK+ Slot Time

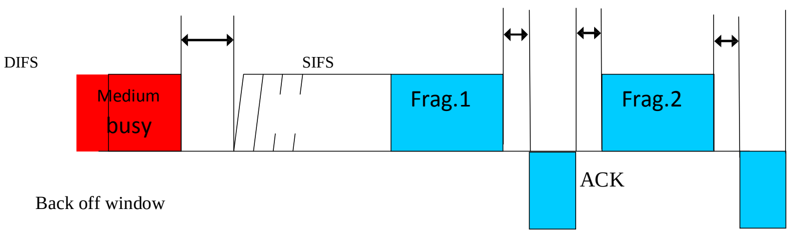

Figure 3 DCF with fragmentation (in general fragments might be more than two)

For calculation the throughput, it is necessary to calculate the average transmit time of a single frame which is depend on two things such as, i) A Successfully transmit time for a single frame. ii) Transmission time between two consecutive frames, if they occur any failed frame transmission.

Let us assume that the (L+28) byte long MPDU is transmitted using one of the four PHY data rates of 1, 2, 5.5 and 11 Mbps. The probability of the successful frame transmission can be expressed in the form

$$p^{m}_{Success}(L) = \left(1 - p^{m}_{e\_data}(L)\right)\cdot\left(1 - p^{m}_{e\_ack}\right)$$

Where $p^{m}_{Success}$ and $p^{m}_{e\_ack}$ are the error probabilities for the data and ACK frame transmissions respectively. This expression is valid for channel errors that are statistically independent which is true for channels without memory, e.g. the AWGN channel.

The term $p^{m}_{e\_ack}$ may be dropped as it is several orders of magnitude less than $p^{m}_{e\_data}$.

Consequently, $p^{m}_{Success}$ can be approximated as:

$$p^{m}_{Success}(L) = \left(1 - p^{m}_{e\_data}(L)\right)$$

The term $p^{m}_{e\_data}$ may be expressed in the form

$$p^{m}_{data}(L) = \left(1 - p^{1}_{e}(24)\right)\cdot\left(1 - p^{m}_{e}(28 + L)\right)$$

Where $p^{1}_{e}(24)$ is the error probability for the preamble which is always transmitted at 1 Mbps and $p^{m}_{e}(28 + L)$ is the error probability for the MPDU transmission. $p^{m}_{e}(L)$ is related to bit error rate (BER) as follows

$$p^{m}_{e}(L) = 1 - \left(1 - p^{m}_{b}\right)^{8L}$$

Where p^{m}_{b} is BER for rate m

Now let us define X as the length of a fragmented frame. The number of fragments of the Length of X is equal to $\left[L/X\right]$ where $[x]$ is the floor function. If X is not a multiple of L then the final fragment size is equal to L – X $\cdot$ $\left[L/X\right]$.

Each successful fragment transmission consists of a data frame transmission, an ACK frame transmission and two SIFS as shown in Figure 4.4. Thus the time needed for a successful fragment transmission is

$$T_{fragment}(X) = T^{m}_{data}(X) + SIFS + T^{m}_{ACK} + SIFS$$

Where $T^{m}_{data}(X)$ and T^{m}_{ACK} denote the durations of the data and ACK frames and are given by

$$T^{m}_{ACK} = \text{tPLCPpreamble} + \text{tPLCPheader} + \frac{14 + 8}{rate(m)}$$

$$T^{m}_{data}(X) = \text{tPLCPpreamble+tPLCPheader+}\frac{28+X}{rate(m)}$$

However, if the fragment transmission should fail for some reason or others the station has to wait for the ACK timeout before repeating the back-off procedure. The average time required to transmit the fragment may be expressed

$$T_{fragment}(X) = p_s(1).T_{reg}(X) + P_S(2).[T_{reg}(X) + T_{def}(1)] + p_s(3).[T_{reg}(X) + T_{def}(1) + T_{def}(2)] + \ldots\ldots\ldots$$

Where

$$T_{reg}(X) = T^{m}_{data}(X) + SIFS + T^{m}_{ACK} + SIFS$$

is a cycle time for delivering $T^{m}_{data}(X)$.

$$T_{def}(k) = \text{ACK\_timeout} + T_{back\_off}(k)$$

Is a time that is needed for an STA to defer till commences with another $T^{m}_{data}(X)$ transmissionafter k unsuccessful transmission attempts.

The average backoff interval associated with a retransmission attempt i is $T_{back\_off}(i)$ and may be expressed in the form

$$T_{back\_off}(i) = \begin{cases} \dfrac{2^{i-1}\cdot(CW_{\min}+1)-1}{2}\cdot slottime, 1 \le i \le 7 \\ \dfrac{CW_{\max}}{2}.slottime, i \ge 7 \end{cases}$$

We may rewrite equation (4.20) in the form

$$T_{fragment}(X) = T_{reg}(X) + \sum_{n=2}^{\infty} p_s(n)\cdot\sum_{i=1}^{n-1} T_{def}(i)$$

The throughput G is defined as the number of bits transmitted in a unit of time

$$G = \frac{L}{\frac{L}{X}\cdot T_{fragment}(X) + DIFS + T_{back\_off}(0) - SIFS}$$

Where L/X is the number of the fragments to be transmitted. We subtract SIFS from the denominator term as the first fragment of the L long frame is sent after the DIFS time. The 802.11b standard states that the CW after each successful transmission shall be reset to zero.

In our model CW will be always zero (i.e. the argument of $T_{back\_off}(0)$) as there is no competition for accessing the channel (there is only one station).

Simulation Parameter Settings

This section provides simulation parameter settings for the IEEE 802.11b, conventional multi-hop system and the PMCA based multi-hop system performance evaluation. For the IEEE 802.11b, we utilize the performance metric's models described. The complete set of simulation parameters and their initial values are shown in table1.

Description	Units	Range of values
Slot	us	20
SIFS	us	10
DIFS	us	50
PLCP Preamble	us	144
PLCP Header	us	48
Minimum Contention Window	-	31
Maximum Contention Window	-	1023

Table 1: Simulation Parameters

III. RESULTS

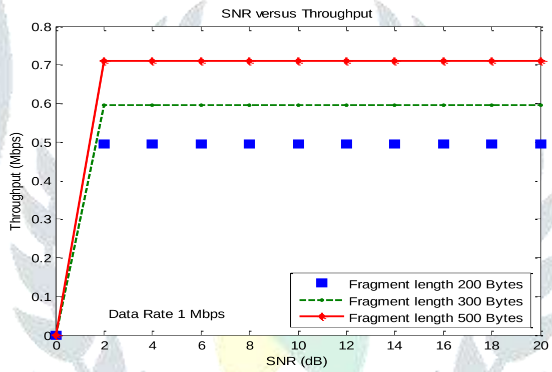

Fig. 4 SNR versus Throughput

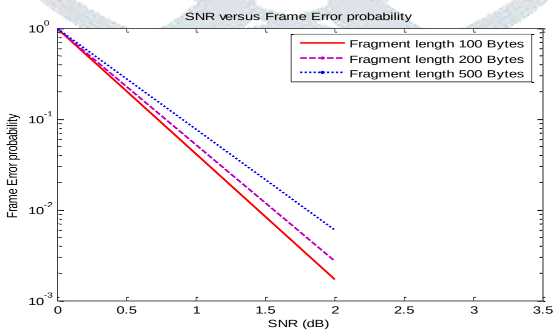

Fig. 5 SNR versus Frame Error Probability

Fig. 5 shows the variation of Frame error probability. This increases with increase in fragment length. So, the fragmentation improves the probability of successful transmission of the MSDU. In case of channel errors, the packet transmission must be rescheduled which results in performance degradation. If the MSDU is fragmented into smaller frames, in case of transmission errors, only the corrupted frame can be retransmitted. The throughput analysis of IEEE 802.11b with various fragment lengths using DBPSK is shown in the Fig.4. The throughput increases with increase in the fragment length.

IV CONCLUSION

In this thesis, taken results from the Bit Error Rate performance of IEEE 802.11b over Rayleigh fading channel and Rician fading channel is presented at various SNR using DBPSK, DQPSK and CCK modulation techniques. The throughput analysis is carried out using IEEE 802.11b. However, in this analysis throughput analysis is carried out for different packet sizes and SNRs at various fragmentation levels.

V.REFERENCES

1. Q. Ni, T. Li, T. Turletti, and Y. Xiao, "AFR partial MAC proposal for IEEE 802.11n," 2004, IEEE 802.11-04-0950-00-000n.
2. P. Lettieri and M. B. Srivastava, "Adaptive frame length control for improving wireless link throughput, range, and energy efficiency," in *Proc. IEEE INFOCOM*, 1998, pp. 564–571.
3. G. R. Cantieni, Q. N. C. Barakat, and T. Turletti, "Performance analysis under finite load and improvements for multirate 802.11," Elsevier Comp. Commun. J., vol. 28, no. 10, pp. 1095–1109, Jun. 2005.
4. RAPPAPORT T.S.: 'Wireless communications: principles and practice' (Prentice Hall, 2002, 2nd edn.)
5. MARCUM J . I.: Table of Q functions'. U.S. Air Force Project RAND Res. Memo. M-339, ASTIA Document AD 1165451, RAND Corporation, Santa Monica, CA, January 1950.