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PERFORMANCE EVALUATION OF MAC PROTOCOLS WLAN

Seema Nayak[*], Gurmeet Singh[**] & Amrita Rai[***]

Ad hoc wireless networks provide infrastructure-free communication, an efficient MAC protocol through which mobile stations can share a common broadcast channel is essential. Present medium access mechanism used are Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), multiple access with collision avoidance (MACA) and CSMA/CA with RTS/CTS. These protocols are designed to reduce the collision probability between multiple stations accessing a medium. CSMA/CA with RTS/CTS and MACA use RTS/CTS exchange mechanism to reserve the channel. In this paper, First theoretical model of WLAN is developed and the maximum possible throughput is calculated. In later part of the paper, for the verification of theoretical mode, simulation environment is developed and detailed simulation is performed using GloMoSim simulator. Finally theoretical and simulation result are compared, which shows the variation of throughput with the variation of packet arrival rate and variation of average end to end delay with throughput.

***Keywords**:* IEEE 802.11, CSMA, CSMA/CA, MACA, RTS/CTS, Performance Evaluation.

1. Introduction

The performance of a wireless network critically depends upon the medium access control (MAC) protocol used [1], [2]. Carrier Sense Multiple Access (CSMA) protocol [3] is often chosen because of its simplicity and scalability. Apart from this, some other MAC layer protocols like MACA, IEEE 802.11 DCF are also used. However, simple CSMA is susceptible to the hidden node (HN) and Exposed-node (EN) problem [4] especially in *ad hoc* networks where a node may communicate directly with every other node in range or using intermediate nodes as relays. Hidden nodes cause costly data packet collisions and thus significantly affect network performance. In order to combat the hidden node problem, the most popular collision avoidance scheme used today consists of a sender-initiated four-way handshake in which the transmission of a data packet and its acknowledgment is preceded by request-to-send (RTS) and clear-to-send (CTS) packets between a pair of sending and receiving nodes. Other nodes that overhear RTS or CTS packets will defer their access to the channel. The *RTS*/*CTS* mechanism was initially proposed in [5] in a protocol called Multiple-Access with Collision Avoidance (MACA). From a network point of view, one of the primary reasons for using the *RTS*/*CTS* mechanism is to avoid network congestion [6] resulting from frequent packet collisions.

This paper is organized as follows. In section 2, the theoretical model of the IEEE 802.11 MAC is presented and the maximum possible throughput is calculated for different MAC layer protocols *i.e.* CSMA, MACA, and IEEE 802.11. Section 3 is devoted for the simulation model for the verification of theoretical results. Results are presented in section 4 in form of graphs and tables. Finally paper is concluded in section 5.

[*] Electronics and Communication Dept., Echlon Inst. of Mgt. & Tech. Haryana, INDIA. *E-mail: seema_jessica@rediff.com*

[**] Electronics and Communication Dept., LIMAT Haryana, INDIA *E-mail: g_singh1gill@yahoo.co.in*

[***] Electronics and Communication Dept., Lingaya's University Haryana, INDIA. *E-mail: amritaskrai@yahoo.com*

2. Theoretical Model and its Analysis

The basic equation for modeling throughput is

$$Throughout = \frac{data}{data + overhead} \times datarate \qquad (1)$$

The equation (1) can be modified in terms of time delays. The throughput can be defined as the times it takes to transfer a certain amount of data message (M). M is a single data message packet / frame in bytes (which does not include header), and T (time) is the total time for transmission in sending M to the destination. The modified equation will become as

$$Throughout = \frac{M}{T} \qquad (2)$$

The timing delays vary with the access method and the speed of network. As we have assumed that there are no collisions in the network, therefore back off (BO) time [7] can be selected randomly from [0, CWmin]. The equation of back off time is given as

$$\text{Backoff Time} = \text{Random ( )} \times \text{a Slot Time} \qquad (3)$$

Where Random = Random Integer [0, CW min].

Slot Time = 20μ*s*, Assuming that BO is randomly distributed from [0, CWmin], giving the average value of CWmin/2. The value of BO would be:

$$BO = (31/2)*20\ \mu s \qquad (4)$$

T = [TDIFS + TBO + TRTS + TSIFS + TCTS + TSIFS + TDATA + TSIFS + TACK + TPHY +TPHY] μs

The values of each fixed delays are shown in the Table.1.

Total time T is a function of data message M (size in bytes) can be written as:

$$T = (aM + k + m)*10\ us \quad (5)$$

Where:

a = (8/Data Rate)

k = (224/data rate)

m = constant delays

224 = 28*8; are the bits of header and trailer, which are not part of payload and hence taken as overhead.

Now using the value of (5); equation (2) will become:

$$Throughput = \frac{8M}{(aM + k + m)} \times 10^{\wedge}6 \quad (6)$$

Table 1
Constant Delays with MAC Access Schemes

Delay(μs)	*CSMA/CA*	*MACA*	*RTS/CTS*
TDIFS	50	50	50
TBO	310	310	310
TSIFS	10	10*2	10*3
TRTS	-	352	352
TCTS	-	304	304
TACK	304	-	304
TPHY	192	192	192
m	866	1228	1452

Equation (6) models the throughput of WLAN. Now we will examine the variation of M for CSMA/CA, MACA and CSMA/CA with RTS/CTS. From the graphs; the throughput is little bit higher for CSMA/CA than CSMA/CA with RTS/CTS. If the network is heavily loaded then the performance of CSMA/CA degrades much faster than RTS/CTS systems. The distribution of Packet Sizes is that 45% of packets are only 44 bytes long, 35% of packets are 512 bytes long and 20% of packets are 1500 bytes long [8]. If we take the average of the packet size distribution then

$$\lambda = 0.45\ (44) + 0.35\ (512) + 0.20\ (1500) = 500 \quad (7)$$

By using above equation we can get the theoretical value of throughput.

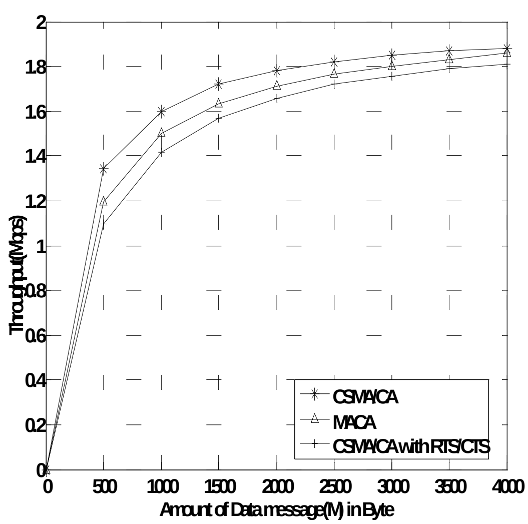

Figure 1: Theoretical Throughput Comparison

3. SIMULATION MODEL

In this section simulation model is given for the verification of our theoretical model. The proposed MAC protocols are implemented in Glomosim [9] and simulations for various packet arrival rates is carried out for topology shown in Figure.1.

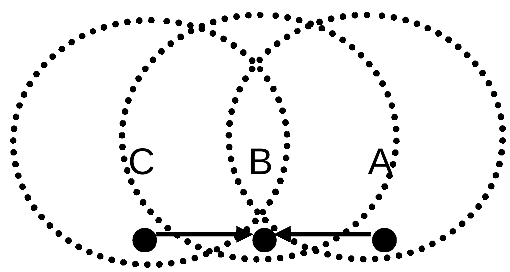

Figure 2

Simulation model taken is

Node 0 ---- 600 m ---- Node 1 ---- 600 m ---- Node 2

In app. conf:

CBR 0 1 0 512 4MS 6MS 0

CBR 2 1 0 512 4MS 0 0

Traffic consists of CBR flows of packet size 512 bytes between nodes 0 and 1 and nodes 2 and 1.

Table 2
Glomosim Parameters Used

Frequency	2.4 GHz
Pathloss Model	Free Space
Noise calculation	SNR bounded
Radio Rx Sensitivity	–91.0 dbm
SNR-Threshold	10.0
Radio–RX Threshold	81.0 dBm
Transmit Power	-15 dBm
Bandwidth	2 Mbps
Packet Size	512 byte
Terrain Dimension	(1500, 1500)

With these parameters, the transmission range is 376 meters and interference range 637 meters. When node 0 sends data to node 1 the distance from node 0 to 1 is 600 m and both are in the transmission range of each other, but node 2 is not in the transmission range of node 0. Thus node 0 and 2 are hidden and leads to packet collision.

4. RESULTS

In this section, the result of throughput and average end to end delay is given and compared for three MAC layer protocols CSMA/CA, MACA and CSMA/CA with RTS/CTS. For simulation of topology shown in Figure 1, Glomosim is used. Performance comparisons between the theoretical and simulation approach in terms of throughput with the variation of packet arrival rate is also given. Finally the variation of average end to end delay with throughput is shown in form of graph.

Table 3
Theoretical vs. Simulation Throughput

Method	*Throughput (Mbps)*	
	Theoretical	*Simulation*
CSMA/CA	1.343	1.24
MACA	1.19	1.09
RTS/CTS	1.095	0.97

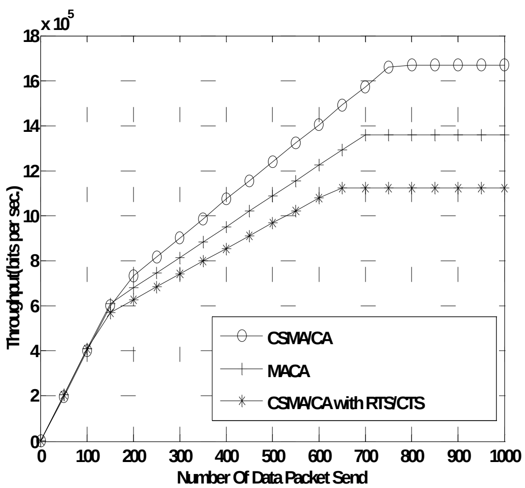

Figure 3: Variation of Throughput vs. Packet Send

The graph shows at low load the throughput of all the protocols is similar but at high load better behavior is obtained when using CSMA/CA instead of MACA and CSMA/CA with RTS/CTS. Because of The use of RTS packets whenever a source has a data packet to send without first sensing the channel, results in an increase in packet collisions and hence decreased throughput. From the graph it is also clear that, in terms of delay CSMA/CA is better. From the table and simulation result the correctness of theoretical result is verified

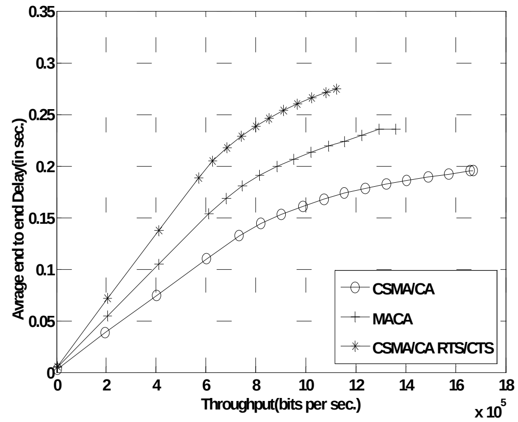

Figure 4: Variation of Average End to End Delay with Throughput

5. CONCLUSION

In this paper the performance of different MAC layer protocols have been discussed. First the expression for throughput for theoretical model is derived. Finally for verifying the correctness, Glomosim is used. From the graph and table it is clear that theoretical model and simulation model are following each other. In terms of delay and throughput CSMA/CA is better because it is providing maximum throughput while taking minimum end to end delay.

6. REFERENCES

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