ISSN:2231-0711
www.ijcset.net

Comparative Analysis of IEEE 802.11b At 2 Mbps &11 Mbps

Minal S. Hardas[1], Amutha JeyaKumar[2]

Electrical Department, Mumbai University
Veermata Jijabai Technological Institute, Matunga.
India

[1]mail2minal@rediffmail.com
[2]amuthajaykumar@vjti.org.in

***Abstract*- The IEEE 802.11 Wireless Local Area standard, WLANs, available in various variants as a/b/g, is one of the most popular wireless standards used in the market today. In this paper, an attempt has been made to analyze and compare the variant IEEE 802.11b using a Smart Call Admission and Rate Control, CARC, policy for Quality of Service, QoS, metrics like throughput, end to end delay and Packet Loss Rate at the channel data rate of 2 Mbps and 11 Mbps respectively. The performance is evaluated for a wireless Adhoc network and the simulation results obtained using Network Simulator-2 shows a superior throughput performance for real-time and non real time traffic at 11 Mbps. But the end to end delay metric show rise in values for both traffics at 11 Mbps as compared to 2 Mbps. Packet Loss Rate shows a remarkable performance at 2 Mbps. Thus, the proposed schemes can well support statistical QoS guarantees for voice traffic and maintain stable high throughput for the best effort traffic at the same time.**

***Keywords*- Quality of Service, WLANs, Distributed Coordination Function, IEEE 802.11b.**

I. Introduction

IEEE 802.11 is the leading standard for WLANs. It adopts the standard 802 Logical Link Control, LLC, protocol but provides optimized Physical Layer, PHY, and Medium Access Control, MAC, sub layers for wireless communications. 802.11 specify two physical layers: Direct Sequence Spread Spectrum, DSSS and Frequency Hopping Spread Spectrum, FHSS. Based on the transmission technologies and operating spectrum, the 802.11 can be classified into three categories: 802.11a (orthogonal frequency-division multiplexing, OFDM, 5 GHz), 802.11b (high-rate DSSS, HR/DSSS, and 2.4 GHz), and 802.11g (OFDM, 2.4 GHz) [2]. All these variants use the mandatory access method, Distributed Coordination Function, DCF, which uses Carrier Sense Multiple Access with Collision Avoidance, CSMA/CA, and algorithm to mediate access to the shared medium [1]. DCF can well support non real-time data traffic but unsuitable for real-time applications where QoS requirements are stringent. Also due to voice and data streams being multiplexed on the same channel in WLANs, the non-real time data traffic load increases and the QoS of voice over WLAN degrades severely [4]. Therefore it becomes a challenging situation to provide QoS for voice traffic while maintaining as high throughput as possible for non real-time data traffic. In this paper we propose a smart and efficient Call Admission and Rate Control, CARC policy, in which the Call Admission Control mechanism regulates real-time traffic to efficiently coordinate the medium contention among voice sources and the Rate Control mechanism regulates non real-time traffic to control its impact on the performance of real-time traffic by allowing the best effort traffic to utilize all the residual channel capacity left by the real-time and streaming traffic while not violating the QoS metrics of the real time traffic thereby enabling the network to approach the maximal theoretical channel utilization [7]. In this paper section II has the brief overview of IEEE 802.11b [2] and it also deals with packet structure format for the standard [3], section III gives the Control Metrics [5], section IV gives the proposed Call Admission and Rate Control scheme [4], section V shows the Simulation results. We have implemented the CARC scheme in Network Simulator, NS-2 [13] and conducted a comprehensive simulation study to evaluate its performance for IEEE 802.11b standard for QoS metrics like throughput, end to end delay and Packet Loss Rate at channel data rate of 2 Mbps and 11 Mbps respectively, and finally section VI Concludes the paper.

II. Brief On Ieee 802.11b

IEEE 802.11b is by all means the most commonly accepted WLAN *(Wireless Local* Area Networks) standard today. The reasons for this are low-cost end-user equipment, very good throughput capacity of up to 11 Mbps and operation in license-free band. 802.11b is based on HR/DSSS and operates at the 2.4 GHz industrial, scientific, and medical (ISM) band with transmission rate from 1 to 11 Mbps [2]. Therefore WLAN technology has moved from enterprise local area networks towards public telecommunication infrastructure. It covers up to 300 feet distance. Its range is quite large and is used where range matters rather than the density.

The IEEE 802.11b standard defines two different packet structures, short and long that are used in the DSSS standard.

The short packet format is intended to reduce the overhead of transmissions while the long packet format is to maintain compatibility with IEEE 802.11 networks [3]. The PHY preamble is used to allow the receiver to get synchronized to the transmitter. The PHY header is the overhead needed by the PHY layer. The remainder of the packet contains the data passed to the PHY layer by the MAC layer. The long packet format for IEEE 802.11b packet as it is transmitted on the physical layer is as shown in Fig. 2.1.

PHY Pream-ble (18 B)	PHY Header (6 B)	MAC Header (34 B)	Ethernet Header (14 B)	IP Header (20 B)	Data Payload+ Header up to (1480 B)	MAC Footer (4 B)

@1 Mbps @ 1, 2, 5.5 or 11 Mbps

Fig. 2.1 Long Data Packet Format of IEEE 802.11b

The IEEE 802.11b parameters required for calculating the metrics for implementing CARC algorithm are listed in [10] the Table I.

TABLE I

IEEE 802.11 b PARAMETERS

Parameters	**802.11b**
SIFS	10 µs
DIFS	50 µs
SLOT	20 µs
PHYSICAL LAYER HEADER LENGTH	192 µs
MAC	34 bits
ACK	14 bits
CW min- CW max	31-1023
RTS Size (Bytes)	20
CTS & ACK Size (Bytes)	14

III. METRICS

The CARC scheme utilizes the channel busyness ratio as the control metric. Channel busyness ratio Rb is the ratio of the time the channel is determined to be busy to the total time. Rb consists of both successful transmissions and collisions. The channel utilization Rs is defined as the ratio of successful transmission periods to the total time [5]. It is seen that the IEEE 802.11b DCF protocol could satisfy the QoS requirements of the real-time traffic and achieve the maximal channel utilization when it is working at the optimal point corresponding to a certain amount of arriving traffic. If the arriving traffic is heavier than this threshold, the WLAN enters into saturation, resulting in significant increase in delay and decrease in throughput; on the other hand, if the arriving traffic is less than this threshold, channel capacity is wasted. However, it is necessary to tune the network that operates on the basis of channel contention to work at this optimal point [7]. The collision probability is small when WLAN works at this optimal point, and hence Rb = Rs. Rb is relatively stable around 0.90 (without request/clear to send, RTS/CTS) or 0.95 (with RTS/CTS). Let BU denote the channel utilization corresponding to the optimal point. CARC should maintain Rb close to BU to guarantee a good QoS level and high aggregate throughput. Hence BU ≈ 0.90 (without RTS/CTS) and BU ≈ 0.95 (with RTS/CTS).

Every node initiates an identical User Datagram Protocol (UDP)/constant bit rate (CBR) traffic and variable bit rate (VBR) flow to a randomly selected neighbor.

IV. SMART CALL ADMISSION AND RATE CONTROL POLICY

The call admission policy admits the new traffic only if the requested resources are available. The Coordinator of the WLAN takes the admission decision for each traffic flow. Let BM denote the share of the bandwidth reserved for real-time voice traffic. 75 % bandwidth is allocated for real-time data traffic, hence BM =0.75 * BU. Let BN denote the share of bandwidth for non real-time traffic. 25 % bandwidth is allocated for non real-time data hence, BN = 0.25 * BU [4]. This ensures maximum channel resources for real-time voice traffic, at the same time non real-time traffic remains operational all the time since it is entitled with some part of channel resources [7]. We model the voice traffic as Variable Bit Rate, VBR and background data traffic as Constant Bit Rate, CBR. Three parameters via; (R, Rpeak and len) are used to characterize the bandwidth requirements of the traffic flows, where R is the average rate, Rpeak is the peak rate (both in bits/sec) and len is the average packet length in bits.

For CBR traffic, R = Rpeak (1)

For VBR traffic, R < Rpeak. (2)

To conduct admission control, the above parameters of voice flows are converted into channel utilization

Parameter 'u' (i.e. the channel time a flow will occupy) as:

u = R / len * Tsuccessful (3)

And upeak = Rpeak / len * Tsuccessful (4)

Similarly for data flow, if 'v' denotes the channel utilization we can have

v = R / len * Tsuccessful (5)

Where, Tsuccessful is the transmission time of one packet, including RTS, CTS, Data and ACK and all the necessary inter-frame spaces i.e. DIFS, SIFS [6].

Therefore,

Tsuccessful = Data + ACK + RTS + CTS + 3 * SIFS + DIFS (With RTS/CTS) (6a)

Tsuccessful = Data + ACK + SIFS + DIFS (Without RTS/CTS) (6b)

Thus (u, upeak) specify voice flow bandwidth requirement for real time traffic and (v) specifies data flow bandwidth requirement for non-real time traffic. When a node wants to establish a flow, it must convert the bandwidth requirement into the form of (u, upeak) for real-time flow and (v) for non real-time flow, and send a request with this requirement, to the Coordinator. Upon receiving a request with these parameters, the Coordinator examines [4] whether there are enough resources to accommodate the new flow i.e. whether the remainder quota of BM and BN can accommodate the new traffic flow by carrying out the following procedure:

For real-time voice traffic-

$$\text{If } (uA + u) \leq BM \ \&\& \ (upeakA + upeak) \leq BU \quad (7a)$$

The Coordinator issues connection admitted message, and

Updates (uA, upeakA) with (uA + u, upeakA + upeak) (7b)
Otherwise the Coordinator issues connection-rejected message.

For non real-time data traffic-The bandwidth requirement of non-real time traffic is into the form of (v)

$$\text{If } (vA + v) \leq BN \quad (7c)$$

the Coordinator issues a connection admitted message and Updates (vA) with (vA + v)
Else access is denied. And the Coordinator issues connection-rejected message.
When the flow ends, the source nodes of the flow should send a "connection terminated" message to the Coordinator. The Coordinator respond with a "termination" confirmed message and updates (uA, upeakA) or (vA) respectively.

V. SIMULATION RESULTS

The IEEE 802.11b based WLAN with 50 nodes in Ad-hoc mode is simulated using the network simulator ns-2 [13]. RTS/CTS mechanism is used and the performance is analyzed using the animator NAM and Trace graph [12]. The Adhoc networks are moving in 600 * 600 m topography, with channel rate of 2Mbps and 11 Mbps respectively and the simulation is run for 200sec. The two ray propagation model is considered in all the simulations.

Real time traffic model (voice) traffic is modeled as Variable Bit Rate, VBR, traffic using the on/off source model, with exponentially distributed on and off periods of 300 ms average each. During the off periods no traffic is generated, while during on periods, traffic is generated at a rate of 32kbps with a packet size of 160 bytes.

Non real time data traffic is modeled as Constant Bit Rate, CBR, traffic where traffic is generated at the rate of 64kbps with a packet size of 1000 bytes and inters packet frame time of 125ms.

The Performance of IEEE 802.11b is investigated for QoS metrics like throughput, average end to end delay and packet loss rate using CARC algorithm at 2 Mbps and 11 Mbps respectively.

TABLE II
SIMULATION RESULTS

SR. No.	QoS Metrics	IEEE 802.11b @ 2 Mbps		IEEE 802.11b @ 11 Mbps	
		VBR	CBR	VBR	CBR
1.	Throughput of sending packets [packets/TIL] v/s simulation time[s]	220	60	380	120
2.	End to end delay[s] v/s packet size[Bytes]	0.035S	0.045S	0.27S	0.46S
3.	No. of voice calls & No. of data calls	13	5	26	14

Metric1-Throughput of sending packets [packets/TIL] v/s simulation time [S]
Results obtained using ns-2 show a superior throughput performance for real-time and non real-time traffic at 11 Mbps as compared with 2 Mbps. The throughput of sending packets for VBR traffic is more than CBR traffic for each of the data rates as shown in Fig. 5.(a), & Fig. 5.(b).

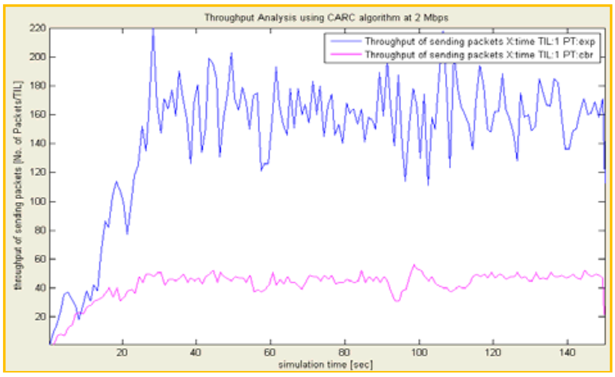

Fig. 5.(a) Throughput Performance at 2 Mbps

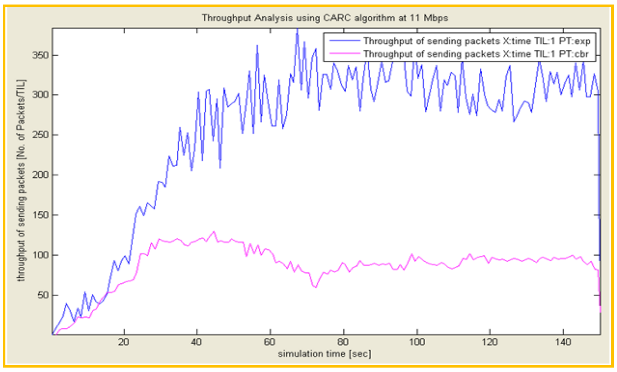

Fig. 5.(b) Throughput Performance at 11 Mbps

Metric 2-Average End to end delay [S] v/s packet size [Bytes]
The average simulation delay plot for each of the data rate is as shown in the Fig. 5.(c) & Fig. 5.(d). It is seen that the average end to end delay shows appreciable performance at 2 Mbps than at 11 Mbps for both VBR and CBR traffic respectively. It is observed that with increase in data rates the average simulation delay increases.

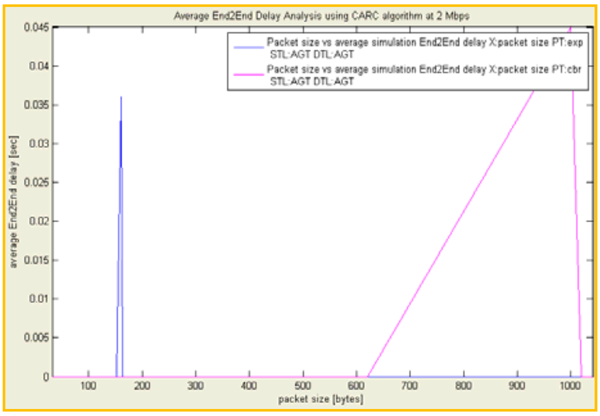

Fig. 5.(c) Average End to End delay at 2 Mbps

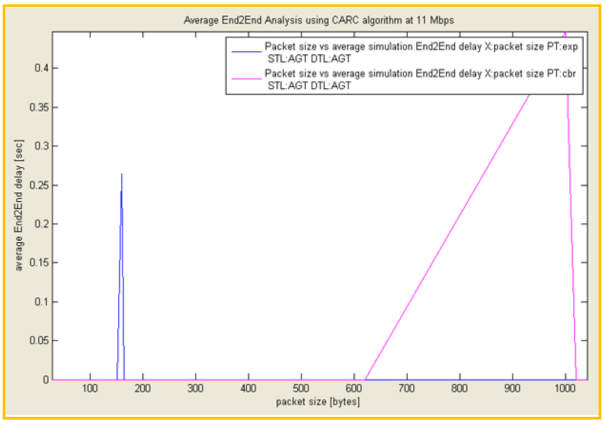

Fig. 5.(d) Average End to End delay at 11 Mbps

Metric 3- Number of voice calls and data calls for VBR & CBR Traffic

It is seen from the Table II that total number of voice calls and data calls supported by 802.11b standard at 11 Mbps are 26 and 14 whereas at 2 Mbps are 13 and 5 respectively. The bandwidth of the real time calls is momentarily utilized by non real time calls thus, achieving the maximum throughput and efficient channel utilization.

Apart from these metrics, QoS metric like Packet Loss Rate, PLR, is compared at 2 Mbps and 11 Mbps respectively. Packet Loss Rate describes number of packets lost in transit between the source (input) and the destination (output). It is observed from Table III that Packet Loss Rate show good results for lower data rates as compared to higher data rates.

TABLE III

SIMULATED VALUES FOR PACKET LOSS RATE

QoS parameter	IEEE 802.11b 2 Mbps	IEEE 802.11 b 11 Mbps
Packet Loss Rate	4.305 %	7.3 %

VI. CONCLUSION

It is seen that using CARC algorithm, Packet Loss Rate for an Adhoc network shows appreciable performance at 2 Mbps as compared to 11 Mbps. The IEEE 802.11b variant can support strict QoS requirements of real-time services while achieving maximum throughput for higher data rates of 11 Mbps respectively. The throughput of sending packets for VBR traffic is more than CBR traffic for both the data rates. The average end to end delay increases with increase in channel data rates. Hence, it is observed that as the channel data rate increases, the throughput increases but at the same time average end to end delay also increases. Hence, it is concluded that there is a tradeoff between throughput of sending packets and average end to end delay i.e., throughput increases at the cost of average end to end delay for higher data rates.

An efficient admission control and rate control scheme (CARC) scheme can well support statistical QoS guarantees for voice traffic and allows best effort traffic to utilize all the residual channel capacity left by the real-time and streaming traffic while not violating their QoS metrics, thereby enabling the network to approach the maximal theoretical channel utilization for both the data rates.

ACKNOWLEDGMENT

The author would like to thank Mrs. Amutha JeyaKumar and Mrs. Smita Lonkar for her valuable guidance that greatly improved the quality of this paper.

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