Computer and Information Science
www.ccsenet.org/journal.html
Vol. 1, No. 4
November 2008

Performance Evaluation of QoS by Combining Medium Access Control and Slow Start in MANETS

J.Premalatha (Corresponding author)
Department of Computer Science and Engineering College
Erode, India
E-mail: premalatha1969@yahoo.com
Dr.P.Balasubramanie
Department of Computer Science and Engineering College
Erode, India
E-mail: pbalu_20032001@yahoo.co.in

Abstract

This paper evaluates the performance evaluation of interaction between Transport and the MAC layer protocols operating in a mobile adhoc network. In Adhoc networks, certain QoS parameters like error rate, delay and packet loss are increased and certain parameters like throughput and delivery ratio are decreased in Transport layer is due to MAC problems and disconnection is also possible due to mobility or power failure. So, combine the mechanisms of these two layers improve the QoS drastically. We examine the effects of two different MAC protocols— IEEE 802.11and IEEE802.11e with Slow start mechanism of TCP. Specifically, we access the impact of multiple wireless hops and node mobility on the throughput performance of TCP on each MAC protocol. Additionally the other Qos parameters of throughput, delay, Bandwidth delay product, delivery ratio and packet loss using slow start of TCP mechanism with two different MAC protocols is also investigated. Results show that in all instances, the QoS parameters 15-20% improvement in throughput, 40-45% improvement in bandwidth-delay product, 10-15% improvement in delivery ratio in IEEE 802.11e than IEEE802.11 and packet loss is reduced drastically to 40-50% in IEEE802.11e where only 3-5%delay is higher in IEEE802.11e than IEEE802.11.

Keywords: Mobile adhoc networks, Medium access control(MAC), Transport layer Protocol(TCP), Slow start and Quality of Service(QoS)

1. INTRODUCTION

In the near future, researchers envision a truly ubiquitous computing environment that will allow users to communicate from anywhere and at anytime. Mobile adhoc networks (MANETs) are part of this vision and aim to provide communication capabilities to areas where limited or no communication infrastructure exist; or, where it is simply more convenient to allow the communication devices to form a dynamic and temporary network among themselves. A "mobile adhoc network" (MANET) is an autonomous system of mobile routers (and associated hosts) connected by wireless links. In current wireless networks, WIMAX or WIFI the wireless mobile node is never more than one hop from a base station that can route data across the communication infrastructure. However, in mobile adhoc networks, there are no base stations. Instead, routing functionality is incorporated into each mobile host and, because of a limited transmission range, multiple hops may be required to allow one node to communicate with another across the adhoc network. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Thus, MANETs can be characterized as having a dynamic, multi hop, and constantly changing topology. While mobile adhoc networks can be used in a standalone mode—where there is no fixed infrastructure, their use is also being considered as an extension to the Internet. Much of the current research of mobile ad hoc networks has focused on the design and development of routing protocols, efficient power consumption, Energy saving techniques, Security in various layers, Enhancement in Qos and cross layer design. However, the success of wireless mobile adhoc networks will also depend significantly on controlling access to a wireless physical layer having relatively low bandwidth links {Paolo, 2006]. Thus, the effectiveness of the wireless medium access control (MAC) protocol and mechanisms will play a central role in the success of MANETS. Several MAC protocols have been developed for wireless environments (i.e. wireless LANS) such as Carrier Sense Multiple Access (CSMA), Multiple Access with Collision Avoidance (MACA), Floor Acquisition Multiple Access (FAMA), IEEE802.11 and IEEE 802.11e. Each MAC protocol is based on multiple design choices and utilizes distinct medium

access mechanisms.

This research centers on investigating the performance of and interaction between TCP and two different MAC protocols— IEEE 802.11and IEEE 802.11e, operating in mobile adhoc networks. Reliable data transfer and congestion control are key requirements for any computer network. TCP, which fulfills both of these requirements, is the most widely used reliable transport protocol in today's Internet and has demonstrated its viability with respect to Internet connectivity. TCP is used to transport a significant portion of Internet traffic such as e-mail (SMTP), file transfers (FTP), and WWW (HTTP). Thus, the use of TCP in mobile adhoc networks is clearly advantageous [Perkins et al, 2005]. However, the defining characteristics (e.g., time-varying, dynamic, multihop, and constantly changing topology) of mobile adhoc networks may result in unpredictable link failures resulting in the poor performance of TCP.

The goal of this paper is, therefore, to study the effects of these characteristics on the performance of and interaction between TCP and the MAC layer protocol operating in a mobile ad hoc network. This includes examining the effects of IEEE 802.11 and IEEE 802.11e MAC protocols on the performance of TCP. Specifically, we access the Qos parameters throughput, delay, Bandwidth delay product, and delivery ratio and packet loss performance of TCP as function of node mobility.

2. RELATED WORK

TCP has been shown to have poor performance over wireless links. Thus, several studies have focused on improving TCP performance in the wireless mobile Environment. These include end-to-end mechanisms such as TCP-SACK and ELN and link-layer protocols such as AIRMAIL, Indirect-TCP, and TCP-Snoop. Such mechanisms and protocols were designed to work in the context of cellular-based networks fixed infrastructure networks. However, the aforementioned schemes have not considered the unique characteristics of adhoc networks, namely multi-hop routing and the lack of a centralized controller and manager (e.g., base stations). Recent work has begun to evaluate the performance of TCP in context of adhoc networks. This work demonstrated how the use of combining the mechanisms of both TCP and MAC protocols improve the QoS parameters. Previous work investigates that IEEE802.11e better than IEEE802.11 [Choi.S, 2003] but not combined with TCP mechanisms. Hence, evaluating the performance of TCP in a mobile adhoc environment and quantifying the effects of the unique characteristics is an open and interesting problem. These results should facilitate the development of mechanisms for improving TCP performance in adhoc networks as well as the design of efficient and scalable quality-of-service (QoS) schemes.

3. SIMULATION AND METHODOLOGY

This simulation study was conducted using NS2 to simulate adhoc network, which consist of 60 wireless/mobile nodes roaming in a 2600 x 400m area. In this dynamic topology, the radio transmission range of each node is approximately 250 meters and the channel capacity is 2Mbits/sec. The free space propagation model is used to determine if a node is reachable. This model predicts received signal strength when the transmitter and receiver have a clear, unobstructed line-of-sight path between them. Received power decays as a function of the T-R separation distance. This study investigates the performance slow start mechanism of TCP over two different MAC protocols:IEEE802.11 and IEEE 802.11e. Both protocols requires carrier sensing before transmission and operates as follows

3.1 IEEE802.11 MAC Protocol

The basic access mechanism for both MAC protocols is the Distributed Coordination Function (DCF). DCF is essentially a Carrier Sense Multiple Access (CSMA) that incorporates Collision Avoidance (CSMA/CA) and a positive acknowledge (ACK) scheme. Receipt of an ACK (from the receiving node) indicates that no collision occurred [Qixiang.P, 2005]. If the sending node does not receive an ACK, then it will retransmit the fragment until it gets acknowledged or discarded after a specified number of retransmissions. Optionally, a mobile node can utilize the virtual carrier sense mechanism, which utilizes request-to-send (RTS) and clear-to-send (CTS) exchanges for channel reservation. Using virtual carrier sensing reduces the probability of two nodes transmitting simultaneously (collisions) because they cannot hear each other (i.e. hidden terminal problem). The difference between IEEE802.11 and IEEE 802.11e is, to assign priority for user packets in IEEE 802.11e and there is no priority assignment for user packets in IEEE 802.11.

3.2 IEEE802.11e MAC Enhanced DCF (EDCF)

The DCF is supposed to provide a channel access with equal probabilities to all stations contending for the channel access in a distributed manner. However, equal access probabilities are not desirable among stations with different priority frames [Maarten et al, 2000,2002]. The emerging EDCF is designed to provide differentiated, distributed channel accesses for frames with 8 different priorities (from 0 to 7) by enhancing the DCF as shown in Table1. As distinct from the legacy DCF, the EDCF is not a separate coordination function. Rather, it is a part of a single coordination function, called the Hybrid Coordination Function (HCF), of the 802.l1 MAC. The HCF combines the aspects of both DCF and PCF.The EDCF adopts eight different priorities that are further mapped into four access categories (ACs) as shown in figure1. ACs are achieved by differentiating the arbitration inter frame space (AIFS), the

initial window size and the maximum window size.

For the AC *i* (*i* = 0, 1, 2,3), the initial backoff window size is CWmin[*i*](= *Wi,*0), the maximumbackoff window size is CWmax[*i*] and the AIFS is AIFS[*i*].

For 0 = *i* <*j* = 3, CWmin[*i*] = CWmin[*j*],

CWmax[*i*] = CWmax[*j*], and

AIFS[*i*] = AIFS[*j*],

and at least one of the above inequalities must be strict. If one class has a smaller AIFS or CWmin or CWmax, the class's traffic has a better chance to access the wireless medium earlier. Four transmission queues are implemented in a station and each queue supports one AC class, behaving roughly as a single DCF entity in the original IEEE 802.11 MAC.

It is assumed that a payload from a higher layer is labeled with a priority value, and it is pushed into the corresponding queue with the same priority value [Xiao.Y 2004,2005,2006]. Each queue acts as an independent MAC entity and performs the same DCF function with a different inter frame space (AIFS[*i*]), a different initial window size (CWmin[*i*]), and a different maximum window size (CWmax[*i*]). Each queue has its own backoff counter (BO[*i*]) that acts independently the same way as the original DCF backoff counter. If there is more than one queue finishing the backoff at the same time, the highest priority frame is chosen to transmit by the virtual collision handler. Other lower priority frames whose backoff counters also reach zeros will increase their backoff counters with CWmin[*i*] (*i*= 0, 1.. . 3), accordingly. Use EDCF (enhanced distributed co ordination function) and Slow start mechanism of Transport layer enhance the MAC performance and also transport layer performance.

4. SIMULATION

The AODV (Adhoc On Demand Vector) protocol, available in NS2 uses dynamic routing in order to deliver packets to any destination in a mobile adhoc network. The random waypoint mobility model, each node is placed randomly in the simulated area and remains stationary for a specified time and then randomly selects a destination from the physical terrain. The node then moves in the direction of the destination point at a speed uniformly chosen between a minimum and maximum speed (meters/sec). To increase the performance there should be different types of priority level or traffic categories (TC) for data transmission in MAC layer and use user priority level of 0,1 and 2.For simulation produce 3 different packets of data and set priority 0(high priority) for large size packet, priority 1 (medium priority) for medium size packet and priority 2(low priority) for small size of packet. To send acknowledgements from transport layer in SIFS interval, a acknowledgement packet which contain less bytes of data is transmitted for all different types of traffic categories. The time slots for various inter frame spacing is set as SIFS=16µs, PIFS=25µs, DIFS=34µs, $AIFS_1$ (priority level=0 or TC1) >=34µs and every contention slot is equal to 9µs interval. If there is no high priority packet for the specified time interval immediately medium level packet are transmitted.

4.1 RESULTS and PERFORMANCE METRICS

To analyze the performance and interaction of TCP and MAC layer protocols, we evaluate them using the following metrics:

4.1.1 Throughput: It is the rate of successful message delivery over a communication channel. This data may be delivered over a physical or a wireless channel and it is usually measured in bits per second (bit/s or bps), and sometimes in data packets.

With 20nodes 802.11 transmitted 8406 bits, 802.11e transmitted 9234 bits successfully. With 60nodes 802.11 successfully transmitted 8286 bits, 802.11e transmitted 9412 bits. The Slow start mechanism of TCP with IEEE802.11e improves throughput 10-15% than IEEE802.11 with Slow start. Figure2 shows comparison of throughput performance of IEEE802.11 with Slow start and IEEE802.11e with Slow start.

4.1.2 Bandwidth-Delay Product: It refers to the product of a data link's capacity (in bits per second) and its end-to-end delay (in seconds). The result, an amount of data measured in bits (or bytes), is equivalent to the amount of data "on the air" at any given time, i.e. data that have been transmitted but not yet received. This product is particularly important for protocols such as TCP that guarantee reliable delivery, as it describes the amount of yet-unacknowledged data that the sender has to duplicate in a buffer memory in case the receiver requires it to re-transmit a garbled or lost packet.

With 20nodes 802.11 transmitted 214187.73 bits where 802.11e transmitted 240017.87 bits successfully. With 60nodes 802.11 successfully transmitted 172308.41 bits where 802.11e transmitted 244467.13 bits. The Slow start mechanism of TCP with IEEE802.11e drastically improves Bandwidth Delay Product 40-45% than IEEE802.11 with Slow start. Figure3 shows comparison of Bandwidth-Delay Product performance of IEEE802.11 with Slow start and IEEE802.11e with Slow start.

4.1.3 Packet Delivery Ratio: It is the ratio between total number of packets received to the total number of packets transmitted.With 20nodes 802.11 transmitted 290 packets and 802.11e transmitted 317 packets successfully. With 50nodes 802.11 transmitted 287packets where 802.11e transmitted 312 packets. The Slow start mechanism of TCP with IEEE802.11e improves delivery ratio 10-15% than IEEE802.11 with Slow start. Figure4 shows comparison of Packet Delivery Ratio performance of IEEE802.11 with Slow start and IEEE802.11e with Slow start.

4.1.4 Delay: The time taken by the packets to reach the destination successfully. With 20nodes 802.11 transmitted with a delay of 13msec, where 802.11e transmitted with a delay of 14msec. The Slow start mechanism of TCP with IEEE802.11e is only 0-5% higher than IEEE802.11 with Slow start and this is acceptable. Figure5 shows comparison of Delay performance of IEEE802.11 with Slow start and IEEE802.11e with Slow start.

4.1.5 Packet loss: The number of packets missed to reach the destination. With 20nodes 802.11 missed 60 packets and 802.11e missed 33 packets. With 50nodes 802.11 missed 63 packets where 802.11e missed 38 packets. The Slow start mechanism of TCP with IEEE802.11e reduces drastically the packet loss from 40-45% than IEEE802.11 with Slow start. Figure6 shows comparison of Packet loss performance of IEEE802.11 with Slow start and IEEE802.11e with Slow start.

5. CONCLUSION

In this paper, evaluate the performance of QoS parameters in MAC layer and its interaction with the transportation layer protocol in a mobile ad hoc network is tabulated in Table.2. This system using IEEE 802.11e and IEEE802.11 MAC mechanisms are contention based channel access function or distributed coordination function that improves quality of service in MAC layer. To improve the performance of at the transport layer will require the design of distributed medium access control scheme and proper packet transmission mechanism like slow start. A suitable MAC layer protocol and slow start algorithm improves quality of service in transport layer.

References

Choi, S., 2003, IEEE 802.11e contention based channel access (EDCF) performance evaluation.

Proceedings IEEE ICC, Anchorage AL, USA.

Maarten Hoeben and Menzo Wentink, 2000, Enhanced QoS through Virtual DCF IEEE 802.11-00/351.

Maarten Hoeben Stefan Mangold, Sai Shankar and Menzo Wentink, 2002, Multiple Frame Exchanges during EDCF TXOP. IEEE 802.11-01/566r3.

Paolo Giacomazzi, 2006. Quality of service for packet telephony over Mobile Ad Hoc Networks, IEEE Transactions on. Networks, 20: 12-20.

Qixiang, P. and Soung C. Liew, 2005. Design of an effective loss distinguishable MAC protocol for 802.11 WLAN. IEEE. Commun. Lett, 9: 781-783.

Xiao, Y., 2004. IEEE 802.1 le.QoS Provisioning at the MAC layer. IEEE. Trans. Wireless Commun.,1536(1284): 72-79.

Xiao, Y., 2005. Performance analysis of priority schemes for IEEE 802.11 and lEEE 802.11e in Wireless LANs.IEEE. Trans. Wireless Commun. 4: 1506-1515.

Xiao, Y., 2006. QoS guarantee and provisioning at the contention-based wireless MAC layer in the IEEE802.11e. IEEE. Trans. Wireless Commun., 13: 14-21

Peterson, 2003. Computer networks, Pearson education private limited, Singapore.

Schiller, J., 2003. Mobile communication. Pearson education private limited, Singapore.

Perkins and Herman D. Hughes(2005), The Interaction of Medium Access Control and TCP in Ad Hoc Networks [Online] Available: www.scs.org/getDoc.cfm?id=1903

Table 1. EDCF user priority table

User priority	Access category	Designation
0	0	Best effort
1	0	Best effort
2	0	Best effort
3	1	Video probe
4	2	Voice
5	2	Voice
6	3	Video
7	3	Video

Table 2. Comparison of QoS Parameters

S.No	Parameters	No. of Nodes	802.11 With Slow Start	802.11e With Slow Start
1	Throughput (bps)	20	8406	9234
		30	8266	9337
		40	8366	9252
		50	8196	9311
		60	8286	9412
2	Delay (sec)	20	0.1340	0.1477
		30	0.1326	0.1486
		40	0.1370	0.1480
		50	0.1310	0.1489
		60	0.1391	0.1505
3	Packet Delivery Ratio (Packets)	20	290	317
		30	290	314
		40	285	316
		50	287	312
		60	290	317
4	Bandwidth Delay Product (bits)	20	214187.73	240017.87
		30	195114.45	248245.30
		40	218268.71	240956.52
		50	208455.60	242702.57
		60	172308.41	244467.13
5	Packet loss	20	60	33
		30	60	36
		40	65	34
		50	63	38
		60	60	33

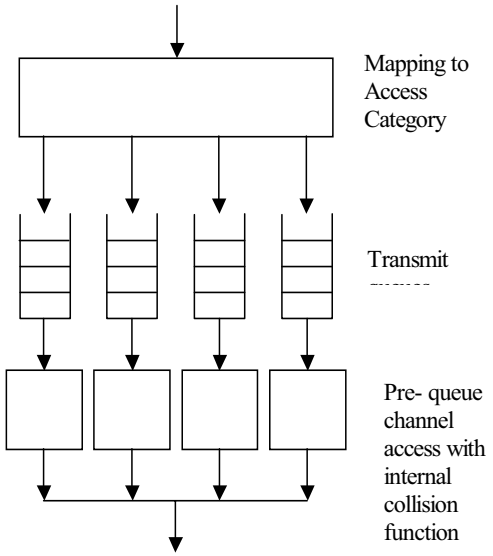

Figure 1. Reference Implementation model of IEEE 802.11e

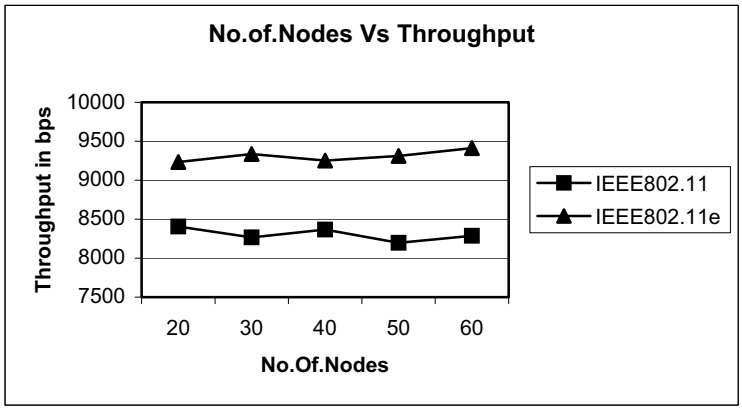

Figure 2. No. of Nodes Vs Throughput

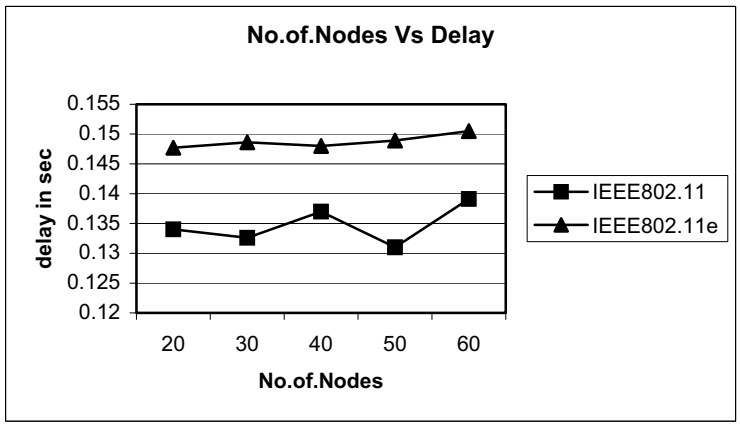

Figure 3. No. of Nodes Vs Delay

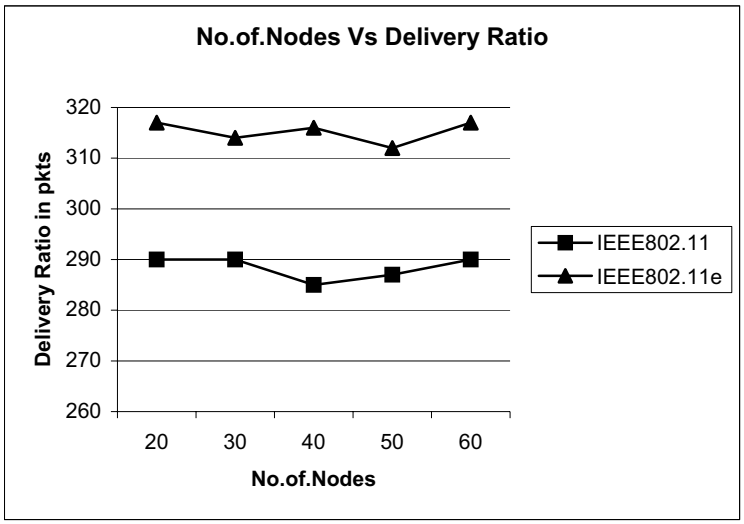

Figure 4. No. of Nodes Vs Delivery Ratio

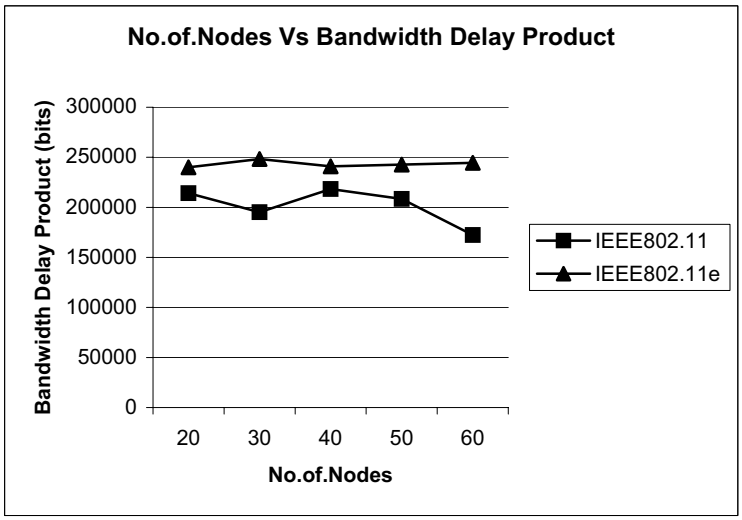

Figure 5. No. of Nodes Vs Bandwidth Delay Product

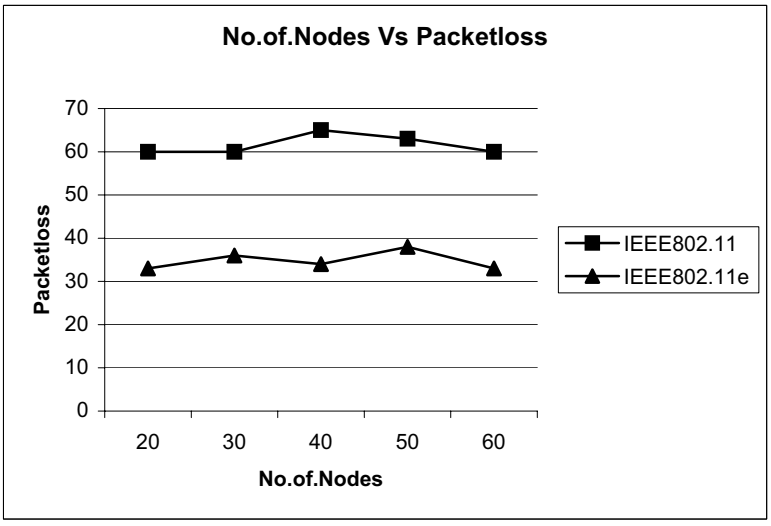

Figure 6. No. of Nodes Vs Packet loss