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Performance improvement of QoS in MANETs

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ABSTRACT

This work proposes a methodology for QoS improvement in MANET based on Medium Access Control (MAC) protocol that takes the above requirements into consideration. This protocol is based on IEEE 802.11 standard, and thus can be easily integrated into existing systems without much difficulty. Here 802.11 and 802.11e with different TCP mechanisms are used to analyze the QoS parameters for MANETs. The proposed system is designed to evaluate the performance of QoS and interaction between Transport layer and the MAC layer protocol operating in a mobile ad hoc network. The system will makes use of IEEE 802.11e MAC mechanism, to improve quality of service in MAC layer, which will improve the quality of service in Transport layer and to suggest a suitable mechanism for improving the quality of service in MANETs.

Introduction

MANET is a network consisting of a collection of nodes, which can communicate with each other without help from a network infrastructure. Mobile ad hoc networks (MANETs) aims at providing 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 ad hoc network" (MANET) is an autonomous system of mobile routers connected by wireless links. In current wireless networks, 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 ad hoc networks, there are no base stations. It can communicate with each other node within radio range through direct wireless links.

Ad hoc supports for QoS provisioning and real-time applications, operative functioning, energy-efficient relaying, load balancing, and support for multicast traffic. 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. Much of the current research aims at Improve the QoS and designing the cross layer in mobile ad hoc networks. 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. 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), IEEE 802.11 and IEEE 802.11e.

This research focuses on measuring the performance of interaction between TCP and two different MAC protocols—IEEE 802.11and IEEE 802.11e, operating in mobile ad hoc 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.

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 operations and Cross-Layer between Transport & MAC layers in 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 packet loss performance of TCP as function of node mobility. There are various mechanisms in Transport Layer and MAC Layer. Figure 1 shows the proposed system of our experiment implementation.

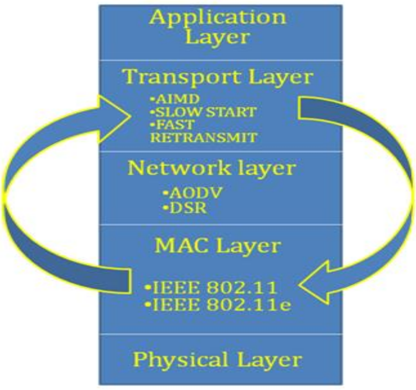

Figure 1: Proposed System

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IEEE 802.11 MAC PROTOCOL

The 802.11 MAC works with a single first-in-first-out (FIFO) transmission queue. The CSMA/CA constitutes a distributed MAC based on a local assessment of the channel status, (i.e., a station is transmitting a frame) or idle. Basically, the CSMA/CA of DCF works as follows: When a frame arrives at the head of the transmission queue, if the channel is busy, the MAC waits until the medium becomes idle, then defers for an extra time interval, called the DCF Inter frame Space (DIFS). If the channel stays idle during the DIFS deference, the MAC then starts the backoff process by selecting a random backoff counter (or BC)[Choi et al]. For each slot time interval, during which the medium stays idle, the random BC is decremented. Receipt of an ACK (from the receiving node) indicates that no collision occurred. 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. 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.

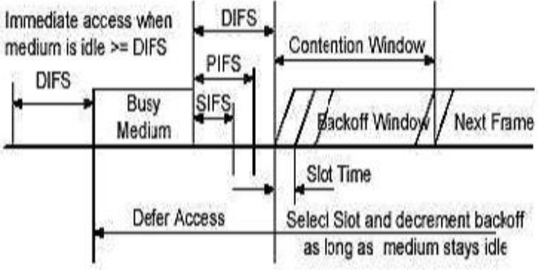

Figure 2: IEEE 802.11 MAC channel access

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 [Sunghyun Choi et al]. 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 Table 1. Figure 3 shows the Reference Implementation model of IEEE 802.11e

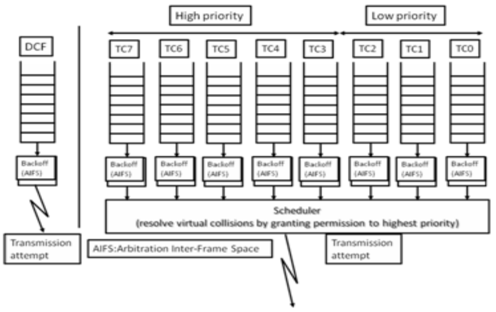

Figure 3: Reference Implementation model of IEEE 802.11e

TRANSPORT LAYER

FAST RETRANSMIT MECHANISM OF TCP

Fast Retransmission Protocol uses an application-specific decision algorithm to determine whether or not to ask for a retransmission for a lost packet, adjusting the loss and latency to the optimum level for the application. TCP acknowledgements are cumulative, i.e., they acknowledge in-order receipt of packets up to a certain packet. If a single packet is lost, the sender has to retransmit everything starting from the lost packet. This results in loss of bandwidth in the mobile network. This loss of bandwidth can be reduced by fast retransmission technique.

TCP can indirectly request a immediate retransmission of packets. TCP sender uses timers to recognize lost segments. If an acknowledgement is not received for a particular segment within a specified time (a function of the estimated Round-trip delay time), the sender will assume that the segment was lost in the network, and will retransmit the segment. The sender retransmits only the lost packets. This will reduces the waiting time of a sender before retransmitting a lost segment and lowers the bandwidth requirements and helps essentially in slow wireless links. Fast retransmission is shown in the figure 4.

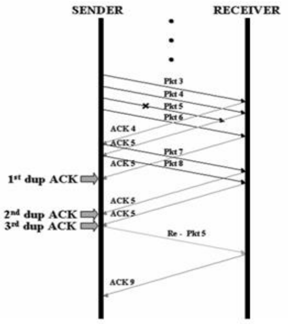

Figure 4: Packets in transmission during Fast Retransmission mechanism

Additive Increase/Multiplicative Decrease

The additive increase/multiplicative-decrease (AIMD) algorithm is a feedback control algorithm used in TCP Congestion Avoidance. Basically, AIMD represents a linear growth of the congestion window combined to an exponential reduction when congestion takes place. The approach taken is to increase the transmission rate (window size) probing for usable bandwidth until loss occurs.

The mechanism is illustrated in the Figure 5

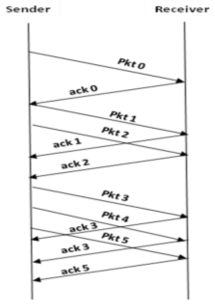

Figure 5 : Packets in transmission during AIMD mechanism

Slow Start

TCP's reaction to a missing acknowledgement is quite drastic, but necessary to get rid of congestion fast enough. The behavior of TCP shows after the detection of congestion is called slow start. The sender always calculates a congestion window for a receiver. Start size of the congestion window is one segment (TCP packet). Now the sender sends one packet and waits for acknowledgement .If this acknowledgement arrives, the sender increases the congestion window one by one, now sending two packets (congestion window = 2). After arrival of the two corresponding acknowledgements, the sender again adds 2 to the congestion window; one for each of the acknowledgements. Now the congestion window equals 4. This scheme doubles the congestion window every time the acknowledgements come back, which takes one round trip time (RTT). This is called the exponential growth of the congestion window in slow start mechanism.

The exponential growth stops at the congestion threshold. As soon as the congestion window reaches the congestion threshold, further increase of the transmission rate is only linear by adding 1 to the congestion window each time the acknowledgements come back. Linear increase continues until the time–out at the sender occurs due to missing acknowledgement, or until the sender detects a gap in transmitted data because of continuous acknowledgements for the same packet. In either case, the sender starts sets the congestion threshold to half of the current congestion window. The congestion Window itself is set to one segment and the sender starts sending a single segment. Figure 6 illustrates the Slow start mechanism.

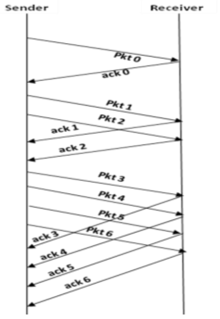

Figure 6 : Packets in transmission during slow start mechanism

CROSS-LAYER DESIGN (TRANSPORT AND MAC LAYER)

CLD is a way of achieving information sharing between all the layers in order to obtain highest possible adaptivity of any network. This is required to meet the challenging Data rates, higher performance gains and Quality of Services requirements for various real time and non real time applications.CLD is a co-operation between multiple layers to combine the resources and create a network that is highly adaptive. Possible inter-layer communication is shown in figure 7.

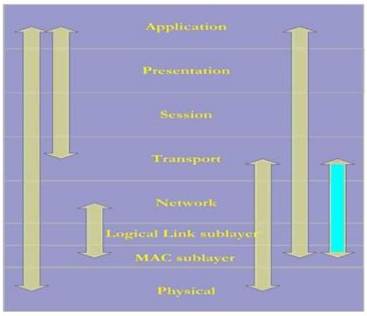

Figure 7: cross-layer design (possible inter-layer communication)

This approach allows upper layers to better adapt their strategies to varying link and network conditions. This helps to improve the end-to-end performance given network resources. Each layer is characterized by some key parameters that are passed to the adjacent layers to help them determine the best operation modes, which best suit the current channel, network and application conditions.

Cross Layer Signaling Methods

Cross-layer design (CLD) signaling approach may be classified into four basic methods.

1. Method I – Packet headers
2. Method II – ICMP Messages
3. Method III – Local Profiles
4. Method IV – Networks Services.

Method I - Packet Headers

Interlayer signaling pipe stores the cross layer information of the Headers of theIPv6 packets. It makes use of IP data packets as in-band message carriers. There is no need to use dedicated message protocol.

Method II – ICMP Messages

A message can be generated at any layer and propagated to any upper layer, thus a message is transferred using these holes rather than a pipe as in method I. The messages are propagated through the layers using the "*Internet Control Message Protocol (ICMP)"* .This is more flexible and efficient method. But, ICMP encapsulated message have to pass by network layer even if the signaling is requires between link and application layer. Only upward ICMP messages are reported.

Method III – Local Profiles

Cross layer information is abstracted from related layer and stored in separate profiles within a Mobile Host (MH).Interested layers can select profiles to fetch desired information. This is not suitable for time-stringent tasks like real time applications.

Method IV – Networks Services

Channel and link information from physical layer and link layer are gathered, abstracted and managed by WCI – Wireless channel Information Servers.

Cross-Layer Design between Transport and Mac Layer

Cross-layer design methods used for interaction between layers. The interactions or communications between layers done through various methods like packet headers, ICMP messages or Interaction Middleware method, local profiles and network services. In these methods Interaction Middleware method (Message Passing) is used for better performance in Cross-Layer Design. Interaction Infrastructure is shown in figure 8.

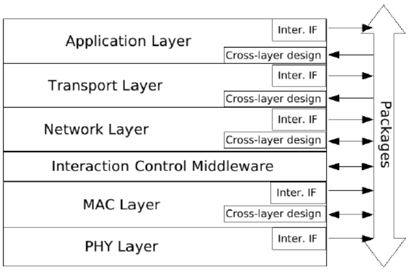

Figure 8: Interaction Infrastructure

Centralized control architecture to solve the CL compatibility and interaction problems. This architecture introduces two additional system components, centralized control middleware and interaction interfaces at each layer. After studying many cross-layer designs, we found out that most of the information flows are from lower layers such as IP, MAC and PHY to upper layers such as TCP and applications. The interactions of cross-layer designs mostly happen in MAC and network layers. Therefore, our control middleware is located in the MAC layer, which has a well-defined interface with the above network layer. The control middleware is made aware of the required parameters by each CL design through a dedicated registration procedure by using the regular data propagation.

Thereafter the combined parameter list is sent to all other protocol stack layers again using the regular data traffic. The additional interaction interfaces at each layer configure and start adding their specific parameters only to the packages sent from that particular layer. The cross-layer information (registration and run time data) is piggybacked at the end of the regular packages and propagated among the layers by using the normal layered messaging procedure. Therefore, the proposed cross-layer architecture does not violate the OSI model, which makes our proposal backward compatible with the standard protocol stack. In addition, such standard interaction interface will reduce the complexity of cross-layer designs that need access to different parameters at different layers.

SIMULATION RESULTS

We used ns-2 to simulate the MAC performance and using this MAC performance will improve the transport layer performance. Using this cross layer design technique, we improve the QoS performance in Mobile Ad hoc Networks. Here we have a collection of n nodes over a common wireless medium, by exchanging different bytes of data (100 bytes,800bytes and 1600 bytes) of different topologies. Each node is equipped with a transmitter, a receiver and a buffer used for storing data. We assume that a node cannot transmit and receive at the same time.(ie., communication is half duplex).To increase the performance there should be different types of priority level for data transmission in MAC layer.

Comparison Graphs

The performance of 802.11e & 802.11 are compared by taking four parameters into account. From the obtained results we can inferred that the performance of 802.11e are improved when comparing with 802.11. The following are the parameters which taken into account for comparison.

1. Throughput
2. Packet Delivery Ratio
3. Delay
4. Bandwidth Delay Product

Comparision Of Fast Retransmission Mechanism

Nodes Vs Throughput

Throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot. Throughput value rises gradually with the nodes and 802.11e Protocol is having higher Throughput than 802.11 Protocol. Throughput variation is shown in the figure 9.

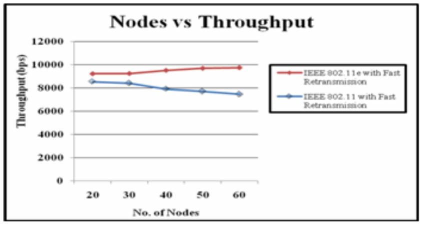

Figure 9 : Nodes Vs Throughput

Nodes Vs Packet Delivery Ratio

Packet delivery ratio (PDR) is the number of data packets delivered to multicast receivers over the number of data packets supposed to be delivered to the multicast receivers. Packet Delivery Ratio for 802.11e is higher than 802.11 protocol. PDR value is measured in terms of packets. Figure 10 shows the performance variation of Packet Delivery Ratio of 802.11 and 802.11e Protocol.

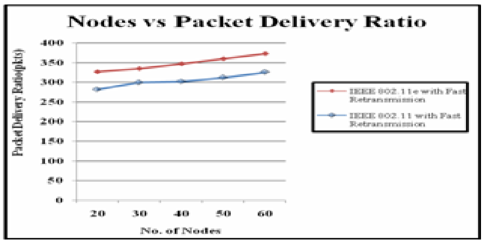

Figure 10: Nodes Vs Packet Delivery Ratio

Nodes Vs Delay

The 802.11e Protocol uses AIFS time interval and therefore it takes an arbitrary time interval to check for the priority of incoming packets. So delay value is higher for the proposed 802.11e Protocol than 802.11 Protocol. The delay variation is shown in the figure 11.

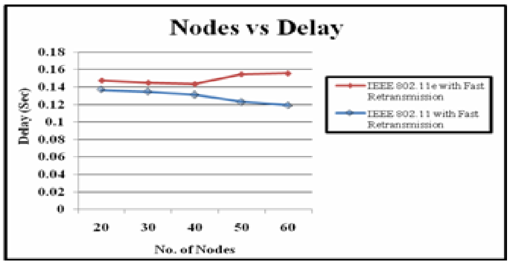

Figure 11: Nodes Vs Delay

Nodes Vs Bandwidth Delay Product

Bandwidth delay product determines the amount of data that can be transit in the network. Increase in delay value may lower the overall QoS value. The 802.11e Protocol is having improved Bandwidth delay product than 802.11 Protocol. Therefore the available link capacity is more in 802.11e than 802.11 which results in better throughput ratio as shown in the figure 12.

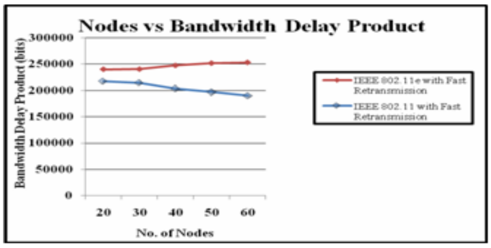

Figure 12: Nodes Vs Bandwidth Delay product

Table 2 shows the performance variation table between 802.11 and 802.11e Protocol. The QoS parameter values for 802.11e are higher than 802.11 Protocol except for delay when the time interval increases. There is a rise in the delay value for 802.11e Protocol since it takes an arbitrary time interval for checking the priority and to group them into anyone of the four access categories.

Conclusion

This project measures the QoS by combining the MAC and Transport layer mechanisms in Mobile ad hoc networks. The two different MAC layer protocols namely IEEE 802.11 and IEEE 802.11e is combined with Fast retransmission technique in the Transport layer and the performance measurement is taken.

The result shows that 802.11e Protocol is having improved performance than IEEE 802.11 protocol in terms of the following parameters like Throughput, Packet Delivery Ratio and Bandwidth delay product.

Future Work

This project employs different mechanisms in different layers namely AODV protocol in the Network layer, IEEE 802.11 protocols in the MAC layer and Fast Retransmission technique in the Transport layer. Performance analysis can be made by choosing various protocols in the Network layer and combine with the MAC & Transport layers. Further analysis can be made by various Cross-Layer Designs.

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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 various Parameters for MAC Protocols for Fast Retransmission with 1 source and 5 receivers

S. No	Parameters	No Of Nodes	IEEE 802.11 with Fast Retransmission		IEEE 802.11e with Fast Retransmission	
			Reno	Newreno	Reno	Newreno
1	Throughput (bps)	20	8532	8532	9218	9172
		30	8397	8397	9238	9185
		40	7905	7905	9504	9593
		50	7701	7701	9680	9381
		60	7456	7456	9735	9629
2	Delay(sec)	20	0.13651	0.13651	0.14749	0.146751
		30	0.13435	0.13435	0.1451	0.14696
		40	0.13104	0.13104	0.1435	0.153488
		50	0.12322	0.12322	0.15488	0.150096
		60	0.1193	0.1193	0.15576	0.154065
3	Packet Delivery Ratio (pkts)	20	282	282	327	322
		30	300	300	335	328
		40	302	302	347	339
		50	312	312	360	350
		60	325	325	373	365
4	Bandwidth Delay Product (bits)	20	217083	217083	239949	238268
		30	214346	214346	240162	238678
		40	203506	203506	247251	249523
		50	196609	196609	251709	244070
		60	190097	190097	253162	250383