ENHANCE QoS IN MANETs USING INTER-LAYER COMMUNICATION (CROSS-LAYER DESIGN)

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ABSTRACT

In mobile ad hoc wireless networks, multiple mobile stations communicate without the support of a centralized coordination station for the scheduling of transmissions. Quality of Service support in mobile ad hoc networks requires acceptable channel conditions, mechanism for channel access. The proposed system is designed to evaluate the performance of quality of service by using IEEE 802.11 in MAC layer with different TCP mechanisms in transport layer with various routing protocols in mobile adhoc network. The system will make use of cross-layer design technique to improve the quality of service in MAC layer, which will improve the quality of service in transport and network layer, and to suggest a suitable mechanism for improving the quality of service in MANETs. The inter-layer interaction performed as protocol independent communication between layers.

Keywords: Mobile ad hoc networks(MANETs), Transport layer Protocol (TCP), Medium access control (MAC), Cross-Layer Design (CLD), distributed co ordination function (DCF), Ad hoc On-demand Distance Vector routing (AODV), Dynamic Source Routing(DSR), Destination Sequenced Distance Vector (DSDV) and Quality of Service (QoS).

1. INTRODUCTION

A wireless ad hoc network is a computer network in which the communication links are wireless. The network is ad hoc because each node is willing to forward data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity. This is in contrast to older network technologies in which some designated nodes, usually with custom hardware and variously known as routers, switches, hubs, and firewalls, perform the task of forwarding the data. Minimal configuration and quick deployment make ad hoc networks suitable for emergency situations like natural or human-induced disasters, military conflicts, emergency medical situations etc.

Typically, ad hoc networks are established among small number of stations, for a specific purpose and for a short period. Since they are setup as a quick alternative to the infrastructure network, they are usually not protected and generally violate most of the corporate policies. They lack good authentication mechanism for users to participate in the network and lack encryption mechanism for data transfer, thus risk exposing important information. If the mobile clients participating in the ad hoc network are also connected to the wired network then the entire corporate data is at risk.

The mobile ad hoc network is a kind of wireless ad hoc network, and is a self-configuring network of mobile routers and associated hosts connected by wireless links the union of which form an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily. Thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet as a hybrid fixed/ad hoc network.

The mobile ad hoc network is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. It is an infrastructure less network. There is no pre image that can be made on how the network will be formed. Even after the formation of the network, the topology is still unpredictable. Although much progress has been done in QoS for wire-based networks, there are still many problems. When designing mobile ad hoc networks, several interesting and difficult problems arise due to shared nature of the wireless medium, limited transmission range of wireless devices, node mobility, and battery limitations.

1.1 QoS in ad hoc networks

Quality of service is defined as "The collective effect of Service Performance which determines the degree of satisfaction to the user of the service". For obtaining the QoS on a MANET, it is not sufficient to provide a basic routing functionality. Other aspects should also be taken into consideration such as bandwidth constraints due to a shared media, dynamic topology since mobile nodes are not stable and the topology may change and power consumption due to limited batteries.

The user can specify the requirements using QoS parameters. Qualities of service parameters are the parameters that control the priority, reliability, speed and amount of traffic sending over a network. Typical QoS parameters include throughput, bandwidth delay product, delay, packet loss, packet delivery ratio that are taken into account for improving the quality of service in mobile ad hoc networks.

2. RELATED WORK

2.1 MAC Layer

The MAC protocol [10] determines which node should transmit next on the broadcast channel when several nodes are competing for transmission on that channel. The existing MAC protocols for ad hoc wireless networks use channel sensing and random back-off schemes making them suitable for best-effort data traffic. Real-time traffic such as voice and video requires bandwidth guarantees. Supporting real-time traffic in these networks is a very challenging task.

In most cases, ad hoc wireless networks share a common radio channel operating in the ISM band or in military bands. The most widely deployed medium access technology is the IEEE 802.11 standard. The 802.11 standard has two modes of operation. They are Distributed Co-ordination Function (DCF) mode and a Point Co-ordination Function (PCF) mode.

The DCF mode provides best effort service, while the PCF mode has been designed to provide real-time traffic support in infrastructure based wireless network configurations. Due to lack of fixed infrastructure support the PCF mode of operation is ruled out in ad hoc wireless networks. Currently the IEEE 802.11 task Group is enhancing the legacy 802.11 standard to support real time traffic. The upcoming is the Cross Layer Design (CLD) technique to improve the QoS

2.1.1 Distributed Coordination Function

DCF is based on Carrier Sense Multiple Access with Collision Avoidance. When a station has data to transmit, it enters a collision avoidance phase where a backoff counter is randomly chosen from 0, 1…CW -1. Initially CW is set to CWmin. For each subsequent retransmission attempt, CW is doubled up to a maximum of CWmax. When the channel has been sensed idle for a period called a DCF Inter Frame Space, the backoff counter begins decrementing once every idle slot time. If the channel is sensed busy, the backoff counter is paused until the channel is once again idle for at least a DIFS period. Once the backoff timer reaches zero, the station can initiate its frame transmission. In DCF, all stations have equal probability to access the channel and share it according to equal frame rate and not according to equal throughput. This offers no support for priority access to the channel for time-sensitive traffic.

2.2 Network layer

Developing a routing protocol that provides QoS is desirable for many applications in MANETs. Efficient routing protocols are needed to establish communication paths between nodes, without causing excessive overheads or computational burden on the power-constrained devices. Many routing protocols have already been proposed. Routing protocols for MANETs are classified based on routing information update mechanism. The various routing protocols are specified below

2.2.1 Ad hoc On-demand Distance Vector Routing

AODV routing protocol [7][8] builds on the DSDV algorithm. AODV is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on a demand basis. It is a reactive routing protocol that uses an on-demand approach to find and establish routes. AODV maintains routes as long as they are needed by the source nodes and it is considered one of the best routing protocols in terms of power consumption and establishing the shortest path. In AODV, each node periodically broadcasts HELLO messages to its neighboring nodes and then uses these neighbors to establish routing and send messages.

2.2.2 Dynamic Source Routing

DSR protocol [7][8] is an on-demand routing protocol that is based on the concept of source routing. Mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continually updated as new routes are learned. The protocol consists of two major phases: route discovery and route maintenance. When a mobile node has a packet to send to some destination, it first consults its route cache to determine whether it already has a route to the destination.

2.2.3 Destination Sequenced Distance Vector

DSDV protocol [7][8] is a table driven routing protocol that is based on bellman ford algorithm. Each node knows the state and entire topology of the network. Routing information must be updated periodically. In order to prevent loops and counter the count to infinity problem, a sequence number which is originated by the destination node tags each entry in the network. The sequence number for each node is chosen randomly and it is usually an even number. Node always assigns an odd sequence number to the link break.

2.3 Transport Layer

2.3.1 Slow Start

The behavior of TCP after the detection of congestion is called slow start[4]. The sender always calculates a congestion window for a receiver. Start size of the congestion window is one segment. 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, that is congestion window equals 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. This is called the exponential growth of the congestion window in slow start mechanism.

2.3.2 Fast Retransmission

Fast Retransmission[4] 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 an 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 or t 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 the sender before retransmitting a lost segment and lowers the bandwidth requirements and helps essentially in slow wireless links. The QoS can be further improved using the proposed work.

2.3.3 Additive increase/multiplicative decrease

The additive increase/multiplicative-decrease algorithm[4][5] 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 probing for usable bandwidth until loss occurs. The policy of additive increase basically says to increase the congestion window by single maximum segment size every round trip time until a loss is detected. When loss is detected, the policy is changed to be one of multiplicative decrease which is to cut the congestion window in half after loss.

3. Performance Evaluation of the Proposed Approach

The proposed system is designed to evaluate the performance of QoS with (1) interaction between Network and MAC layer protocol and (2) interaction between Transport and MAC layer protocol operations in MANET. The system will make use of cross layer design technique to improve the quality of service in MANETs.

3.1 Cross Layer Design

Cross Layer Design (CLD) [1] is a way of achieving information [2] sharing between all the layers in order to obtain highest possible adaptability of any network. This is required to meet the challenging data rates, higher performance gain and Quality of Service 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. CLD also provides the protocol independent layer communication.

This approach allows upper layers to better adapt their strategies to varying link and network conditions. 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. Proposed inter layer communications between MAC and Transport layer is shown in figure 4.

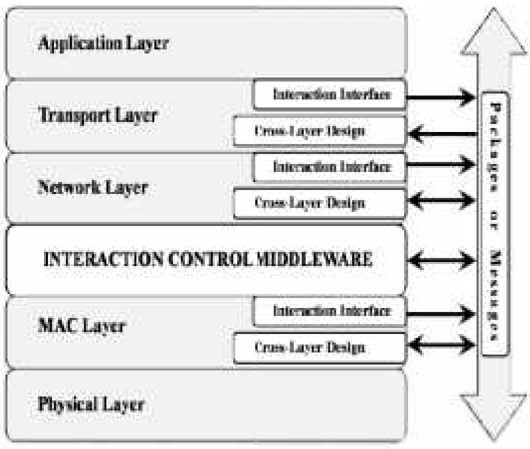

Figure 4 Proposed Inter-layer communication (Cross-Layer Design)

3.2 Interaction between Network and MAC layer protocol

The performance of AODV, DSDV and DSR with MAC layer. From the obtained results we can inferred that the performance of AODV with MAC layer are improved.

3.3 Interaction between Transport and MAC layer protocol

The performance of [11] QoS is analyzed by slow start, Fast retransmission and AIMD with MAC layer. From the results the QoS could be improved by using fast retransmission mechanism with 802.11.

4. Simulation Environment

The proposed approach was evaluated in an NS-2 simulation environment. In the simulation, each mobile host moves in the simulation area following the random waypoint mobility model. The random waypoint model is commonly used for simulating the movement pattern of mobile host in a MANET. Figure 2 shows the simulation model. Figure 1 Show the simulation model.

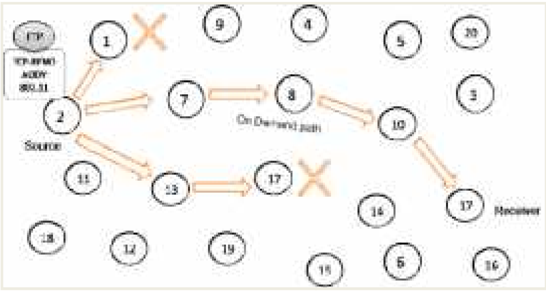

Figure 1 Simulation Model

4.1Performance Metrics and Compared Schemes

The following Three performance metrics were used in the simulation experiments.

1. Throughput
2. Delay
3. Packet Loss

Simulation Parameters

The simulation was carried out in a grid of 1000 m 1000m with 20 to 50 nodes roaming in the simulation area. Further simulation parameters used in the experiments are shown in Table 1.

Table 1 simulation Parameters

Parameters	**Value**
Propagation	Two Ray Ground
Antenna	Omni Antenna
Queue	Drop Tail / PriQueue
Mac	IEEE 802.11
Routing Protocol	AODV, DSDV & DSR
Agent	TCP-New Reno, Slow Start & Selective Repeat / UDP
Traffic	FTP / CBR
Simulation Area	1000m x 1000 m

1. Throughput is calculated by using the formula such as

$$TP_r = \sum_{i=0}^{N} P_r$$

T = (TP$_r$ / (t X 8 / 1000000))

Where N = Number of receiver nodes, P $_r$= Packets Received in N nodes, TP$_r$= Total Packets Received, T = Throughput, t =time.

2. Delay is calculated by using the formula such as

$$TD_l = \sum_{i=0}^{N} (D_l)$$

Where TD$_l$ =Total Delay, D$_l$ =Delay in N nodes

3. Packet loss is calculated by using the formula such as

$$TP_l = \sum_{i=0}^{N} P_{dr}$$

Where TP$_l$ = Total Packet Loss, P$_{dr}$ = Packet drop in N nodes

Table 2 Comparison of various routing protocols with MAC Protocol

S.No	Parameters	No. of Nodes	Routing protocols		
			AODV	DSDV	DSR
1	Total Packet Received (Throughput) (bps)	20	8008	8160	7919
		30	8199	7909	6720
		40	8428	7476	5839
2	Delay (ms)	20	0.1281	0.1305	0.1267
		30	0.1311	0.1265	0.1075
		40	0.1348	0.1196	0.0934
3	Packet Loss (packets)	20	305	315	300
		30	305	302	252
		40	315	287	225

Table 2 shows the performance variation between 802.11 and various routing protocols. The result shows that AODV Protocol provides the better performance with IEEE 802.11 when compared to other two Protocols.

TABLE 3 comparison of various transport layer mechanisms with IEEE 802.11

S. No	Parameters	No. of Nodes	IEEE 802.11		
			New Reno	Slow start	Selective Repeat
1	Total Packet Received (Throughput) (bps)	30	8573	8509	8494
		40	7480	7224	7312
		50	6917	6876	6881
2	Delay (ms)	30	0.13716	0.13614	0.13910
		40	0.11968	0.11558	0.11698
		50	0.11064	0.11004	0.10448
3	Packet Loss (packets)	30	17211	17463	17246
		40	18632	18999	18866
		50	18924	19257	19160

Table 3 shows the performance of QoS by combining different transport layer mechanisms with IEEE 802.11.The result shows that Fast Retransmission (new Reno) mechanism provides the better performance with IEEE 802.11 when compared to other two mechanisms.

4.1 Comparison Graphs

Nodes Vs Throughput

Throughput is high for AODV routing protocol and fast retransmission mechanism when compared to other two protocols and mechanisms such as DSDV, DSR, slow start and selective repeat. Throughput variation is shown in the Figure 2 and 3.

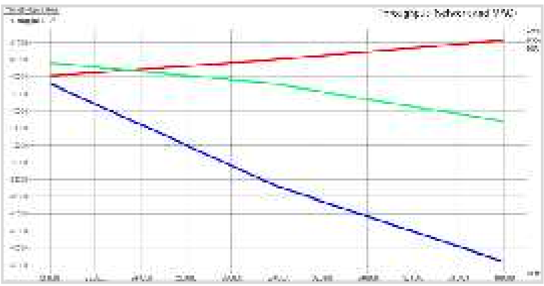

Figure 2. Throughput based on routing protocols

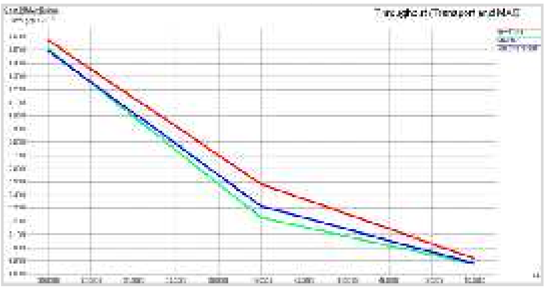

Figure 3. Throughput based on Transport layer

Nodes Vs Delay

Delay is high for AODV routing protocol and fast retransmission mechanism when compared to other two protocols and mechanisms such as DSDV, DSR, slow start and selective repeat. Delay variation is shown in the Figure 4 and 5.

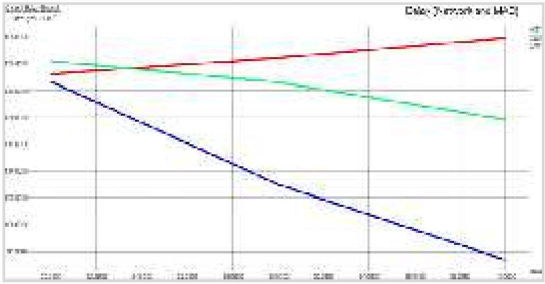

Figure 4. Delay based on routing protocols

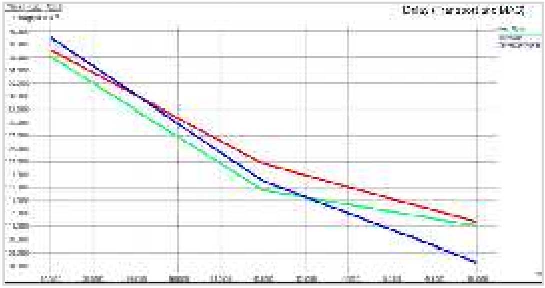

Figure 5. Delay based on Transport Layer

Nodes Vs Packet Loss

Packet Loss is low for AODV routing protocol and fast retransmission mechanism when compared to other two protocols and mechanisms such as DSDV, DSR, slow start and selective repeat. Packet loss is shown in the Figure 6 and 7.

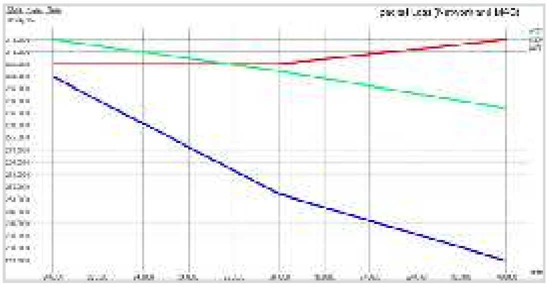

Figure 6. Packet Loss based on routing protocols

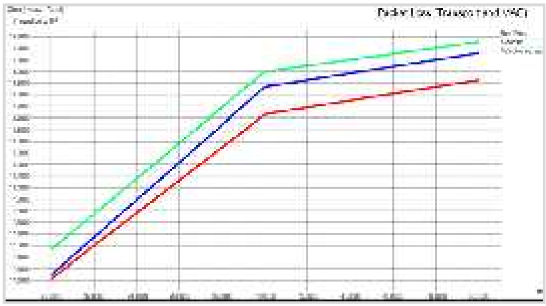

Figure 7. Packet Loss based on Transport Layer

5. CONCLUSION

In this research we evaluate the performance of QoS by combining the MAC, Network layer and transport Layer mechanisms in Mobile ad hoc networks. The various network layer protocols such as AODV, DSDV and DSR are combined with IEEE 802.11 protocol and the performance measurement is taken. The various transport layer mechanisms such as slow start, fast retransmission and selective repeat is combined with IEEE 802.11 and the performance measurement is taken. The result shows that AODV protocol and Fast retransmission with IEEE 802.11 protocol is having improved performance than other protocols in terms of the following parameters like Throughput, Delay and Packet Loss. Further analysis can be made by cross layer designs. In future, further analysis can be made by providing cross layer designs between MAC Layer, Network Layer and Transport layer with default implementation, which will improve QoS performance in MANETs.

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