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Collision Avoidance and Minimization of Delay using CSMA/CA with Jam Signalling in MANET

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Abstract
Medium access control protocol plays an important role in providing fair and efficient allocation of limited bandwidth in wireless mobile ad-hoc network. The basic medium access model in the IEEE 802.11 standard, known as DCF (Distributed Coordination Function), is widely used in wireless LANs and MANET, but 802.11 base we cannot remove the collision and we get maximum data drop through collision and there arises the problem of retransmission of collision packet and this collision gradually increases the overhead of the network. Hence we propose a method using CSMA/CA with jam signal that provide the sufficient information to the sender about congestion and channel shared node information and avoid the collision condition. We also analyse the behaviour of TDMA, 802.11 and our proposed CSMA/CA with jam signalling technique, and get the results using simulation based on parameters like routing load, packet delivery ratio, throughput and end-to-end delay .
Keywords— MANET, DCF, CSMA/CA, Throughput, Packet Delivery Ratio

I. INTRODUCTION

Mobile devices joined with wireless network interfaces will become an essential part of future computing environment consisting of infra-structured and infrastructure-less wireless LAN networks (MANET) [3]. Wireless LAN suffers from collisions and interference due to the broadcast nature of radio communication and thus requires special medium access control (MAC) protocols. These protocols employ control packets to avoid such collisions but the control packets themselves and packet retransmissions due to collisions reduce the available channel bandwidth for successful packet transmissions. At one extreme, aggressive collision control schemes can eliminate the retransmission overhead but at the cost of large control overhead. At the other extreme, the lack of control over collisions offers zero control overhead but it may need to expense large amount of channel bandwidth for retransmissions.

Distributed coordination function (*DCF*) is the basic medium access method in IEEE 802.11 [6], which is the most popular wireless LAN standard, and it makes prudent tradeoffs between the two overheads. DCF supports best effort delivery of packets at the link layer and is best described as the *Carrier Sense Multiple Access with Collision Avoidance* (*CSMA/CA*) protocol.

While DCF works reasonably well in infra-structured wireless LAN environment, this is not necessarily true in a *mobile ad hoc network* (*MANET*) environment. A MANET is an infrastructure-less multi-hop network that consists of autonomous, self-organizing and self-operating nodes, each of which communicates directly with the nodes within its wireless range or indirectly with other nodes via a dynamically computed, multi-hop route.

While the multi-hopping technique can potentially maximize the channel utilization by allowing multiple simultaneous transmissions occurring separated in space [4, 5], all participating nodes must undertake the role of routers engaging in some routing protocol required for deciding and maintaining the routes. In comparison to one-hop wireless networks with base stations, multi-hop networks suffer from more collisions because nodes are not partitioned into a number of disjoint cells but overlapped successively in space. Therefore, congestion at one particular area in a MANET may affect the neighbouring areas and can propagate to the rest of the network. In addition, multi-hopping effectively increases the total data traffic over the network by a factor of the number of hops. Moreover, it potentially causes self-generating collisions in addition to those from other data streams since each node acts as a router and uses a single network interface to receive a packet as well as to forward the previous packet of the same data stream to the next hop node.

The paper organization is as follows: section 2 describes the related work. In section 3 CSMA/CA is described, in section 4 we give the objective. In section 5 and 6 we give problem statement and the proposed solution. Next, network simulation results are presented in section 7 followed by conclusions and future work in section 8.

II. Related Work

Several studies have dealt with CSMA/CA and TDMA media access technique in MANET and here we discuss all of them.

Sunil Kumar, Vineet S. Raghavan et al [1], proposed "Medium Access Control protocols for ad hoc wireless networks: A study" describes MAC (media access control) protocols, the various issues involved have mostly been presented in isolation of each other. They attempt to present a comprehensive survey of major schemes, integrating various related issues and challenges with a view to providing a big-picture outlook to this vast area. They present a classification of MAC protocols and their brief description, based on their operating principles and underlying features. In conclusion, they present a brief summary of key ideas and a general direction for future work.

Khaled Abdullah Mohd Al Soufy et al[2], proposed "A Quality of Service Aware Routing for TDMA-Based Ad hoc Networks" In this paper, they propose a QoS aware routing for time division multiple access (TDMA) based ad hoc networks. Our protocol tries to identify multiple paths each of which is capable of providing the QoS in terms of the number of time slots at its own or by combining it to a group of paths. Their protocol incorporates a procedure to determine the available time slots in a localized and distributed fashion.

III. CSMA/CA Descriptions

DCF (Distributed Coordination Function) uses the Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) scheme to share the wireless medium amongst wireless stations or mobile nodes. The carrier sense is achieved through two possible ways [7, 8, and 9]:

- *Physical-Carrier sensing:* CSMA/CA implements listen-before-talk scheme, according to which any node willing to transmit data must sense the wireless channel in order to determine whether another station is transmitting. If the channel is detected as being idle the station initiates the transmission, otherwise the transmission is deferred for a random period of time. In addition, CSMA/CA employs an acknowledgment mechanism, in accordance with which the receiving station transmits an acknowledgment (ACK) packet back to the sender, after a short interval of time, to indicate a successful reception. In case the ACK packet is not received, the data packet is considered lost and a retransmission is scheduled.
  Through physical carrier sensing we avoid the collision and provide collision free communication
- *Virtual-Carrier Sensing:* The optional "virtual carrier sensing" mechanism, specified in the IEEE 802.11 standard, is employed by Request-To-Send/Clear-To-Send (RTS/CTS) handshake. Its purpose is to prevent wireless stations from accessing the wireless channel simultaneously. Therefore, it eliminates the interference caused by the hidden stations and decreases the packet collisions, which improves the network throughput. RTS/CTS packets are exchanged prior to data transmission, if the data frame size is larger than the specified RTS threshold, to reserve the wireless channel for the sending station. The process is initiated by the sending station, which senses the channel and sends RTS packets if it finds the channel idle. The sending station waits for a CTS packet from the receiver before it starts the effective data transmission.

IV. Objective

Our objective is to provide collision free communication as well as reliable network to achieve following goals:

- Our proposed scheme aims at providing efficient and fast data transmission with collision free communication and maximum channel utilization.
- Its will provide congestion control technique through contention mechanism
- Our proposal is very useful in communication network because it will provide cost less communication between mobile nodes.
- It does also provide behavior of 802.11, TDMA and CSMA/CA media access control technique in MANET environment.

V. Problem Statement

Our aim to apply MAC (media Access control) as CSMA/CA (Carrier sense multiple access with collision avoidance), TDMA (Time division multiple access) and 802.11 Wireless LAN mechanism in mobile ad-hoc network and analyse our result in all cases.

In our approach we would be finding out number of collision packet at the time of 802.11 and resolve collision through the TDMA and CSMA/CA mechanism. For this, we will use routing protocol AODV (Ad-hoc on demand distance vector) and analyse result in the form of routing overhead minimization, throughput, packet delivery ratio and TCP (transfer control protocol), UDP (User datagram protocol).

The above approach is simulated using network simulator (NS-2). We minimize the congestion of the network using CSMA/CA and TDMA techniques since both approaches sense the media and avoid collision in mobile ad-hoc network.

VI. PROPOSED SOLUTION

Here we propose CSMA/CA with RTS/CTS method and increase the performance of the network. We also comparatively analyse the behaviour of MAC layer mechanism 802.11, TDMA and CSMA/CA. In CSMA/CA technique, from a network point of view, one of the primary reasons for using the *RTS/CTS* mechanism is to avoid network congestion. According to RTS/CTS mechanism sender node sends RTS packet (request to send packet) to destination and destination receives RTS packet. The receiver broadcasts CTS (clear to send packet) to all neighbours including sender node , so that only first RTS sender node can communicate with the destination node and all other nodes wait for next round trip time. This mechanism provides collision free communication between communicator nodes. CSMA/CA also use contention window scheme. In CSMA/CA case, in our simulation we set minimum contention period and maximum contention period and avoid collision, but with 802.11 we cannot use RTS/CTS mechanism. Hence there are maximum chances of collision in our network.
If we set media access technique as TDMA we get slow communication because TDMA uses time quantum for each communicator node and reserves time slot for each communicator node. This mechanism is suitable for collision free communication but with slow communication.

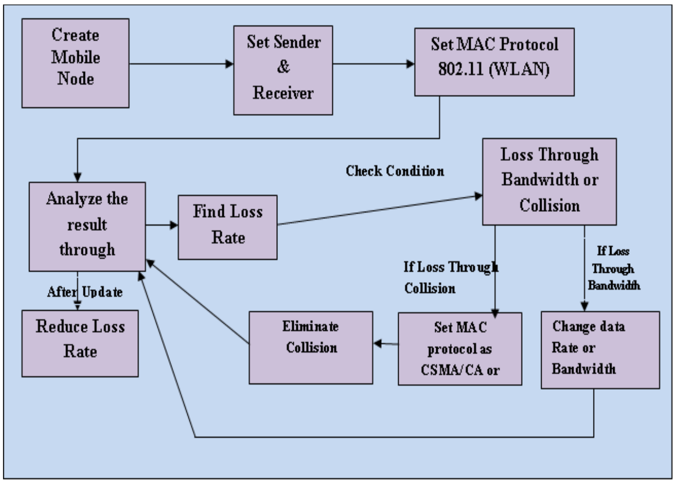

Figure1: Proposed Architecture

In CSMA/CA mechanism a node wishing to transmit data has to first listen to the channel for a predetermined amount of time to determine whether or not another node is transmitting on the channel within the wireless range. If the channel is sensed "idle," then the node is permitted to begin the transmission process. If the channel is sensed as "busy," the node defers its transmission for a random period of time. Once the transmission process begins, it is still possible for the actual transmission of application data to not occur.
Collision avoidance is used to improve CSMA performance by not allowing wireless transmission of a node if another node is transmitting, thus reducing the probability of collision due to the use of a random truncated binary exponential back off time.
CSMA/CA also sends RTS (request to send) and CTS (Clear to send) Message to sender node so that other nodes cannot use the busy channel. This provides collision free transmission. But 802.11 mechanisms cannot send any RTS and CTS message. Hence collision occurs and our throughput decreases and packet drop rate increases in case of 802.11.

VII. NETWORK SIMULATOR WORKING LAYER ARCHITECTURE

Here we deploy the structure of layer scheme used by the NS-2 simulator. According to deployment, we use a five layer structure. In layer one we set the parameter of physical property. Every mobile node sends data through electromagnetic waves or via infrared. So we use propagation mode as two ray ground wave. In two ray ground wave scheme, data is sent in shorter distance and hop by hop manner. No static device is needed, because in mobile ad-hoc network we assume that all nodes are within nearby range, but in case of satellite and TV broadcasting we use propagation mode as sky and Line of sight mode for longer distance transmission with all wireless devices as both static and dynamic in nature.

In physical layer we also use wireless channel scheme and different type of antenna, but mobile ad-hoc environment primarily uses Omni-directional antenna, because we cannot predict as to in which direction device is present. Omni-directional antenna provides same range in all directions.

The data link layer is split into two: MAC (media access control) and LL (Logical link) control layer. LL is same in both the cases of wired and wireless schemes. The difference lies only in the MAC mechanism. In our simulation we analyse result in three different cases 802.11 (wireless LAN) CSMA/CA and TDMA techniques. In case of 802.11 schemes collision occurs on the network because there is no RTS and CTS message in this case. But in case of CSMA/CA technique RTS and CTS messages are used. Hence we can avoid collision and increase the throughput of our network. TDMA mechanism also provides collision free environment, because every sender node works according to time slices.

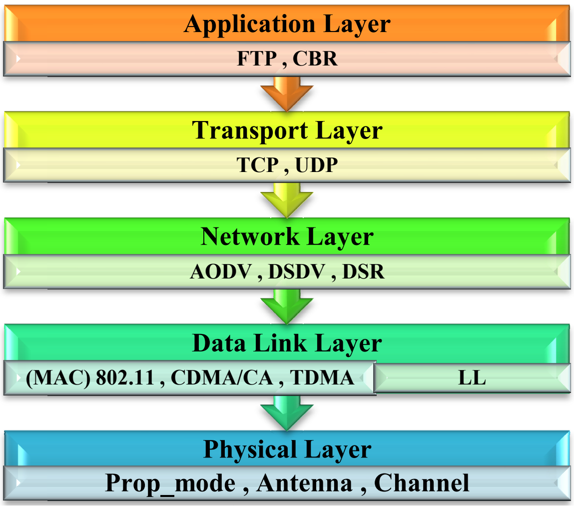

Figure2: Layer Architecture

In layer three we use various routing protocols like AODV, DSDV and DSR, but in our simulation we use AODV routing protocol, which provides on demand routing capability.

In fourth layer we use transport protocol and here combine the function of both presentation and session layer. Basically in that layer we set TCP or UDP protocol. TCP gives reliable communication but UDP gives unreliable communication but UDP provides fast transmission. Transport layer works as agent because it provides the data from application layer to routing layer.

In application layer we set FTP protocol and CBR (constant bit rate) data traffic.

TABLE I

Simulation Parameters For Case Study

Simulation parameters to make the scenario of routing protocols and provide initialization of each node and produce the network environment that work are as follows

Number of nodes	30
Dimension of simulated area	800×600
Initial node energy (joules)	Random
Routing Protocol	AODV
MAC	802.11 , TDMA , CSMA/CA
Simulation time (min)	100
Radio range	550m
Traffic type	CBR,FTP
Packet size (bytes)	1024
Number of traffic connections	14
Maximum Speed (m/s)	Random
Node movement	Random

TABLE 1: SIMULATION PARAMETER

A. Scenario for Connection Establishment

Here we show the snap shot of thirty nodes. They are sensing the neighbours to establish connection between the source node and destination node through intermediate nodes. In this scenario the red and green colour nodes shows transmitter and receiver and black colour shows intermediate nodes. We create this scenario through Network Animator. We also analyse node motion as well sender and receiver node communication [10].

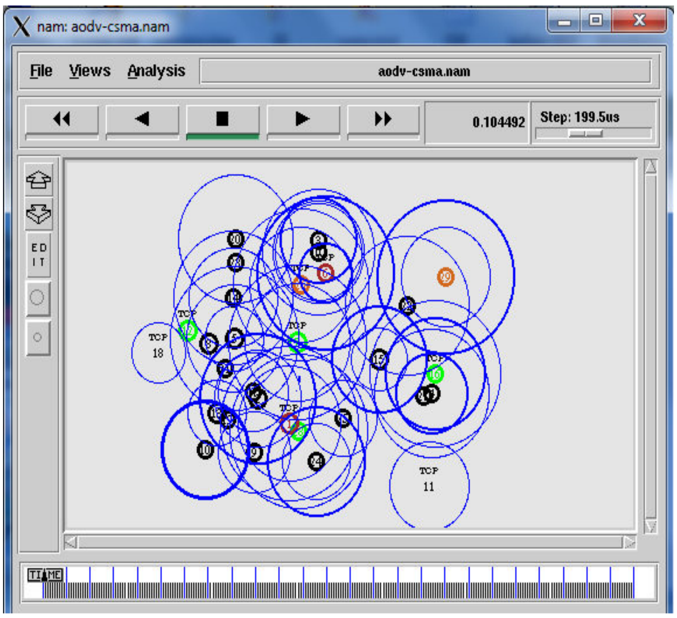

Figure 3: Nodes are sensing their neighbour for establish connection.

B. UDP packet analysis in AODV with MAC layer receiving Analysis

Here we deploy result for UDP Analysis through gnuplot graph and analyse UDP (user data gram protocol) total packet receiving analysis in all three media access techniques. UDP works as agent between application and network layer and also provides un-reliable communication because UDP cannot send acknowledgment. Here x-axis shows Time and y-axis shows number of packets, and through lines we analyse result. The red line shows the result in case of 802.11. The total number of packets received by the receiver is nearly 230 packets. The blue line shows the result in case of TDMA (time division multiple access). Here total number of packets received by the receiver is 310 packets. The green line shows the result in case of CSMA/CA (carrier sense multiple access with collision avoidance). Here total number of packets received by the receiver is nearly 340 packets. This concludes that our packet reception is very good in case of CSMA/CA.

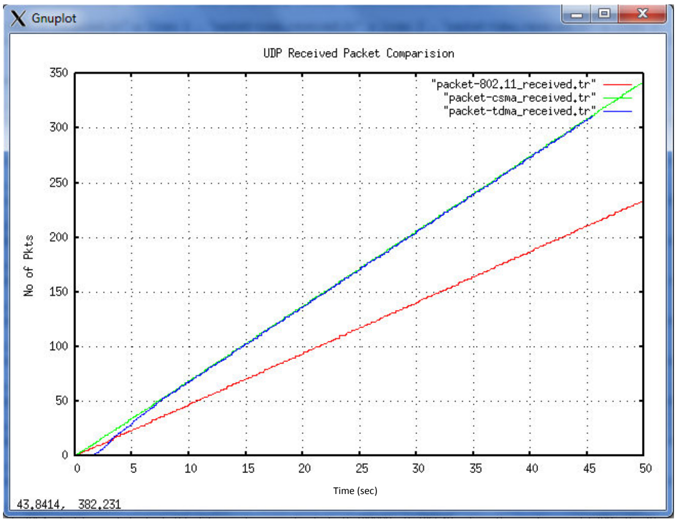

Figure4: UDP Packet Received Analysis

C. Packet Delivery Ratio Analysis

In this simulation thirty mobile nodes are created. The packet delivery ratio is a ratio between packets received by the authentic receiver and genuine packets sent by sender at current time.

$$PDF = \left(\frac{Rx}{Send}\right) * 100$$

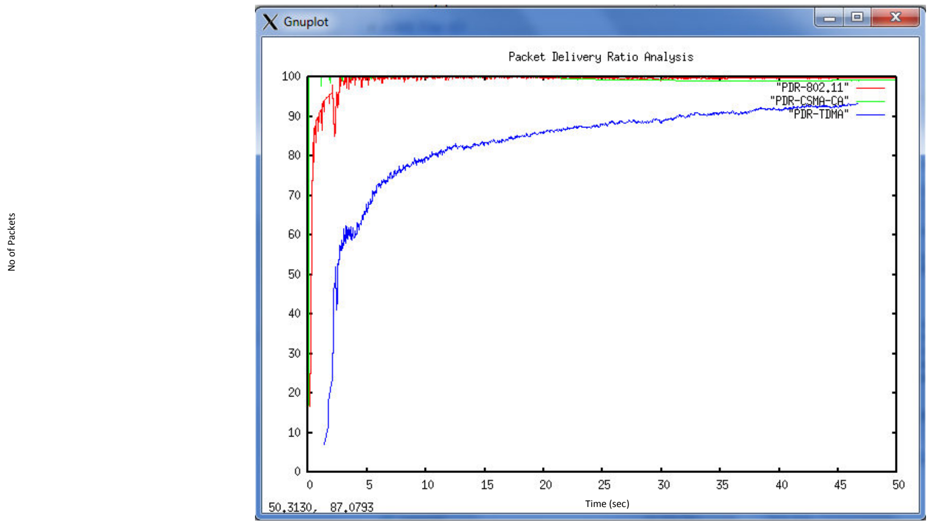

Figure 5: Packet Delivery Ratio Analysis

If packet delivery ratio is higher that means our performance is good. Here in our result we get packet delivery ratio and conclude that in case of 802.11 and CSMA/CA we get 100% successful data delivery to the destination. But if we apply TDMA technique in MAC layer the packet delivery ratio nearly 90% which is less than the 802.11 and CSMA/CA.

Packet delivery ratio is a very useful parameter for network analysis because on that parameter we assure data delivery percentage.

D. Routing Load Analysis

Routing over head means number of routing packets (out of total number of packet travelling on the network) flooding the network. According to various definitions, lesser the routing overhead, better the performance of our network. Greater routing overhead implies that network performance is poor because maximum bandwidth and time is being used by the routing packets. According to resultant graph routing overhead is maximum in case of 802.11 (nearly 900 routing packets) and minimum in case of CSMA/CA approach (nearly 400 routing packets). According to result our performance is poor with 802.11.

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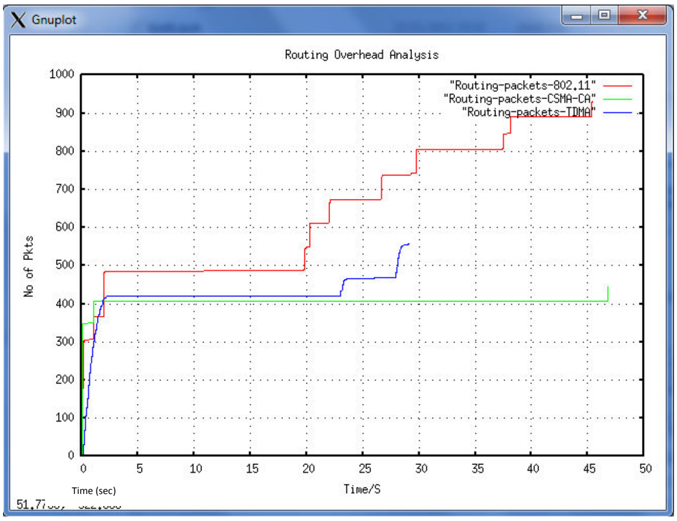

Figure6: Routing Analysis Graph

E. Overall Evaluation All Three Medium Access Technique

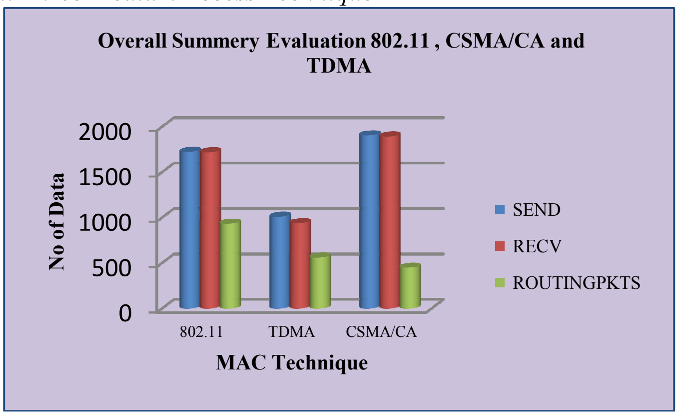

Figure8: Overall analysis

Here we show the results in case all three media access techniques and compare the results. According to our result CSMA/CA scheme gives very good performance with routing load, because with CSMA/CA number of routing packets are less than 500. With TDMA routing overhead is 500 and with 802.11 routing overhead is nearly 900.

According to various analysis we conclude our result through above table that shows CSMA/CA is very good scheme for mobile ad-hoc network.

F. Throughput Analysis

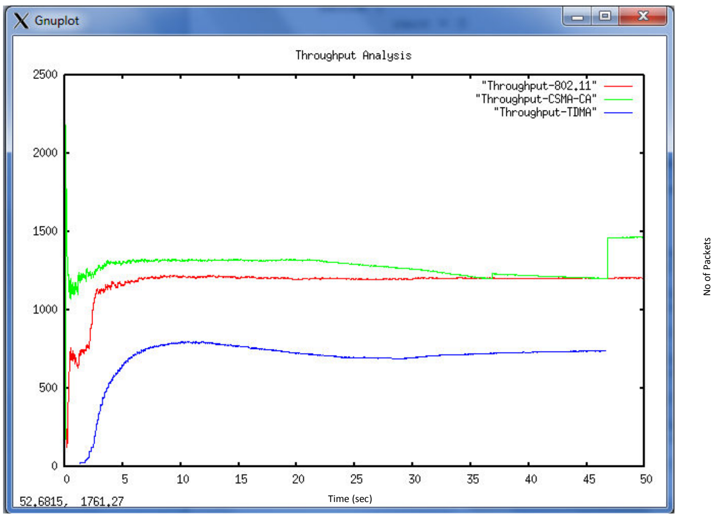

Figure 7: Throughput Analysis

Throughput means per unit time packet received by the receiver. Higher the throughput better is the network performance. Here we compare our result on the basis of throughput graph with all three media access techniques. According to deployment CSMA/CA gives better throughput performance i.e., nearly 1500. In case of 802.11 throughput is nearly 1200 and in case of TDMA our throughput is nearly 800 packets received by receiver.

VIII. Conclusion and Future Work

Here we propose collision avoidance in MANET using CSMA/CA and compare with TDMA and 802.11 techniques. In our proposition we also apply congestion arrival condition elimination and resolve collision occurrence problem because collision depends on the congestion. We can increase the network performance through that technique and also increase the data sending as well as receiving percentage and minimize routing overhead. In our simulation we take random motion of nodes and random speed in all three cases and find out average end-to-end delay. In case of 802.11 average end-to-end delay is 27.25 ms. With TDMA average end-to-end delay is maximum that is 1243.21 ms but in CSMA/CA case average end-to-end delay only 0.1 ms which is very good. Finally we conclude that our approach gives better performance as compared to all other techniques.

In future the module can be simulated under WiMAX with MANET environment and we can also apply energy issue of MANET nodes. In future we can design secure schemes with reliable communication in MANET and analyse the performance of the network.

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