Adaptive Unreachability Reporting Mechanism for MANET

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Abstract – Mobile Ad-Hoc Network (MANET) is wireless networks consisting of a collection of mobile nodes with no fixed infrastructure, where some intermediate nodes should participate in forwarding data packets. Energy conservation is a critical issue in ad hoc wireless networks for node and network life. Enhanced Medium Access control (eMAC) protocol prevents link/routing failures, hidden/exposed terminal problems and broadcast storm problems using an adaptive unreachability reporting mechanism with more energy consumption. Furthermore, An adaptive table broadcasting technique is proposed to distribute topology information in mobile ad hoc networks (MANETs). In this paper, a cross layer design for enhancing the distance based broadcasting protocol is proposed in terms of energy consumption. Instead of using the distance, the reception signal strength is considered. The necessary transmission power to reach an intended device is obtained using the beacons.If the furthest node can be reached using less power than the default value, the transmission power is reduced and it saves energy. Different proposals for enhancing the algorithm are proposed, and they not only save energy but also highly reduce the number of collisions.

Keywords – **Energy efficiency, Mobile Ad-hoc Networks, cross layer design, unreachability and distance based broadcasting.**

I. INTRODUCTION

Mobile ad-hoc network (MANET) is composed of clusters of self-organized wireless stations without a need to utilize any preinstalled infrastructure. Due to the prospective of self- organized deployment, lots of practical applications have been conceived for MANETs and the efficiency of MANETs depends on the performance and reliability of the medium access control (MAC) protocol applied in such environments.

The unreachability problem becomes more severe in multihop environments and results in packet dropping, starvation of part of traffic flows, and possibly unnecessarily network-layer rerouting [2]. The protocol in [1] adds a couple of new control frames to ease the reporting of the unreachability situation to solve the receiver-blocking problem. When a station is notified about an upcoming data communication due to which it will be unreachable, it is given an opportunity to inform its one-hop neighbors about the forthcoming unreachability. In principle, right after the RTS/CTS negotiation and before commencing the actual DATA transmission phase, the stations, which will shortly become unreachable, are given the chance to report their imminent unreachability status using a designated broadcast frame called individual communication pause (ICP). Collisions may occur among broadcasted ICP frames. Such collisions are caused by unconditional ICP frame broadcasting, it refers to it as ICP broadcast storm. Here,the broadcast storm problem is solved by introducing a technique to prevent unnecessarily simultaneous unreachability reports and maintenance of a double-hop neighborhood (DHN) graph by every station. The DHN graph of each station gives an estimate on its DHN topology. By incorporating topology-awareness and smarter decision-making algorithms into the MAC protocol, the impact of the unreachability problem is reduced, resulting in much more efficient channel utilization and higher transmission capacity.

One of the main problems in dissemination is the broadcast storm problem [7]. Not only the problem was presented in [7] but some different techniques for minimizing its effects were introduced, like (1) the probabilistic scheme where nodes resend the message with a predefined probability. (2) The counter based approach that forwards the message in terms of the number of copies received.(3) The distance based technique that considers candidate nodes for forwarding those further from the source than a predefined distance. (4) In the location based approach,the receiver knows the position of the source, so it is able to calculate precisely the additional area covered with the forwarding. (5) Finally, in the cluster based scheme,nodes are distributed in clusters. Only those nodes considered as head or gateway are candidates for forwarding. All these approaches try to minimize the number of forwarding nodes. In this scheme, the distance based broadcasting protocol is considered,that aims at selecting forwarding nodes in terms of the distance between the receiver and the source node, and enhancing it by minimizing the transmission power every node uses for the broadcasting process in order to save energy and reduce the number of collisions.

Energy consumption is more important aspect because ad- hoc networks are composed of devices that rely on batteries. Reducing the transmission power will directly increase the battery life of the nodes and thus, the network lifetime. The contributions of this paper are two folds: (1) adding energy efficiency features to the distance based approach by reducing the transmission power of the source nodes,(2) analyzing the influence that reducing the transmission power has over other nodes in terms of the number of collisions or the interference level.

II. RELATED WORK

A.Introduction

Literature survey is carried out by analyzing many papers relevant to unreachability problem like hidden/exposed terminal problems and distance based approach to reduce energy consumption of nodes in MANETs. The researches carried out by different authors are surveyed and the analysis done by the researchers are discussed in the following paragraphs.

B. Dual Busy Tone Multiple Access -A Multiple Access Control Scheme for Ad-Hoc Networks

Z. J. Haas and J. Deng [3], proposed that the dual-BT multiple access (DBTMA), where two out-of-band Busy tones (BTs), i.e., BT_t and BT_r are deployed to protect RTS and DATA frames, respectively, the former is always activated by the source station when an RTS frame is being transmitted, while the latter is triggered by the destination station when it is receiving a DATA frame. In contrast, DUCHA utilizes two channels separately for control and data frames. RTS and CTS are transmitted in a separate control channel to avoid collisions with the data packets. Negative Clear to send (CTS) is used to solve the receiver-blocking problem and is also transmitted in the control channel. An out of-band receiver-based BT is used to solve the hidden-terminal problem. In ad hoc networks, the hidden and the exposed terminal problems can severely reduce the network capacity on the MAC layer. To address these problems, the ready-to-send and clear-to-send (RTS/CTS) dialogue has been proposed in this literature. However, MAC schemes using only the RTS/CTS dialogue cannot completely solve the hidden and the exposed terminal problems. A new MAC protocol DBTMA scheme operation is based on the RTS packet, two narrow bandwidth and out of band busy tones.

C. AMACA—A New Multiple Access Collision Avoidance Scheme for Wireless Lans

K. Ghaboosi and B. H. Khalaj [1],proposed that "hidden- and exposed terminal" are among the main problems in ad-hoc WLAN networks. In addition, there are scenarios where the desired destination is located in the range of other transmitters, so that the efforts on setting up communication with this terminal will fail due to collisions occurred between desired control packets and unwanted received data packets at destination. In such scenarios, conventional protocols can not address the problem efficiently, resulting in throughput and channel utilization degradation. By using the same PHY of IEEE802.11 and malting slight changes in its MAC layer, a new MAC protocol is presented to address such problems. The performance of the this method is better than IEEE 802.11 and DBTMA besides, in addition to solving the above problems, it improves channel utilization and reduces the total overhead.AMACA is a MAC-only modification based on the IEEE 802.11 standard. In this scheme, the issue of *QoS* is addressed by *Prior Channel Reservation* feature. Due to the modified features, the total overhead is reduced, resulting in higher channel utilization. In addition, the resulting average jitter delay of received data in AMACA is expected to be less than the other protocols.

D. A Distributed Energy-Efficient Routing Algorithm Based on cross layer design

F. Zheng,H. Lu,W.Wang and Q.Sun[12], proposed a distributed energy-efficient routing algorithm for mobile Ad Hoc networks (MANETs). the cross-layer design paradigm is adopted. The distance from the source node to the destination node is estimated based on the received signal strength indication(RSSI) of the packets and is used to adaptively adjust the backoff time of the MAC layer. The distance threshold and a packet count threshold are used to schedule the transmissions of packets in the Network layer. The algorithm is distributed and works without needing any global network information or control packet. The results of this method show that the routing algorithm is energy-efficient and drastically alleviates the Broadcast storm problem.For coping with the Broadcast Storm Problem, a distributed energy-aware routing algorithm is presented for MANETs. The algorithm selects rebroadcast nodes based on the received signal strength information extracted from the physical layer and the nodeneighboring information extracted from the network layer. It adaptively adjusts the backoff time in the MAC layer and the packet delay time in the network layer.

III.ENHANCED MEDIUM ACCESS CONTROL (eMAC)

For reducing the unreachability problem, the general architecture of eMAC protocol is chosen and it is analysed. The main aim is to introduce a technique to avoid the spread of unnecessarily simultaneous unreachability reports, and therefore, the Double Hop Neighbourhood (DHN) graph is maintenance by every station. Each station can be either mobile or stationary. The DHN graph of each station gives an estimate of its DHN topology. This may be accomplished by overhearing Request to Send / Clear to Send (RTS/CTS) control frames if the unreachable station is situated in the communication range of the unreachability cause (i.e., unreachability of type I).On the other hand, for those stations situated in the interference range of the unreachability cause but not its communication range (i.e., unreachability of type II), this goal may be achieved by overhearing individual communication pause (ICP) frames of type I received right after a BT of a particular duration.

In this case, the unreachable station of type II broadcasts an ICP frame of type II for which there are two address fields: The first address field carries the MAC address of an unreachable station of type I from which an ICP frame of type I has been received, and the second address field carries the MAC address of the unreachability cause. In this architecture, an ICP frame generated by an unreachable station of type I is referred to as an ICP frame of type I. Similarly, an ICP frame generated by an unreachable station of type II is referred to as an ICP frame of type II. The former has only one address field used for carrying the MAC address of the unreachability cause, while the latter has two address fields. For simplicity, an ICP frame of type I is denoted by ICPv1. Similarly, an ICP frame of type II is denoted by ICPv2. In addition, its duration/ID field is used to indicate the duration of unreachability. the announcement of an upcoming unreachability status is performed either right after an overheard RTS and/or CTS frame (unreachability of type I) or upon overhearing an ICP frame of type I received right after a BT of a particular duration (unreachability of type II). Basically, the eMAC table is generated from the DHN graph. On the other hand, upon reception of all one hop neighbors' eMAC tables, each station either constructs or updates its local DHN graph as well. To clarify this issue, consider the network topology illustrated in Fig.1. In this configuration, station "A" can receive eMAC tables from all its immediate one hop neighbors, i.e., stations "B," "C," and "F."

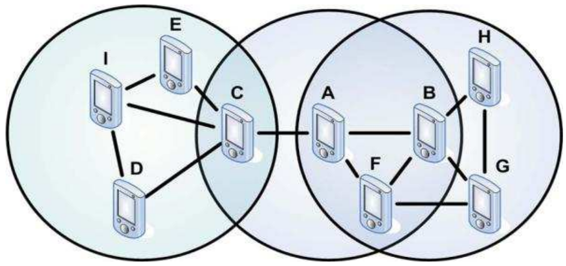

Fig.1. Exchange of Topology Information using eMAC.

Similarly, station "B" is able to obtain tables from stations "A," "F," "G," and "H." Station "A" is able to easily construct a DHN graph to mimic its DHN topology. Now, Assume that stations "G" and "H" are willing to perform a long-term data exchange using packet fragmentation. In this scenario, "G" is supposed to serve as the source station, and "H" is assumed to be the destination station. as well. Here, "A" needs to receive only one ICP frame to be informed about the unreachability of "B" and "F."

For the case of an unreachable station of type II, the same approach is followed by Station "A." As in ICP frames of type II, both the MAC address of an unreachable station of type I, from which an ICP frame of type I has been received, and the MAC address of the unreachability cause are appended station "A" concludes that not only "B"and "F" but that any one-hop neighbor of these two stations will be unreachable as well. The Fig.1. shows exchange of topology information using eMAC table.

A. DHN Graph

The DHN graph is a time-variant data structure denoted by G(V (t),E(t)), where V (t) represents the set of its vertices, and E(t) stands for the set of its edges at a given

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time instant t. Based on topology information received from one-hop neighbors in the form of eMAC tables, the DHN is accordingly updated. When the DHN graph is updated, the synchronous eMAC table, which is denoted by Ξ(t), is generated. Each station records all its neighbors in its local DHN represented by a set of vertices classified into two different categories. One-hop neighbors are grouped together to form the class-N group. Each member of this group is simply referred to as a class-N neighbor. Fig.2. illustrates the DHN graph maintained by station "A"

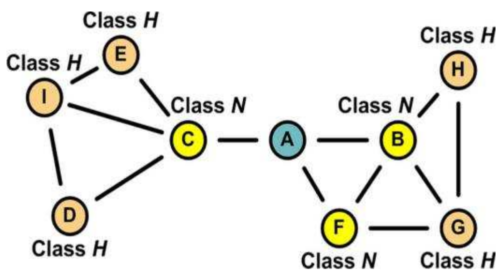

Fig.2. DHN Graph Maintained by station 'A'.

In addition, double-hop neighbors are grouped into another set named as a class-H group,each member of this group is class- H neighbour.Principally, in the DHN graph, there should be a unique edge connecting each class-N neighbor to the local station, which is the owner of the DHN graph. On the other hand, class-H neighbors are connected to the local station via a couple of edges and obviously through class-N neighbors.

B. eMAC Table structure

Each station maintains two different versions of the eMAC table at any time. One is called the synchronous eMAC table and is denoted by Ξ(t). This table is directly generated from the local DHN, whenever it is updated. The second table is denoted by Ξ and represents the latest version of the eMAC table that has been broadcasted over the air interface. Basically, each station should broadcast its synchronous eMAC table Ξ(t) in a regular fashion; whenever the synchronous eMAC table Ξ(t) is broadcasted in its corresponding due beacon interval (BI), the existing Ξ table is simply replaced by Ξ(t).

C. eMAC Table Maintenance and Broadcasting Rules

When the DHN graph is updated due to the reception of new neighborhood topology information, the synchronous eMAC table Ξ(t) is consequently regenerated. This means that the DHN and Ξ(t) keep the most up-to-date information about the DHN and one-hop neighborhood of the local station,1 respectivel. As stated earlier, the most up-to-date version of the eMAC table should be broadcasted in a regular fashion. To determine how frequent and when the eMAC tables are broadcasted, the number of BIs that have to elapse before broadcasting the latest version of the eMAC table is specified. When the synchronous eMAC table Ξ(t) is broadcasted in its due BI, it is also saved as Ξ to represent the last version of the local eMAC table that has been broadcasted over the air interface.

IV.DISTANCE BASED (DB) BROADCASTING ALGORITHM

Distance Based (DB) is one of the different schemes proposed for minimizing the effects of the broadcast storm problem when disseminating information in wireless networks. The protocol makes use of the distance between the source node and the receiver.The idea is that a node receiving a broadcast message for the first time will compute the distance to the source node. If this distance is small, the contribution to the dissemination performing this forwarding is negligible and therefore, the message is not resent. Only nodes that are separated at least a minimum distance from the source node resend the message. This minimum distance is a predefined threshold, D. The protocol also includes a delay before forwarding a received message, and if the same message is heard more than once (during this waiting time), the delay is cancelled. Fig.3.represents the functioning of the algorithm. Considering node *A* broadcasts a message *m*, nodes *B* and *C* will not resend *m* because the distance from those nodes to *A* is smaller than D. Nodes *E*, *F* and *G* will wait for a random number of slots. If node *F* finishes the waiting time first, it will forward the message and, thus, node *E* will hear it and calculate the distance from node *F*. as the distance is smaller than *D*, node E will the packet

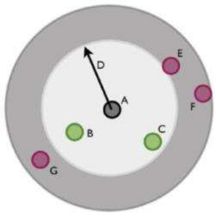

Fig.3. Mechanism of DB.

A. Enhanced DB

In this section we explain the procedure followed to implement the broadcasting algorithm, and also the improvements introduced to the original protocol, DB.

1) Implementation

For calculating the distance between a source and a destination, the signal strength of the received packets is used to estimate how far two nodes are.In this implementation, the threshold D is not in terms of distance (m) but power (dBm).It is called *borders Threshold* as it defines the nodes that are considered to be far from the source and therefore close to the border.The value used for this parameter is *-90 dBm*. This value was experimentally chosen, and any value below it supposes that the source and destination nodes are separated at least 2/3 of the maximum coverage. A node is not able to decode a received packet if the reception power is lower than *-95 dBm*, this is called the *end Threshold*.Therefore, all nodes whose reception energy vary from [-95, -90] dBm are candidates of forwarding the broadcasting message.Every device sends a *hello* message (or beacon) to alert devices within a close area about their presence.

A device receiving these beacons is able to keep track of all neighbors around.In this situation the algorithm is able to take decisions depending on this value. When a broadcast message is sent, the receiving node will check the reception power, if it is below the *borders Threshold* (*-90 dBm*), it will consider itself as a bordering node and thus, sets the delay

.2).Enhancements

An ad hoc networks,and devices depend on battery, saving energy supposes one critical aspect. One of the new features added to DB is reducing this energy consumption using transmission power reduction.

3) Reducing Transmission power

In any wireless transmission, as the electromagnetic wave propagates through the space, the power of the signal suffers from path loss attenuation causing a reduction in the signal power. The relation between the transmitted power and the power finally received at the destination in terms of dB is expressed as,

Received Power = transmitted Power - loss ----- **(1)**

Thus, a node receiving a beacon will be able to estimate the loss that packet suffered during the transmission, using the reception power detected at the physical layer.Every node keeps and updates the reception power of each of its neighbors in a list. When a device wants to send a broadcast message, it will be able to estimate the the packet loss. If a node can estimate the loss the packet is going to suffer, it will be able to reduce its transmission power and use only the necessary one to get the furthest one hop neighbor. Thus, reducing the transmission power for sending broadcast messages directly decreases the energy consumption of the device, without degrading the performance of the broadcasting process. so that the furthest node is receiving the packet with the minimum reception power allowed to correctly decode the message. That means, its reception power should be the *end Threshold*. the new reduced transmission power can be calculated as,

Transmission Power = loss + end_Threshold ---------**(2)**

From the above equation, it is possible to estimate the maximum transmission power needed to reach the furthest neighbor in the one hop neighborhood. If it is less than the default transmission power, It is reduced in order to save energy, Therefore, reducing the transmission range from *r* to *r’* decreases the energy consumption with no detriment of the network connectivity as shown in Fig.4..

Reducing the transmission power for sending broadcast messages not only improves the energy consumption in wireless networks, but also reduces the interference level of devices in a close area.Each device has the *end Threshold* from which on, if the received signal strength is lower, the device will not be able to recover the data transmitted, but this reception will be considered as noise and will increase the interference level of the deviation.

Using Different Delay Techniques

DB stops the random delay when a repeated message is heard. Then,if the distance from the new source node is smaller than the threshold D, the message is discarded and no retransmission is performed. Otherwise, the forwarding starts. Instead of stopping the delay when a repeated message is heard, the possibility of keeping tracks of the received energy and continue the delay are considered.

In this section, the behavior of two different techniques are considered and comparing them to the original proposal of DB,

1. In the first one a fixed delay inversely proportional to the received power is considered. the procedure to calculate the delay in terms of the reception power is shown as,

Power Delay = -1/rxPower-borders_Threshold-1---- **(3)**

2. The second proposal considers a random delay chosen from an interval whose size also varies with the reception power. That is, the waiting time will be chosen between [0, *power Delay*] and the delay varies from 0 to 1 second.

V.SIMULATION RESULTS

To evaluate the performance of proposed protocol, extensive simulations are provided for the system throughput, delay, jitter, and overhead and compare the achieved results with Enhanced MAC (eMAC) protocol. The propagation model is the two-ray ground model, the transmission range of each station is approximately 250 m, the carrier sensing range is approximately 400 m. The channel rate is set to 2 Mb/s and mobile nodes exist in an area 2,500 [m] x 2,500 [m]. In this simulation study, the following performance metrics are evaluation.

The comparative delay analysis for eMAC and Enhanced Distance Based (EDB) protocol on varying the offered load. The graph shows that eMAC protocol has less end to end delay compared to EDB protocol even if the end to end delay increases.

B. Jitter

This jitter is defined as the variation in the packet delay. High jitter means the difference between delays is large and low jitter means the variation is small.

jitter

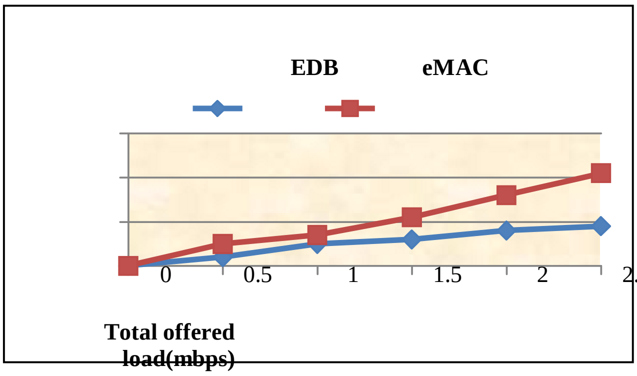

Fig.4 shows the average frame jitter versus the total offered load in megabits per second. The EDB protocol shows the best performance compared with eMAC protocol when the offered load varies between 0.5 and 2.5 Mb/s.

D. Energy consumption

Energy Consumption

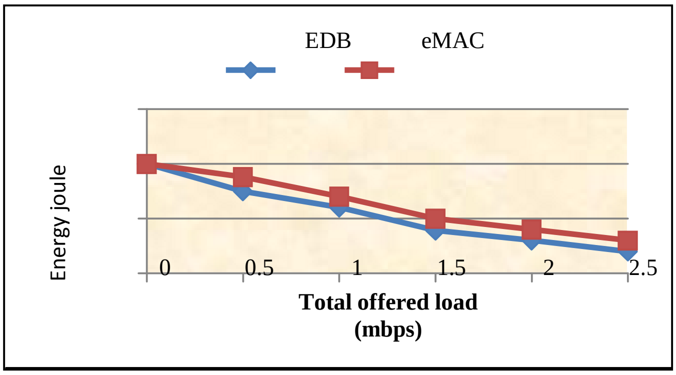

Fig.5. Performance of energy consumption across various loads.

Fig.8 presents the energy consumption. The Comparison of energy consumption for EDB with that of the eMAC protocol is shown. It is clearly seen that energy consumed by Enhanced DB protocol is less compared to other schemes.

E. Throughput analysis

The term throughput is the ratio of the total amount of data that a receiver receives from a sender to a time it takes for receiver to get the last packet. A low delay in the network translates into higher throughput.

One hop throughput is the number of data packets transmitted between two successive nodes.

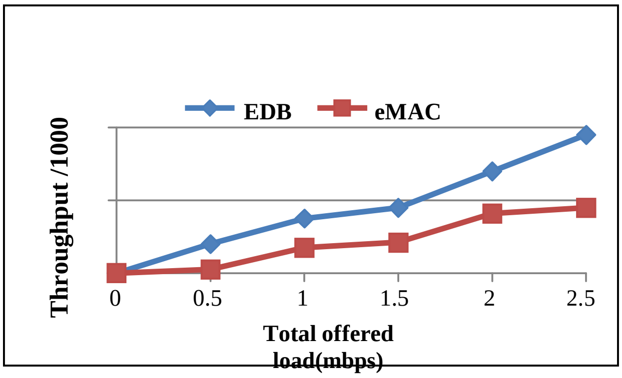

Fig.6 illustrates the one hop throughput for different schemes when the total offered load varies. It shows that EDB has high throughput compared to eMAC protocol even if the one hop throughput increases.

End-toEnd throughput

The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

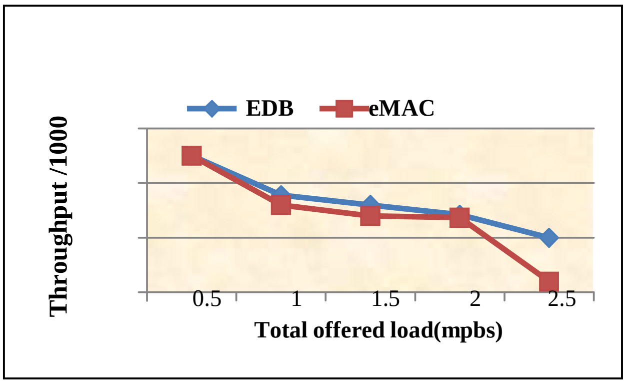

Fig.7. End-to-end throughput Analysis.

Fig.7 shows the aggregate end-to-end throughput versus the total offered load in megabits per second. eMAC shows the worst performance compared with EDB protocol when the offered load varies between 0.5 and 2.5 Mb/s.

VI..CONCLUSION

The unreachability problems have addressed here without deployment of more than one communication channel. The proposed eMAC protocol scheme prevent the unreachability problem, resulting in much more efficient channel utilization and higher transmission capacity by implementing topology- awareness and smarter decision-making algorithms into the MAC protocol. It has been shown that the unreachability problem can be addressed in a better way, leading to an adaptive and robust topology-aware protocol with more energy consumption. An energy saving strategy for the well known distance based broadcasting algorithm DB is proposed.

For decreasing the energy consumption, a reduction in the transmission power is performed when possible.This is really useful when the network is not very dense reducing up to 86.97% in the best case, but when the number of devices is big, the node does not reduce the transmission power so much since there are usually nodes close to the border. This strategy of reducing the transmission power is saving at least 7.55% of energy per forwarded message.As a result from the experiments performed, The enhanced distance based (EDB) protocol is the one that generally behaves better than the enhanced medium access (eMAC) protocol.In this work enhanced distance based protocol is able to reduce energy without degrading the network connectivity and that also reduces the number of collisions in a

95.41%.The simulation results have showed that the EDB protocol has better performance than enhanced medium access protocol in terms of end to end delay, jitter, throughput analysis and overhead.

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