Energy Efficient Routing in MANET Using a Centralized Scheduler

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Abstract: *A MANET is a self configuring network that involves numerous mobile nodes. MANETs use wireless connections to connect to different networks. The throughput and the network lifetime in Mobile Ad-hoc NETworks (MANETs) is improved using EC-MAC protocol with a centralized scheduler. This protocol enhances energy efficiency of MANETs and sustains the energy level of all the mobile nodes for a longer time. The intermediate nodes involved in data transmission can be selected based upon residual energy and location information. It provides a selection algorithm that chooses nodes with a suitable channel state, better location or position, an optimized energy drainage and better data transmission rate. The selection of a centralized scheduler not only preserves energy but also helps in a timely and orderly delivery of data without any collisions in the network.*

Keywords: Network Lifetime [1], Energy Efficiency, Residual Energy, Location Information, Transmission rate, Centralized Scheduler, Democratic Leader Finding Algorithm(DELFA)

1. Introduction

MANETs are mobile adhoc networks that can configure on their own using wireless connections. An example of MANET is a standard Wi-Fi connection which is used almost anywhere and everywhere in the world these days. MANETs are characterized by a dynamic network topology [2] as the mobile nodes present in the network are always on the move. Because of this constant movement, there is an energy constraint which forces the mobile nodes to lose their full quota of energy easily [3], reducing the network lifetime.

However, there is a great deal of risk involved in communication over a MANET as they are not always secure. They are generally prone to various security attacks [4]. A mobile ad-hoc network (MANET) is an infrastructure less network of mobile nodes and has great applications in today's world. As the nodes are mobile, it becomes very important to retain the information of the various mobile nodes present in the network. This piece of information has a huge role to play in routing that takes place in the network. In MANETs, routing generally take place on top of the Logical Link Layer in the network. The rise of wireless networking and technology provides a huge scope for research and development [2] [5] [6] [7] in the field of MANET. One of the complications in MAC i.e., the overhead, is reduced and by doing so, the node transmission efficiency is increased. The existing work emphasizes on the increase of throughput but fails to consider other factors like mobile battery power, energy level efficiency and network life time.

DEL-CMAC Protocol

Unlike CMAC, DEL-CMAC focuses on the extension of the lifetime of a network. DEL-CMAC importantly increases the lifetime of the network by considering the overheads, interference due to cooperation and energy consumed by various mobile nodes. A best relay selection strategy based on DEL-CMAC is devised to increase the network lifetime. Many tests [3] [7] and evaluation schemes have concluded that DEL-CMAC increases the

network lifetime but compromises on throughput and neglects the delay in delivery of data.

The existing CMAC protocol is upgraded to DEL-CMAC by including two selection strategies.

-Utility based best relay selection
-Spatial Reuse Enhancement using NAV

2. Existing Method

The MAC (Media Access Control) layer is an underlying layer of the data link layer which is responsible for providing reliability to upper layers for the point-to-point connections established by the lower most layer of the seven layer OSI model, which is the physical layer. The MAC sub layer interfaces with the physical layer and is represented by protocols that define how the shared wireless channels are to be allocated among a number of mobiles.

CMAC Protocol

In MANET, relays or intermediate nodes have been used to increase the lifetime of the network by transferring packets of data from source to destination which lie far apart from each

2.1 Utility Based Best Relay Selection

The existing scheme utilizes instantaneous information on channel state. This protocol cannot be used in the high traffic networks where the numbers of mobile nodes are large. The position of the mobile nodes can be found by using the Global Positioning System. This can be included in the existing scheme by making use of a control frame in DEL CMAC. DEL CMAC chooses the best intermediate nodes by using the back off scheme based on utility.

2.2 Spatial Reuse Enhancement

Due to the process of relaying and difference in transmission power of mobile nodes, the interference

ranges in DEL-CMAC also differ during a single session of transmission. In order to avoid this and thereby save energy, NAV settings are required. NAV restricts the use of physical carrier sensing, which reduces the energy drainage. In the existing paper, the communicable ranges of the source, destination and relay is sectioned into five different regions. Since difference in transmission power leads to difference in transmission ranges, there are two ranges for the relay nodes present in the network.

3. Proposed Method

The Energy Conserving-Medium Access Control protocol was formulated mainly to help increase the energy efficiency of a network. The energy protocol generally involves a network with a definite infrastructure. This network consists of a base station that serves mobiles in its coverage area. This concept can be applied to a mobile ad hoc network by allowing the mobiles to select a centralized scheduler that goes on to carry out the activities of the base station. Initially, the centralized scheduler is selected using a centralized algorithm [8]. The centralized scheduler in MANET can be a mobile node that has the maximum residual energy, higher buffer and also the greatest communication range. It is notable that the mobile nodes with an extended coverage [9] help in mitigating several network attacks.
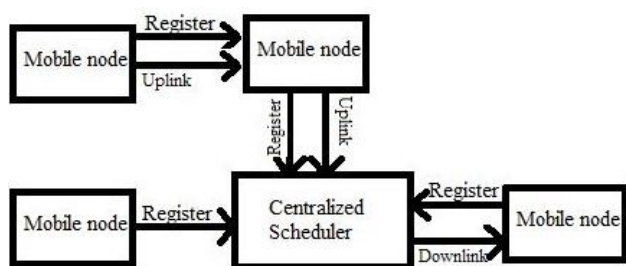

Figure 1: Architecture Diagram

The first phase of the proposed scheme requires all the mobile nodes present in the network to register with the centralized scheduler. Once all the mobile nodes have registered with the central node, uplink and downlink transmissions can take place according to the scheduled order.

In this protocol, Frequency Synchronization Message is used to provide the mobile nodes with the synchronization details and the order of uplink transmission. Each registered mobile node transmits new connection requests in order to upload its data onto the centralized scheduler. This also avoids the collisions that can take place in a network. Mobile nodes that enter the coverage range of the central node need to register with it in order to participate in future data transmissions. This process is carried out whenever a new mobile node enters the network. The collisions or overlap of requests that maybe a possibility in this phase is combated with the help of a varied Aloha algorithm.
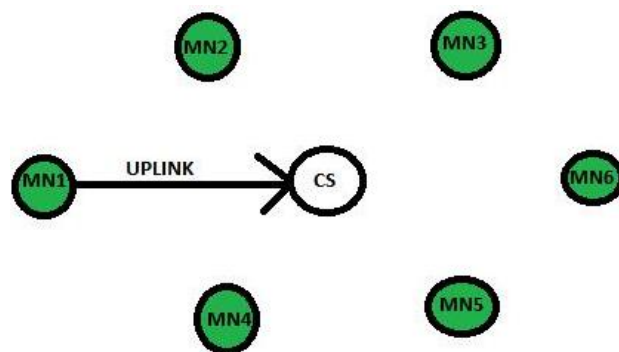
DATA UPLINK
Figure 2a: Data Uplink

This process provides a large window of time for the centralized scheduler to allot the transmission order. The central scheduler sends a schedule message that contains the slot information for the data uplink phase. Downlink transmission from the central node to the destination node is scheduled considering factors like the urgency of data to be delivered. Thus, uplink and downlink slots are allocated using various scheduling algorithms.
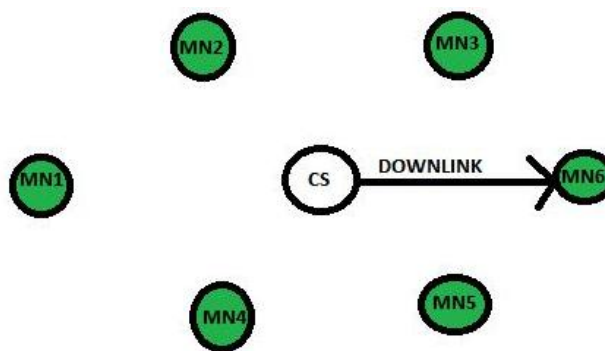
DATA DOWNLINK
Figure 2b: Data Downlink

Energy drainage is drastically reduced in the network because of the utilization of a central mobile node. Therefore, collisions in the network are avoided and this lessens the number of data re-transmits. The mobile nodes that act as destination nodes need not supervise the communication channel as a result of scheduled transmissions. The central mobile node may also upgrade the schedule so that mobile nodes send and receive data within similar time slots. The priority round robin scheme described in scheduling algorithms provides for contiguous slot allotment lessening turnaround time. Algorithms that take into consideration the mobile energy level [10] [11] are helpful in improving the performance of low battery power mobiles.

Data transmissions can be compressed at the source node using Huffman's compression technique in order to reduce the data overload at the centralized scheduler relatively. The data on downlink transmission to the destination could be decompressed using the same technique.

The frames that are used in this scheme are fixed length frames as they are much better and far suited to conserve energy. Since the energy usage plays a major part in the proposed scheme, the election of the next central scheduler after the energy drainage of the current central scheduler periodically monitoring the network in search of possible successors.

4. Energy Conservation Mechanism

4.1 Huffman Compression Scheme

This data compression scheme is incorporated along with our proposed scheme. The mobile node which acts as the source compresses the data packets to be sent using Huffman compression technique [11]. For instance, a file that has 200 MB data is compressed to 140 MB or thereabouts, which results in high speed delivery of data in a short interval of time that in turn increases the node energy level.

$$F(u,v) = \frac{1}{4} C(u)C(v) \left[\sum_{x=0}^{7} \sum_{y=0}^{7} f(x,y) * \cos\frac{(2x+1)u\pi}{16} \cos\frac{(2y+1)v\pi}{16} \right]$$

Figure 3a: Huffman Compression

With such compression techniques at the network's disposal, packet losses can be tremendously reduced. The compressed data packets are delivered to the destination node at a much faster rate within a short span of time. The destination node uses the same Huffman's decompression technique to decompress the original data. For instance, 140 MB is decompressed back to 200 MB.

$$f(x,y) = \frac{1}{4} \left[\sum_{u=0}^{7} \sum_{v=0}^{7} C(u)C(v)F(u,v) * \cos\frac{(2x+1)u\pi}{16} \cos\frac{(2y+1)v\pi}{16} \right]$$

where $\quad$ $C(u), C(v) = 1/\sqrt{2}$ $\quad$ *for u, v = 0*

$\quad\quad\quad\quad$ $C(u), C(v) = 1$ $\quad\quad$ *otherwise*

Figure 3b: Huffman Decompression

Huffman scheme is the safest way of compression as the data remains intact even after undergoing compression and decompression. Huffman technique involves encoding the symbols according to their frequency of occurrence in a document or file. As a result of this technique, the nodes use minimum amount of energy in a single transmission and thereby improve the network lifetime as a whole.

4.2 Design Concept

In the proposed scheme, Huffman data compression technique is used along with the energy conserving protocol, which is the advancement of DEL-CMAC protocol in many ways. Source mobile node compresses the sending data using this compression technique, which results in quick and safe delivery [14] of data. After the downlink process, the data is decompressed and the original data is retrieved. Each node computes its energy consumption. We can note a significant increase in the extension of the network life time by this analysis.

5. Algorithm Used

5.1 The DELFA Algorithm

The approach of the DELFA algorithm similar to the system followed by various democratic countries. Following the parliamentary system in a democratic nation, this creates a house of "best" nodes, Figure:4. This group comprises nodes that have better capabilities like battery backup, computation power. For simplicity, we consider the residual battery power as a parameter to elect the central node and scale it to 0-100. In this algorithm, initially the house has nodes whose node-weights are between 70 and 100. According to node-weights (battery power), the nodes become the group members. Other nodes that have node weights less than 70 are not allowed to become a member of the group because nodes with less battery power may crash during election or shortly after.

STEP 1: The number of nodes in the network are calculated and taken as the value of N.

STEP 2: Let the battery power of each node in the network be considered as the node-weight W.

STEP 3: Let the house H contain nodes whose node-weight w is above 69, that is,

for(i=1;i<=N;i++)

if(Wi>69) i∈ H

STEP 4: The first-best node is elected as the President P.
STEP 5: The second-best node is elected as the Leader L of the network and performs the functions of the centralized scheduler.

STEP 6: The third-best node is elected as the Vice-Leader VL and acts as a fail-safe node along with the President node in the absence of the leader node.
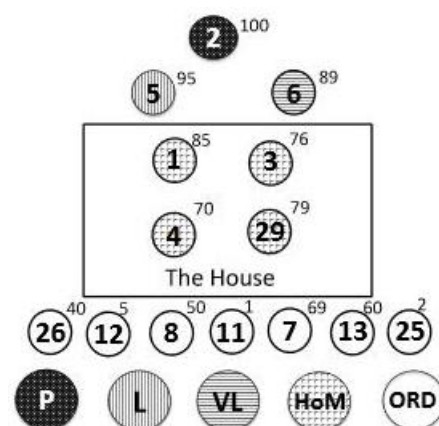

Figure 4: The abstract view of DELFA Algorithm

After execution of the algorithm, we select three best-nodes as per maximum battery power, the first best-node is known as the President node (P), the second best-node as the Leader node (L), and the third best-node as the Vice-Leader node (VL). Out of these three best-nodes, the leader node, L, fulfills all the requirements of the network

[15]. The other special nodes, P and VL, provide their services to the network in the absence of the leader node. When the leader fails, the node VL (or P) takes over until a new leader is elected from the house. Unlike other algorithms, it elects a new leader from the group instead from all the N nodes. Hence, the election process has reduced election latency and number of messages exchanged.

6. Performance Metrics

The proposed scheme and the existing scheme are compared on the basis of various parameters such as the resultant throughput, the delay in data delivery, packet losses that take place during the data transmission and the residual energy of the individual nodes. The performance measure of both the schemes has been thoroughly described below:

A. Throughput

Figure:5 shows the performance measure of DEL-CMAC and EC-MAC protocol in terms of throughput. Throughput is the amount of data sent from the source to the destination in a network. The graph clearly shows that the proposed scheme has higher throughput than the existing scheme.
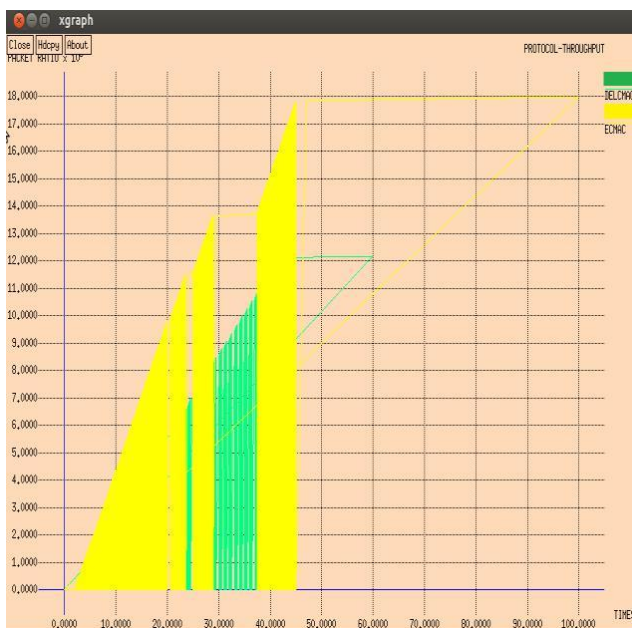

Figure 5: Throughput of DEL-CMAC vs EC-MAC

B. Residual Energy Level

Figure:6 showcases the fact the mobile nodes have a much better residual energy with respect to time while following the proposed scheme than while following the existing scheme. Thus, the proposed scheme is better and increases the network lifetime prolonging the residual energy [16] of individual devices.
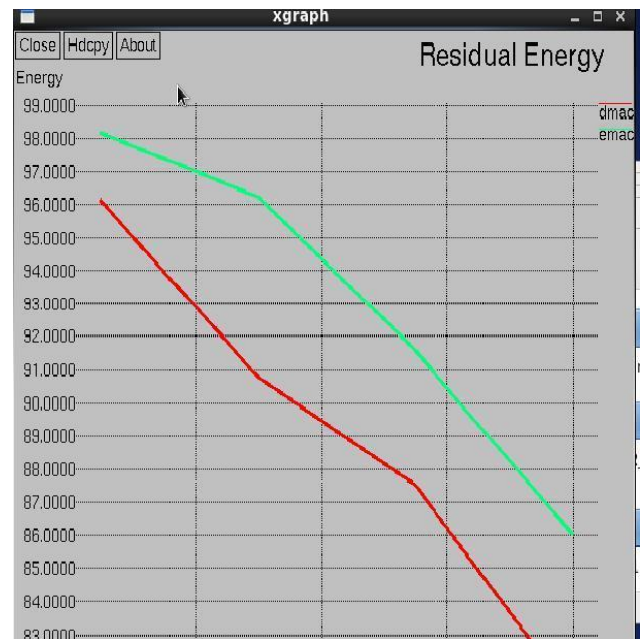

Figure 6: Residual energy of DEL-CMAC vs EC-MAC

C. DELAY

Figure 7 shows that the delay in the delivery of data to the destination is much reduced when the proposed scheme is followed.

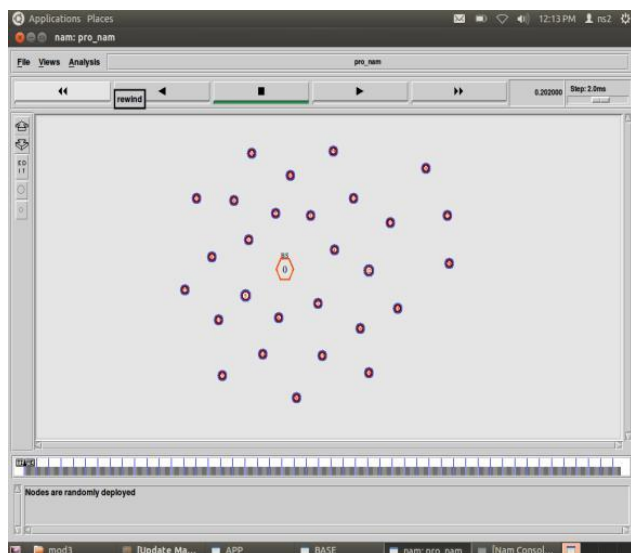**Figure 7:** Delay in DEL-CMAC vs EC-MAC

D. Packet Loss

Figure 8 shows that the packet losses during the data transmission phase in the proposed scheme are lesser when compared to the existing scheme.
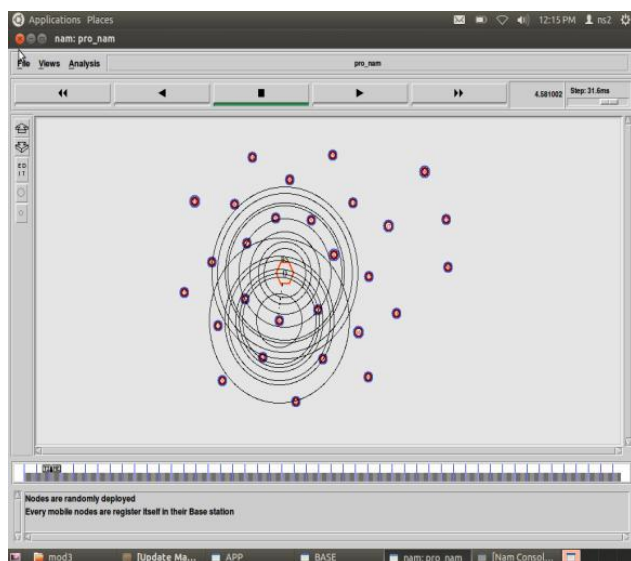
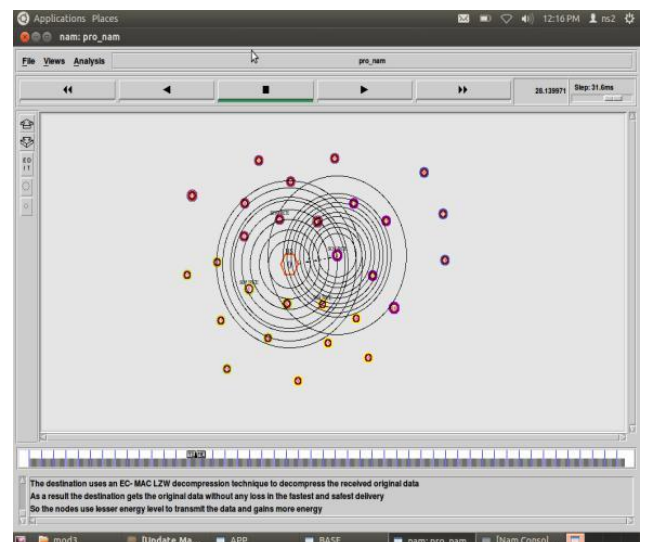**Figure 8:** Packet loss in DEL-CMAC vs EC-MAC

7. Screenshots

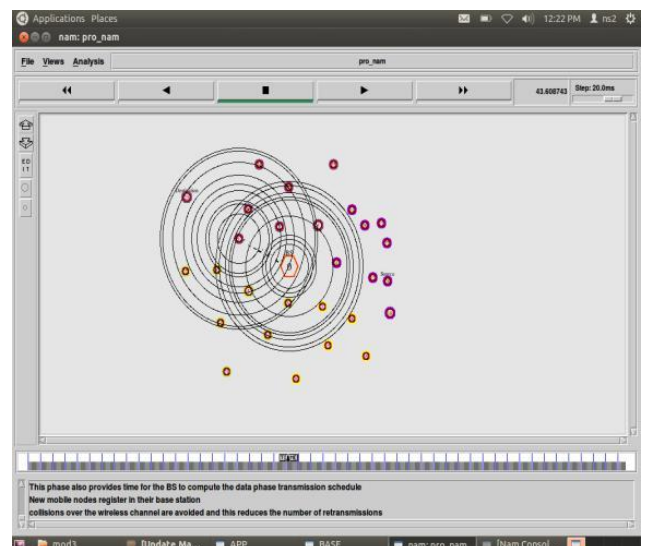### A. Election of a centralized scheduler

B. Register Phase

C. Uplink Phase

D. Downlink Phase

8. Conclusion

In this proposal, the usage of a centralized scheduler helps in drastically reducing the number of data re-transmits and the delay in delivery of data is also substantially reduced. The data being sent from source to destination is compressed using a compression scheme and sent to avoid overload at the base station or the central mobile node. Thus, the application of a centralized mobile node increases the network life time and thereby helps in an energy efficient routing in MANET.

9. Future Work

From the above system conclusions, it is seen that the energy of the individual nodes of the network and the network lifetime as a whole can be improved. The data is sent from the source to the destination through a single main node that primarily acts as a head or leader of the mobile adhoc network. Though this centralized scheduler is elected through an algorithm, more number of

parameters can be added to this selection process in order to make it much more efficient.

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