Demand Based Effective Energy Utilization in Mobile Ad Hoc Networks

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Abstract

Mobile Ad Hoc Networks (MANET) are the collection of mobile nodes without any centralized infrastructure. The underlying assumption is that the intermediate nodes cooperate in forwarding packets. Mobile nodes collects the route information through overhearing and stores these information in route caches with the use of Dynamic Source Routing (DSR) Protocol. These nodes consume power unnecessarily due to overhearing the transmissions of their neighbors. Due to this, the network performance is improved but more energy consumption occurs unnecessarily. The main goal of the work is to reduce the effect of overhearing using the Demand Based Energy Efficient (DBEE) algorithm. The mobility of the nodes results in stale routes, due to the lack of route cache updation. For that, a cross layer framework is implemented along with the DBEE to improve route cache performance in DSR. By using the cache timeout policy we can easily prevent stale routes from being used. The cache timeout of individual links are found by Receiving Signal Strength Indicator (RSSI) information. By simulation results the proposed algorithm achieves better performance than the existing methods.

Keywords - MANET, DSR, Stale route , Cache timeout policy and RSSI.

1. INTRODUCTION

1.1. Mobile Ad Hoc Networks (MANET)

In MANETs, a network is formed dynamically through the cooperation of an arbitrary set of independent nodes. There is no prearrangement regarding the specific role each node should assume. Instead, each node makes its decision independently, based on the network situation, without using a pre-existing network infrastructure. Ad hoc networks have the characteristics such as dynamically changing topology, weak physical protection of nodes, the absence of centralized administration and high dependence on inherent node cooperation. When the topology keeps changing, these networks do not have a well defined boundary and thus network based access control mechanism such as firewalls are not directly applicable. The major concern in MANET is the conservation of energy due to the limited lifetime of mobile devices.

1.2. Dynamic Source Routing (DSR) Protocol

DSR [1] is a source routing protocol. In DSR the source node starts and takes charge of computing the routes. When a node S wants to send messages to node D, it firstly broadcasts a route request (RREQ) which contains the destination and source node's identities. Each intermediate node that receives RREQ will add its identity and rebroadcast it until RREQ reaches a node who knows a route to D or the node D. Then a reply (RREP) will be generated and sent back along the reverse path until S receives RREP. When S sends data packets, it adds the path to the packet's headers and starts stateless forwarding. During route maintenance, S detects the link failures along the path. If it happens, it repairs the broken links. Otherwise, when the source route is completely broken, S will restart a new discovery.

1.3. Overhearing in MANET

Overhearing [2] means a node picks up packets that are destined for other nodes. Wireless nodes will consume power unnecessarily due to overhearing transmissions of their neighboring nodes. Wireless nodes consume power unnecessarily due to overhearing the transmissions of their neighbors. This is often the case in a typical broadcast environment. For example, as the IEEE 802.11 wireless protocol defines, receivers remain on and monitor the common channel all the time. Thus the mobile nodes receive all packets that hit their receiver antenna. Such scheme results in significant power consumption because only a small number of the received packets are destined to the receiver or needed to be forwarded by the receiver. DSR gathers the route information through overhearing. Overhearing improves the routing efficiency in DSR by eavesdropping other communications to gather route information but it spends a significant amount of energy.

1.4.Stale Route links Problem in DSR

The wireless link is broken due to node mobility and upstream node propagates a RERR packet to remove stale route information from route caches of the nodes.

Sometimes route caches often contain stale route information for an extensive period of time. Now, overhearing could make the situation even worse. This is because the Dynamic Source Routing (DSR) generates more RREP packets for a route discovery to offer alternative routes in addition to the principal one. While the primary route is checked for its validity during the communication between the source and the destination, alternative routes may remain in route cache unchecked even after they become stale. This applies also for all their neighbors because they learned and kept them by means of unconditional overhearing which is node S transmits packets to node D through a precomputed routing path with three intermediate nodes but in this case each and every node overhears the transmission which results in the energy consumption as well as less network lifetime.

2. Previous Work

Hu C et.al [4] developed the 802.11 Power Saving Mode (PSM) applicable in multihop MANET with Dynamic Source Routing (DSR) protocol. The drawback in integrating the DSR protocol with 802.11 PSM comes from unnecessary or unintended overhearing and DSR depends on broadcast flood of control packets.

Ashish K et.al [12] & Charles E Perkins et.al [13] proposed the on-demand routing protocols DSR and AODV, before sending a packet to the destination, discovers a route. Route maintenance is invoked when node detects link failure. In order to avoid route discovery for each packet, on-demand routing protocols utilizes cache routes previously learnt.

Lim S et.al [11] explored a mechanism called RandomCast mechanism. Here a node may decide not to overhear i.e. a unicast message and not to forward and a broadcast message when it receives an advertisement during an ATIM window, thereby reducing the energy cost without affecting the network performance. In addition to the energy consumption, overhearing brings in several undesirable consequences. It could aggravate the stale route problem, the main cause of which is node mobility.

Sree Ranga Raju [14] proposed a conservative approach to gather route information. It does not allow overhearing and eliminates existing route information using timeout. This necessitates more RREQ messages which in turn results in more control overheads in routing**.** Ashish Shukla [3] proposed a cache timeout policy to predict route cache lifetime, and to expunge stale route cache entries, which are timed out. Many techniques have been proposed for route cache organization and its effect on the performance of on-demand routing protocols. But the concentration of cache timeout policy is very less.

It is used in route cache implementation to prevent stale route from being used. So, a technique for reducing the unintended overhearing of neighboring nodes is done with the help of RandomCast mechanism and for prevention of stale route problem, a cross-layer cache timeout policy is implemented. Time out policy derives cache timeouts of individual links that are present in route cache by utilizing Received Signal Strength Indicator (RSSI) information. So to fulfil the objective and to overcome the drawbacks, a message overhearing and forwarding mechanism called RandomCast [11] is chosen which makes a judicious balance between energy and network performance.

The paper is organized as follows. The Section 2 describes with overview of DSR protocol. Section 3 deals with the levels of overhearing and stale route problem in DSR. Section 4 is devoted for the implementation of cross layer framework. Section 5 describes the performance analysis and the last section concludes the work.

3. Implementation of Cross-Layer Approach With DBEE Algorithm

Our proposed work is based on the RandomCast [11] and the design is carried out based on DBEE – Cross Layer Approach. A node in an ad-hoc network learns routing information by overhearing or forwarding packets to other nodes and keeps the learned routes in the route caches. We have used the frame format of RandomCast for both unicast and broadcast packets has been discussed below,

3.1. The Modified ATIM frame

The mechanism enables a transmitter to choose no, overhearing for its neighbours, specified in the ATIM frame and is available to its neighbouring nodes.

FC	DI	DA	SA	BSSID	SC	Frame Body	FCS	MAC	OC
2	2	6	6	6	2	0	4	2	4

PV	Type	ST	To DS	From DS	More Frag	Retry	Pwr Mgt	More Data	WEP	Order
2	2	4	1	1	1	1	1	1	1	1

Fig.1.Modified Frame Format

For practicality, it is implemented in the context of IEEE 802.11 specification by slightly modifying the ATIM frame format. ATIM frame is a management frame (type 00_2) and its subtype is 1001_2 according to the 802.11 standard. The RandomCast protocol utilizes two unused subtypes, 1101_2 and 1110_2, to specify randomized and no overhearing, respectively. An ATIM frame with the original subtype 1001_2 is recognized as unconditional overhearing and thus conforms to the standard. When a node (its MAC address MA) wakes up at the beginning of a beacon interval, it receives an ATIM frame or a unicast packet. The ATIM frame contains the receiver address (DA) and subtype (ID). The node decides whether or not to receive/overhear the advertised packet in the following data transmission period based on DA and ID. MAC is used for accessing the medium. OC means Overhearing Count, which is used for measuring the overhearing from the source to destination node. It would remain awaken to receive it if one of the following conditions is satisfied:

1. The receiving node is the anticipated destination.
2. If the node is not the destination and unconditional overhearing is opted.
3. If the node is not the destination, the randomized overhearing is opted.

For each of the unicast packets, DSR uses the following overhearing mechanism, they are as follows,

a. Randomized overhearing for RREP packets
b. Randomized overhearing for data packets
c. Unconditional overhearing for RERR packets

3.2 An Overhearing and Forwarding Mechanism for Broadcasting Packets

This overhearing and forwarding mechanism can be applied to the broadcast packets such as RREQ to allow randomized overhearing; this avoids redundant rebroadcast of the same packet in dense mobile networks. On the other hand, the rebroadcast decision must be made conservatively. This is because a broadcast packet may not be delivered to all nodes in the network when conditional rebroadcast is used. The rebroadcast probability (P_F) is set higher than overhearing probability (P_R). In overhearing, different broadcast packets are given, they are as follows

i. Randomized rebroadcast for RREQ packets
ii. Unconditional rebroadcast for ARP (address resolution protocol) request

Even though RandomCast reduces energy consumption by allowing the sender to specify the desired level of overhearing, the problem arises due to node mobility since the node mobility results in stale routes in route caches. This stale route problem will again be a cause for energy consumption. To make the RandomCast mechanism more effective stale route avoidance is necessary and this is done by implementing the cross layer framework which depends on cache timeout policy.

3.3 Stale Route Avoidance in DSR by Cache Timeout Policy

Nodes movements result stale route cache entries. Cache staleness is a big problem in link cache scheme where individual links are combined to find out best path between source and destination. A cache timeout policy is required to expire a route cache entry, when it is likely to become stale. DSR makes aggressive use of route cache to avoid route discovery. The performance of DSR heavily depends on efficient implementation of route cache. In this, a new cross-layer approach for predicting the route cache lifetime is presented. This approach assigns timeouts of individual links in route cache by utilizing Received Signal Strength Indicator (RSSI) values received from wireless network interface card.

4. Demand Based Energy Efficient (DBEE) – Cross Layer Approach

In our proposed demand based energy efficient algorithm (DBEE), the topology is changed dynamically according to the network traffic requirements. DBEE is integrated with the cross layer approach [3] to predict the route cache life time and find the stale route information. Initially a small set of nodes is computed which form a connected set, while the other nodes are put off to conserve energy. This connected set is used for routing the packets under low network load. If bulk data is transferred between a pair of nodes, the topology dynamically changes along the path between these nodes to minimize the power consumption.

Steps involved in the modified DBEE - Cross layer approach as follows:

Step 1:

The first phase chooses a small set of nodes that constitutes independent set of the network. Here , we have considered 3 factors like energy factor, mobility factor, utility factor.

In energy factor, Let E_0 denote the initial node's energy and E_t be the amount of energy of a node at time t. So the energy factor E_i of the node i is calculated as

$$\frac{E_o - E_t}{E_o}.$$

Mobility factor (M_i) can be derived as the ratio of Received signal strength and Probability of overhearing rate to the energy consumption at the source to be transmitted.

Utility factor is derived as nodes that have a large number of neighbour nodes which have less conditional overhearing. It is denoted as U_i

By forming these three factors within the limitation of region R, the node moves independently with the reducible amount of overhearing.

Step 2:

The second phase is electing more nodes to ensure that the selected nodes form a connected set. Remaining other nodes go to sleep to conserve energy.

Step 3:

In the third phase, the redundant nodes are removed in each region R.

Step 4:

In fourth phase, the topology is dynamically changed with the use of power control technique to minimize the total power consumption. In this technique, all nodes consume more power when it receives full transmission power. This can be reduced by choosing low energy cost path. The minimum receiving power is calculated as

$P_r = P_t G_t G_r h_t^2 h_r^2 / d^4$

h_t, h_r, G_t, G_r - Antenna height and gain of the transmitter and receiver.

d is the distance between transmitter and receiver.

The actual power is given as,

$$\zeta p, q = K \frac{P_t}{P_r} + W$$

K is function of h_t, h_r & d.

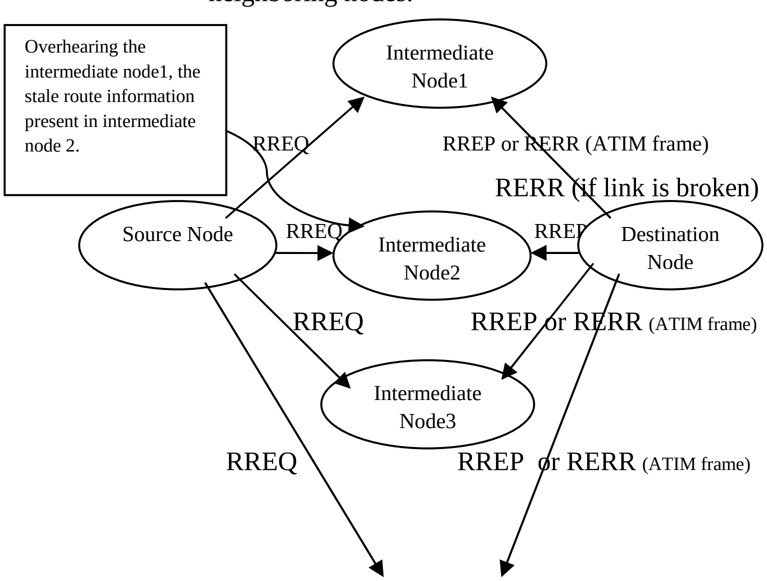
W is the energy consumed by each receiving node.

In DBEE algorithm, the energy consumption is minimized along the routing path using the power control technique during the transmission.

Step 5:

The steps for removing stale route information is as follows

1. RREQ packet will be broadcasted to all the nodes.
2. The overhearing level will be set in the frame type field of ATIM for RREP and RERR packets.
3. Nodes in the network may overhear the RREP and able to stores the route information in route caches.
4. If there is any link break, RERR is propagated to the source node by an upstream node, so that it can be deleted these stale route from route cache.
5. The stale route information will be present in some of the neighboring nodes due to the overhearing of RREPs.
6. Route cache is updated based on RSS by cache timeout policy to remove stale routes from the neighboring nodes.



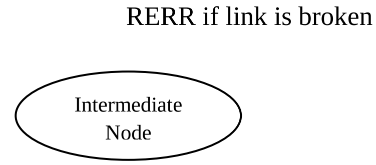


Fig.2.Use Case Scenario of DBEE – Cross Layer Approach

5. Performance Analysis

We use NS2 to simulate our proposed algorithm. In our simulation, 101 mobile nodes move in a 1000 meter x 1000 meter square region for 50 seconds simulation time. All nodes have the same transmission range of 100 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table 1

No. of Nodes	100
Area Size	1000 X 1000
Mac	802.11
Radio Range	100m
Simulation Time	50 sec
Traffic Source	CBR
Packet Size	80 bytes
Mobility Model	Random Way Point

5.1 Performance Metrics

We evaluate mainly the performance according to the following metrics.

Control overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

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

Packet Delivery Ratio: It is the ratio of the number .of packets received successfully and the total number of packets transmitted.

The simulation results are presented in the next part. We compare our DBEE – CRA with the RANDOMCAST and 802.11PSM in presence of overhearing environment.

Figure 3 shows the results of average end-to-end delay for varying the nodes from 20 to 100. From the results, we can see that DBEE-CLA scheme has slightly lower delay than the RANDOMCAST and 802.11PSM scheme because of authentication routines.

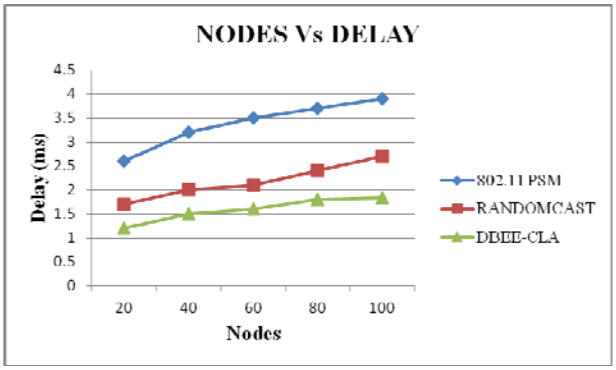


Fig. 3. Nodes Vs End to end Delay

Fig. 4, presents the energy consumption. The Comparison of energy consumption for DBEE-CLA, RandomCast and 802.11 PSM. It is clearly seen that energy consumed by DBEE-CLA is less compared to RandomCast and 802.11PSM.

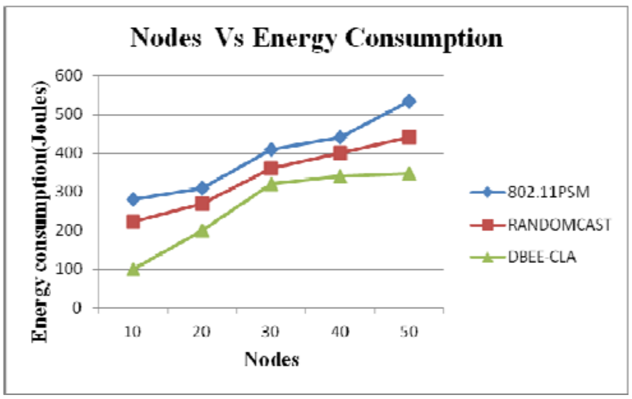


Fig. 4. No.of Nodes Vs Energy Consumption

Fig. 5, presents the comparison of overhead. It is clearly shown that the overhead of DBEE-CLA has low overhead than the RandomCast and 802.11PSM.

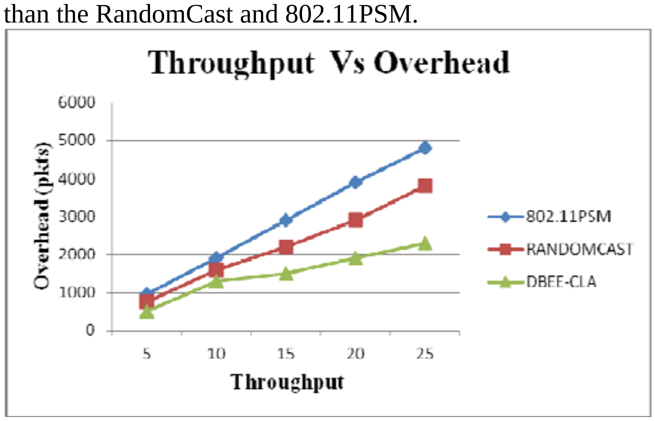


Fig. 5. Throughput Vs Overhead

Figure 6 shows the results of Mobility Vs Delay. From the results, we can see that DBEE-CLA scheme has slightly lower delay than the RANDOMCAST and 802.11PSM scheme because of authentication routines.

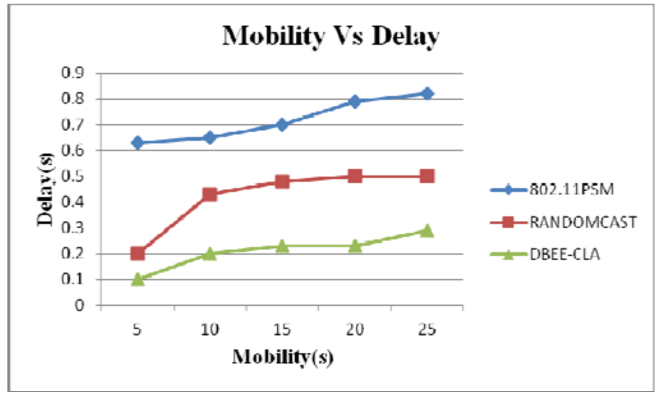


Fig. 6. Mobility Vs Delay

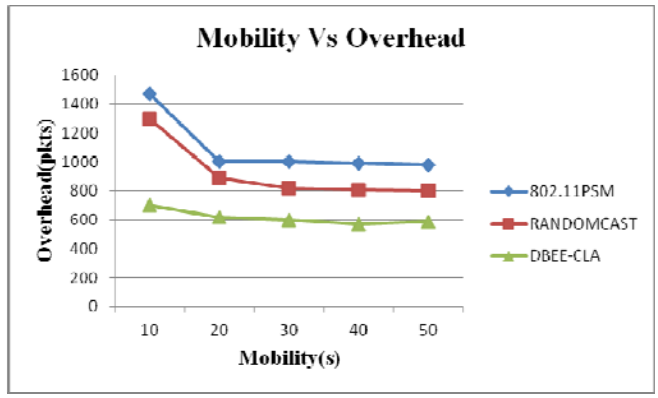


Fig.7.Mobility Vs Overhead

Fig. 7, presents the comparison of overhead while varying the mobility from 10 to 50. It is clearly shown that the overhead of DBEE-CLA has low overhead than the RandomCast and 802.11PSM.

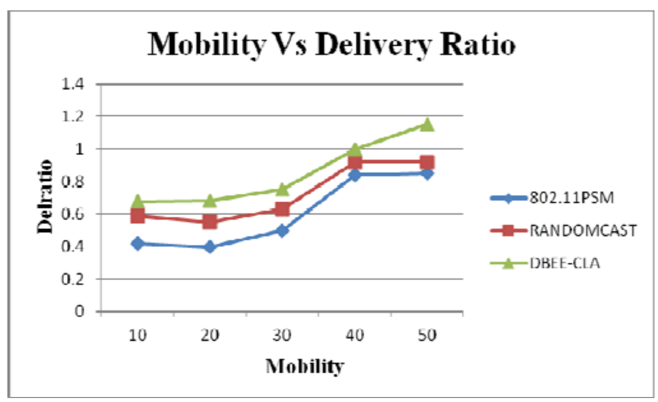


Fig.8. Mobility Vs Packet Delivery Ratio

Figure 8 show the results of average packet delivery ratio for the mobility 10, 20…50 for the 100 nodes scenario. Clearly our DBEE-CLA scheme achieves more delivery ratio than the Randomcast and 802.11PSM scheme since it has both reliability and security features

6. Conclusion

In MANET, mobile nodes are moving randomly without any centralized administration. Due to that, the node consumes more energy unnecessarily. In this paper, we have developed a demand based energy efficient with cross layer approach which attains minimum energy consumption to the mobile nodes. In the first phase of the scheme, minimum energy consumption is achieved using DBEE algorithm. It uses three factors called utility factor, energy factor, mobility factor to favor packet forwarding by maintaining minimum energy consumption for each node. In first phase, all the redundant nodes are removed. We have demonstrated the energy estimation of each node. In second phase, the stele route problems are avoided using the Cross layer approach. By simulation results, we have shown that the DBEE - CLA achieves good packet delivery ratio while attaining low delay, overhead, minimum energy consumption than the existing schemes Randomcast and 802.11 PSM while varying the number of nodes and mobility.

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