Modified PUMA Multicast Routing Protocol for Mobile Ad hoc Network

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Abstract—**Mobile Ad Hoc Networks (MANETs) are a self-configuring network of mobile nodes connected by wireless. In MANETs each mobile node not only act as a host and it also act as a router. Multicast routing protocols are plays very important role in MANET. The primary objective of a multicast routing protocol for MANETs is to support the propagation of data from a sender to all the receivers of a multicast group while trying to use the available bandwidth efficiently in the presence of frequent topology changes. Multicasting can improve the efficiency of the wireless link when sending multiple copies of messages by exploiting the inherent broadcast property of wireless transmission. However, offering energy efficient multicast routing is a difficult and challenging task. In recent years, various multicast routing protocols have been proposed for MANETs. These protocols have distinguishing features and use different mechanisms. In this paper Modified PUMA routing protocol improves the network performance in terms of energy consumption and transmission failures. It reduces the load on wireless nodes by selecting the route with minimum energy with maximum hop count. And also SMAC is used to save the energy values of wireless nodes. In multicast environment, by combing both of these techniques to increase the network performance in terms of energy consumption, transmission failures, packet dropping and end to end delay.**

Keywords- MANETs, Multicast Routing Protocols, PUMA, SMAC, MEMHMRP

I. INTRODUCTION

MANET is a type of ad hoc network that has the characteristics of mobility and self-configuring. Multicasting is the form of communication where group of nodes would like to send and receive information from each other. The purpose of a multicast routing protocol for (MANET) is to maintain the broadcasting of information from a source to all the destination of a multicast group with the efficient use of existing bandwidth. Multicasting is very essential in MANET because it reduces bandwidth consumption and broadcasting cost of communication. The multicast routing protocol is further categorized into tree-based, mesh-based and hybrid-based multicast routing protocol depending upon how the paths among group nodes are created.

In tree based multicast routing protocol, there is the establishment of single path between two nodes. Such protocols are bandwidth efficient and power efficient as they require less number of information. In mesh based multicast routing protocol, the set of interrelated nodes forms the mesh structures. The mesh establishment is done by using core points and route discovery is done by broadcasting the information. Such protocols are vigorous in character but protect complex structure provoking control overhead. Hybrid multicast routing protocols are the grouping of characteristics of both mesh-based and tree-based multicast routing protocol. PUMA is mesh-based multicast routing protocol and MAODV is tree-based multicast routing protocol [4].

However, it would be a difficult and challenging task to offer energy efficient and reliable multicast routing in MANETs. It might not be possible to recharge / replace a mobile node that is powered by batteries during a mission. The inadequate battery lifetime imposes a limitation on the network performance. To take full advantage of the lifetime of nodes, traffic should be routed in a way that energy consumption is minimized. In recent years, various energy efficient multicast routing protocols have been proposed. These protocols have unique attributes and utilize different recovery mechanisms on energy consumption.

II. SURVEY OF ENERGY EFFICIENT MULTICAST ROUTING PROTOCOLS

MANETs are lack of fixed infrastructure and nodes are typically powered by batteries with a limited energy supply wherein each node stops functioning when the battery drains. Energy efficiency is an important consideration in such an environment. Since nodes in MANETs rely on limited battery power for their energy, energy-saving techniques aimed at minimizing the total power consumption of all nodes in the multicast group (minimize the number of nodes used to establish multicast connectivity, minimize the control overhead and so on) and at maximizing the multicast life span should be considered. As a result of the energy constraints placed on the network's nodes, designing energy efficient multicast routing protocols is a crucial concern for MANETs, to maximize the lifetime of its nodes and thus of the network itself [14], [15].

2.1 Energy-Efficient Location Aided Routing (EELAR)

Energy Efficient Location Aided Routing (EELAR) Protocol [3] was developed on the basis of the Location Aided Routing (LAR) [16]. EELAR makes significant reduction in the energy consumption of the mobile node batteries by limiting the area of discovering a new route to a smaller zone. Thus, control packet overhead is significantly reduced. In EELAR, a reference wireless base station is used and the network's circular area centered at the base station is divided into six equal sub-areas. During route discovery, instead of flooding control packets to the whole network area, they are flooded to only the sub-area of the destination mobile node. The base station stores locations of the mobile nodes in a position table. Simulations results using NS-2 [17][18] showed that EELAR protocol makes an improvement in control packet overhead and delivery ratio compared to AODV [19], LAR [20], and DSR [21][22] protocols.

2.2 Online Max-Min Routing Protocol (OMM)

Li et al proposed the Online Max-Min (OMM) power-aware routing protocol [12] for wireless ad-hoc networks dispersed over large geographical areas to support applications where the message sequence is not known. This protocol optimizes the lifetime of the network as well as the lifetime of individual nodes by maximizing the minimal residual power, which helps to prevent the occurrence of overloaded nodes. In most applications that involve MANETs, power management is a real issue and can be done at two complementary levels (1) during communication and (2) during idle time. The OMM protocol maximizes the lifetime of the network without knowing the data generation rate in advance. The metrics developed showed that OMM had a good empirical competitive ratio to the optimal online algorithm [12] that knows the message sequence and the max-min achieves over 80% of the optimal node lifetime (where the sender knows all the messages ahead of time) for most instances and over 90% of the optimal node lifetime for many problem instances [5].

2.3 Power-aware Localized Routing (PLR)

The Power-aware Localized Routing (PLR) protocol [23] is a localized, fully distributed energy-aware routing algorithm but it assumes that a source node has the location information of its neighbors and the destination. PLR is equivalent to knowing the link costs from the source node to its neighbors, all the way to the destination. Based on this information, the source cannot find the optimal path but selects the next hop through which the overall transmission power to the destination is minimized [5].

2.4 Minimum Energy Routing (MER) Protocol

Minimum Energy Routing (MER) can be described as the routing of a data-packet on a route that consumes the minimum amount of energy to get the packet to the destination which requires the knowledge of the cost of a link in terms of the energy expanded to successfully transfer and receive data packet over the link, the energy to discover routes and the energy lost to maintain routes [13]. MER incurs higher routing overhead, but lower total energy and can bring down the energy consumed of the simulated network within range of the theoretical minimum the case of static and low mobility networks. However as the mobility increases, the minimum energy routing protocol's performance degrades although it still yields impressive reductions in energy as compared performance of minimum hop routing protocol [24].

2.5 Lifetime-aware Multicast Tree (LMT) Protocol

The Lifetime-aware multicast tree routing algorithm [10] maximizes the ad hoc network lifetime by finding routes that minimize the variance of the remaining energies of the nodes in the network. LMT maximizes the lifetime of a source based multicast tree, assuming that the energy required to transmit a packet is directly proportional to the forwarding distance. Hence, LMT is said to be biased towards the bottleneck node. Extensive simulation results were provided to evaluate the performance of LMT with respect to a number of different metrics (i.e., two definitions of the network lifetime, the root mean square value of remaining energy, the packet delivery ratio, and the energy consumption per transmitted packet) in comparison to a variety of existing multicast routing algorithms and Least-cost Path Tree (LPT) [25]. These results clearly demonstrate the effectiveness of LMT over a wide range of simulated scenarios.

2.6 Lifetime-aware Refining Energy Efficiency of Multicast Trees (L-REMIT)

Lifetime of a multicast tree in terms of energy is the duration of the existence of the multicast service until a node dies due its lack of energy. L-REMIT [8] is a distributed protocol and is part of a group of protocols called REMIT (Refining Energy efficiency of Multicast Trees). It uses a minimum-weight spanning tree (MST) as the initial tree and improves its lifetime by switching children of a bottleneck node to another node in the tree. A multicast tree is obtained from the "refined" MST (after all possible refinements have been done) by pruning the tree to reach only multicast group nodes. L-REMIT is a distributed algorithm in the sense that each node gets only a local view of the tree and each node can independently switch its parent as long as the multicast tree remains connected that utilizes an energy consumption model for wireless communication. L-REMIT takes into account the energy losses due to radio transmission as well as transceiver electronics. L-REMIT adapts a given multicast tree to a wide range of wireless networks irrespective of whether they use long-range radios or short-range radios [1], [8].

III. EXISTING SYSTEM

PUMA

Protocol for Unified Multicasting through Announcements is a multicast routing algorithm that is generally working for a mesh based network. PUMA is based on multicast announcements (MA) and forwards packet from multicast sender to its destination within a multicast group [3] [9]. A Multicast Announcement is composed of Group ID, Core ID, Distance to Core, parent node sending latest announcement and notifies other nodes while an announcement is been sent. PUMA elects one of the nodes as core node and thereby informs other nodes of the elected core. PUMA being a mesh based multicast protocol is capable of collecting many receivers together and is liable to have many paths to reach the destination node. The multicast announcements in PUMA are capable of performing [3] [6] [8] [9]:

1) Dynamic election of core node:

PUMA elects one of the receiving nodes of the group as core of the group, and informs every router about the relative next hop to the elected core in each group. Each router will have one or more paths to reach the core node. Receiver searches for shortest path between itself and core and then connects the core node. A mesh member is flooded with data packets, and each packet is numbered such that as soon as a duplicate packet is encountered in will get dropped [3] [7].

2) Multicast Announcement Propagation:

A node that is elected as core keeps on sending multicast signals to the corresponding receivers. A connectivity list will be generated at each node as the multicast announcement reaches the receiving node. A connectivity list consists of details about parent node and distance to core. A node stores data from various MA that arrives from neighboring nodes. A new MA overwrites values that have lesser sequence number within that group [3]. Only latest information about sequence number will be kept for a given group A connectivity list stores the time of receiving the multicast announcement from the node, ID of the neighbor from which it was received and the multicast announcement. Best multicast announcement has to be selected.

3) Mesh Creation and Maintenance

In this step, only the receiving nodes are considered as member of the mesh, if the node is the receiving node it sets the flag as TRUE. Non receiving nodes are depicted as mesh members if they have at least one child. A node is predicted to be child node if

(i) It is the member of the mesh and sets the mesh member flag to be TRUE.

(ii) The nodes distance to core is lesser than distance of the neighbor to core.

A node will be a mesh member if it has a child node and depicts that it lies on the shortest path from core to receiver.

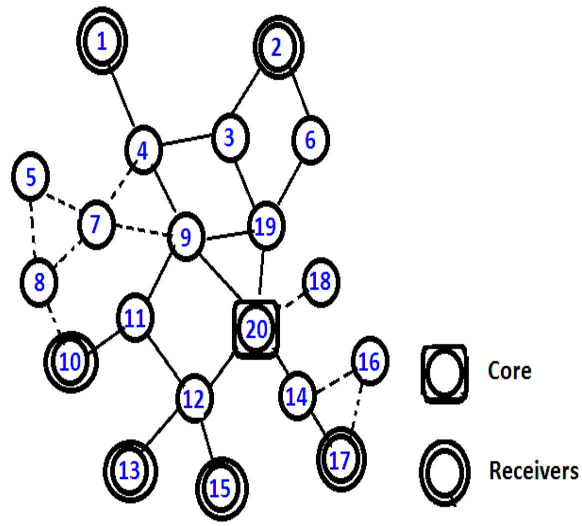

Fig 1. Mesh Establishment and Maintenance

As represented in Fig 11, node 20 is treated as core and other nodes in the group mark the connectivity list distance field by adding one to the finest entry. The receivers (nodes 1, 2, 10, 13, 15, 17 and 20 update the mesh member status to 1. node 3 and node 6 become mesh-members after receiving multicast announcement from qualified mesh child node2 as the distance to core is same. Similarly, nodes 4, 9, 12, 19 and 14 become the mesh members as the overall distance to the core node from mesh members is small. The procedure continues until the shortest paths are detected to the core from the receivers in the mesh. In this example, the route between the node 2 and core 20 of distance 3 exist through 2-3-19-20 and 2-6-19-20 and both paths are part of the mesh.

IV. PROPOSED SYSTEM:

In this proposed system, Modified PUMA routing protocol route selection done by Min Energy Max Hop count based Multicast Routing Protocol (MEMHMRP) .It reduces the load on nodes in multicast mobile ad hoc networks and also sensor media access protocol (SMAC) is used to save the energy of wireless mobile nodes.

Modified PUMA:

The entire routing process of proposed system is same as basic PUMA routing protocol except route selection. In proposed system, route selection is based on the Min Energy Max Hop count based Multicast Routing Protocol (MEMHMRP). PUMA is based on multicast announcements (MA) and forwards packet from multicast sender to its destination within a multicast group. A Multicast Announcement is composed of Group ID, Core ID, Residual Energy(RE), Distance to Core, parent node sending latest announcement and notifies other nodes while an announcement is been sent. PUMA elects one of the receiving nodes of the group as core of the group, and informs every router about the relative next hop to the elected core in each group. Each router will have one or more paths to reach the core node. Receiver selects path from itself and core based on the residual energy value and hop count. First receiver searches the total number of existing paths from itself to core node and after that receiver compares remaining energy values with minimum threshold value for each path. After receiver node selects path which path having minimum energy with maximum hop count path from itself to core node.

Sensor Media Access Protocol (SMAC):

SMAC [10] protocol is a medium access control (MAC) protocol designed for wireless sensor networks. Wireless sensor networks use battery-operated computing and sensing devices, so reducing energy consumption is the primary goal in SMAC protocol. SMAC uses a few novel techniques to reduce energy consumption and support self-configuration. It enables low-duty-cycle operation in a multi-hop network. Nodes form virtual clusters based on common sleep schedules to reduce control overhead and enable traffic-adaptive wakeup. SMAC uses in-channel signaling to avoid overhearing unnecessary traffic. Finally, SMAC applies message passing to reduce contention latency for applications that require in-network data processing. The primary mechanisms SMAC adopts as follows:

A. Periodic Listen and Sleep

In many sensor network applications, nodes are idle for long time if no sensing event happens. Given the fact that the data rate is very low during this period, it is not necessary to keep nodes listening all the time. SMAC reduces the listen time by putting nodes into periodic sleep state. The basic scheme is that each node sleeps for some time, and then wakes up and listens to see if any other node wants to talk to it. During sleeping, the node turns off its radio, and sets a timer to awake itself later. All nodes are free to choose their own listen/sleep schedules. However, to reduce control overhead, it prefers neighboring nodes to synchronize together. Nodes exchange their schedules by periodically broadcasting a SYNC packet to their immediate neighbors.

B. Collision Avoidance

If multiple neighbors want to talk to a node at the same time, they will try to send when the node starts listening. In this case, they need to contend for the medium. SMAC adopts virtual and physical carrier sense, and the RTS/CTS exchange for the hidden terminal problem. All senders perform carrier sense before initiating a transmission. If a node fails to get the medium, it goes to sleep and wakes up when the receiver is free and listening again. Broadcast packets are sent without using RTS/CTS. Unicast packets follow the sequence of RTS/CTS/DATA/ACK between the sender and the receiver. After the successful exchange of RTS and CTS, the two nodes will use their normal sleep time for data packet transmission. They do not follow their sleep schedules until they finish the transmission.

C. Adaptive Listening

The scheme of periodic listen and sleep is able to significantly reduce the time spent on idle listening when traffic load is light. However, when a sensing event indeed happens, it is desirable that the sensing data can be passed through the network without too much delay. SMAC proposes an important technique, called adaptive listen, to improve the latency caused by the periodic sleep of each node in a multi hop network. The basic idea is to let the node who overhears its neighbor's transmissions (ideally only RTS or CTS) wake up for a short period of time at the end of the transmission. In this way, if the node is the next-hop node, its neighbor is able to immediately pass the data to it instead of waiting for its scheduled listen time. If the node does not receive anything during the adaptive listening, it will go back to sleep until its next scheduled listen time.

D. Overhearing Avoidance

SMAC tries to avoid overhearing by letting interfering nodes go to sleep after they hear an RTS or CTS packet. Since DATA packets are normally much longer than control packets, the approach prevents neighboring nodes from overhearing long DATA packets and following ACKs.

E. Message Passing

A message is the collection of meaningful, interrelated units of data. The receiver usually needs to obtain all the data units before it can perform in-network data processing or aggregation. The disadvantages of transmission a long message as a single packet is the high cost of re-transmitting the long packet if only a few bits have been corrupted in the first transmission. However, if we fragment the long message into many independent small packets, we have to pay the penalty of large control overhead and longer delay. The reason is that the RTS and CTS packets are used in contention for each independent packet. SMAC fragments the long message into many small fragments, and transmit them in a burst. Only one RTS and one CTS are used. They reserve the medium for transmitting all the fragments. Every time a data fragment is transmitted, the sender waits for an ACK from the receiver. If it fails to receive the ACK, it will extend the reserved transmission time for one more fragment, and re-transmit the current fragment immediately.

V. RESULTS AND ANALYSIS:

To evaluate our proposed routing protocol (Modified PUMA), an extensive simulation study is performed using the NS-2 simulator. We compare this proposed protocol with the basic PUMA multicast routing protocol. The simulation is carried out for 100 seconds and using a topology size of 1000 meter * 1000 meter. We use the two Ray ground as a model of propagation and the Constant Bit Rate (CBR) as a traffic type.

Modified PUMA:

Below xgraph shows relation between average hop counts versus energy consumption. We see that the graph plots energy consumption for the two routing protocols corresponding with average hop count. We also note that our proposed multicast Modified PUMA routing protocol consumes less power than basic multicast PUMA routing protocol. This is because of MEMHMRP select path based upon minimum reaming energy and maximum hop count. Moreover, our proposed routing protocol reduces the energy consumption and also prevent the link failures in multicast mobile ad hoc networks.

Table1: Energy consumption with respect to different hop counts

Initial Energy	Average hop count	Energy consumption
10	2	9
10	4	6
10	6	3

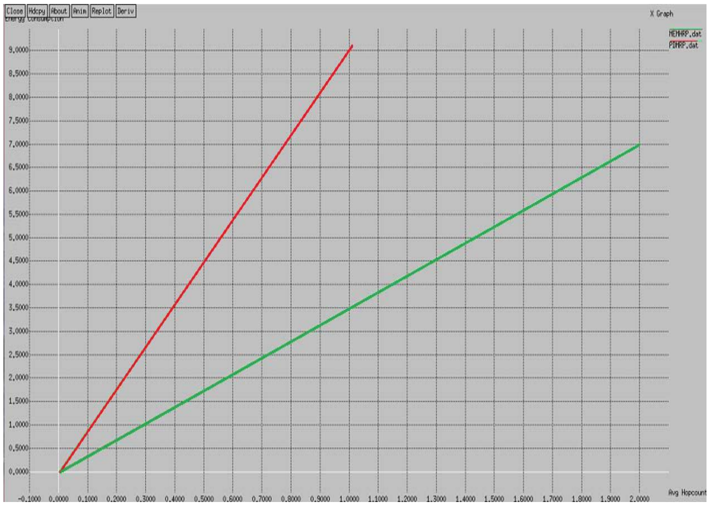

Figure 2. Avg Hopcount vs Energy Consumption

SMAC:

Below xgraph shows relation between passive nodes (nodes are not in use) versus remaining energy in multicast environment. We see that the graph plots remaining energy for the two routing protocols corresponding with passive nodes. We also note that to save power of wireless mobile nodes by using SMAC protocol than the without use of SMAC. SMAC reduces the power consumption by changing the node states from sleep state to active and active to sleep state vice versa.

Table2: Average Reaming Energy of with SMAC and without SMAC

Initial Energy	Average Passive Nodes (Which are not active while data transmission)	Average Reaming Energy (Without using SMAC)	Average Reaming Energy(With SMAC)
10	8	16	40
10	10	25	50
10	15	18	75

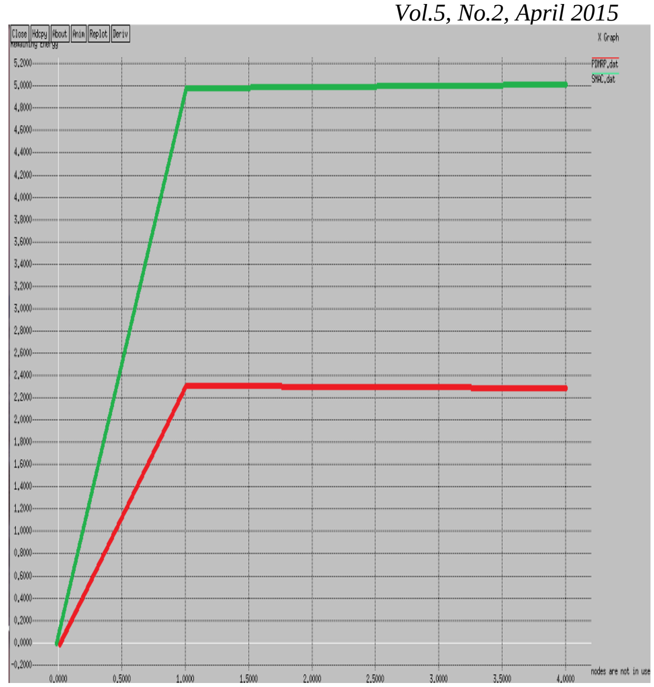

Figure 3. Passive nodes (nodes are not in use) vs remaining energy

VI. CONCLUSION

A mobile ad hoc network (MANET) has collection of autonomous mobile nodes, each node communicates directly with the nodes within its wireless range or indirectly with other nodes in a network. In order to provide reliable communication within a MANET, an efficient routing protocol is required to discover routes between mobile nodes. Energy efficiency is one of the major challenge faced in MANETs, especially in designing a routing protocol. In this paper Modified PUMA routing protocol improves the network performance in terms of energy consumption and transmission failures. It reduces the load on wireless nodes by selecting the route with minimum energy with maximum hop count. And also SMAC is used to save the energy values of wireless nodes. In multicast environment, by combing both of these techniques to increase the network performance in terms of energy consumption, transmission failures**,** packet dropping and end to end delay**.**

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