

Power Aware Geographic Multicast Routing for Reducing Packet Loss in MANET

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Abstract

A Mobile Ad Hoc Network is a decentralized network that consists of mobile nodes. This paper presents a power aware geographic routing to increase the packet delivery ratio in the mobile ad hoc network. It considers residual battery capacity and relay capacity of the node. In the proposed system the network is divided into square zones and a group leader is selected depending upon the residual battery capacity of the node to send multicast packets. The proposed model is simulated using NS 2.34. The proposed model is compared with existing algorithms. The proposed work gives best results in terms of network lifetime, throughput and packet delivery ratio.

Index Terms—Mobile ad hoc network, residual battery capacity, relay capacity, multicast.

1. Introduction

A Mobile Ad hoc Network (MANET) is a collection of mobile nodes. The mobile nodes can freely move anywhere. The mobile nodes are formed as a network with help of decentralized network. The problem of routing in mobile ad hoc networks is difficult because of node mobility. Due to mobility and frequent topology changes frequent link breakage occurs. Each node operates with the limited battery power to forward the data packets from the source to destination. To reduce the battery usage power aware routing is required. For this reason, many researchers have been devoted to design an energy aware routing protocol for MANETs [2]. In MANET, to conserve node energy many different power aware routing have been proposed [3]. Several studies tried to increase the node lifetime and network lifetime by using the power aware metrics [4]. In [5] the various power aware routing metrics in MANET is presented while transmitting data from the source to destination. Minimum total transmission power routing (MTPR) model is used to minimize the consumption of total transmission power of nodes participating in a path [6]. Paths containing with

more number of hops is selected. End to end delay is increased. It does not consider residual battery capacity of the node. So it does not increase the lifetime of node. Minimum Battery Cost (MBC) algorithm has minimized the total cost of a path and has inversed to the remaining battery capacity of all the nodes in a path [7]. Min Max Battery Cost Routing (MMBCR) algorithm tries to optimize the overall lifetime of a network instead of end to end delay. It uses the residual battery capacity of all the nodes, while selecting a path for transmission. Conditional min max battery cost routing algorithm uses the minimum transmission power as a metric to route the data packets [9].

1.1. Multicast

In general conventional MANET multicast protocols can be divided into two main categories, tree based and mesh based. The tree based protocols construct a tree structure for the multicast delivery, and the tree structure is known for its efficiency in utilizing the network resource optimally. However, maintaining tree structure in these conventional protocols is very difficult, and the tree connection is easy to be broken and the transmission is not reliable. The mesh based protocols are proposed to enhance the robustness by providing redundant paths between the source and destination pairs at the cost of higher forwarding overhead. These protocols generally do not have scalability due to the overhead for route searching, group membership management, and tree/mesh structure creation and maintenance over the dynamic topology of MANET. The geographic routing gives best results in terms of packet delivery ratio. Geographic routing is combined with power multicast routing in manet.

This paper focuses on power aware multicast algorithm for MANETs. The data packets are transmitted from source to group of destination nodes through the intermediate nodes. The whole network is divided into zones. In each zone a leader is selected depending upon the residual battery capacity and relay capacity of node. The leader

can define the path of data packets from source to destination. It chooses a path with nodes have high relay capacities and residual battery powers.

2. Related works

Suresh Singh et.al (1998) has presented a case for using new power aware metrics for determining routes in WANET [12]. It present five different metrics based on battery power consumption at nodes. It shows that using these metrics in a shortest cost routing algorithm reduces the cost/packet of routing packets by 5-30% over shortest hop routing. These new metrics ensures that the mean time to node failure is increased significantly. The shortest cost routing does not increase the packet delays. Reductions in cost can be obtained by using shortest cost routing as opposed to shortest hop routing.

Juan A. Sanchez et.al (2006) has evaluated the problems that arise when considering that messages can be lost and propose a new geographic routing protocol which takes into account the probability of error transmission to achieve a high delivery ratio while reducing the energy consumed to the minimum possible [13]. Routing has two important phases. First one is to choose the relay and second one is to pass the message to that relay. Algorithms such as GPSR are made upon the assumption that the link layer is perfect so they focus only on the selection of the best relay neighbour. It can be reached directly as it is a neighbor but when there are others neighbours it might be possible to use them as relays to send it a message. The new routing protocol achieves almost perfect results in terms of delivery rate and energy consumption.

Jeffrey E. Wieselthier et.al (2000) has developed the Broadcast Incremental Power Algorithm (BIP) [10]. The objective is to construct a minimum power tree, rooted at the source node that reaches all of the other nodes in the network. For wireless networks, this is a difficult problem for which no scalable solutions appear to be available at this time. The total power associated with the tree is simply the sum of the powers at all transmitting nodes. This is a node based metric because it enables to exploit the wireless multicast advantage. It shows that improved performance can be obtained when exploiting the properties of the wireless medium; networking schemes should reflect the node based nature of wireless communications, rather than simply adapt link based schemes originally developed for wired networks.

Pariza Kamboj et.al (2008) has proposed a power efficient multicast routing protocol for mobile ad hoc networks called Power Aware Multicast Reactive Routing Protocol (PAMRRP) [6]. It uses power aware metrics to extend the lifetime of each mobile node and the whole

network as well. The proposed routing protocol PAMRRP employs the techniques of Cautious Distribution of Forwarding Load, Reduction in Control Overheads, and Proactive Tree Maintenance with a view to maximize the lifetime of a network with dynamic topology. It considers the battery capacity of the nodes as a crucial resource of the system and extends the lifetime of each mobile node and network by avoiding using low power nodes. This cautious Distribution of Forwarding Load using Reliable Reduced Broadcast Search Algorithm (RRBSA). The RRBSA algorithm avoids low power nodes for considering them as members of the multicast tree. While searching for a destination RRBSA periodically examine the available battery power (ABP) of the nodes falling in the route and compare the power reserves against two threshold values. It uses reduced broadcast leading to less overheads and less chance of network clogging as well. It offers reliable transmissions of data and decreased average latency in finding new route in case of nodes' failure by reconfiguring the routes using proactive maintenance of the tree. The lifetime of mobile nodes and of network is prolonged by avoiding using low power nodes for general applications. The protocol provides battery power conservation and minimized overall transmission power for each connection request by drastically reducing the broadcasting of control packets with the help of algorithm RRBS.

Wen Lin Yang (2005) has proposed a heuristic called Efficient Link Replacing (ELR) algorithm for determining a multicast tree for the problem [17]. The ELR algorithm begins with a two level multicast tree and then iteratively replaces the high power links with lower power links in order to reduce the total power required by the multicast tree. It constructs a two level multicast tree. Based on the two level multicast tree constructed it replace a high power link with a certain number of links, which are associated with lower power. When a high power link is selected for deletion, it needs to reconnect node and its sub tree back the current multicast tree to keep all destination nodes. The reconnection is done by making node the parent node of node and its sub tree. The multicast tree generated by the link replacing procedure gives greater than the given delay constraint Δ . That is, the number of hops of the longest path from source node (the root) to a destination node (a leaf) is greater than Δ . This undesirable result can be avoided by considering only lower power links which can form a path with delay not greater than Δ . The results show that for a given delay constraint the multicast tree found by ELR algorithm requires less power than the one found by the MIP method. It concludes that the ELR is a suitable method for constructing energy efficient multicast trees subject to QoS supports for real

time multimedia systems deployed on wireless networks.

Yuan Peiyan et.al (2012) has presented an energy constrained multicast routing protocol (ECMRP) [19]. The main idea of ECMRP is that routing forwarding decisions should be based on each node's energy level. The goal of this paper is good energy balance among mobile nodes, which eventually results in a longer lifetime of the network. This paper uses a simple mechanism of delay. The node is classified into five states transmitting, receiving, listening, sleep and dead. When the left energy of a node is equal to zero, the node is into dead state automated.

3. Proposed work

In this work, it considers residual battery capacity and relay capacity of the node to send multicast packets. The whole network is divided into square zones. In each zone a leader is selected depending upon the residual battery capacity and relay capacity of node. The key factor is packet delivery ratio. The proposed work maintains three tables namely neighbor node table, routing table and group table to forward data packets from one node to another node.

3.1. Neighbor node table

Every node can maintain the details about neighbor nodes. This table contains node position, node id, residual battery capacity and relay capacity of the node.

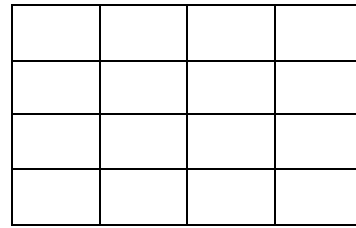
3.2. Routing table

This table maintains the current route used. It contains sequence number, source number, destination number and route expire time. If a source node wants to send multicast packets then it checks a valid route for destination in its routing table. It does not find any valid route source node can send RREQ towards destination. If a valid path is found then the destination send RREP packets to source node. After receiving valid paths it selects the shortest path among all and adds this entry to the routing table.

3.3. Group table

It maintains details about multicast group members. It contains group address, group sequence number, leader address, hop count to group leader.

3.4. Zone separation



.Figure.1 Zone Separation

The whole network is divided into square zones. The zone size will be same for all zones. Due to mobility the nodes can move to different zone.

3.5. Leader selection

Case 1: The node having higher residual battery capacity can be selected as a leader node follows.

$$BC_i(t) = a_i - b_i - c_i - d_i$$

Where $BC_i(t)$ is the residual-battery capacity of node I and a_i is initial battery of I. b_i is the number of packets transmitted by I, c_i is the number of packets received by I. d_i is the number of packets transmitted by I as an intermediate node up to time t.

$$a = BC_i(0)$$

$$b_i(t) = \sum_{\lambda=0}^{T_i(t)} (pc(\lambda) + Tc(\lambda))$$

$$c_i(t) = \sum_{\lambda=0}^{R_i(t)} (pc(\lambda) + Rc(\lambda))$$

$$d(t) = \sum_{\lambda=0}^{I_i(t)} (pc(\lambda) + Rc(\lambda) + Tc(\lambda))$$

Case 2: If any nodes having equal residual battery then it chooses node (N_c) with high relay capacity of the node as a leader node follows.

$$RC_i = \sum_{t=0}^{T_i(t)} Nc(t) + \sum_{T=0}^{I_i(t)} Nc(t)$$

The leader node defines the path of the data packets from source to destination. Where $T_i(t)$ is Number of packets is transmitted by the node I as a source node up to time t. $R_i(t)$ is Number of packets is received by the node I up to time t. $I_i(t)$ is

Number of packets is passed through node I as an intermediate node up to time t. $P_c(\delta)$ is Processing cost of a packet δ . $T_c(\delta)$ is Transmitting cost of a packet δ . $R_c(\delta)$ is Receiving cost of a

packet δ . $RC_i(t)$ is Relay-capacity of the node i . λ is Arrival rate of the packets. N is Number of group members/nodes. T is tree.

3.6. Multicast tree construction

Every node can send their residual energy level to the leader through control messages. The leader can maintain the residual energy of all nodes in its zone table. The multicast tree can be constructed with high residual energy nodes. The low residual energy nodes can be avoided for participating as a member in multicast tree. The threshold residual energy value is maintained. The nodes having residual energy below threshold value can avoid as a member of multicast tree by the group leader. Others nodes are used for transmission.

3.7. Leader change

Due to mobility of nodes the nodes can move from one zone to another zone. And during the packet transmission the residual battery capacity of the nodes can be reduced. The leader can be selected again and again for a particular interval once. By choosing high residual battery capacity nodes for transmission the link breakages can be avoided. This increases the packet delivery ratio.

4. Results and discussion

The proposed model is implemented using network simulator 2.34. The proposed model is compared with existing algorithm for different perspectives such as packet delivery ratio, network lifetime, throughput, energy consumption.

4.1. Description of Simulation Area

The proposed work has considered an area of 1,000 mts \times 1,000 mts with 31 nodes. The nodes are placed at the initial positions and move to a defined area. Grid topology is considered with 802.15.4 MAC layer and two ray ground radio propagation models. Drop tail queue type is used to queue the packet in buffer limit is 100. Omni direction antenna is used which has transmission range of 15m. Constant bit rate (CBR) at the size of 512 bits is used as packet size. Run time simulator is 400s.

4.2. Performance Evaluation

4.2.1. Network Lifetime

Network Lifetime is defined as the duration of the network until the last node failure. Figure.2 shows the network lifetime of the proposed model and existing model for various speeds of nodes. From the results, it concludes that the proposed

model is always kept maximum number of nodes alive for longer period of time as compared to others. By selecting high residual energy nodes for data transmission the failure of the node can be avoided. It increases the lifetime of the networks.

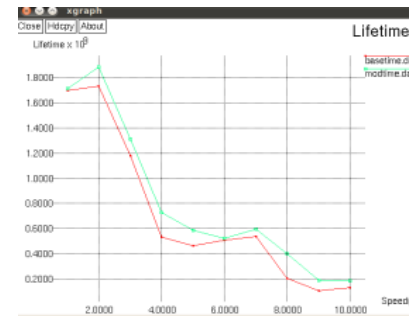


Figure.2. Variation of Network lifetime with Speed

When the speed of node is increased the network lifetime is decreased because of node failure. From Figure.2. there is 1.69424e+09 and 1.33477e+08 network lifetime in existing model when speed of node is 1 and 10. But network lifetime in proposed model is 1.7128e+09 and 1.89008e+08 when speed of node is 1 and 10 respectively.

4.2.2. Energy consumption

The energy consumption is defined as the total consumed power of all nodes after data transmission.

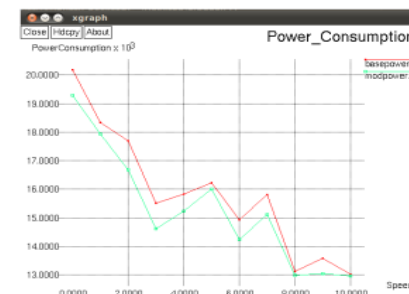


Figure.3. Variation of Energy consumption with Speed

Figure.3.shows the energy consumption of the proposed model and existing model for various speeds of nodes. The proposed model has less energy consumption than existing model. When speed of the nodes is increased the energy consumption of node is decreased.

3) Packet Delivery Ratio

Packet Delivery Ratio (PDR) is defined as the ratio of the data packets delivered to the destinations to those generated by the constant bit rate sources. Figure.4 shows the PDR of the proposed model and existing model for various speeds of nodes. The proposed model has high packet delivery ratio than the existing model. The

effective primary path selection mechanism in proposed model avoids packet drop and failure of node in the network.

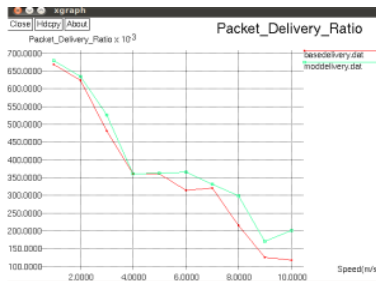


Figure.4. Variation of Packet delivery ratio with Speed

The path is chosen based on the maximum residual energy of the node. In existing model the high residual energy path can be chosen for transmission. In proposed model the high residual energy nodes can be chosen for transmission. When speed increased from 1 to 10, the PDR is decreased as shown in Figure 4. When the speed is 1 and 10 the PDR of existing model is 66.92% and 11.84% respectively; where it's 67.92% and 20.22% in proposed model.

4) Throughput

The throughput is defined as the average rate of successful message delivery. Figure 5 shows throughput of the proposed model and existing model for various speeds of nodes. The result shows that the proposed model has high throughput than the existing system. When speed of the nodes is increased the throughput is decreased. In existing model the high residual energy path can be used for transmission. Sometimes it contains some of the low residual energy nodes. In proposed model the low residual energy nodes can be avoided for transmission. The number of successful message delivery is increased because of this when compared to existing model.

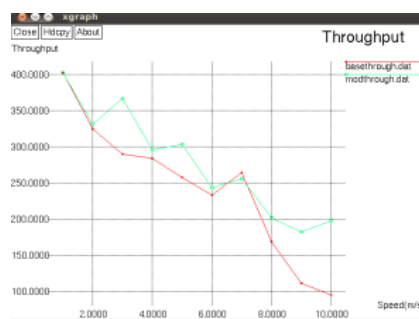


Figure.5. Variation of Throughput with Speed

5. Conclusion and future work

MANETs are collection of mobile nodes. The mobile nodes are energy constrained. In the proposed work the entire network is divided into square zones. In each zone a leader is selected based on the residual energy of the node. The leader can define the path of the data packets from source to destination. Simulation is carried out for the following parameters: network lifetime, throughput, energy consumption and packet delivery ratio using NS 2.34. The energy consumption is reduced in proposed work when compared to existing work and also the network lifetime, throughput, packet delivery ratio is increased. In existing work the leader is changed dynamically due to the loss of residual energy of leader.

In future work, group leader is selected based on some other parameters to make it stable and to increase the performance like network lifetime, energy consumption, throughput, packet delivery ratio and to decrease packet loss further.

6. References

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