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Energy reduction aware multicast routing for mobile ad hoc networks

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Abstract

QoS Multicast routing is difficult in Mobile Ad hoc Network (MANET) due to limited resources. Each node in MANET is constrained by their limited battery power for their energy. The energy is reduced as the time goes off due to the packet transmission and reception. Energy management techniques are necessary to minimize the total power consumption of all the nodes in the network in order to maximize its life span. Our proposed protocol Energy Reduction Aware Multicast (ERAM) aimed to find a path which utilizes the minimum energy to transmit the packets between the source and the destination. The required energy for the transmission and reception of data is evaluated at the MAC layer. The network layer makes use of it to find the minimum energy path. ERAM is implemented on Multicast Ad hoc On Demand Distance Vector Routing Protocol (MAODV) to manage the energy consumption in the transmission and reception of data. Simulation results of ERAM show the energy consumption has been reduced.

Keywords: Energy, Multicast, MANET, QoS, MAODV, MAC.

Introduction

A mobile ad hoc network is a group of mobile wireless nodes which communicate with one another without any fixed networking infrastructure. As communication occurs in groups, multicasting is an efficient way to deliver the information to a group. Routing protocols generally establish the shortest path based on the number of hops between the source and the destination. In MANET, the routing protocols have to route the packets depending on the MANET constraints such as battery power in addition to the shortest path. The limited battery supply to mobile node in MANET forces the routing protocols to minimize the power consumption and maximize the network life time. Energy is consumed in MANET during the transmission and reception of data, propagation of control packets, retransmission and overhearing. We concentrate in reducing the power consumption during the transmission and reception of data. Each node in MANET transmits data with the maximum energy value of 0.283 watts regardless of the distance between the nodes. Also the mobile nodes expend some energy in transmission and reception of data. We have utilized the metrics received signal strength, link quality and the distance between the nodes to compute the energy required to transmit the data from a node to its neighboring node. The energy computed is involved in the selection of the optimal path which requires minimum energy to route the data from source to destination

Existing solutions available for the energy minimization are: The route is alternated using the backup route to extend the network life time and so that overhead is small (Liansheng *et al.*, 2007). Energy efficiency and load balancing is used as a tradeoff in the selection of the optimal route which has nodes with sufficient residual battery power. Routing task is distributed over the nodes to reduce the energy consumption in the transmission (Djamel Djenouri & Nadjib Badache, 2006). Energy Mean value algorithm is applied to enhance the performance of the routing protocol (Jin-Man Kim *et al.*, 2006). Control packets are minimized to reduce the energy consumption (Varaprasad, 2007).Another technique employs improved energy levels and hello mechanisms to minimize the energy consumption (Taiyuan, 2009). Flow Argumentation Routing (Chang & Tassiulas, 2000), Power Aware Localized Routing (Stojmenovic & Lin, 2001) and Minimum Energy Routing (Doshi & Brown, 2002) protocols attempted to reduce the transmission energy of nodes and does not include nodes which has low energy.

ERAM

Energy reduction aware multicast algorithm consists of two phases. The first phase computes the power required for each node to contact its neighbors and store it in a table called the power table along with the MAC address. The second phase utilizes the power table to select the optimal path that requires minimum energy to route the data from source to destination. To compute the required power, the first phase employs metrics link quality, received signal strength and the distance between the nodes.

At MAC layer

The steps involved in the computation of power in the MAC layer are as follows.

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- Computation of link quality.
- Computation of the distance between the neighboring nodes.
- Computation of power based on link quality and the distance between the neighboring nodes.
- Computation of power table.

Computation of link quality

If the node is in sleeping mode or the energy goes zero then drop the packet
Else
Link Quality = Pr/RXThresh (Pr – the receiving power of a signal from a sender d meters apart)
LQ – Link Quality
If LQ > 255 then level = 1
Else
If LQ > 200 and LQ < 255 then level = 2.
Else
If LQ > 175 and LQ < 200 then level = 3.
Else level = 4.

Computation of distance between the nodes

(dist – Distance between the nodes)
If dist > 0and < 100 then level =1
Else
If dist > 100and < 200 then level =2
Else
If dist > 200and < 300 then level =3
Else level = 4.

Computation of power

If dist = 1 and LQ =1 then
Power required = very low.
Else
If dist = 1 and LQ =2 then
Power required = low.
Else
If dist = 2 and LQ =1 then
Power required = low.
Else
If dist = 2 and LQ =2 then
Power required = medium.
Else
If dist = 2 and LQ =3 then
Power required = very high.
Else
If dist = 3 and LQ =1 then
Power required = medium.
Else
If dist = 3 and LQ =2 then
Power required = high.
Else
If dist = 3 and LQ =3 then
Power required = very high.

Computation of power table

The computed power of each node is stored along with its MAC address. The power table is updated to the Network layer, the routing protocol MAODV (Yufang Zhu & Thomas Kunz, 2004) .MAODV then uses this table to find out the minimum energy path. This path is used to transmit and receive the data.

At network layer

Each node in MAODV maintains three tables unicast Routing table, Multicast Routing Table and Group Leader Table. ERAM modifies the fields in the unicast Routing Table so as to store the power needed to contact its neighbors. The fields in the unicast Routing Table are destination IP address, destination sequence number; hop count to destination, last hop count, next hop interface and power. Multicast Routing Table is maintained for each multicast group. Group leader table maintains the multicast group address along with its group leader address and the next hop towards the group leader.

Route discovery

Source node initiates a RREQ to the multicast address if the source has data to send to a multicast group and there exists no route. When the group leader or a member of the desired multicast group receives multiple RREQ packets, it selects the one with the highest sequence number and the lowest hop count and unicast a RREP to the requesting node. The RREP packet contains the distance of the replying node from the group leader, power required to transmit from the replying node to its receiving node and the current sequence number of the multicast group. RREP packets update the power in the unicast routing table along that path. When the receiving node receives more than one RREP packet, it forwards all the RREP packets. Among the entire RREP packet, the packet which has the minimum energy required is selected. The path which requires minimum energy is selected at the source on the reception of RREP. This minimum energy path is used to transmit data so as to enhance the network life time and to reduce the energy consumption.

Simulation results

Simulation of ERAM is performed and compared with MAODV using NS-2 to evaluate the protocol. A total of 50 nodes were simulated for duration of 1000s in an area of 1000m × 1000m.The mobility model is the random way point to model the mobility of the nodes in the network with the pause time of 0-500m/s. The MAC layer protocol used was IEEE 802.11. The transmission range for each node was 250m and the channel capacity was 2 Mbps. The initial energy of the node is 1000 joules. The metrics used for comparison are packet delivery ratio and power consumed.

Fig.1. compares the packet delivery ratio of the protocol ERAM with MAODV. As the number of receivers is increased the packet delivery ratio remains constant due to the selection of the minimum energy path in routing packets in ERAM. Packet delivery ratio in MAODV decreases as the number of receivers is increased. Fig.2. shows the average residual energy of the node after the occurrence of transmission and reception of the data. The initial energy of the node is 1000 joules. Energy

Fig.1. Number of receivers vs PDR

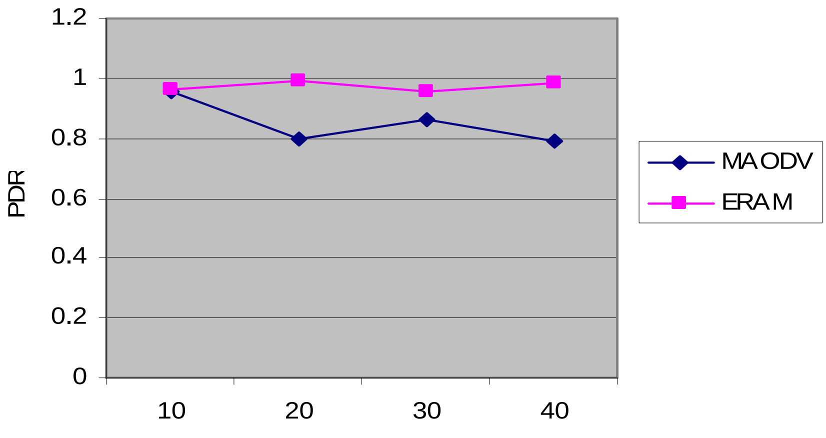
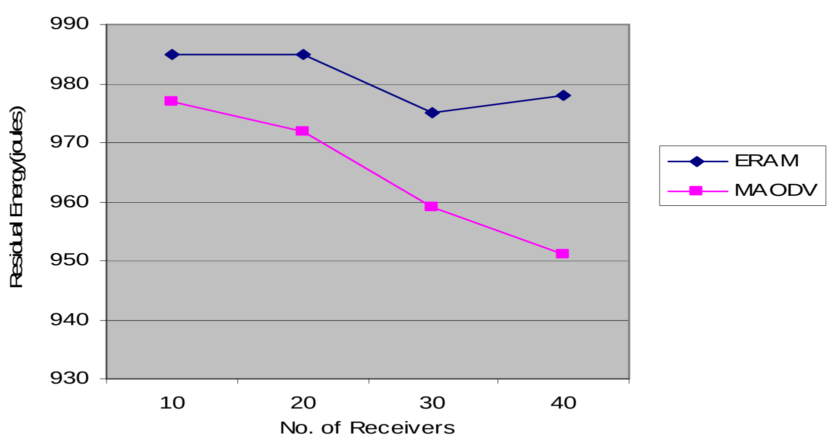


Fig.2.Number of receivers vs residual energy



consumed is less in ERAM even as the number of receivers is increased. This is due to the selection of the minimum energy path based on the metric link quality, received signal strength and the distance between the nodes. But MAODV transmit and receive the packet with the default maximum energy irrespective of the distance and so consumes more energy.

Conclusion

Energy minimization is achieved in multicast routing protocol MAODV by concentrating the layers network and MAC. MAC layer utilize the parameters received signal strength, link quality and the distance between the nodes to compute the power required in the transmission and reception of data instead of using the maximum default power value. The computed power is utilized in the network layer to find the optimal path which uses the minimum power to transmit data between the source and the destination. As a future work the application layer can also be included by means of the application metrics.

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