ENERGY EFFICIENT MULTICAST ROUTING PROTOCOL FOR MANET

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ABSTRACT
Ad hoc network is a collection of wireless, mobile, dynamic, and arbitrarily located nodes. The nodes cooperate with each other to create an infrastructure less temporary low cost network. The high mobility of nodes results in rapid changes in the routes, thus requiring some mechanism for determining new routes with minimum overheads and bandwidth consumption. Such infrastructure less networks use multicast routing protocols to manage random and uncertain events like rescue missions, disaster recovery, crowd control etc. The typical MANET routing protocols of IETF are shortest routing protocols and do not consider the energy aware problem. Because the ad hoc network is an energy constrained system with the portable devices. The energy saving of network is important rather than shortest path. The existing multicast routing protocols suffer from many drawbacks [1, 2]. The shortest path consumes more energy due to repeated usage. This makes network partition and reduce the network lifetime. This paper presents a protocol called “Energy Efficient Multicast Routing Protocol (EEMRP)” which has extended the lifetime of each mobile node by evenly utilization of energy.

KEY WORDS
Wireless networks, ad hoc networks, energy consumption, energy level and multicast routing

INTRODUCTION
Energy management is defined as the process of managing the sources and consumes of energy in a node or in the network as a whole for enhancing the lifetime of the network. Shaping the energy discharge pattern of a node’s battery to enhance the battery life and finding routes that result in minimum total energy consumption in the network and also the battery life is improved using distributed scheduling schemes [1]. An energy efficient routing is a critical problem in wireless networks due to the severe power constraint of wireless nodes [2].

Wireless nodes with no preexisting and fixed infrastructures can form mobile ad hoc network. In order to provide communication throughout the network, wireless nodes cooperate to handle network functions, such as packet routing. One example of a mobile ad hoc network, which can be readily, deployed in
diverse environments, such as health care, military, and disaster detection, to collect and process useful information in an autonomous manner [2] and [7].

Mobile devices are often deployed in wireless networks, whereas most of them operate on batteries such as cellular phones, portable digital assistants (PDAs), and laptops in situations with no available power supply [5] and [8]. Energy efficiency is of particular interest in the design of wireless networks due to limited battery capacity. Along with the increasing trend of using mobile devices as a means of communication, the battery life of a mobile terminal becomes one of the bottlenecks to supporting high-quality multimedia services or huge data transmission, even affects roaming capability. The demand for universal wireless access, along with the development of wireless applications including location aware services and mobile transactions has been motivated [4], [6] and [9].

**EEMRP**

*The Idea of EEMRP*

Routing has always been one of the key challenges in MANETs and the challenge becomes more difficult when the network size increases. Many routing protocols for MANETs have been proposed and these protocols can be classified into different categories according to different criteria [3], [4] and [6]. It classified by the manner in which they react to network topology changes, routing protocols can be grouped into proactive (or table-driven) protocols and reactive (or on-demand) protocols (though several hybrid protocols exist). Proactive protocols propagate topology information periodically and find routes continuously, while reactive protocols find routes on demand [10] and [11].

![Fig.1: Product Perspective](image_url)
Fig. 2: Route Discoverer

<table>
<thead>
<tr>
<th>Src</th>
<th>Dest</th>
<th>No of times bytes transferred</th>
<th>Bytes Transferred</th>
<th>Inter Dep Time</th>
<th>Start Time</th>
<th>End time</th>
</tr>
</thead>
</table>

Src – Source, Dest – Destination, Dep - Departure

Fig. 3: Constant Bit Rate Generator

<table>
<thead>
<tr>
<th>Packet Type</th>
<th>Source Address</th>
<th>Destination Address</th>
</tr>
</thead>
</table>

Fig. 4: Beacon Request Packet

<table>
<thead>
<tr>
<th>Packet Type</th>
<th>Source Address</th>
<th>Destination Address</th>
<th>Present Battery Power</th>
<th>Multicast ID</th>
</tr>
</thead>
</table>

Fig. 5: Beacon Reply Packet

<table>
<thead>
<tr>
<th>Node address</th>
<th>Available Battery Power</th>
</tr>
</thead>
</table>

Fig. 6: Neighbor Node Energy Table

<table>
<thead>
<tr>
<th>Multicast ID</th>
<th>List of nodes in a particular group</th>
<th>Total Group size</th>
</tr>
</thead>
</table>

Fig. 7: Group Membership Table
Generally, reactive protocols outperform proactive protocols in terms of packet delivery ratio, routing overhead, and energy efficiency. DSR-MB protocol and MAODV protocol are two well-known multicast routing protocols. The ad hoc network is energy-constrained system with the portable devices. The routing protocols like DSR-MB and MAODV are taking only shortest path to reach the destination.

The shortest path consumes more energy due to repeated usage. This makes network partition and reduce the network lifetime [1] and [2]. The EEMRP not only makes the system energy consumption down but also prolongs the system lifetime and improves the delay characteristics.

The studies show that EEMRP has a better delay performance, lower energy consumption and longer network lifetime. The main idea of EEMRP is that routing forward decisions should be based on each node’s energy level. The ultimate goal of our approach is a good energy balance among mobile nodes, which eventually results in a longer lifetime of the network. The paper addressed multicasting environment and threshold energy level is set for each node. If each node energy level has above than threshold level then it is used for packet forwarding. The MRP algorithm used to calculate the energy in each node and reduce the more energy consumption in a way of choosing the nodes, which has threshold level. The product perspective is shown in Fig.1. The incoming packet is having the energy information of each node that will be analyzed through energy measurement process. After the above process, the best node will be selected and also optimal path selected through routing process.

**SYSTEM ARCHITECTURE**

The overall system architecture consists of the route discoverer is shown in Fig.2. The architecture contains the following modules. Ad hoc network topology creation, route request

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**TABLE I : Constant Bit Rate Generation**

<table>
<thead>
<tr>
<th>Src node</th>
<th>Destn node</th>
<th>No of times the bytes trans</th>
<th>No of bytes trans</th>
<th>Inter Dep time in sec</th>
<th>Sim Start time in sec</th>
<th>Sim End time in Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>250</td>
<td>512</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>250</td>
<td>512</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>250</td>
<td>512</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>250</td>
<td>512</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>250</td>
<td>512</td>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
</tbody>
</table>
packet generator, energy measurer, neighbor energy table, forming group membership, flooding controller.

**The simulation model and performance analysis**

The simulator for evaluating routing protocol of MRP is implemented with the network simulation version 2 (Glomosim2.02). Our simulation assumes the initial energy with 2, 4, 6 and 8 Joule and 100 mobile hosts placed randomly within a 1000m×1000 m area. Radio propagation range for each node is 250 m and channel capacity is 2 M bit/s. The node mobility speed is between 0m/s and 40 m/s generated by uniform distribution and the pause time is 0 s, which means the node, is always moving in the entire simulation period. Each simulation executes for 600s. The simulation altogether produces 40 kinds of stochastic topologies, each group of initial energy corresponds 10 kinds and the collected data is the averaged over those 10 runs. A traffic generator named CBR Generator is developed to simulate constant bit rate sources in Glomosim2.02 is shown in Fig.3. Each CBR package size is 512 bytes and transmits one package for every second. This paper has chosen this value because smaller payload sizes penalize protocols that append source routes to each data packet. The channel and radio model is two-ray ground reflection model [9], which considers both the direct path and a ground reflection path. It is shown [3] that this model gives more accurate prediction at a long distance than the free space model. MAC layer uses IEEE 802.11’s DCF (distributed coordination function [3], which is the basic access method used by mobiles to share the wireless channel under independent ad hoc configuration.

It uses a RTS/CTS/DATA/ACK pattern for all multicast packets. The access scheme is Carrier Sense Multiple Access/collision avoidance (CSMA/CA) with acknowledgments.

**B. Measurement of time and energy**

The following formula used to find the energy level in each node.

Energy (E) = Power × time --- equation (A)

That is, when a node is transmitting or receiving a packet, the energy consumption is directly proportional to transmitting or receiving power and the transmitted time.

The time is calculated as

Time = $8 \times \text{Packet size/Bandwidth}$--- equation (B)

Substituting equation B in equation A

$E_{tx} = P_{tx} \times 8 \times \text{Packet size /Bandwidth}$--- equation (C)

$E_{rx} = P_{rx} \times 8 \times \text{Packet size /Bandwidth}$--- equation (D)

Where $E_{tx}$ and $E_{rx}$ are energy consumed when packet is transmitted and received respectively. $P_{tx}$ and $P_{rx}$ are power consumed when packet transmitted and received respectively.

The energy consumed when nodes are forwarding a packet is equal to the sum of transmitting and receiving the packet,

$E_t = E_{tx} + E_{rx}$  ------------------- equation (E)
When a node is participated to forward a packet then net energy is calculated as

\[ \text{Energy} = E - E_t \quad \text{equation (F)} \]

When a node is not participated to forward a packet then net energy is calculated as

\[ \text{Energy} = E - E_s \quad \text{equation (G)} \]

Where \( E_s \) is sleeping node energy.

When a node is not participated to forward a packet then net power is calculated as

\[ \text{Power (P)} = \text{Power} - \text{Battery Sleep Power} \quad \text{equation (H)} \]

The MRP measures the energy of each node and finds the optimal route based on the energy information that is available in node cache. The node satisfies the threshold level chosen for packet transmission.

C. Neighbor Energy Table Formation:
The beacon request packet sends to every node as shown in Fig.4. The nodes receive the beacon request packet replies energy of each node through beacon reply packet as shown in Fig.5. The neighbor node energy table is formed using both the packet information as shown in Fig.6.

D. Group Membership Formation
The group membership is formed using the beacon request packet, beacon reply packet and neighbor node energy table information as shown in Fig.7.

OPTIMAL ROUTE ALGORITHM
The following algorithm used to identify the optimal route.

Best Neighbor Node Selection Algorithm (Data Packet DP, Neighbor Node Energy Table Size (NET), Multicast Size)
This algorithm Used to choose the next best node for data forwarding.

Step 1: Get the Data Packet, NET size and multicast size as input parameters.

Step 2: If NET size value is equal to 1 then forward data packet.

Step 3: If NET size is not equal then compare the NET IP address with multicast IP address and check the nodes are visited or not.

Step 4: If it is not visited then assign the multicast IP to the node and forward it.

Step 5: Repeat the third step until the entry is equal to NET size and multicast size

Get_Farthest_Node (Data Packet DP)
This algorithm Used to find the farthest node, when no group member is found in NET

Step 1: Get the Data Packet IP as input parameters.

Step 2: Compare NET Battery power with Minimum Battery Power.

Step 3: If NET battery power is less than Minimum Battery Power then get the farthest node.

Not_visited_algorithm (Node address, Data Packet DP)
this algorithm used to find whether the node to which data packet is proposed to be forwarded has already visited or not.

Step1: Get the List of nodes visited from the DP.

Step 2: Compare the node address with list of node address.
**Same Group Algorithm (Data Packet DP)**
This algorithm used to find whether the destination address field of DP is same as to that of nodes multicast address or not.

**Step 1:** compare the multicast address field of data packet header with multicast ID of the node.

**Step 2:** If both the id’s are equal return true otherwise return false.

**EEMRP Algorithm (Data Packet DP):**
This algorithm used to route the data packet to group of nodes with efficient energy saving.

**Step 1:** check the group is same or not.

**Step 2:** If it is same then update the data packet header and process step 3.

**Step 3:** If group size is greater than zero then run best neighbor node selection algorithm.

**Step 4:** If the group is not same and group size is less than zero then exit from the function.

**Identification of the optimal route**
The threshold level is set for each node. The EEMR protocol measures node energy. An each node energy level is above than threshold level then it is used for packet forwarding. The protocol finds the optimal route based on energy in each node cache. The node satisfies the threshold level chosen for packet transmission.

**SIMULATION RESULT**

**Node placement and Simulation Time**
The nodes are placed using (x, y, z) values as shown below. The ten nodes are having the following values.

C:\glomosim-2.02\glomosim\bin>glomosim configured in

<table>
<thead>
<tr>
<th>Group A</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Node 0 (210.35, 159.63, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 1 (479.92, 134.36, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 2 (540.09, 148.58, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 3 (908.71, 162.70, 0.00).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Node 4 (61.90, 267.30, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 5 (485.42, 339.31, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 6 (660.72, 354.36, 0.00).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Node 7 (977.70, 341.71, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 8 (239.05, 681.22, 0.00).</td>
<td></td>
</tr>
<tr>
<td>Node 9 (267.73, 613.37, 0.00).</td>
<td></td>
</tr>
</tbody>
</table>

**Constant Bit Rate Generation**
The constant bit rate is generated using the format as shown in Fig.4. The Table I shows, the node 0 and 9 are source and destination node. The node 0 transferred 512 bytes to node 9 with simulation time of 15 minutes.

**Creating the header class – EEMRP.H**
In This file a data structure for the new packet is to be specified. The route request, route error and route reply format specified.

**Creating the header class – API.H**
The header file contains network, transport and application layer information. In this file power level and idle time are set.

**Creating the header class – RADIO.H**
The header file contains radio related information are set. That is transmitted power; gain and energy of the node are set.

**Creating the parsec engine file – Radio.pc**
In this file energy formula implemented and threshold level are set to check the node energy level.

**Packet Sent Report**

The packet sent report Fig.8. Shows, the nodes 0 to 5 in x-axis are transferring packets to particular nodes. The y-axis shows the number of packets is used for transmission.

![Packet Sent Report](image1)

**Fig.8. Packet Sent Report**

**Packet Received Report**

The packet received report shown in Fig.9. The nodes 5 to 9 in x-axis are receiving packets from the source node. The y-axis shows the number of packets is received during the routing.

![Packet Received Report](image2)

**Fig.9. Packet Received Report**

**Remaining Energy Left in Each Node**

The Fig.10 shows, nodes 1 to 30 shows energy consumed by each node. The small line indicates that the nodes consumed more energy and heavily participated in packet transmission. The tall line indicates that the nodes consumed less energy and lightly participated in packet transmission.

![Remaining Energy Left](image3)

**Fig.10 Remaining Energy Left in Each Node**

**Percentage Error Value**

The percentage error value for a group of nodes is shown in Fig.11. This shows the group of nodes not receiving the packet when some other group of nodes transmitting the packet. The reason behind that some nodes may not have sufficient energy to transmit or the node may be moved from one group to other while transferring packets from one node to other.

![Percentage Error Value](image4)

**Fig.11 Percentage Error Value**
The Table V shows that the group of nodes having percentage error value. A group of nodes are showing the error value 0 when error is not occurs and some nodes are showing the error when error is occurs. It shows that the packets are not reached the destination properly.

**Hits Information Sent**

The Fig 12 shows that the groups of nodes are sent the hit information when the packets are correctly received by group of nodes.

**Miss Information Sent**

The Fig 13 shows that the groups of nodes shows miss the packet when nodes are not receiving the packet correctly.

**Performance Evaluation**

The performance evaluation shows that the comparison between existing algorithm and EEMRP algorithm. The EEMRP algorithm shows the 70 percentage better performance compare with existing algorithm.

From the result, the following information obtained.

- The MRP protocol consumes less energy for the node participating in routing.
- The MRP protocol reduces the end-to-end delay.
- The MRP protocol reduces the overhead.

**CONCLUSION**

In order to implement the energy efficient multicast routing algorithm a wireless topology is created. When a node receives a packet, it opens the packet and performs time calculation. The nodes are grouped based on the energy of the neighbor node. The packets are forwarded to the group of nodes and route cache consistency functions are incorporated that the extent to which the consistency is maintained and
analyzed. The EEMRP algorithm is implemented for multicasting environment with 70% efficient energy of saving and save the life time of the network. The limitation in the system is energy consumption is linear when numbers of nodes are increased.

REFERENCES


