Energy Efficient Maximum Lifetime Ad-Hoc Routing

(*EEMLAR*)

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***Abstract*— A mobile ad-hoc network which does not use a wired network and base station system is composed of a group of mobile and wireless nodes. There are various types of restrictions. The biggest restriction is the confined energy of the batteries. In recent years, mainly focused on the shortest path method to minimize energy, which might result into network failure because some nodes might exhaust fast as they are used repetitively, while some other nodes might not be used at all. This can lead to energy imbalance and to network life reduction and much research has been under taken to not only improve the Energy storage but also to lengthen the networks Lifetime. In this paper, we propose the EEMLAR (Energy Efficient Maximum Lifetime Ad-Hoc Routing) algorithm to improve the networks lifetime in MANET (Mobile Ad-hoc NETwork). One Improvement for the AODV protocol is to maximize the Networks lifetime by applying an Energy efficient maximum lifetime Ad-Hoc Routing algorithm which considerate node energy-aware. We came to know about the effectiveness of EEMLAR algorithm with existing AODV by using NS-2.**

Keywords-component- Mobile Ad-Hoc Networks, energy-efficient routing, simulation analysis, wireless node network Lifetime, Algorithm.

I. INTRODUCTION

A mobile ad-hoc network (MANET) is composed of a group of mobile, wireless nodes which cooperate in forwarding packets in a multi-hop fashion without any centralized administration. Applications of MANETs occur in situations like battlefields, major disaster areas, and outdoor assemblies. A working group called “MANET” has been formed by the Internet Engineering Task Force (IETF) to study the related issues and stimulate research in MANET. MANETs are self configuring wireless networks without any centralized control. As the radio range of mobile nodes is usually small, the nodes must cooperate with each other to keep the network alive. The communication between two nodes usually includes several intermediate nodes forwarding the data packets between the endpoints. Every node acts as a router. The nodes can communicate without any established infrastructure.

The nodes, such as mobile phones, laptops and PDAs, in MANETs are generally lightweight and they operate on batteries. The life of a node is directly proportional to the battery in the device operating at the node. There are many efforts going on both in the industry and the academic research community to design mechanisms to save battery-life in these low powered devises. Hardware manufacturers are now making more energy-efficient devices such as energy efficient CPUs, low power displays units, efficient algorithms for hardware processing and high-density batteries.

Battery power of the nodes is primarily consumed while transmitting packets (in addition to performing the processing in the nodes). As, MANETs are multihop, there are chances of a node’s involvement in data transfer irrespective of not being a target or a source. The routing algorithm decides which of the nodes needs to be selected in a particular communication. Thus, routing algorithms play an important role in saving the energy of a communication system and the life of the nodes and thus of the whole network.

II. RELATED WORK

A. AODV based Energy Efficient Routing Protocol for Maximum Lifetime in MANET:

In this section the author Mr. Jin-Man Kim explained that the energy remaining in the nodes participating in the path between the source and the destination is accumulated and delivered to RREQ message using a new field added to the RREQ message (using 11 bits of the reserved filed). In this case, the destination node does not give a RREP reply immediately to RREQ arrive first, but waits for 3 *

NODE_TRAVERSAL_TIME, receives RREQ destined for the node, and adds the energy of nodes participating in the path. By dividing the whole energy calculated into the number of nodes participating in the network, which is obtained using the hop counter, they obtain the mean energy of network on the participation path.

B. Energy Efficiency of Load Balancing in MANET Routing Protocol

In this section the author Sunsook Jung, discussed about the node caching enhancement of AODV presented in [11]. Then they discuss the adaptive workload balancing technique applied to MANET routing protocol in [12]. Finally, they present a new node caching AODV with adaptive workload balancing which combine the protocols from [11] and [12].

Lee et. al. presented in [12] workload-based adaptive load balancing technique that is based on the idea that by dropping rout request packets (RREQ) according to the load status of each nodes, nodes can be excluded from route paths. This algorithm uses the length of the message queue in nodes and the outstanding workload which is defined as the combination of the queue length and residence time of packets in the queue.

C. Enhancing the Performance of MANETs by Monitoring the Energy Consumption and Use of Mobile Relays

In this method Mr. Niranjan N Chiplunkar considered the rate of energy consumption with a node having multiple thresholds. So for heavy load application (high rate of energy consumption like video) the threshold may be set high. On reaching this threshold the node becomes critical. At this point, the service of a mobile relay is required to balance the load [13].

D. Remaining-Energy Based Routing Protocol for Ad-Hoc Network

In this section Prof. Amir Rajabzadeh considered Remaining-Energy Based Routing (REB-R) protocol leads nodes towards broadcasting their energy level alongside the data to their neighbors and let nodes choose their parents with highest energy level and forward data to it. They proposed A node broadcasts two types of packets. First one is FWD_ROUTE and the other one is DATA. For these two types, we use a bit to distinguish packet’s type and the mentioned bit is “type” bit. For “energy” part, single precision floating point numbers or number of residual packets could be used.

E. A Novel Energy-Efficient Approach to DSR Based Routing Protocol for Ad Hoc Network

In this method Prof. Jinfeng Ding proposed an energy efficient routing protocol NCE-DSR(Number of times nodes send Constraint Energy DSR), this protocol is based on DSR and marks related to the number of times of sending message are added to the datagram for routing protocol. The nodes with relatively more number of times of sending message are protected when in use, routing cost function is designed for route choice to prolong the survival time of each node and that of the whole network.

F. An Energy Efficient Flat Routing Protocol for Wireless Ad hoc Network

In this section Prof. Sanjay Kumar Dhurandher proposed a new routing protocol, called Energy Efficient Dynamic Source Routing (E2DSR) that is energy efficient [15]. Energy efficiency is a critical issue for battery-operated mobile devices in ad hoc networks. As mentioned, unbalanced power consumption may not only result in earlier node failure in overloaded nodes, but also lead to network partitioning and a decrease in route reliability [16]. So, there is a need to both improve energy efficiency and balance battery consumption among nodes in MANET to reduce the number of critical nodes in the network.

Rest of this paper is organized as follows: section 3 presents proposed algorithm. System simulation model, implementation details and simulation results are explained in Chapter 4. Finally, Chapter 5 presents the conclusion of the current work and future work.

Conventionally used algorithms such as DSR [2] and AODV [1] do not take care of energy in nodes in determining a route that leads to an imbalance of energy level in the network. Some nodes die out soon as they are used in most of the packet transmission paths and on the contrary, there are nodes that are not used even a single time. This energy imbalance affects the reliability of the system. Our proposed algorithm involves energy metrics that help in finding out such a routing path that does not leave nodes exhausted and that selects a better energy saving path. Our algorithm tries to establish a balance of energy among the nodes. It also provides a mechanism by which an Administrator can adjust parameters such as energy and time saving. For example, at the start the Administrator may wish to have a routing policy more suitable for time saving and after some duration, s/he might switch to energy saving.

III. . PROPOSED ALGORITHM

A. Design criteria considered in our algorithm

- keeping track of the residual battery power
- Keeping track of previously used paths
- Keeping back-up paths
- Keeping track of the message overhead
- On-demand calculation/update of routing tables
- Sending data packets at a lower energy compared to the RREP/RREQ

- Moving the nodes to sleep mode when they are not being used
- Requiring a node to send packets with energy
- proportional to the distance rather than with fixed energy
- Using a hierarchical routing technique
- Using directional antennas
- Transmitting the data packets by taking into
- consideration the actual amount of energy required to transmit

B. *Need to prolong Ad-Hoc network Lifetime*

A key challenge in ad hoc wireless network is achieving a long lifetime of nodes that carry limited amount of battery energy. It could be impossible or inconvenient to recharge the battery in the remote location therefore, the crucial requirement is to prolong the network life time.

C. *Energy Efficient Maximum Lifetime Ad-Hoc Routing: EEMLAR*

We consider the power level of each node while calculating the route, in order to increase the network life. Whenever a node is involved in any transaction, it loses some amount of energy whose value depends on factors such as the nature of packets, their size and the distance between the nodes. An optimization function considers all these factors and decides which one, amongst all the discovered paths, should be selected for an energy-efficient transmission.

In all the earlier algorithms, there is a high probability of repetitively selecting a particular node (the "best node" according to some criterion), which can lead to early exhaustion of the node, thereby affecting the network connectivity. However, we have considered individual battery power in considering the path, that is, if there is a path with a node having very low energy level, then optimization function does not choose that path, irrespective of whether that path is time efficient. Also, the number of hops is an important criterion, as the large number of hops will help in reducing the range of power transmission and, thus, saving energy. Time is also a criterion, as the lower the time, the shorter will be the path, and the lower will be the total amount of energy consumed. But some nodes might get overused and die out quickly.

D. *Optimization Function:*

The objective is to find out best energy efficient algorithm that will lead to the maximization of system lifetime. The energy cost function for selecting the energy efficient path is calculated by

$$\text{Cost} = \text{time} + \frac{1}{\textit{remaining energy of node in route}} + \frac{1}{\textit{no.of hops}}$$

D. *(a) Time*:

It is the simulation time taken by RREQ to reach the destination from the source for a particular route.

D. (b) Remaining energy of node in route

It is the sum of the remaining energy available at all the nodes in the route under consideration.

D. (c) Number of Hops:

It is the total no. of nodes present in the route under consideration.

E. *Pseudo Code:*

In this Section, we present the pseudo-code of the proposed EEMLAR algorithm.

A node wants to transmit data packet:

```
If (path→ destination is found in RT && path ≠ expired)
  {
     Selected path ( )
  }
       Else                    // find the path
{
   Void find path ( );
   Broadcast RREQ to neighbor nodes;
Valid RREQ received by nodes;
        If
          {
  {
      RREQ receiving node = destination node;
      If
        {
          RREP has been sent by destination node;
          It is a duplicate RREQ, reject it;
      Else
          If it is the first RREQ from the source;
          Setup the timer for δt duration;
```

```
            }
         }
         Do the corresponding entry in seen table;
         Wait for new valid REQ until δt time out.
       }
   Else,
       {
         Node is intermediate node;
       Do the corresponding entry in seen table;
       Find path ( )
      }
Void selected path ( )
 {
   Source transmits data through the selected path;
  Else
       {
         If some valid back-up path which is not
         timed out, select that path;
         Selected path ( )
         Else
             {
Send RREQ again or logout
             }
       }
```

At destination node:

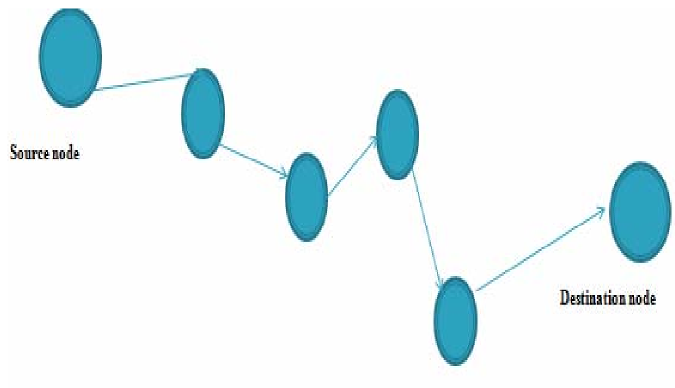
```
  If
       {
         Time interval δt passes;
          Calculate best path with lowest cost;
         Also take some backup paths;
          Send RREP;
       }
```

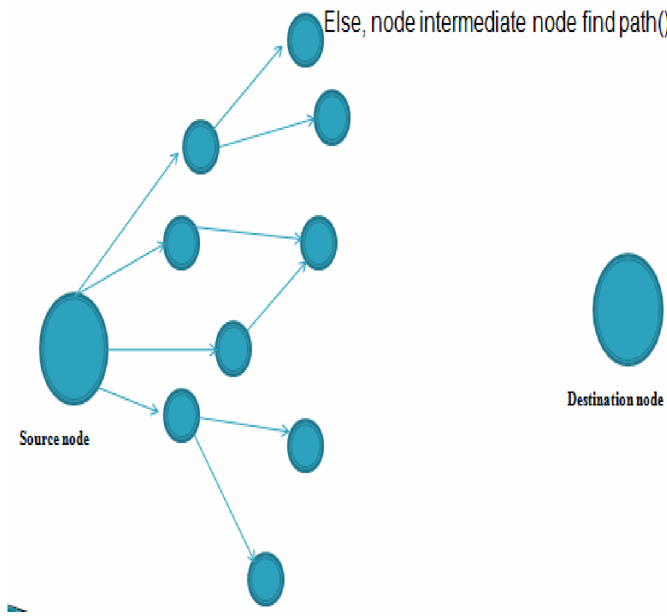
At source node :

```
 If
     {
           Source receives RREP within timeout interval;
           Source updates RT with those selected path;
           Selected path ( )
     }
```

F. Operation of the Proposed Algorithm: EEMLAR

When a source node wants to transmit data to destination, first it looks whether there is any existing valid (whose entry has not expired) path in the routing table. If it exists, the node uses that path. Otherwise, it sends RREQs to its neighbor nodes. When a node (either destination or intermediate) receives RREQ, it ensures that the received RREQ is not a duplicate RREQ, in order to prevent looping paths. If the neighbor node is the destination, it sends RREP. Otherwise, the neighbor nodes see whether they have any valid path in their tables. If they do, they forward RREQs to that path. Otherwise, they send new RREQ to all their neighbor nodes to find the destination. When the destination gets the first RREQ, it waits for ∂t time and collects all other RREQ coming in this time interval. After time, it calls the optimization function to determine the best path to select and send RREP. It also stores some other relatively inferior paths as backup paths, which may be used if there is some network failure, thereby avoiding energy and time wastage in recalculating the path. When the source gets the RREP, it sends the data packets.





The criterion for setting the value of ∂T: ∂T is the time for which the destination node should wait for other RREQ packets after getting the first RREQ. ∂T is determined by the density of the node. If density is high, the value of this parameter should be less, as compared to partially isolated network. The value of this parameter should be optimum for energy saving as it will help in finding more optimum paths and also in preventing the case of waiting in excess or in short time.

IV. SIMULATION ANALYSIS AND RESULTS

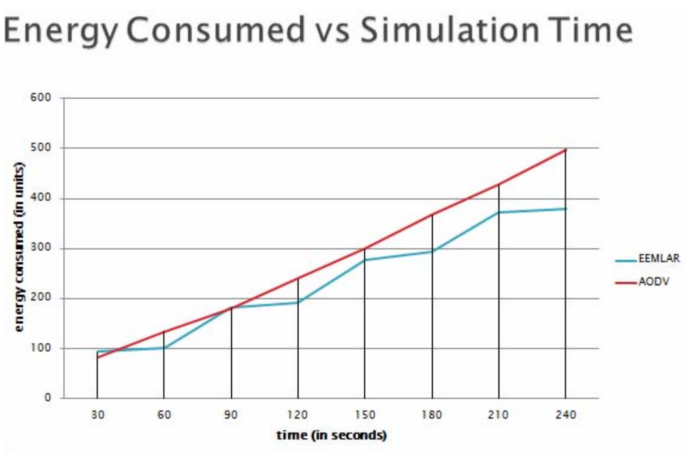
We propose a New-AODV protocol which extends the entire network lifetime in an Ad-hoc network environment through NS-2[17]. Each mobile node, by nature, has an important role in an Ad-hoc network. Particularly, each node's energy state has a huge influence on the entire network lifetime.

We attempted to extend the entire network lifetime by adjusting RREP delay.

As a result, we know that applying Energy efficient maximum lifetime Ad-Hoc routing (EEMLAR) to AODV protocol via NS-2 does have a positive result in extending the entire network lifetime.

We selected a 2000m x 2000m dimension area with 20, 30,40,69,80,100 nodes. A node's location was set to be random and the nodes have a random speed varying from 0 to 10m/s.

The main objective of designing EEMLAR was to Increase the network life, by distributing the network load and selecting paths containing nodes with higher Power levels. The graph in Fig. 4.1 shows the total energy consumed in different sessions, by AODV and EEMLAR.



From Fig. IV. (a) we infer the following:

IV. (a) Energy Consumed:

EEMLAR does not perform too well in the beginning as compared to AODV, but it improves later. Initially, it is not better than AODV because, initially, all the energy of the nodes are equal. So, we uselessly wait for δt time as all paths have equal energy in the beginning. AODV does not wait for time and is thus better performing in the beginning. But at a later stage, as time increases, there is some imbalance of energy that comes into play and then our algorithm's effect comes into play.

IV. (b) Network Lifetime:

We can see that Energy consumed in EEMLAR is less compared to AODV. Fig. IV (b) shows the trend in the network life. Network life was observed to be proportional to the energy left in the nodes. It was also observed that EEMLAR increases the network life by avoiding the repeated usage of nodes.

The graph in Fig. IV (c) shows the available power level of the nodes in the paths selected by EEMLAR and AODV. It was observed that AODV, during the path selection, selects Nodes 8,12,14 and 18 and it does not choose Nodes 10,13,15 and 16. We can see there is a great node energy variance in AODV.

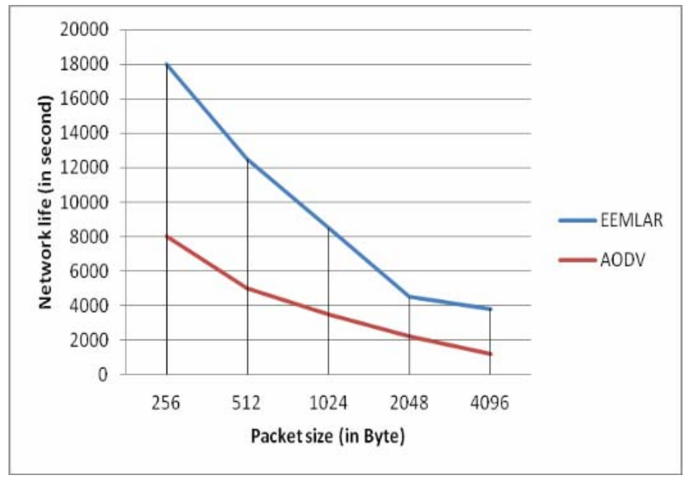


Fig. IV (b) EEMLAR helps increasing in Network Life

When we repeat this experiment with EEMLAR, we can see all nodes energy level taken in the path have little variance. We did this experiment with 30 nodes and found that AODV chooses the same nodes every time irrespective of there being a danger of some node getting depleted of energy faster (Nodes 8, 12, 14 and 18, in this case). On the other hand, EEMLAR keeps changing path as time goes on and maintains the energy load balance.

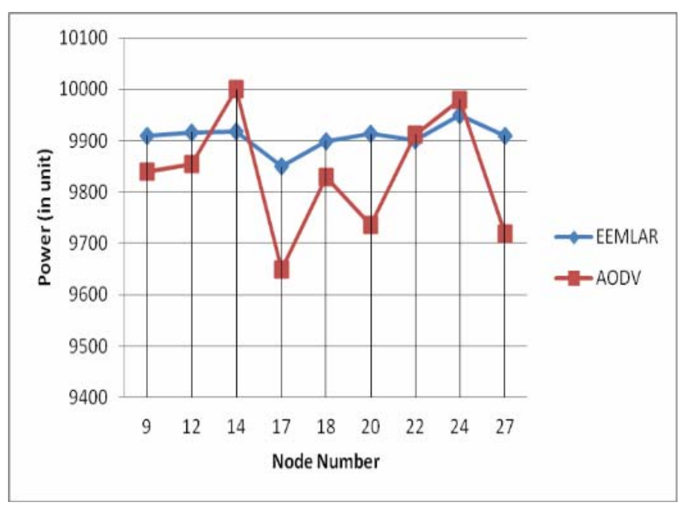


Fig IV(c) Available Power level of the node in the selected path

IV (C) Remaining Node Energy:

Fig. IV (d) shows the remaining node energy defines the amount of remaining energy of all nodes at the end of simulation.

Simulation results from the graph show that in EEMLAR energy consumed from each node is almost same, whereas in case of AODV, energy consumed at various nodes has very large variations. Some nodes are almost exhausted, whereas some nodes have large amount of energy remained, in case of AODV.

This happens because AODV chooses same node every time whereas EEMLAR tries to find optimal energy efficient path every time.

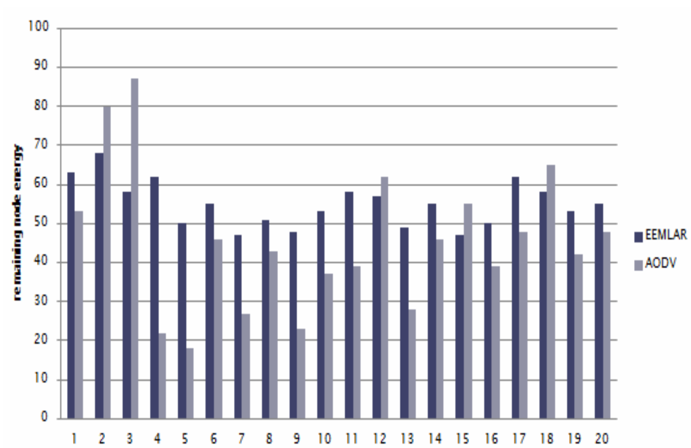


Fig IV (d) Remaining energy of all nodes at the end of simulation.

V. CONCLUSIONS AND FUTURE WORK

The simulation results showed that our algorithm performs better than the popular conventional on demand routing algorithm, AODV, in the following respects:

Network Life: Network life increases as we save energy in the individual nodes, by providing load balancing. Thus, implicitly, the network life increases as well.

Energy Consumed: Total energy consumed by our algorithm is much less compared to AODV.

Future work should also investigate the feasibility of applying different techniques to improve the performance of the proposed approach. Introducing the advantages of clustering and directional antennas in our approach and keeping their harmful effects away should also be studied. The problem of automatically updating the workload and node requirements in the network should also be studied. In this paper, energy efficient maximum lifetime Ad-Hoc routing EEMLAR has been introduced that provide energy efficient path for data transmission and maximize the lifetime of entire network. In simulation scenario we have consider 20 to 100 nodes that can communicate with in Ad-Hoc network. For large scale network where more number of nodes can communicate with the creation of an Ad-Hoc network. Then we require an specific problem definition and routing algorithm required.

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