International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

Energy Efficiency and Network Lifetime Improvement in MANET using AOMDV

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***Abstract*—MANET is a network of devices that can move independently across the network. It lacks a fixed infrastructure. Since the devices are moving across the network, its battery will weaken quickly and lifetime of the MANET will decrease. Thus energy consumption is treated as one main drawback in MANET. This paper deals with a strategy to improve the energy efficiency and network lifetime in mobile ad hoc network by using a multipath routing protocol AOMDV. The proposed EE AOMDV uses energy thresholds to select energy efficient paths from available paths at the time of routing. Analysis of the proposed EE AOMDV protocol is conducted using NS2. When AOMDV is compared with EE AOMDV, the results indicate that the proposed EE AOMDV is more energy efficient than AOMDV. The parameters used for the analysis are energy consumption of the network and lifetime of the network by varying node speed, data rate and simulation time. The proposed EE AOMDV performs better in all scenarios.**

***Keywords*—MANET, AOMDV, EE AOMDV**

I. INTRODUCTION

MANETs are constructed using several mobile devices. These devices can communicate through wireless links without the need for central control. In MANETs routing functionality is integrated into mobile nodes and thereby provide effective
network operation. The network is characterized by dynamic topology. In MANET each device is powered using the battery and the limited battery power of devices becomes an issue. As the battery capacity of devices gets exhausted, the links between communicating devices may break and thus it will affect the network survivability. So it is necessary to provide a provision for saving the energy or battery level of the network in an appropriate way. Such networks are very helpful in a
lot of situations like military applications, emergency rescue operations, education, sensing, and gaming, personal area networking[9][10]. Military is one of the most relevant application domains of mobile ad hoc networks because we can't set up a fixed infrastructure in the enemy territories or inhospitable terrains. In this situation MANET provides the required communication within no time. So even the soldiers move freely, the network should connected without any communication hindrance. MANET is useful in emergency rescue operations. Due to natural disasters like Tsunamis, hurricanes, earthquake etc, the entire communication infrastructure in an area can be unusable and hence restoring the communications rapidly is essential. In education sector MANET communication can be used in campus, virtual classrooms and during meetings. Sensor network is a type of MANET in which power is a main concern. Sensors are used to measure the temperature, humidity, pressure in the atmosphere. In this scenario a MANET can be used to collect these required information. MANET can also useful in Personal Area Network to share information between devices like laptops, mobile phones etc. These devices create a network to share the information to and from each other.

Adding energy efficiency in routing process can improve the efficiency and lifetime of the MANET by routing the data traffic through routes with high energy level. Multipath routing protocols provide with alternate paths during each route discovery process. This will decrease the number of route discovery processes since there are backup routes already available in case one path fails. In the proposed Energy Efficient AOMDV (EE AOMDV), two parameters are considered in order to select best paths. One is residual energy of nodes in the path and another one is the hopcount of the path. This will select paths with shortest distance and higher energy levels first. When such paths are not available it will select path based on shortest distance.

AOMDV finds multiple routes during each route discovery process. It is useful in highly dynamic networks where link failures and route breaks likely occur. If AODV is used in this scenario, a new path discovery is invoked as each path fails and increase the overhead and latency. If multiple alternate paths are available this limitation can be avoided. In AOMDV, a new path discovery is invoked only when all routes to the particular destination fails. AOMDV is such a multipath protocol which is an extension of AODV because it uses already available information from AODV. This will reduce the overhead[1].

Each copy of route request a node receives during the route discovery indicates an alternate reverse path. If a node accepts all such redundant route request packets, it will create routing loops. To prevent formation of such loops and to guarantee loop freedom AOMDV uses advertised hop count. Advertised hop count is the greater hop count of all routes available at that node. It will never change for same sequence number. Advertised hop count get updated as the sequence number updates. AOMDV uses advertised hop count rather than hop count in AODV. Nexthop in AODV is replaced by nexthop list and corresponding hopcounts in AOMDV. AOMDV uses three control packets RREQ, RREP, and REER. Before data transmission the source node will start a

International Journal of Engineering Research & Technology (IJERT)
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route discovery by flooding RREQ packet. Due to flooding an intermediate node may receive redundant copies of same RREQ. This duplicate packets undergo a check to find reverse paths. The reverse paths are chosen based on loop freedom and RREP packets are generated by the node and transmit back to the sender using these reverse paths. Like intermediate nodes destination also form reverse route and in response to each RREQ arrives the destination, it produces a RREP. The RERR packet is used for route maintenance. When a connection break, RRER is generated and forward to the sender. On the way when the intermediate node get this error message, it will check whether the node sends the RERR is its nexthop. If so it will make this route table invalid and forward the error message to the source node. Path discovery process is represented below in Figure1 and Figure2 [2].

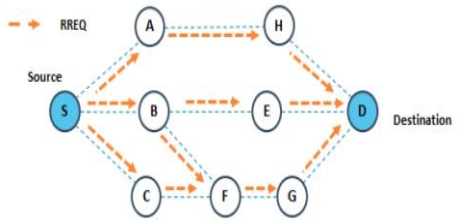

Figure 1:Route request flood

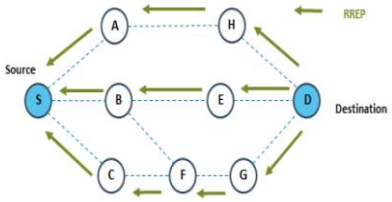

Figure 2:Route reply flood

Two types of disjoint path exist, the node-disjoint path and link-disjoint path. In a node-disjoint path, there is no common node exists in a specific path other than the source and destination nodes. In a link-disjoint path, there is no link in common. Figure 3 illustrates the notion of node and link disjoint paths. The routes ABE, ACE, and ADE have no common node or link, as illustrated in Figure 3(a). Thus, they are link and node-disjoint paths. Figure 3(b) shows the routes ABCDE and ACE have node C in common; however, there is no link in common, which makes a link-disjoint path without a node disjoint path. Lastly, Figure 3(c) illustrates the routes ABCE and ABE, which have both the link AB and the node B in common; therefore, they do not have a disjoint path[3].

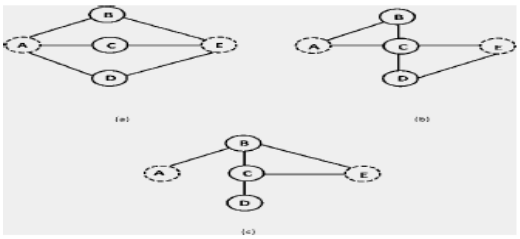

Figure 3: Link and Node disjoint paths

II. LITERATURE SURVEY

Omar Smail and Bernard Cousin [4] proposed a multipath routing protocol called AOMR-LM. AOMR- LM is based on AOMDV which uses a path classification method based on the remaining energy level of nodes forming the paths. This energy classification can be high, average or low. The key idea is to build homogeneous routes in terms of energy level. Thus energy consumption of nodes can be balanced .

Devi Manickavelu1, Rhymend Uthariaraj Vaidyanathan [5] proposed a lifetime prediction algorithm based on PSO for route recovery in MANET. The proposed method predict lifetime of link and node based on mobility and energy drain rate. These parameters undergo fuzzification and fuzzy rules are generated to decide node's status using predictions. The node status can be weak, normal or strong. This status information is exchanged between all nodes. Before transmitting data to another node, its status is verified.

Baolin Sun, Chao Gui, Pengyuan Liu [6] a multipath routing optimization algorithm in MANET based on genetic algorithm. The main idea behind the algorithm is to finds the node with minimum remaining energy in each route when selecting the routes. It can balance energy consumed by individual nodes and enhances the entire network's lifetime and energy variation.

Jinkuan Wang, Cuirong Wang [7] proposed a method in which no information regarding the neighbor hoods needs to be stored by the nodes. To estimate the link's stability, link expiration time is used. Based on LET alternate stable paths are discovered by the critical LET zone and thus ensures reliable data transmission. This adaptive maintenance assures continuous data transmission.

Prasanta Kumar Manohari , Niranjan K [8] proposed a protocol named EAOMDV. It depends on AOMDV but choose routes between sender and destination based on RCF. RCF or route cost function is evaluated based on battery level and present traffic on nodes.

III. PROPOSED EE AOMDV

EE AOMDV uses energy thresholds for selecting the nodes with high residual energy. In this way, energy consumption can be reduced for the whole network. The proposed EE AOMDV protocol aims to select paths with high remaining energy and less energy utilization. This avoids link failures caused due to the depletion of node's energy and thereby increasing the lifetime of the network and improves the energy performance in MANETs. The algorithm determines which of the devices in the network need to be selected in a particular route. When we select mobile devices without considering it's remaining energy level while deciding the routes will leave an uneven energy level in the entire network. Devices on the routes which has the least remaining energy level could suddenly end up depleted while other devices stay connected. This will cause the early demise of certain devices. EE AOMDV takes three types of information to select the best routes. They are the remaining energy level of all nodes in the path, the distance of the path and finally the energy consumed by all nodes in the path. The best route will

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

be the route that has the highest energy level and less distance. By doing so it can improve the energy efficiency and lifetime of the network. When such routes are unavailable it will select alternate paths with the shortest distance. Algorithm1 describes this process.

Algorithm1 :
1) Select source and destination for routing
2) Source node starts route discovery process
3) During route maintenance each node will checks its remaining energy level with a threshold value (high1)
4) For every nodes in the path if remaining energy > high1 && hopcount < minimum_hopcount
select that path for communication in the network
5) Else if select path with shortest distance and use that path for communication.
6) Send the periodic route discovery.

Now by using energy consumption rate between two time slot instead of just taking the remaining energy of the node at a particular time, the algorithm is modified. Compared the energy consumption rate of the nodes in the route discovery, route reply, and route maintenance processes. Each mobile device will calculate the energy it consumed between two time slots. The hello time interval is used for this purpose. The energy consumption rate between two time slots can be calculated using Algorithm 2[2].

Algorithm 2 :
1) $Energy_{time1}$ and $Energy_{time2}$ are the remaining energies at time1 and time 2
2) for each hello time interval, calculate
3) Energy Consumption rate = (($Energy_{time2}$ -$Energy_{time1}$) / $Energy_{time1}$) * 100

When a node receives a RREQ packet, RREP packet or HELLO packet it will check the energy consumption rate with threshold values selected (say thld1,thld2,thld3). During the route discovery phase, when the energy consumption rate for a particular node is greater than thld1(for RREQ) or greater than thld2(for RREP), it will drop the packet. Here thresholds are selected based on simulation results where thld1 is greater than thld2. Otherwise, it continues to transmit the packet further. During route maintenance, each node checks the energy consumption rate with another threshold thld3 and if the energy consumption rate is greater than thld3 it will mark paths true to indicate that this path has greater energy consumption and hence it's energy level might be low. The algorithm3 includes this process.

Algorithm 3 :
1) Begin route discovery process
2) If a node receives RREQ packet and if the Energy Consumption rate >thld1 goto 4 else goto 5
3) If a node receives RREP packet then check whether Energy Consumption rate >thld2, If yes goto 4 else goto 5
4) Drop the packet
5) Check the Energy Consumption rate for all nodes in the path and if Energy Consumption rate >thld3, mark that path to indicate high energy consumption or low energy level.
6) stop

During path selection, the algorithm chooses paths with high energy and shortest distance first. When no more such paths are available it will select the alternate path with the shortest distance.

IV SIMULATION AND ANALYSIS

The tool used for implementing the project is NS2. 35. Graphs are generated using xgraph. I have installed ns2. 35 in ubuntu 1.04 using the steps mentioned in [11]. Energy consumption and Network lifetime are analyzed for AOMDV, EE AOMDV using remaining energy level(EE AOMDV1) and EE AOMDV using energy consumption rate (EE AOMDV2). The analysis shows that EE AOMDV performs better in all situations. Energy consumption and network lifetime is calculated by varying nodespeed, simulation time, and data rate. As node speed increases AOMDV consumes more energy than both EE AOMDV1(EE AOMDV using node's remaining energy level) and EE AOMDV2(EE AOMDV usig energy consumption rate). Similarly as simulation time increases energy consumption of all protocols increases whereas AOMDV has more consumption and EE AOMDV2 has the least. Figure 6. shows energy consumption with respect to data rate. X axis of the graph contains packet sending time interval .As this time interval decreases data rate increases and as data rate increases ,more energy is consumed. But EE AOMDV has less consumption compared to AOMDV. In Figure 7 X axis of graph shows speed and Y axis indicates no.of dead nodes.As node speed increases more nodes are exhausted in AOMDV. While EE AOMDV1 and EE AOMDV 2 has less number of dead nodes compared to AOMDV. Hence it improves network lifetime. As in Figure 9, as the time interval for sending packets reduces(more packets send and data rate increases),the no.of dead nodes increases. But AOMDV has more deadnodes.EE AOMDV using the remaining energy level(EE AOMDV1) has lesser dead nodes than AOMDV. The network life time can be improved further using EE AOMDV which uses energy consumption rate(EE AOMDV2). Simulation results shows that EE AOMDV has longer network lifetime.

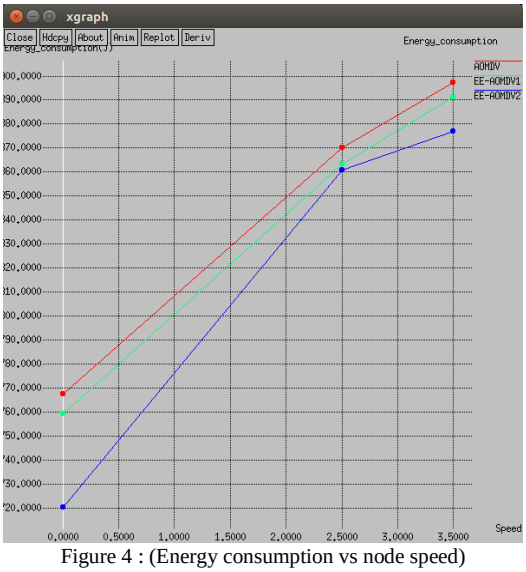

Figure 4 : (Energy consumption vs node speed)

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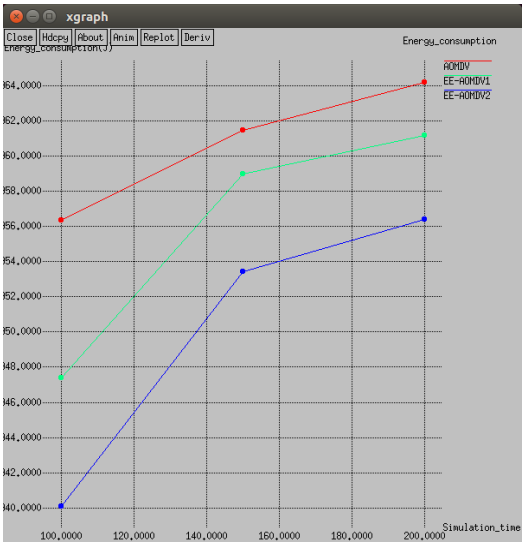

Figure 5 : (Energy consumption vs simulation time)

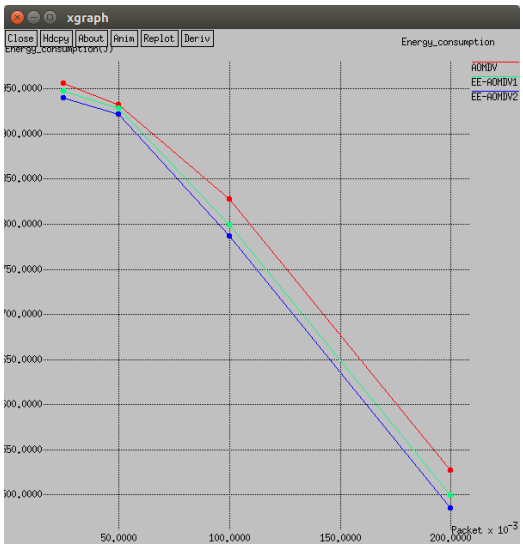

Figure 6 : (Energy consumption vs datarate)

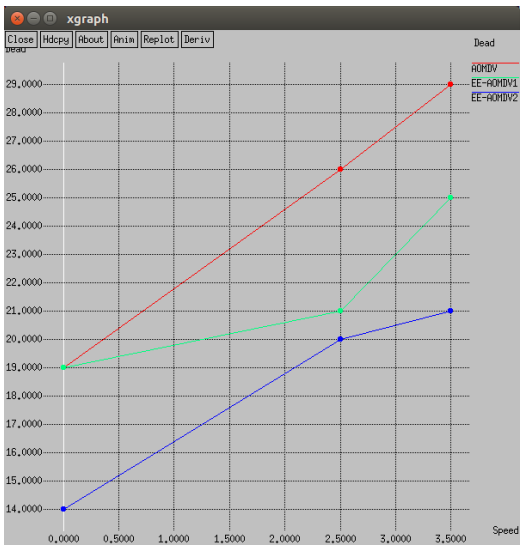

Figure 7 : (No.of dead nodes vs node speed)

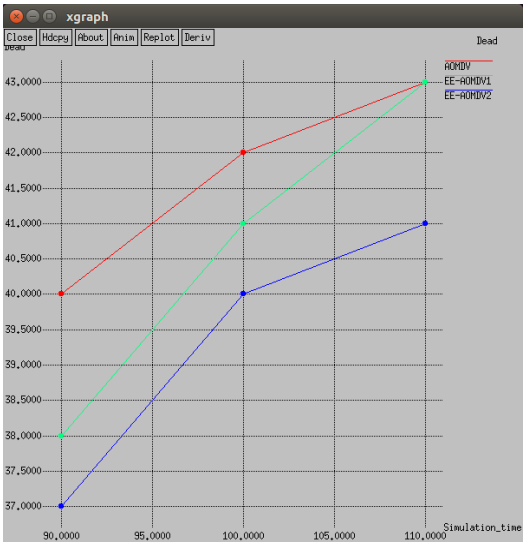

Figure 8 : (No.of dead nodes vs simulation time)

Figure 9 : (No.of dead nodes vs packet sending time interval)

V CONCLUSION

MANETs or Mobile ad hoc networks are infrastructure less networks that is very useful in military and other applications such as emergency rescue, personal area networking ,education sectors or in a place where no means of cellular communication is available . MANET consist of several mobile devices or nodes which can communicate each other without the help of a central authority. Every devices in MANET are powered by the battery. Due to the frequently changing topology of MANETs chances of draining the battery of mobile devices in the network are high. With the help of energy efficient routing, we can save the energy level of the network to an extent. In this system, an energy efficient multipath protocol called EE AOMDV is proposed which uses different energy thresholds to select more efficient paths. Result analysis of the simulation shows that EE AOMDV provides better results than AOMDV. In this system, thresholds are selected based on simulation results. In the future we can enhance the efficiency of the system further by incorporating analytical methods to calculate the thresholds.

International Journal of Engineering Research & Technology (IJERT)
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