Improving Network Lifetime of Mobile Adhoc Network using Modified LAR

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Abstract- *Mobile Ad-hoc network (MANET) is a group of wireless mobile devices that are self-organized. They create a network that is dynamic in topology and is without a central coordinator or base station. A reduced network lifetime is the major challenge of MANET due to restricted battery life of mobile device and inefficient routing protocols. This paper presents the development of an Improved Energy aware routing protocol IE-AODV which is an improvement on the existing energy aware AODV routing protocol. All nodes in the network calculate their present processing state (PPS). Route selection is done based on the present processing state of nodes. To further reduce overhead, a Time to live (TTL) threshold value and a PPS threshold value was set. When the PPS of a node is below the threshold value, the node is not considered in the routing path. Simulation results showed that IE-AODV has improved the network lifetime of energy aware AODV routing protocol by reducing the network overhead. IE-AODV improved the network lifetime by 2.3% as a function of number of nodes and 4.9% as a function of node mobility over the E-AODV protocol. In conclusion, the performance of IE-AODV is better than E-AODV in terms of network lifetime.*

Keywords: TTL, PPS, MANET, AODV, Energy Aware.

I. INTRODUCTION

Wireless networks are classified into two types, one with a specified base station or infrastructure and the other is without specification in terms of infrastructure [11][6]. Mobile Ad-Hoc Networks (MANETs) are wireless networks that are dynamic in topology and as such their topologies changes [4][12]. Due to the absence of a central coordinator, routing in ad- hoc wireless network is now complex [5][15]. This justifies the distributed pattern of routing whereby all nodes coordinate themselves to enable communication in the given network area [2][14]. Energy aware Ad-hoc On-Demand Distance Vector (AODV) route search ensures that a source node transmit control packets which include majorly the Route Request (RREQ) packet and the route reply (RREP) packets [3]. This is shown in fig 1 and 2 [10]. In order to take full advantage of the lifetime of nodes, traffic should be routed is in such a way that energy consumption is significantly minimized as energy efficient routing improves the battery life of nodes [4][8]. This paper presents an Improved Energy aware routing protocol (IE-AODV), IE-AODV routing is based on restricting the TTL value of control packets to a maximum threshold value in order to reduce network overhead. Also, to mitigate network overhead during route search, the LAR protocol was adopted. Route search is done based on the present processing state of nodes. Nodes with high value of PPS were selected as routing path [1]. The PPS of nodes calculates the current input traffic of nodes and their current energy. In this paper, we simulate and compare the network lifetime of two routing protocols; Energy aware routing protocol (E-AODV) based on current processing state of nodes and Improved Energy aware routing protocol (IE-AODV) [11] [16]. The methodologies of this work consisted of first creating the source and destination in the NS2 environment, implementing the knapsack algorithm for calculating node Present Processing State (PPS), using the Location Aided Routing (LAR) scheme for route search in terms of restricted TTL , defining and simulating a basic scenario, and finally, by varying the number of nodes and node mobility[9][8]. The performance metric is the network lifetime in terms of number of nodes and node velocity.

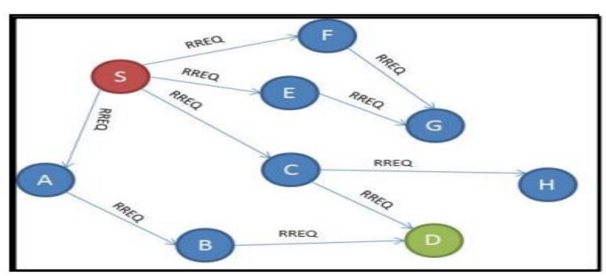

Fig 1: RREQ transmission for route search in AODV [20].

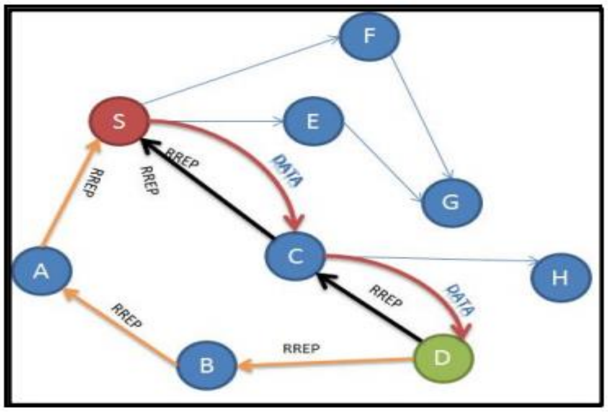

Fig 2: RREP transmission for route search in AODV [20]

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II. RELATED WORK

The effect of altering the TTL value in a control packet was proposed by [1]. It was adopted b in a control packet. It was adopted by the researchers to show route discovery process in AODV routing protocol with the aim of mitigating network overhead. With respect to diameter TTL parameters is selected based on the diameter were arbitrarily chosen in the work. In order to analyze the effects of TTL parameters (TTL threshold and TTL increment) on route discovery process, simulation was carried using OPNET simulator. The result of the work showed that performance of route discovery, link failure and repair depends on optimal value of TTL increment and threshold. However, in their work, a lot of node energy will be expended as constant route update is required for node location during route search thereby reducing network lifetime. Also, the work did not take into account the challenges encountered during data packet forwarding such as; the possibility of a node becoming a bottleneck as this will reduce the systems throughput**.** Performance comparison of energy efficient AODV protocols in MANET was proposed by [14]. Simulation results showed that the work was able to optimize the control messages handling process of AODV routing protocol to conserve the energy of nodes. To achieve this, a threshold level of energy was adopted which strictly determines if a node should participate in routing process or not. This decision presents the possibility of such a node to suffer bottleneck (point of congestion) as node would want to process many packet based on its energy alone and this will lead to rapid draining of energy, delay of packet transmission and subsequently, energy consumption. The work also experience large route search delay due to frequent update of routing table during route search and this may lead to a reduced network lifetime.

A system which is a type of hybrid MANET protocol that makes use of functionality of both topology based routing and position based routing protocols was proposed by [13]. The paper proposed a new design for 802.11 MANET protocol which is a hybrid of features from AODV and LAR protocols for mobile nodes which helps against the possibility of collision and reducing end-to-end delay for a single source. The proposed system suggests that only a single source is allowed to communicate with an intermediary node at a giving time not minding the fact that the current intermediary node has the capacity to process packets from multiple source with respect to its energy and buffer size. Hence the proposed system introduces source delay, reduced throughput and power consumption as other sources who attempt to transmit via a common intermediary node most have to wait till when the network is sensed to be free. A modified local route repair method from the existing one was developed by [17]. The work improved the existing local route repair method in AODV to ensure an efficient quality of broadcast of packets and minimize flooding process. To achieve this, the developed scheme initially creates the group of mobile nodes and then broadcast packets. If the link breaks or fails, the requestor (intermediate node that only forwards request in both sides) node broadcast RREQ packet after increasing the destination sequence number and waits for RREP. However, the work did not consider altering the TTL value of the RREQ packet in other to provide efficient number of routes as this will minimize the scope of link failure. Also, the possibility of a node becoming a bottleneck was not considered as this may result in link failure and hence reduce the network throughput. A new energy aware reactive routing protocol based on current processing state of node for MANET to avoid the node to become a bottleneck (point of congestion) was proposed by [11]. The work showed that if the choice of a routing path is based on a node satisfying a threshold level, there is a possibility of having heavy traffic on that path because a node may be accepting heavy traffic due to its current energy which may lead to quick nodes energy depletion. This effect will lead to low throughput, congestion and thus the intermediate node becomes a bottleneck. The protocol finds energy efficient route from source to destination based on the concept of knapsacks problem in which route is selected based on node energy and input buffer traffic in other to avoid a node to become a bottleneck and thus achieved an increase in the lifetime of the network. Thus, during route search, the work considered metrics such as bandwidth and energy of nodes for choosing a route path. The research proposed a mechanism that addressed two important network performance parameters that is, network lifetime and throughput. The simulation indicated that the developed mechanism is better than the existing energy aware AODV routing protocols. However, in terms of routing, the network maintained the topology based algorithm of the AODV that requires routing update frequently. This route update consumes energy as nodes need to update their routing table as topology is dynamic.

Hence, the packet delivery ratio of the network will be reduced significantly due to increase in latency. Moreover, the protocol will experience over or under search of valid route to the destination due to unspecified TTL threshold value for packet transmission [19] [20]. This effect will alter the route search time and traffic overhead therefore reducing the network lifetime. An Energy Efficient Ad Hoc Distance Vector (EE-AODV) routing protocol which enhanced the existing AODV routing protocol was developed by [18]. The adopted EE-AODV has enhanced the RREQ and RREP handling process to save the energy in mobile devices. EE-AODV considers some level of energy as the minimum energy which should be available in the node to be used as an intermediary node (or hop). When the energy of a node reaches to or below that level, the node should not be considered as an intermediary node, until and unless no alternative path is available. Simulation results show that lifetime of network increased in EE-AODV as compared to AODV. However, the network lifetime can also be increased if the network routing overhead is mitigated.

III. METHODOLOGY

This work developed an improved energy aware routing protocol (IE-AODV) using a modified Location Aided Routing protocol (mLAR) to mitigate network overhead and thus increase the network lifetime of nodes. The developed protocol selects route with highest PPS value within a set TTL threshold value of 7.

A. Assumptions of IE-AODV routing protocol

1. A network area of 500x500 was considered with 100 nodes randomly distributed.

2. To implement mLAR, the source node is assumed to know the previous location of the destination node in the given network area.

3. All nodes in the given network area are assumed to be transmitting and a dense network scenario was considered.

B. Developed Routing Algorithm

The improved energy aware routing protocol IE-AODV has reduced the network overhead of MANET by optimizing the RREQ handling process. IE-AODV considers node with high PPS value as routing path for data transmission. The routing process for IE-AODV to achieve higher network lifetime is as below:

1) For route search process, the LAR technique was adopted which helps to mitigate the overhead experienced during route search in the traditional AODV routing protocol.

2)During transmission, if a node receives a packet, it decrements the TTL by a value of at least 1 and if the TTL count remains greater than 0, the node forwards the packet otherwise it drops it and sends a route error message towards the sending node. A default TTL value of 1 is initially set in the transmission packet at the first iteration. The TTL values to be used by the RREQ packet in the other iteration will be computed by finding the average of a set of defined TTL values. This is shown in table 1. To reduce overhead, a TTL threshold value was set which defines the number of hops a packet is allowed to transit during transmission process following an iterative manner. Steps 1 and 2 above define the mLAR technique. The flowchart is shown in figure 3.

Table 1: Iterative TTL value for control packet

Number of iteration of set n	ttl_a	ttl_b	ttl_c	TTL_{avg}
1	Default TTL			
2	2	3	4	3
3	4	5	6	5
4	6	7	8	7

3) In order to mitigate the possibility of having bottleneck nodes, all nodes in the route request region calculate their PPS using the concept of knapsack problem which is now used as metric for selecting routing paths for data transmission. The optimization equation is given as [11]:

$$V\left[j, E\left(k_j\right)\right] = \max\left(V\left[j-1, E\left(k_j\right)\right], k_j + V\left[j-1, E\left(k_j\right) - E_j\right]\right)$$
(1)

where:
j = Current processing packet
n =Maximum number of packet
k_j = Size of communication packet

$E(k_j)$ = Energy required by a node to treat k_j size of packets
E_j = Maximum energy of intermediate node
V= Value of a given parameter

Nodes with high value of PPS are selected as nodes for routing data. The PPS threshold value was set as 5j in terms of energy and 2Mbps in terms of node current traffic. The rest of the process follows the normal AODV protocol for sending packets. The flowchart for PPS evaluation based on the knapsack algorithm is shown in figure 3.

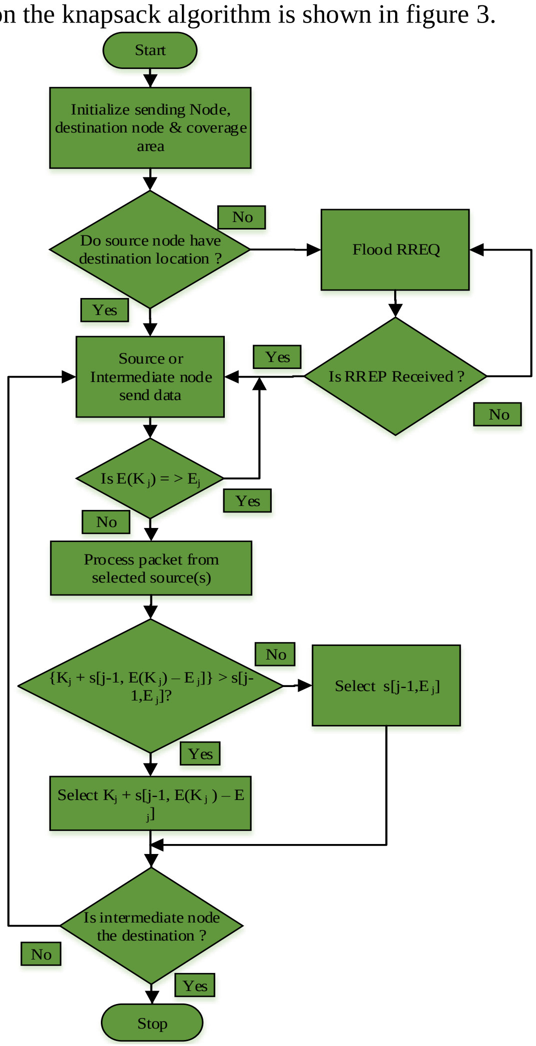

Fig 3: The flowchart for PPS evaluation

4) Upon receiving first RREQ packet, the node will calculate its PPS and attach it to the packet and then send it to the next intermediary node if such a node is not the destination node.

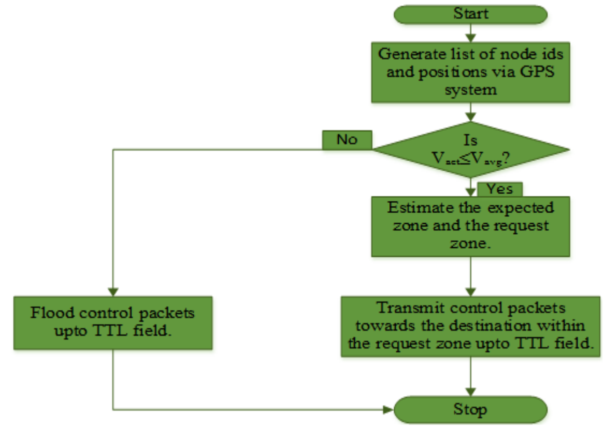

Fig 4: Flowchart of mLAR routing protocol

IV. SIMULATION ENVIRONMENT

The simulation results in this paper were obtained using NS-2 to perform comparison between IE-AODV protocol and E-AODV. NS2 is a discrete event, object oriented, simulator which includes the property of node mobility, a realistic physical layer that includes a radio propagation model, radio network interfaces and the IEEE 802.11 Medium Access Control protocol using the Distributed Coordination Function [7][8]. Table 2 shows the simulation parameters of this work.

Table 2: Simulation Parameters

Parameter	Value
Simulator	NS-2 version 2.35
Simulation time	300s
Propagation model	Two- ray ground
Routing protocols	E-AODV, IE-AODV
MAC	802.11
Traffic source	CBR, FTP
Antenna	Omni Antenna
Packets size	512 bytes/packet
Link layer (LL) type	Logical Link (LL)
Mobility model	Random waypoint model
Pause time type	30s
Area of network	500m x 500m
Queue type	Drop-tail

V. RESULTS

Figure 4 shows the result of the performance of E-AODV and IE-AODV in terms of network lifetime against number of node. Number of nodes ranging from 0 to 50 was used to check the corresponding network lifetime for the two protocols. In this work, the network lifetime is the time the first node in the network dies due to node energy depletion. For the E-AODV protocol, during route search process, packets are flooded in the whole network area. During simulation for both approaches, it was observed that an increase in the number of nodes leads to an increase in the network lifetime. This is because an increase in the number of nodes leads to a better node proximity which reduces transmission energy as node transmission range are now closer. Also, an increase in the number of nodes in a given network area leads to a possible increase in available routing path for packets hence reducing the processing energy that could have been consumed by fewer number of nodes. It is observed that for both approaches, the network lifetime for 0 to 10 number of nodes was the same. This is because the node proximity and available routing paths at that level was not significant enough to alter the network lifetime. However, the simulation result in the figure shows that the performance of IE-AODV generally outperforms E-AODV in terms of network lifetime due to the introduction of mLAR. This is because the network at that point experienced a bottleneck node in its path and needed to reset its TTL value using equation 1 in order to increase system performance during the transmission process.

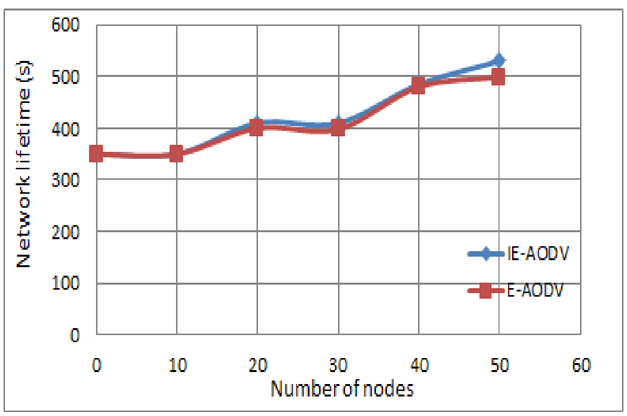

Fig 4: Network lifetime against number of nodes

Figure 5 shows the result of the performance of E-AODV and IE-AODV in terms of network lifetime against node mobility. The random way point (RWP) mobility model with node speed ranging from 0 to 50 (m/s) was used during simulation to check the network lifetime of the network by varying the speed of nodes. For both protocols, it was observed that as the speed of the node increases, the network lifetime generally appreciates. The network lifetime is shorter for low speed than at high speed due to the fixed pause time during mobility. This concept implies that a higher speed helps to give transmitting nodes more choice for proxy intermediate nodes to route packet hence leading to an even distribution of energy in the network, therefore improving network lifetime. The simulation result in figure 5 shows an improvement in network lifetime of IE-AODV over E-AODV. This is because the network area considered for the transmission of packets is the route request region and the expected region. Hence a defined transmission area at a fixed pause time and node speed implies that nodes in the IE-AODV have a reduced network area for packet transmission which would mitigate overhead, transmission energy and processing energy. It was observed that the network lifetime of IE-AODV drops at 40m/s to 480 seconds to be at the same level with that of E-AODV. It implies that at 40m/s, the processing nodes cover the same network area at an instant of time. Hence, the energy distribution at that speed was the same as the choice of available intermediate node was equal.

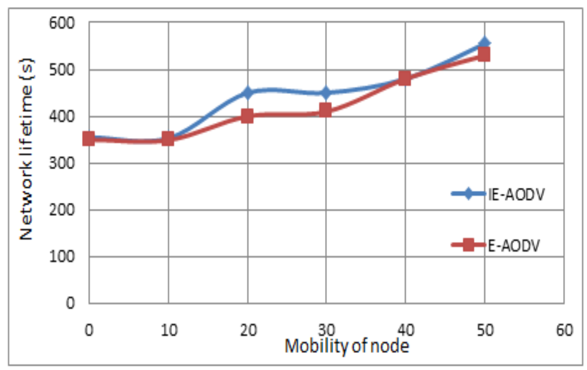

Fig 5: Network lifetime against number of nodes

VI. CONCLUSION

This paper presents the results of the network lifetime of IE-AODV and E-AODV. The results obtained from the simulation allow us to conclude that the network lifetime for IE-AODV is better than that of E-AODV. The developed IE-AODV protocol selects route based on nodes with high PPS value also taking into consideration the TTL for routing packets. IE-AODV was able to improve the network lifetime by 2.3% as a function of number of nodes and 4.9% as a function of node mobility over the E-AODV protocol.

VII. RECOMMENDATION

i. The work can be extended by developing a routing protocol that mitigates the initial time complexity during routing.
ii. Development of a routing protocol that will be efficient in both dense and less dense environment.
iii. The IE-AODV technique can be tested in Wireless Sensor Networks (WSN).

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