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ESLR - Energy Based Stable Link Routing in Mobile Adhoc Networks

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Abstract: Mobile ad hoc network (MANET) comprises of highly dynamic mobile nodes where reliable and stable path routing is a major issue which affects uninterrupted communication. There are so many stable routing protocols are developed as a promising solution. Nevertheless, while developing stable routes energy based a vital role. This paper proposed a novel energy based stable link routing (ESLR) protocol that chooses high energy routes to create stable link communication. In our proposed technique, traffic manager elected to control the entire operation of the network. For that it observes all the activities of every single node that participating in the communication. When a node wants to send packets, the traffic manager chooses routes between the source-destination pair based on energy i.e. next forwarding link is created between the highest energy nodes. Thereby the stable links are created which can perform long-lasting communication. The proposed protocol has minimum of five routes for every single source-destination pair. So, without any delay next alternate path is selected if anyone of the intermediate node reaches its minimum energy. The simulation is performed to observe the performance of the proposed ESLR protocol. In experimental results, the observed performance of the proposed technique is compared with the existing AODVM and LSMRP protocols in terms of routing control overhead, number of route discovery and average end-to-end delay and the results are plotted.

Keywords : Mobile ad hoc network (MANET), stable link, stable route, traffic manager, energy based stable link routing (ESLR) protocol, AODVM and LSMRP protocols

I. INTRODUCTION

Mobile Ad-Hoc Network (MANET) is defined as a type of wireless network that comprises of mobile nodes. Each of its mobile nodes can make communication with other nodes without requiring any additional network resources. MANET does not form any fixed network infrastructure for communication and their mobile nodes are freely and independently moved within the network in a dynamic manner. Some of the fundamental characteristics of MANET are: they are self-generated and self-arranged; their nodes are highly dynamic in nature, it has the capability to reconfigure the network [1, 2].

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Due to the highly dynamic nature, the mobile nodes are randomly moved with high velocity and it does not possess any centralized network authority to observe network activities. When a sender creates a packet for transmission, then the available routes are accessed which are pre-estimated and stored in a routing table. MANET routing protocols are categorized as proactive, reactive and hybrid routing protocols [3].

In proactive routing protocol, the routing tables are frequently updated by exchanging control packets among the mobile nodes. This produces high congestion overhead and consumes high memory to store all the routing updates of the whole network [4]. At any time, the routing table possesses the exact and updated routing information of the network which is one the major benefit of the proactive routing protocols. In reactive routing protocol, a route is established from source to destination, when there is a need. Here the routing tables are not updated frequently which are stored and maintained at the memory [5, 6]. Thus, it has minimum congestion overhead and requires less memory. It is the major advantage of the reactive routing protocol and it also stores the time for route discovery process. In order to minimize the network latency, the proactive and the reactive routing protocols are designed. The characteristics of both proactive and reactive protocols are combined to produce hybrid routing protocol [7]. In this paper, a novel energy based stable link routing (ESLR) protocol is proposed that chooses stable links based on the energy of intermediate nodes. Here the traffic manager is elected to control the entire network which also provides the stable routes for each source-destination pair and it has pre-computed routes of five numbers. Here highest energy links are created to form stable route. The alternate path is selected when a node reaches its minimum energy without any delay since the routes are previously computed. The proposed protocol is compared with the existing AODVM and LSMRP protocols to prove its performance.

The rest of the paper is organized as follows. Section 2 reviewed some of the link stability or stable link routing protocols. In Section3, the proposed technique is presented in a detailed manner and the section 4 explained the experimental results. Finally the paper is concluded in Section 5 with future work.

II. RELATED WORK

In this section, some of the previous works discussed about link stability of mobile ad-hoc networks are given.

Srinivasan and Kamalakkannan [8] have presented a new protocol to enhance the process of route maintenance named Route Stability and Energy Aware Routing-Ad Hoc On- Demand Distance Vector (RSEA-AODV).

In order to proactively create an alternate path, a few network parameters such as residual energy, length of the interface queue, and the signal strength are observed for data transmission. In this article, the authors aimed to improve link stability and reduce energy consumption while discovering alternate routes.

Pandey [9] has aimed to provide network stability for both self and neighboring nodes by estimating the stability factor of each participating node. Here, the routes are established between source and destination nodes using this stability factor.

Brahmbhatt and Kulshrestha [10] have reviewed several mechanisms for route stability which is mainly based on a metric called Quality of Service (QoS) in mobile networks. In this article, both the link stability and route stability is improved by the QoS parameters which also enhances the performance of the network.

DeRango et al [11] have presented a novel Link stAbility and Energy aware Routing protocol as a solution of biobjective optimization issue. The major aim of this paper is to provide stable links with minimum energy and reduced drain rates in MANETs. Gulati and Kumar (2014) have reviewed several link stability protocols for enhancing the QoS in mobile networks.

Gaurav Singal et al [12] have estimated each link of MANETs by proposing a novel Link Stability based Multicast Routing Protocol (LSMRP) which is a multicast routing protocol. The authors have applied the proposed protocol to achieve better resource utilization and to minimize the routing overhead of the network.

Hui Xia et al [13] have aimed to improve the link stability by integrating link stability estimation model and the Multicast AODV model in mobile ad hoc networks. The main objective of this paper is to minimize the overhead of the network and enhance the network performance.

Rajendiran and Srivasta [14] suggested a multicast routing protocol for discovering the most stable route beween source and destination. Here, some of the network parameters such as distance from source to destination, received power, and quality of the link are observed to estimate the stability of the link in MANET. Nayak and Gupta (2015) have reviewed the performance of three MANET routing protocols: AODV, Dynamic Source Routing (DSR), and Zone Routing Protocol (ZRP) to minimize the energy consumption.

AOMDV protocol [15] observes source and destination and creates and computes multiple link-disjoint routes between them in a mobile ad hoc network. There are two major activities involved in AOMDV such as estimating several loop-free routes and discovering link-disjoint routes. The existing AODV protocol rejects duplicate RREQ messages at neighbor and intermediate nodes. But the AOMDV permits their nodes to receive and execute duplicate

RREQ messages if such duplicate message enters through a route which does not comprise the intermediate nodes.

At each node, this technique creates multiple loop-free routes. AODVM protocol [16] is an extension of AODV protocol which finds multiple node-disjoint paths among source and destination nodes in a mobile ad hoc network. In AODVM, the intermediate nodes accept duplicate RREQs and record the information of those obtained duplicates in the table of RREQ. It re-transmits those received duplicate RREQs instead of rejecting them. In RREQ table, some information is stored such as source of the RREQ, destination of the RREQ, all the neighbors who transmit the RREQ message, and some other information. Dissimilar with the AODV and AOMDV protocols, even if the intermediate nodes of AODVM possess the paths to the destination nodes, they never reply back by RREP to the source of the RREQ. Rather, the source node receives the reply RREP from the destination node for each sent RREQ through the route transmitted by the RREQ message.

Another extension of AODV is MP-AODV protocol [17] which finds and creates two node disjoint paths, two link-disjoint paths, or two hybrid paths among sources and destinations of the mobile ad hoc network. Here, the process of route discovery is divided into two stages: one is major route discovery and another one is backup route discovery. At first, it initiates and creates the major route and after that it performs backup route discovery process. It only keeps one alternate route. The created route between any two nodes is either link-disjoint or node-disjoint. It initially tries to create two node-disjoint paths. If the major and backup routes are not found, then it finds and creates two link-disjoint paths to enhance the data transmission reliability. It employs an extra one-bit flag to differentiate the control messages in the major paths and backup paths. This paper presents a novel energy based stable link routing (ESLR) protocol. Here the stable links are created between highest energy nodes and the traffic manager is elected to compute five numbers of stable links for each source and destination transmission previously. Therefore, an efficient and uninterrupted communication is achieved.

III. RESEARCH CONTRIBUTION

In our daily life, communication plays a vital role. Wireless communication has to guarantee Quality of Service to provide efficient communication. For that routing protocols are designed. The main aim of the article is to design a stable link routing protocol that computes and chooses a stable link between source and destination nodes where high energy nodes are selected to create stable links. By the way frequent topology changes of the network are tackled while maintaining QoS requirements of the communication.

A. *NETWORK MODEL*

Mobile ad-hoc network (MANET) is formed with number of mobile nodes and each node possesses unique node ID. These mobile nodes are freely and randomly move throughout the network and the network topology is dynamically and frequently varying.

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At any time, a new mobile node may join or existing node may leave from the network and node failure may occur i.e. the energy of a node may reduce below the fixed threshold at any time during communication. Each node in the network possesses the details about its neighbor nodes. To attain reliable network communication, bi-directional communication links are used.

B. *PROPOSED METHODOLOGY*

In this paper, we proposed a novel energy based stable link routing (ESLR) protocol to attain efficient communication in MANET. The name itself defines the stable links are selected based on the energy of intermediate nodes. As per the network model, the network is deployed. In our proposed technique, an entity called 'Traffic Manager (T_{mgr})' plays an important role. The traffic manager is nothing but a node which posses highest energy, increased memory, and maximum bandwidth. The detailed operation of traffic manager is given in the following section.

C. *TRAFFIC MANAGER*

In MANET, the election of traffic manager is initiated after the network deployment. Each node communicates one another by sharing its energy, memory and bandwidth status. Among them, a node that possesses maximum bandwidth, highest energy and increased memory is chosen as the traffic manager. The structure of the T_{mgr} is illustrated in Figure 2. The following operations are performed by the traffic manager.

After choosing the traffic manager, the remaining nodes communicate the T_{mgr} to show their liveliness in the network and then the T_{mgr} observes a few parameters such as node ID, initial energy, current energy, number of neighbor nodes, list of neighbors, neighbor distance, and node status.

Node ID	Initial Energy	Current Energy	No. of Neighbors	Neighbor list	Neighbor distance	Node status	Incoming Node ID	Exit Node ID

Figure 2: Structure of Traffic Manager

As mentioned above, each mobile node possesses unique identification called node ID and the initial energy is the energy level before participating the packet transmission. All the mobile nodes periodically updated their current energy status to the traffic manager to choose alternate and efficient link.

Some of the neighbor details like number of neighbors, list of neighbor nodes, and the distance of each neighbor nodes are computed for each participating mobile nodes. These details are periodically updated due to the mobility of the nodes.

In mobile network, each node has one of the three statuses such as source node, intermediate node, and destination node. From that, it is known that a mobile node should perform sending or bypassing or receiving the packets. After each communication the node status is updated.

Incoming node defines a new node enters into the network and the unique ID of the node is observed. Likewise, exit node defines a node that exit from the network and its node ID and its other details are removed.

II. *ROUTING MECHANISM*

Routing process is initiated after the election of Traffic Manager. As we know that each mobile node is registered with the T_{mgr} by communicating all its details like location, energy level, node status, and neighbor details. If a node wants to send packets to a destination, then it communicates its status to the T_{mgr}. The following steps involved in the process of routing.

After receiving the status of the requesting node, the T_{mgr} updates the node status as source node. In our proposed routing, if a node acts as a source node or destination node then it cannot act as intermediate node until the completion of the transmission.

The proposed protocol creates and maintains a routing table for each source destination pair. It creates routes using the obtained details of all the participating mobile nodes in the network. Figure 3 demonstrates the routing table of T_{mgr} and each routing can be performed using this routing table where route details are stored.

Source Node ID	Destination Node ID	No. of intermediate nodes	No. of possible routes	Routes					Intermediate status
				Route 1	Route 2	Route 3	Route 4	Route 5	

Figure 3: Routing Table of T_{mgr}

The T_{mgr} observes the source ID and destination ID after receiving the request from a node. Then it computes the number of nodes present between the requesting source and destination pair. Then it initiates the process of route discovery.

Based on the energy of intermediate nodes, the proposed protocol computes the number of all possible routes. It computes minimum of 5 possible routes and stored in the routing table to avoid communication delays. The communication between a source-destination pair completes within the stored 5 routes.

The intermediate status is used to observe the intermediate nodes that reach its minimum energy. If a node is going to reach its minimum energy, then it updates its status to the T_{mgr} which updates its routing table and provides alternate route. Thus, without breaking the current link or route, an alternate path is selected and efficient communication is achieved.

E. *ROUTING PROTOCOL*

In order to achieve efficient communication, stable links are selected to create stable route which is our major objective.

For that we proposed a novel energy based stable link routing (ESLR) protocol which is a multicast and multi-hop routing protocol. It follows First Come First Serve (FCFS) policy. In our proposed protocol, the stable links are created based on the energy. For requesting source, it chooses first five energy neighbors to create five paths.

At first, the source node prefers the highest energy comprising neighbor as its intermediate node. Then, that intermediate node chooses its highest energy neighbor. If the highest energy neighbor is busy (i.e. it is participating in previous communication) then it chooses second highest energy comprising neighbor as its intermediate node. This process continues until reach the destination.

Likewise, there are five routes are computed previously and stored in the routing table and the communication takes place through the pre-determined paths. If anyone of the intermediate node reaches is minimum energy, then the next route is used to continue the transmission without any delay.

In our proposed routing, there is another factor involved for alternate path selection. At anytime, anyone of the intermediate nodes between a source- destination pair may wants to send packets or receive packets i.e. it wants to act as a source or destination node. Then it communicates its status to the T_{mgr} and it updates its status and chooses alternate path because the source and destination nodes cannot act as intermediate nodes in our routing.

Algorithm for proposed ESLR protocol

1. *Node randomly deployed*
2. *Elect Traffic manager// control by whole network traffic*
3. *Obtain node information // energy, memory, bandwidth*
4. *Choose high performance node // highest energy, increased memory, maximum bandwidth*
5. *Traffic managerincludes*
6. *{*
7. *Node id; Initial energy; Node location; Node energy; Neighbor details etc;*
8. *}*
9. *← Update the nodes information;*
10. *// for stable link*
11. *→;*
12. *→„*
13. *Routing process starts control by Traffic manager*
14. *{*
15. *Case A: Queue availability*
16. *→*
17. *Check route status □*
18. *Status updated □ some routes are available;*
19. *Update information*
20. *End case A;*
21. *}*
22. *Case B*
23. *→*
24. *Queue is busy*
25. *{*
26. *Check route status □*
27. *Status updated □ Queue busy;*
28. *Divert upcoming packets □*
29. *Update information*
30. *End case B;*
31. *}*
32. *Case C*
33. *→;*
34. *Partially used Queue*
35. *{*
36. *Check route status □*
37. *Status updated □ some space available;*
38. *Divert upcoming small traffic packets*
39. *Update information*
40. *End case C;*
41. *}*
42. *←*
43. *End case*
44. *Continue process until reach destination*

F. *NETWORK TRAFFIC*

Network traffic plays an essential role in efficient communication. Generally, each intermediate node possesses a queue length where the transmitted packets are temporarily stored during communication. The proposed protocol is not a priority routing which includes priority for multimedia packets that has huge size. But it follows FCFS policy. So regardless of the packet size the routing is performed.

The proposed routing protocol initially prefers highest energy neighbor to create more stable link. If it sends small size data, its queue is mostly available. So the second requesting transmission can include such highest energy node in its transmission. The availability of the queue of intermediate node is classified into three following types.

- Available
- Partially available
- Busy

Available status indicates that the queue of the intermediate node is unused. So, the communication between a source-destination pair can obviously choose such intermediate node comprising highest energy to attain better communication performance.

Partially available status defines the queue is only partially used and most of its queue length is unused. This type of nodes can be used for other communication to avoid resource wastage. By the way the network resources are completely utilized to perform efficient communication.

Busy status denotes that the full queue length is currently in use and it cannot carry any further packets. Therefore, next available and highest energy node is selected to create a route.

IV. EXPERIMENTAL RATIO

The performance of the proposed technique is observed by conducting simulation in Network Simulator-2 (NS-2) environment which uses a link layer protocol of IEEE 802.11 as a MAC layer protocol. The simulation parameters are given in Table 1.

Simulation Parameter	Value
Simulator	NS-2
Simulation time	100 s
Number of nodes	100
Simulation area	1500 × 1500 m^2
Mac Protocol	IEEE 802.11
Data rate	24 Mbps
Radio range	100m
Mobility model	Random way point model
Antenna	Omni directional antenna
Node speed	10-30 m/s
Packet size	512 bytes
Traffic type	Multicast constant bit ratio

Table 1: Simulation parameters

The proposed protocol is simulated over the area of 1500 × 1500 m^2 with 100 mobile nodes in the network. Using Random way mobility model, these nodes are moved freely and randomly within the network area. Network traffic is generated by the source to the multicast destinations using multicast constant bit ratio and the mobile nodes are moved between the speed of 10-30 m/s. The data rate of the network is 24 Mbps.

Some of the performance metrics are used to evaluate the performance of the proposed ESLR protocol like routing control overhead, number of route discovery, and average end-to-end delay. To prove the performance of the proposed protocol it is compared with the existing stable path routing protocols such as AODVM and LSMRP protocols.

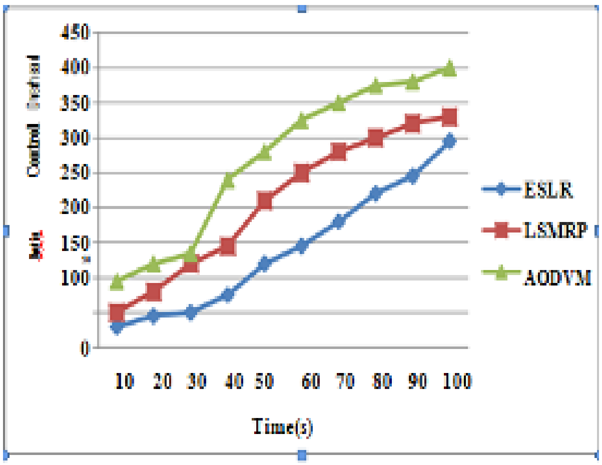

Figure 4: Time (s) vs. Routing Control Overhead

In Figure 4, time and routing control overhead of the proposed and existing protocols are compared. Routing overhead is nothing but the number of routing packets required to perform network communication. In X-axis time values are taken and the Y-axis comprises the observed measures of the routing overhead. From the figure, it is observed that the existing AODVM and LSMRP protocols possess increased routing overhead compared to the proposed ESLR protocol.

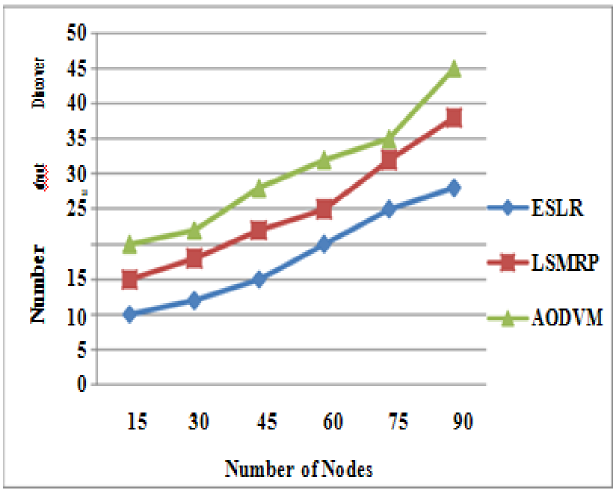

Figure 5: Number of Nodes vs. Number of Route Discovery

In Figure 5, number of route discovery is plotted against number of nodes. This comparison plot is plotted for the proposed ESLR protocol and the existing AODVM and LSMRP protocols where the X-axis and Y-axis possess the measures of number of nodes and number of route discovery respectively. The performance of all three protocols is observed from the figure which proves that the proposed protocol has reduced number of route discovery. Therefore, when compared existing protocols the proposed protocol provides better performance.

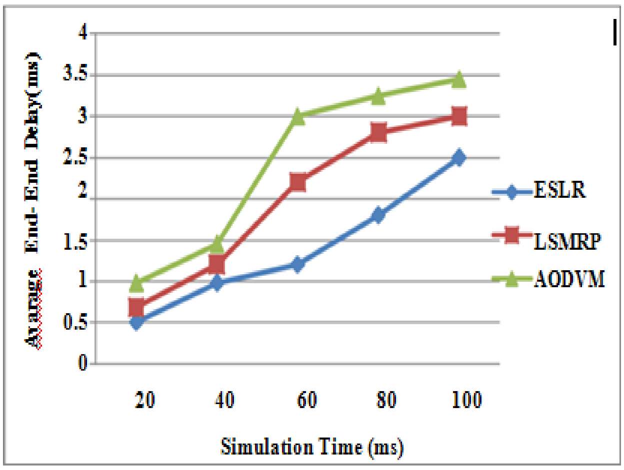

Figure 6: Simulation Time (ms) vs. Average End-to-End Delay

The Figure 6 is the plot of average end-to-end delay against simulation time of the proposed and existing protocols. In X-axis and Y-axis, the simulation time and the average end-to-end delay is plotted respectively.

The average end-to-end delay is defined as the measure of time between the packets sent to the packets received from the source to the destination which also comprises the buffering time as well. From the plot, it is clear that the proposed protocol has reduced average end-to-end delay compared to the existing AODVM and LSMRP protocols.

V. CONCLUSION

In this paper, a novel energy based stable link routing (ESLR) protocol is proposed in MANET. The major objective of this work is to provide efficient and uninterrupted communication. For that stable links are computed to create stable route to achieve long-lasting communication through a single path. The optimal stable paths are selected based on the energy and the traffic manager plays a vital role in choosing highest energy route. Since the traffic manager possesses the periodically updated information of all nodes in the network and it also has minimum of five pre-computed routes for every single source-destination pair. In our proposed technique, the available network resources such as energy and memory (i.e. queue length) are completely utilized without any wastage to attain efficient communication. The network traffic of the proposed work is discussed which shows the effective resource utilization. The simulated performance of the proposed ESLR protocol is compared with the existing AODVM and LSMRP protocols and the observed results are plotted which shows the proposed protocol has better performance than the others. In Future, this work is extended by including security concerns.

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