A Novel Routing Algorithm Based On Link Failure Localization for MANET

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Abstract

The routing in Mobile Ad hoc Network (MANET) is a critical task due to dynamic topology. Many routing protocols were proposed which are categorized as proactive and reactive routing protocols. Route maintenance is a great challenge in MANET due to frequent link failure which causes high data loss and delay. To counter such problems, lots of link repair mechanisms were proposed, but all these have their own limitations. This paper proposes a novel routing algorithm for route maintenance based on Link Failure Localization called DSR-LFL. DSR-LFL takes decision on the basis of location of failure link in source route. Simulation results shows DSR-LFL improve the Packet Delivery Ratio, Throughput and decrease the Routing Overhead, End-to-End Delay as compared to Dynamic Source Routing (DSR) protocol.

Keywords— *DSR, MANET, DSR-LFL, routing, salvage*

I. INTRODUCTION

Mobile Ad hoc Network is a group of wireless mobile nodes which cooperate in forwarding packets in a multi-hop fashion without any centralized administration. The nodes are mobile and their movements are random, therefore MANET has dynamic topology. Because of this dynamic topology, link failures in MANET's are frequent. This causes many problems such as data loss, delay, and other factors such as packet delivery ratio etc, which degrades performance of the network. Routing in MANET is critical due to its dynamic topology. Many routing protocols for MANET have been proposed and these protocols can be classified as proactive and reactive routing protocols [11].

Reactive routing protocols are most popular due to their low frequency of route discovery as compared to pro-active routing protocols. The DSR [1], [14] is one of the commonly used reactive routing protocols for MANET. DSR protocol has two main mechanisms: Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain routes in order to send the data packets to the destination. In spite of this, the link failure could significantly increase the overhead and decrease the performance because link failure may cause packet loss, delay and may also need a global broadcasting for new route discovery, if any other route is not available in route cache.

Route maintenance is great challenge in MANET, it is required to overcome the causes of link failure. To overcome the link failure problems, lots of local link repair mechanisms [2, 3, 4, 5, 6, 7, 8] were proposed. But these mechanisms does not take the decision on the basis of location of failure link in source route and does not take advantages of *relay node* location in source route. The proposed routing algorithm is based on location of the failure link in source route.

Rest of the paper is organized as follows. In Section 2, DSR route discovery and maintenance mechanism is briefly described. Section 3, several existing route repair mechanisms are briefly discussed. Section 4, describes the proposed algorithm. In Section 5, simulation parameters and compared results of DSR-LFL is listed out. Finally, conclusions are drawn in Section 6.

II. DSR ROUTE DISCOVERY AND MAINTENANCE

DSR is a reactive and simple protocol. The key characteristic of DSR is based on the concept of source routing. DSR protocol has two main mechanisms: Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain routes in order to send the data packets to the destination.

2.1 Route Discovery

Fig.1 shows the route discovery mechanism of DSR. Whenever source node (S) wants to sends data packets to the destination node (D). First, it checks its route cache for a route to the destination, if route is found then source forward the packet according to route. Otherwise, source node (S) broadcasts Route Request Packet (RREQ) to its neighbour nodes which are in its transmission range.

Each RREQ packet contains source address, destination address, request ID, and route record.

When any node receives a route request packet, it processes the request according to the following steps:

1. If this route request is found in this node's list of recently seen requests, then discard the route request packet and do not process it further.
2. Otherwise, if this node's address is already listed in the route record in the request, then discard the route request packet and do not process it further.
3. Otherwise, if the destination of the request matches this node's own address, then the route record in the packet contains the route by which the request reached this node from the source of the route request. Return a copy of this route in a route reply packet to the source.
4. Otherwise, append this node's own address to the route record in the route request packet, and re-broadcast the request.

The route request thus propagates through the ad hoc network until it reaches the destination node, which then replies to the source. In our example, when a route request packet arrives at the destination node (D), it returns a Route Reply Packet (RREP) along with the reverse of a recorded path to the source node (S), which is (S, A, C, G, D).

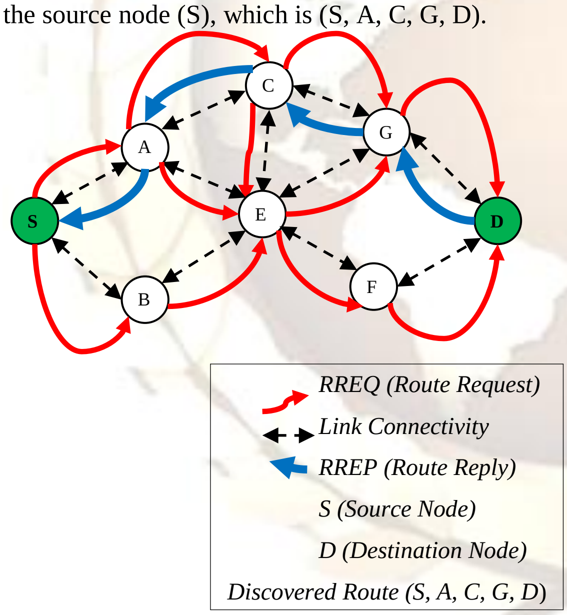

Fig. 1 DSR Route Discovery

2.2 Route Maintenance

When *relay node* transmitting the packet and found that the next node in source route is not reachable due to any reason then it sends route error to source. To salvage the packet *relay node* first check its route cache for any other route to destination, if route found then it forwards the packet and inform the source about new route to destination. When source node receives route error packet then it discards all routes which contain the failure link.

III. EXISTING ROUTE REPAIR MECHANISMS

Many route repair mechanisms for MANETs were proposed. Some of them are described bellow:

Localized Route Repair (LRR) Technique [2], in this technique aim is to patch the route between the two nodes of the broken path through some other link or node. In this approach, the Time-to-Live (TTL) field of the IP packets is used to limit the request zone to two hops.

Dynamic Source Routing based on Downstream node's Information (DSR_DI) [3] contains two algorithms: *local relay node cache search algorithm* and *local area route discovery* for new routes to any downstream node of original error route. When link failure occurs, DSR_DI apply *local relay node cache search algorithm* to find other route to any downstream node. Otherwise, it apply *local area route discovery algorithm* to find route to any downstream node. The DSR-DI protocol improves the performance of DSR protocol.

In Proximity Approach to Connection Healing (PATCH) [4] if the link breaks off, there should exist, in most cases, some indirect route from *relay node* to the original next node in the source route through some neighbour nodes. In these situations, if a request packet is sent out to find the original next hop or other node which is at the further part of the original route with limited TTL (e.g. 2 hops), the possibility of repairing the current route should be high and the overhead should be much lower than using End-to-End global recovery.

In Witness-Aided Routing (WAR) [5] when link breakage occurs, it performs local recovery by broadcasting of the data packets with some predefined hop limits. WAR provides fast route recovery, but it needs high control overhead because data packet is broadcasted as a recovery packet.

Associability Based Routing (ABR) [6, 7] is a routing scheme to select the routes likely to be long-lived. However, if link breakage occurs, two cases arise. In case one if *relay node* is located at the first half of the route (i.e., it is nearer to the source than to the destination), then a route error is reported to the source, and the source will initiate route discovery to recover the route. In case two *relay node* will broadcast a route request with a hop limit equal to the remaining number of hops that was in the currently failed route. Only the destination is able to reply to the route request. If this succeeds, this route is remedied and no route error will be reported. Otherwise, a route error will be reported to the node preceding *relay node*, which will in turn repeat trying the above two cases again. This process is recursively repeated until either the broken route is remedied or one host at the first half of the original route is reached. But this approach takes more bandwidth and longer delay if the above recursion keeps on failing.

Relative Distance Micro-discovery Ad Hoc Routing (RDMAR) [8] employs a similar approach of local repair as ABR. However, the region of the localized route repair is estimated from the history distance between the current relay node and destination node using a location prediction model.

An Analytical Model of LRR Technique is given by Ramnath et.at [2], which is being described below.

3.1 Analytical Model

To develop a detailed model of the system and analyze the performance of the LRR technique, we assume certain parameters and arrived at an expression for the traffic in ad hoc networks.

3.1.1 System Model

We assume that there are n nodes in the system, all the nodes have the same distribution of moving speed and direction and the same transmission range r. We assume that:

1. The average route length between the source and destination is E_L.
2. The duration of the packet arrival is an exponentially distributed with mean $1/\lambda$.
3. All n mobile hosts in the network have the same transmission range r.
4. The time between location changes for each node is an exponentially distributed with mean $1/\mu$. (Note that μ is zero when the network is static).
5. The density of nodes is same at all points in the network, where area of the network is represented by A.

Theorem 1. The probability P0 that a particular mobile node
Y is in the vicinity of node X is

$$P_0 = \min(1, \pi r^2/A)$$

Theorem 2. The average number N_m of neighbours for a node
can be given by

$$N_m = \sum_{K=0}^{n-1} k \binom{n-1}{k} P_0 (1-P_0)^{n-1-k}$$

Theorem 3. The probability P_B that a link is broken while a
packet is being transmitted is

$$P_B = \mu/(\lambda + \mu)$$

3.2 Limitations of Existing Algorithms

3.2.1 DSR

- Flooding causes more bandwidth consumption.
- Lots of error messages.
- More packet drops.
- Performance decreases as network size increases.

3.2.2 Local Link Recovery Mechanisms

- Always takes decision on the basis of local information.
- Overhead on all intermediate nodes is more.
- All intermediate node work on same mechanism irrespective of their location in the source route.

3.2.3 Mechanism Based on Downstream Nodes Information

- If failed link is far away from the destination then it may cause overhead on intermediate nodes.
- If nodes are highly movable then more links failure occurs and may degrade the performance of the network.

IV. Proposed Algorithm

To overcome the limitations that have been discussed above, this paper introduces new algorithm DSR-LFL based on DSR which take decisions on the basis of location of the *Relay Node* (where link failure is detected) in source route.

4.1 Description of DSR-LFL

When route is failed, the DSR, DSR-LRR [2], DSR-DI [3] and PATCH [4] do not take decision on the basis of failed link location in source route. The proposed algorithm DSR-LFL is the route maintenance algorithm based on DSR takes decision on location of the failure link in source route. DSR-LFL divide source route into three equal regions if possible, otherwise *Source* and *Destination Regions* will be of equal size and the *Middle Region* will be larger as compared to other regions as shown in fig.2. One is for nodes near to source called Source region, second is for nodes near to destination called Destination region, and third is called middle region.

Flow Chart of Proposed algorithm DSR-LFL is shown in fig.3.

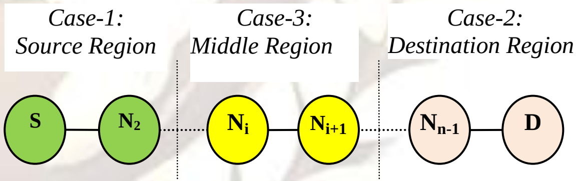

Fig. 2 Partitions of Source Route

When relay node forward packet to next node in source route and it founds link failure is occur then proposed algorithm DSR-LFL work as follows:

1. First, *Relay Node* searches its route cache for other route to destination.
2. If route is found then forward the packet to destination using new route and inform to source about this new route.
3. Otherwise, *Relay Node* identifies its location in the failed source route. Relay node belongs to any one of the region.
4. If *Relay Node* belongs to *Source Region*, then sends Route Error message to source, because relay node is close to source. Now source will take decisions.

5. If *Relay Node* belongs to *Destination Region*, then relay node will take advantages of down stream nodes information [3] to find new route to destination, because relay node is close to destination. If new route is found, relay node forward the packet and inform to source about new route.
6. If *Relay Node* belongs to *Middle Region*, then it is better to recover the link locally using one hope or two hope request. So *Relay Node* applies *Local Link Recovery*. If link recovery is successful then relay node forward the packet and inform to source about new route.

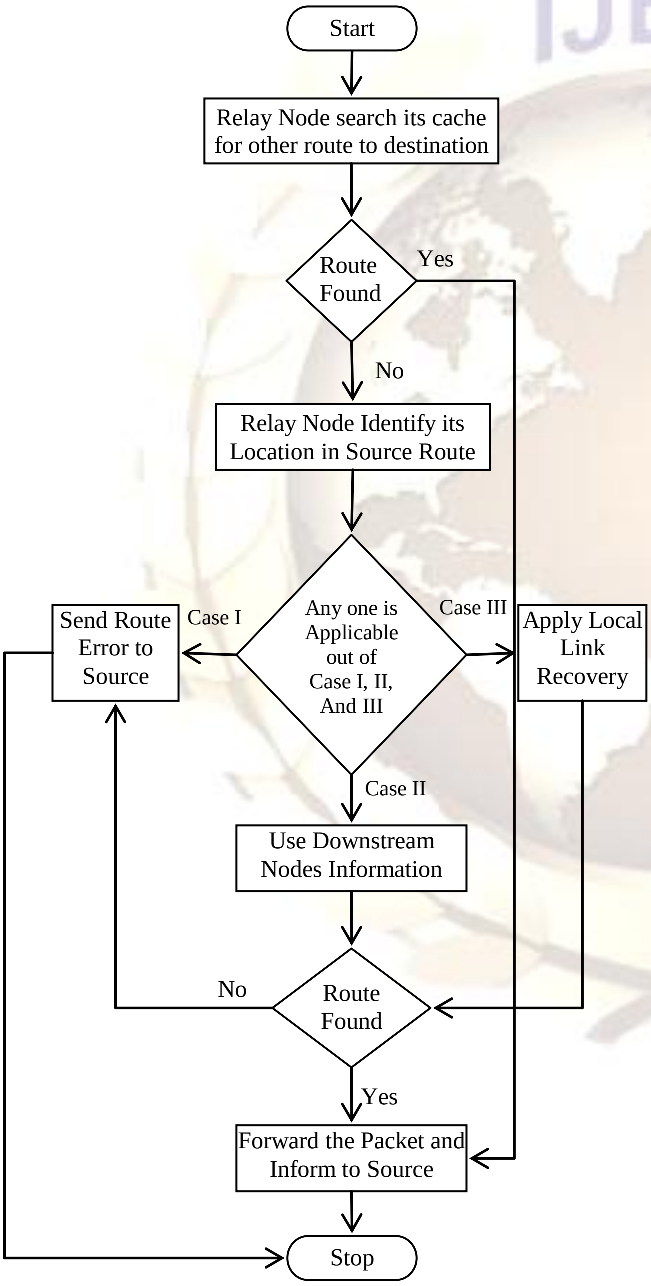

Fig.3 Flow Chart of DSR-LFL

V. SIMULATIONS

5.1 Simulation settings

Simulations were carried out using NS-2.34, network simulator, to evaluate the proposed mechanism. We compared DSR-LFL with DSR protocol. To emphasize the effectiveness of the proposed mechanism, a long map of 1000m*1000m was used and the number of nodes is 20, 40, 60, 80, 100, 120 and 140. The fastest speed of the node's movement is 20m/s. Each simulation time is 200 seconds. The pause time of the nodes is 20 seconds and CBR transmission is used. Table-1 shows the simulation parameters. We used the following properties to evaluate the performance of DSR-LFL and DSR protocols: packet delivery ratio, end to end delay, normalized routing load and throughput.

Parameter	Value
Mobility pattern	Random way point
Traffic	CBR transmission
Transmission range	250 m
Mobility	Pause time 20s, speed 0-20 m/s
Map	1000m*1000m
Number of Nodes	20, 40, 60, 80, 100, 120, 140
Simulation time	200 s

Table 1: Simulation Parameters

5.2 Simulation result and analysis

Fig.4 shows the comparison of Packet Delivery Ratio (PDR) between DSR and DSR-LFL. We can see that initially packet delivery ratio keeps increasing as number of nodes are increases, but when number of nodes is more than 60 packet delivery ratio decreases. At low density, DSR-LFL does not show much advantage over DSR, but at high density DSR-LFL shows more advantages. Table-2, Shows the packet delivery ratio of DSR and DSR-LFL.

Number of Nodes	DSR	DSR-LFL
20	95.0254	94.9290
40	96.1026	95.0655
60	96.4539	96.9000
80	93.8570	94.3320
100	93.4542	94.0937
120	89.9083	93.1727
140	79.1242	87.5502

Table-2: Packet Delivery Ratio

Fig.5 shows the comparison of End-to-End delay between DSR and DSR-LFL. We can see that when number of nodes is less then difference between end to end delay of both DSR and DSR-LFL is very less but as the number of nodes is increases the end to end delay in DSR-LFL is much less as compared to DSR. Table-3, Shows the end to end delay of DSR and DSR-LFL.

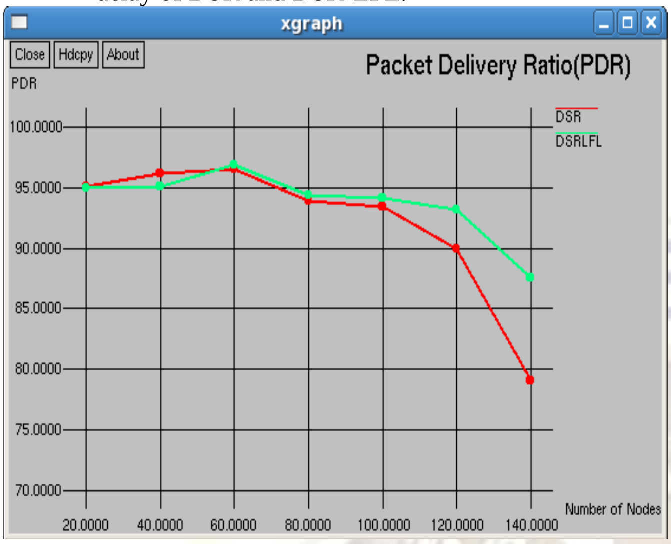

Fig.4 Packet Delivery Ratio

Fig.5 End-to-End Delay

Number of Nodes	DSR	DSR-LFL
20	314.235	315.382
40	346.379	363.471
60	165.076	178.596
80	314.613	188.632
100	228.937	211.681
120	379.892	278.596
140	763.496	362.417

Table-3: End-to-End Delay

Fig.6 shows the comparison of Normalized Routing Load (NRL) between DSR and DSR-LFL. Results shows that when number of nodes are less DSR-LFL load is equivalent to that of DSR, but when number of nodes is more than 60 the load in DSR-LFL is very less as compared to DSR. The performance of DSR is good when the number of nodes in network is less, as the number of nodes is increases the performance of DSR is decreases. But DSR-LFL performs well in such conditions. Table-4, Shows the normalized routing load of DSR and DSR-LFL.

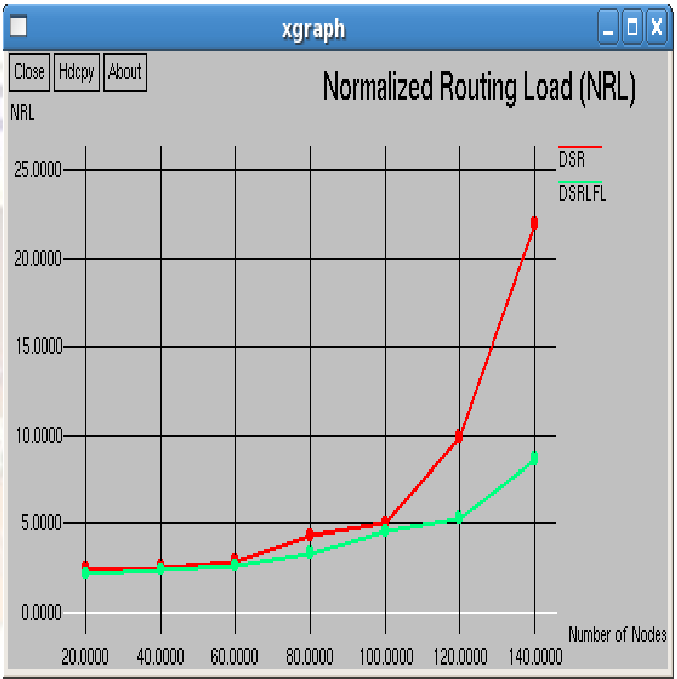

Fig.6 Normalized Routing Load

Number of Nodes	DSR	DSR-LFL
20	2.431	2.201
40	2.520	2.368
60	2.873	2.612
80	4.315	3.327
100	5.015	4.614
120	9.893	5.316
140	21.937	8.637

Table-4: Normalized Routing Load

Fig.7 shows the comparison of Throughput between DSR-LFL and DSR. Results show that the throughput of DSR-LFL is very good as compared to DSR. It shows that the salvaging of packets in DSR-LFL is more as compared to DSR. Table-5, Shows the throughput of DSR and DSR-LFL.

Number of Nodes	DSR	DSR-LFL
20	19439.88	19426.47
40	19463.00	19593.14
60	19761.49	20116.22
80	19352.31	19351.33
100	19274.81	19180.28
120	18315.59	19252.50
140	16125.53	18094.82

Table-5: Throughput

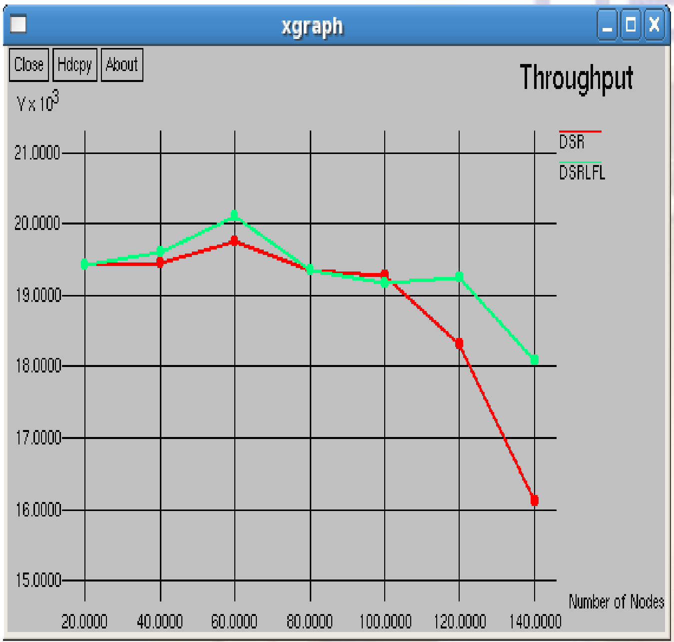

Fig.7 Throughput

VI. CONCLUSION

The DSR-LFL is a route maintenance algorithm. It will take decision on the basis of location of failure link in source route. Source route divided into three regions, and depends on the region of relay node DSR-LFL will apply suitable mechanism for route maintenance. DSR-LFL use downstream nodes information and also repair local link breakages to salvage the packet. DSR-LFL improves the packet delivery ratio and throughput. It reduces the normalized routing load and end to end delay of the network. Our simulation shows DSR-LFL performed well in dense map, as compared to DSR. Thus, DSR-LFL improves the scalability and route maintenance performance of DSR.

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