



Local Route Repair in MANET for on Demand Routing Protocol: A Review

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Abstract: *Ad hoc networks are the infrastructure-less wireless network in which there is no central access point. MANETs are the ad hoc networks in which nodes are mobile. Due to continuous mobility of nodes, topology is highly dynamic and unpredictable. Due to mobility of nodes probability of link failure is high as nodes can move away from the active path and remains no longer accessible. Local route repair is the mechanism that is used to repair the broken link by the upstream node on which the link is broken without notifying the source node. Local route repair is implemented on reactive routing protocol. . Reactive routing protocols are the routing protocol in which routes are established only when needed i.e. when there is communication between nodes. Local route repair decrease the routing overhead as the link is repaired quickly as compared to the source repair. Local route repair provides the scalability to the routing protocol. This paper presents some mechanisms that have been used to improve and optimize a local route repair on reactive routing protocol. AODV is used as the reactive routing protocol for the local route repair.*

Keywords: *AAODV, AODV-BA, EAODVLRT, Local Repair, MANET, PLSS.*

I. INTRODUCTION

Mobile ad hoc network (MANET) [1] is one of the challenging areas of wireless networks. MANET is an ad hoc network and comprised of mobile node that communicates using wireless link. In MANET, each mobile node is equipped with wireless transmitters and receivers using antennas. Nodes in MANET communicate with each other by using these transmitters and receivers. In MANET, as nodes are free to move, nodes may not remain in coverage area of each other. For the nodes which are not in the transmission range, communication is done by using multi-hop mechanism. Nodes in MANET have characteristic like dynamic topology, bandwidth and energy constraint and limited physical security. Due to these differences, routing in MANET is more difficult than the wired networks. In MANET, an active route can have a link break due to mobility of nodes or empty battery of node as in that case a node cannot perform its intended function of forwarding packets. At that time, source can decide to reconstruct the path for further data transfer. This paper presents some mechanisms of local route repair. In this paper on demand routing protocol is used for local route repair. On demand routing protocols for MANET are AODV, DSR, and TORA etc. AODV is used to show the performance of different mechanism. This paper is organized in five sections including the present one. Section 2 provides the description of route repair in MANET. In Section 3 work done by different researchers is presented. In Section 4 performance comparison of all the approaches is presented. In the end, the conclusion based on literature is provided along with suggestions for future work.

II. ROUTE REPAIR IN MANET

On demand routing protocol discovers the route only when it is needed. Once a route is established, the node uses it until the destination is reached or the route expires. Due to node mobility, node move away from the path thus link breaks. When a link breaks, there are two possibilities either the data transfer is stopped permanently or link is repaired for further data transfer. Link repair is of two types as in [2], one is source repair and the other is local repair. In source repair, route is repaired by path maintenance [3] method, when the link is broken, an error message is sent to notify the source node. Then the source can reinitiate the route discovery process again if the route is still needed. In this mechanism, the network is flooded with routing messages. Source repair works fine for small network but in large networks it induces more routing overhead. In local repair [4], when the link breaks, the node upstream to that link can repair the link, by initiating a route discovery process. As intermediate node may be closer to the destination than the source node, so the route discovery must be fast with less routing overhead. In next section work done by different researchers on local route repair is presented. In AODV both route repair can be implemented. In this section a brief description of AODV is given.

A. On Demand Routing Protocol

These routing protocols discover routes between a pair of source and destination only when it is needed. On demand routing protocol eliminates the additional cost of maintaining routes that are not used. But in on-demand routing

protocol, as time progresses a route may not remain optimal to use. With movement of nodes, link breaks occur frequently in these routing protocols. In on-demand protocol, a route is used until it expires. On demand routing protocol examples are AODV, DSR and TORA etc. On demand routing protocols, reduces the number of routes in between source and destination thus saves a lot of space on each node. This saved space can be used for storing extra information in routing table like bandwidth and power utilization at each node.

B. Ad hoc On Demand Distance Vector (AODV) Routing Protocol

AODV [3] is an on demand routing protocol. AODV supports both unicast and multicast communication between nodes. AODV uses hop by hop routing which means routing not only involve source node but also intermediate node takes part in it. AODV is most used protocol in ad hoc networks. AODV uses symmetric links between neighboring nodes. AODV combines the features of DSR and DSDV. AODV uses a broadcast route discovery mechanism as is also used in the DSR. To maintain the most recent routing information between nodes it borrows the concept of destination sequence numbers from DSDV. AODV involves separate process for route discovery and for Route maintenance. AODV also uses routing table for maintaining routing information. This is called route table management [3].

1. Route Discovery: First source node initiates the Route Discovery [3] process when it needs to communicate with another node. To discover a new path, source node broadcast a route request (RREQ) packet to all its neighbors. When the RREQ packet goes to intermediate nodes that node first check its routing table. If a valid route is present then the node reply with a RREP packet and if not then the node rebroadcast the RREQ packet to its own neighbor. If a node gets more than one copy of a RREQ packet for the same broadcast id then the node drop that packet and does not forward duplicate copy. Route discovery set a path in two phases one is reverse path set-up and other is forward path set-up.

1.1 Reverse Route set-up: For reverse route formation, a node must store the address of the neighbor in its routing table from which the RREQ packet has been received first [3].

1.2 Forward Route Set-up [3]: When an intermediate nodes receive RREQ packet. The node first checks the RREQ destination sequence number with the one that is present in its routing table. If the intermediate node's sequence number is less than that in RREQ packet, then the intermediate node does not use that route and send no reply to sender. If sequence number at intermediate node is larger or equal to the RREQ sequence number, then the node reply to the neighbor from which the RREQ packet has been received with a RREP packet. As the RREP travels back to the source, each node along the path set up a forward pointer to the node from which the RREP came. If a node receive more than one route reply, then it forward that route reply RREP to the source only whose current destination sequence number is high or at least equal to the destination sequence number present at node but with small hop count. It also ensures that the routing information is up to date and quickest. As the source node receives first RREP, it starts transfer of data.

2) Routing Table: AODV has separate routing table for both unicast and multicast routing. The routing table has all the useful information for a node like sequence number, lifetime of a route, hop count etc. Besides these values it also has an entry for a timer called route request expiration time [3] and route cache timeout [3] after which the route is considered as invalid. Like DSDV, its routing table also has sequence number for all routes. These sequence number ensures loop free path. This information helps when any link between the paths breaks. When a new route is discovered then the node first checks the destination sequence number present in its table. Destination sequence number gives information about the freshness of route [3].

3) Route Maintenance [3]: During data delivery if the source node moves away the path is lost than it can reinitiate the route discovery process. When an intermediate node on the route moves away from the path then a route error message is sent to source. To detect link failure hello messages and link layer acknowledgement is used [3]. When a link break is noticed on source node then the source node can re-initiate route discovery if the route still needed by the source.

AODV used so much because it can handle different types of mobility rate with different types of data traffic. AODV also reduces routing overhead of control packets and modifications are further applied to improve scalability of the protocol. AODV applies local repair when the upstream node is closer to the destination [4]. There are many ways to improve the local route repair in AODV. Some of these methods are described in next section.

III. EXISTING APPROACHES FOR LOCAL ROUTE REPAIR IN MANET

Many researchers have done a lot of work on local route repair on reactive routing protocols. Some provides techniques to improve the existing method of local route repair. Some provides new method to be included in the routing protocol.

A. Extended Ad hoc On Demand Distance Vector Local Repair (EAODVLRT) For MANET

P. Priya Naidu and M. Chawla presented a novel approach to minimize the routing overhead of AODV local repair trail as in [2]. The route is searched for two times by default in the previous AODV model but in EAODVLRT protocol it can be maximized to seven times in the particular route. In the EAODVLRT algorithm Flooding can be minimized by the local repair technique. The main idea of this paper is to use perimeter routing for neighbor discovery. In this paper the pre-existing local repair mechanism of AODV is extended. In perimeter routing protocol a planar graph is constructed by

using RNG. Use of perimeter routing prevents the overlapping of links between neighbor nodes. Perimeter routing forwards the packets by using the right hand rule across the faces in the planar graph. In the network perimeter model described in this paper, a packet traverses successively through closer faces of a planar sub graph of the full radio network connectivity graph, until reaching a node closer to the destination. This new protocol performs better in terms of throughput, packet delivery ratio, routing overhead and end-to-end delay [2].

B. An Algorithm For Improvement Of Link Failure (ILFRP) in MANET

V. K. Goal, R. Shrivastava and V. Malik proposed a routing protocol which provides better performance for link failure in [5]. The protocol described that the path between source and destination considers the remaining power of node and available bandwidth. This paper presented three methods for detection of failed link and then provides a way to improve the link failure problem. These are Hello messages, MAC feedback and Passive acknowledgment. Hello messages are used to determine link existence. This paper used bandwidth and power information available at each node. For this, the available power list and bandwidth list is contained in the RREQ packet. It determines the minimum available power between source and destination. Then the source chooses the path which has maximum power. This new protocol called as ILFRP improves the link failure problem [5].

C. AODV with break-avoidance (AODV-BA)

A. Akbari, M. soruri and A. Khosrozadeh in [6] proposed a new route maintenance algorithm to avoid route breaks based on AODV and called it as AODV-BA(AODV with break avoidance). This new route maintenance algorithm avoids route breaks. The main idea of this approach is to detect the link break before it happens and then try to overcome the problem. For this in this algorithm, each intermediate node on an active route detects the danger of a link break to the upstream node and reestablishes a new route before route breaks. The proposed algorithm is based on four elements which are the received radio, the overlap of routes, the battery and the density. On detecting the danger of the link break, it notifies the danger to the upstream node. Received radio detects the danger of the link break due to the distance between nodes being farther than the communication range. Two-Ray Ground Reflection model is used as the radio propagation model. When there is a certain intermediate node on several active routes, the transmission delay increases by the traffic loads and also the battery of the node is quickly consumed. When the battery is less than the threshold, the node notifies the upstream node the danger of the link break. When the number of neighbor nodes around each intermediate node increases and the density rises, the transmission delay increases by competing of acquiring the wireless channel [6]. By using all these approaches, the possibility of link break is detected. Then further improvement can be implemented to handle the problems Performance evaluation of AODV-BA composed with AODV id has been done by the computer simulation using ns-2 [6].

D. Prediction Based Link Stability Scheme (PLSS)

G. Nair and N.J.R. Muniraj proposed a Prediction based Link Stability Scheme (PLSS) to make a correct balance between stability of path, link, neighbor node and total mobile nodes as in [7]. In the proposed scheme, there are 4 steps to achieve the predictive stability in whole network. These steps are stability of neighbor nodes, path from source to destination, calculation of mobile node stability and network lifetime prediction for a particular path. Stability is the quality which asserts the network environment's consistency. To measure stability of nodes two parameters are used in this approach are mobility and link loss. The main focus of this paper is to find more number of stable nodes from source to destination and then use these stable nodes to send a data packet. Performance analysis is done on NS3 for the proposed algorithm [7].

E. Advance-Ad hoc on demand distance vector (AAODV)

A. Porwal et al. proposed an approach called Advance-Ad hoc on demand distance vector (AAODV) routing protocol in [8]. This scheme solves the problem of intermediate route building in Ad hoc on demand distance vector routing protocol (AODV). AAODV uses two concepts one is Ad-hoc on demand Distance Vector with Backup routing (AODV-BR) and the other is local recovery with limited TTL value in case of failure of local recovery in first attempt. For the proposed routing protocol AAODV, some changes are made in RREQ, RREP packet and in routing table. A flag *k* is introduced in RREQ packet whose value when 1 shows the first look in alternate routing table. A flag *p* inserted in RREP packet indicates the local recovery is performed. A variable *total* is included in routing table that indicates total number of hops from source to destination. A variable *count* is included whose value indicates number of times local recovery is performed. A flag *long* is included in routing table whose value indicates hop metric increased in local recovery. For evaluating the performance of the proposed scheme, it is compared with AODV, AODV-BR and Bypass-AODV [8].

F. Congestion Controlled Route Repair

K. S. Rao, L. Shrivastava [9] proposed a modified AODV to controlled congestion by applying efficient local route repair method. The main idea of this approach is to use binary exponential back off strategy for route discovery. In this method, first time a source node broadcasts a RREQ, it waits for some time for the reception of RREP. If a RREP is not received within that time, then the source node sends a new RREQ with waiting time equal to twice of previous. For calculating waiting time for the RREP after sending the second RREQ, the originator node must use a binary exponential back off. If a RREP is not received within this timeout, another RREQ may be sent, up to a limit. For each additional attempt, the waiting time for the RREP is multiplied by 2, so that the time conforms to a binary exponential back off. In

this proposed modification, the local repair has invoked according to of hop count distance. It has invoked only when the broken link is closer to destination than the source [9].

G. New Adaptive Routing Protocol for Manet

M. S. E. Soliman et al. [10] proposed a new MANET routing protocol called as AODVLRT and it is a modification to local repair in AODV. In AODVLRT repair trial can be more than once while in AODV local repair is done just with one trial. In AODVLRT, when a route failure happens, the upstream node increments the destination sequence number by one and then it initiates its first local repair trial by broadcasting RREQ packet with $TTL = LR_TTL_START$. LR_TTL_START has been choose to be equal 2 in finding a repair from the first trial and in the same time the small value for TTL will reduce the routing message overhead. Simulation was carried out with the GloMoSim library. Traffic sources used is CBR. The mobility model used is random waypoint model and twenty data session is used in simulation. From the simulation results it is concluded that AODVLRT is suitable for the applications that need low routing message overhead but AODVLRT is not suitable for the applications that need low average end to end delay. Result shows that AODVLRT is suitable for the applications that need high throughput [10].

H. Local Repair with Handoff Approach for on Demand Routing Protocols in Ad Hoc Networks

M. Chawla, J.Singhai and J.L.Rana proposed an approach for local repair with handoff in AODV in [11]. In this approach, route rebuilding is done after route error by intermediate node rather than by source node. This approach uses the distance between the node where the link breaks to the destination of the node and then it uses a handoff approach for further improvement. In this paper, a new algorithm was defined for the local route repair process. This algorithm maintains some variable on the basis of which the repair decision is taken. It also measures the link strength; if the link becomes weak but no link break then the route rebuilding is done by the source node. If the link breaks, then call a procedure local repair () defined in [11]. In local repair(), it checks the `err_hop_count`[11] and on the basis of its value the intermediate node decides to rebuild the route and call router handoff [11] or it leaves the repair for the source node.

I. Performance Enhancement of Reactive on Demand Routing Protocol in Wireless Ad Hoc Network

V. P. Patil et al [12] proposed an improved AODV routing protocol by including route repair scheme to overcome the link failure problems of its predecessor. In proposed scheme, each node in the network maintains a single alternate route for sending and receiving data packets. If the link breaks between two intermediate nodes then the upstream node can use that alternate route instead of dropping data packets. In this proposed approach, destination send two route reply messages and when a node listen both replies, it will keep the better one in its primary route entry and the other worse one in its secondary route entry. In the proposed approach, the data packet also carries the information about the node, which has an alternate route in its path. Two extra fields are added in the Data packet one is `Backward_ID` (BID) which is the address of the node which is the nearest from the upstream node of the broken link with alternate route to the destination while the second is `Backward_Hop_Count` (BHC) which is the length of the alternate route to the destination from the node BID. Whenever a link breaks between two nodes, the upstream node of the broken link checks whether it has an alternate route or not. If it finds the route, it will send the data packet by using its alternate route. Network simulator NS-2 is used to implement the proposed scheme [12].

J. On Demand Local Link Repair Algorithm for AODV Protocol

J. Jain, R. Gupta and T.K. Bandhopadhyay [13] proposed a new local repair scheme in order to overcome the deficiency of the existing local repair schemes. In this method, route discovery is similar to AODV but, for route maintenance a new algorithm is introduced. The method used an Ant algorithm for finding new route in local repair. The new proposed algorithm is inspired from the ant colonies meta-heuristic. In case of route failure, forward packets are used to collect information about the network and backward packets are used to update the routing information in the nodes for the local link repairing. In this scheme, nodes are required to keep the next two-hop node address for each route entry in routing table. In local repair process, node not only tries to discover the route to the destination node of data packet, but also attempts to establish the route to its downstream node. The proposed scheme will be highly adaptive, efficient and scalable and mainly reduces end-to-end delay in high mobility cases [13].

K. An Effective and Scalable AODV for Wireless Ad hoc Sensor Networks (AODV-ES)

S. Sethi, A. Rout and D. Mishra [14] proposed an effective and scalable AODV (called as AODV-ES) for Wireless Ad hoc Sensor Networks (WASN) by using third party reply model, n-hop local ring and time-to-live based local recovery. All the essential functionality of AODV, including route request (RREQ), route reply (RREP), route error (RRER), HELLO messages have been implemented in AODV-ES for route discovery and maintenance. Third party reply strategy in AODV-ES works efficiently with the n-hop local ring search to reduce routing overhead. Third party reply in local ring search compares the hop count difference with local ring radius. The hop count difference must be less than local ring radius .

Only in that case, the RREQ packet is further processed. If node is destination then it send route reply message else it checks it routing table. If a valid route is found it send route reply message. If not then the node forwards the RREQ packet to its neighbor. The AODV-ES protocol maintains an invariant that destination sequence numbers monotonically increase along a valid route, which is used to prevent routing loops. The procedure for all three strategies is given in [14]. Simulation is performed on NS-2 with linux operating system.

L. An Efficient Approach For Local Repairing In Mobile Ad hoc Network

M A. Gafur, N. Upadhayaya, S. A. Sattar [15] proposed an efficient approach for local repairing in Ad hoc On Demand Distance Vector (AODV) routing protocol. In this paper, two different approaches for route discovery are presented; one is used in the normal case i.e when it finds a fresh route from source to the destination and another in the case when it finds a route from intermediate node with broken link to the destination node, which is the case of local repair. When a request comes, first it checks whether it is a fresh route request or a local repairing attempt. A Route in Repair flag is used for this purpose. If the request is fresh route request, then the protocol works same as conventional AODV. But if the Route in Repair flag is set then the proposed protocol is used in local repair mode. Route Discovery process in local repairing mode is different from the normal mode. After route discovery, the proposed approach check the route optimality with $TTL=D/2-1$. If TTL exceeds the $(D/2-1)$ it is sure that one or more reverse hop is takes place and it is suboptimal path to the destination. Such suboptimal path is unacceptable and another better route will be explored next time the packet sends after a fresh route discovery process carried out. To evaluate the performance of the improved local repair scheme NS-2 network simulator is used. Simulation results show that the new local repair scheme outperforms the local repair scheme in the basic AODV protocol [15].

IV. PERFORMANCE COMPARISON OF VARIOUS METHOD

TABLE I

Sr No.	Name of Approach	Performance Comparison with AODV
1	EAODVLRT	EAODVLRT has lower routing message overhead than AODV. EAODVLRT has higher throughput than AODV routing protocol. Average packet delivery ratio is higher in case of EAODVLRT.
2	ILFRP	It will improve the link failure prediction in terms of power between source to destination.
3	AODV with break-avoidance (AODV-BA)	AODV-BA is more effective than AODV in terms of number of route breaks decreases, packet arrival ratio raises, end to end delay decreases and routing overhead increases.
4	Prediction Based Link Stability Scheme(PLSS)	PLSS achieves better performance in terms of packet delivery ratio, delay, overhead, network lifetime, energy consumption than the existing method.
5	Advance-Ad hoc on demand distance vector (AAODV)	AAODV gives better performance then AODV and it reduce the route maintenance time when the link break is occurs. AAODV minimizes the routing overhead.
6	Congestion Controlled Route Repair	In this approach, packet delivery fraction is increased and normalized routing load, average end to end delay and packet loss is decreased.
7	New Adaptive Routing Protocol For Manet	This new routing protocol has lower routing message overhead but it has higher average end to end delay. It has higher throughput than AODV
8	Local Repair with Handoff Approach	It keeps routing overhead and end-to-end delay low while optimizing overall throughput as compared to the existing routing protocol
9	Performance Enhancement of Reactive on Demand Routing Protocol	This scheme enhances the packet delivery ratio and reduces the routing load and end to end delay on mobile network
10	Demand Local Link Repair Algorithm for AODV Protocol	This algorithm is expected to reduce end to end delay as compared to delay in pure AODV protocol and expect to increase in throughput
11	AODV-ES	AODV-ES has better performance with higher PDR and lower end-to-end delay as compared to AODV
12	An Efficient Approach For Local Repairing In Mobile Ad hoc Network	The proposed Modified AODV (MAODV) is performed better than traditional AODV in terms of packet reception in heavily loaded network as well as lightly loaded network.

V. CONCLUSION AND FUTURE WORK

This paper presents the various mechanism to improve the local repair in reactive routing protocol proposed by researchers has been studied. All these method provides some improvement in the reactive routing protocol. Some methods improved the throughput, packet delivery ratio and decrease delay. In some approaches, two or more mechanisms are combined to give a better performance. By improving the local repair technique, the performance,

efficiency and scalability of reactive routing protocol can be improved. There are also some factor that can be taken with local route repair mechanism like power management and bandwidth minimization. These modifications can further improve the efficiency and performance of the routing protocol. Therefore these are the aspects which are to be looked upon in future.

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