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On Demand Multipath Routing Algorithm for Adhoc Wireless Networks

K.V.Kulhalli[1], Prajakta Rane[2]

Abstract

In this paper, a new shortest multiple routing algorithm for MANETs is proposed. This is based on DSR, but makes the destination nodes get the shortest unattached routes correspondingly only the destination nodes can respond to the routing request (RREQ), and the intermediate hosts rebroadcast the shorter RREQ packets with some conditions, besides, there are also some changes done for the route maintenance. A Shortest Multiple Routing Algorithm (SMSR) based on the DSR protocol is presented. The intention of the algorithm is to get more topology messages and the correspondingly shortest routes.

Keywords

MANETs, DSR, SMRR, Multipath routing.

1. Introduction

On-demand routing protocols have gained more popularity in mobile ad hoc networks as compared to other routing schemes because of their abilities and efficiency. Currently there are many on- demand routing protocols for mobile ad hoc networks (MANETS). All these Protocols make use of, a single route and do not utilize multiple alternate routes and paths. Multipath routing allows the establishment of multiple paths between a single source and single destination node and when a path breaks an alternate path is used instead of initiating a new route discovery, hence multipath routing represents a promising routing method for wireless mobile ad hoc networks. Multipath routing achieves load balancing and is more resilient to route failures. Recently, numerous on-demand multi-path routing protocols have been proposed for wireless mobile ad hoc networks of these protocols showed that they achieve lower routing overhead, lower end to-end delay and alleviate congestion in comparison with single path routing protocols.

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Kshama V Kulhalli, Department of information Technology, Shivaji University/ D.Y.Patil. College of Engg. & Technology, Kolhapur, India.

Prajakta Rane, Electronics &Telecommunication, Shivaji University/ D.Y.Patil. College of Engg. & Technology, Kolhapur.

Mobile ad hoc networks are the collection of wireless mobile nodes which dynamically interchange data within themselves without its dependency on a fixed base station or a wired backbone network [1]. These nodes have a limited transmission range and therefore, each node seeks the help from its neighborhood nodes in forwarding packets and hence the nodes in an ad-hoc network can act as both routers and hosts, thus a node may forward packets between other nodes as well as run user applications. MANETs are characterized by their limited power, processing, and memory resources and also with the high degree of mobility [5]. Multiple hops are usually needed for a node to exchange information with other node in the network because of the limited transmission range of the wireless network nodes. Therefore this becomes a crucial issue in designing a MANET. Thus the key challenge here is to route with minimum overheads even in dynamic conditions. Here overhead can be defined in terms of the routing protocol control messages that consume both channel bandwidth as well as the battery power of nodes for communication/processing [6]. On-demand routing protocols build, maintain only the necessary required routes in order to reduce the routing overheads [2]. They manage to organize themselves dynamically with minimum memory overhead and lower bandwidth requirement compared to table driven protocols (proactive protocols). In spite of this, there are still some bottlenecks in the initial .pioneering versions of on-demand routing protocols, more and more research work is carried out to rectify many of these problems. For example, many on-demand routing protocols, such as Associativity Based Routing (ABR), Dynamic Source Routing (DSR) [4,13,14] and Ad hoc On-demand Distance Vector (AODV) [3,7,9] use a single route per data session. Hence it is essential to initiate a new route if the active route is broken. Extensive discussion and analysis is done on single path on demand routing protocols. Multipath on demand routing protocols is the current research topic for MANETs. Multiple disjoint paths from a source to a destination are established in multipath routing protocols. Thus improving resilience to network failures and allow

for network load balancing. Thus these effects are particularly very important in networks with high node density (and the corresponding larger choice of disjoint paths) and high network load (due to the ability to load balance the traffic around congested networks). The work done on Single path (or Unipath) routing in MANETs has been proposed in [3] [4]. In this paper, a new multiple routing algorithms based on DSR for MANET is proposed.
The paper is organized in the following sequence. Unipath routing MANETS is explained in section 2. The new algorithm is presented in section 3 with explanation. Section 4 provides the analysis and simulation results of DSR and multiple routing algorithms. Conclusions are in drawn in section5.

2. Unipath Routing in MANETs

The two important classes of ad hoc routing protocols are table-based and on-demand protocols [10]. In table-based protocols [8] [9], each node maintains a routing table containing routes to all nodes in the network. The nodes need to exchange messages periodically with routing information and keep the routing tables updated. For this reason routes between nodes are computed and are also stored, even when they are not actively used. Especially for large, highly mobile networks Table-based protocols may not be practical. A considerable number of routing messages have to be exchanged in order to keep routing information accurate or updated, because of the dynamic nature of ad hoc networks.
In on-demand protocols, nodes only compute routes when there is a demand for routes from nodes. Therefore, on-demand protocols are more scalable to dynamic large networks [3] [4]. When a node wants to know the route to another node, it starts a route discovery process to find a route. The main two important phases of On-demand protocols consist of Route discovery and Route maintenance.

A. Route Discovery

The process of finding a route between two nodes (see Figure 1) is known as Route discovery. The route discovery process starts to find out a route between two nodes when a source has no entry for a destination in its routing cache.

B. Route Maintenance

The process of repairing a broken route or finding a new route in the presence of a route failure (see Figure 2) is Route maintenance. When a node tries to forward a message, and there it detects a link break, which means the next node is not in a reachable condition, then route maintenance process starts.

The Unipath routing protocols are the recent and most currently proposed routing protocols for ad hoc networks. Only a single route is used between a source and destination node in Unipath routing. Dynamic Source Routing (DSR) and the Ad hoc On-demand Distance Vector (AODV) protocols are the two most widely used on-demand protocols.

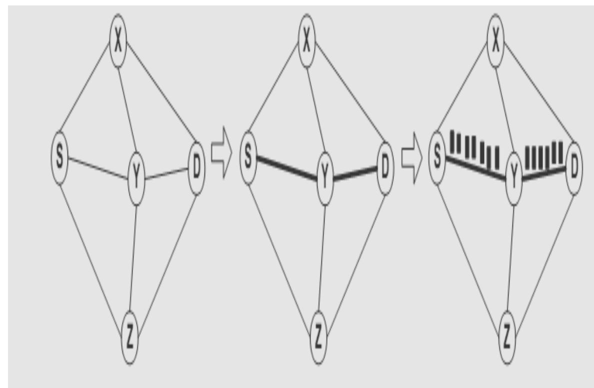

Fig. 1: An example of route discovery in an ad hoc network. In order for node S to send data to node D, it must first discover a route to node D. Node S discovers a route to node D going through node Y, and sets up the route. Once the route is established, node S can begin sending data to node D along the route

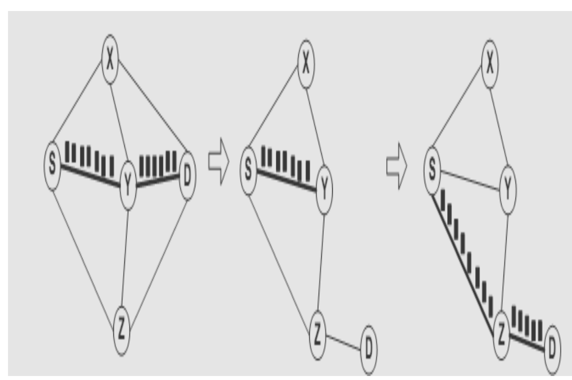

Fig. 2: An example of route maintenance in an ad hoc network. Node S sends data along an established route to node D through node Y. When node D moves out of range of node Y, this route breaks. Node S finds a new route to node D through node Z, and thus can begin sending data to node D again

3. Multiple routing algorithm

The congestion or disconnection is happening on one of paths of the ad hoc network where the single path routing attention has been paid to multiple routing [11] [12] whose concept has been used for circuit switched and packet switched networks, as it provides an easy mechanism to distribute traffic and balance the network load, as well as provides fault tolerance. The SMSR (the shortest multiple source routing) a new multiple routing algorithm is proposed here. It applies the similar route discovery of DSR protocol, but the difference is that only the destination node can replay the RREP packet and all the intermediate nodes rebroadcast the shortest RREQ(here we recognize the RREQ which includes the fewest hops is the shortest one)by some restrictions. Then, the destination may get some shortest disjoint routes correspondingly. As the link failure in one path will not affect the others therefore only disjoint routes are selected here. Some changes in Route maintenance that suits for ad hoc networks are done here. The explanation about the new algorithm is as follows:

A. Route Discovery

The source node S, initiates route discovery by flooding the network using query messages (RREQ) seeking some routes to the destination when there is no route in its cache.

On the receipt of the RREQ packet, the intermediate nodes will not respond to any route reply (RREP) message to the source node irrespective of whether there's any route messages about the destination or not. It also ensures the validity of the routes found in the process of the route discovery. The processing of the intermediate nodes is summarized as follows:
Whenever any intermediate nodes receive a RREQ, they will first compare with the packet which exists in its cache. If the hops that are included in RREQ of the cache are more than that in the new arrived RREQ, then the data in the cache needs to be updated. The new arrived RREQ will be then be rebroadcasted, or else the RREQ should be thrown away. If the intermediate nodes receive the RREQ for first time that then, the node stores it and rebroadcast the same. In this process, the shortest route between the intermediate node and S will be found. The reason for us pursuing the shortest route is that it can more or less solve the problem that routes may be easily broken if they are too long because of dynamical changing network topology in a large-scale ad hoc network.

The intermediate nodes will not transfer the RREQ request immediately but wait for a fixed delay and carry out handling when it detects that the next hops itself are the destination nodes. Let us consider the following problems:
Suppose the node "N" is an intermediate node and its next hop is the destination node, then depending on, the condition if the node N receives a RREQ at first time, it will keep the RREQ and then transfers it to the destination node. If it receives the RREQ again, then N should carry out the comparison. If the result is that, the hops of the RREQ are fewer than that in N's cache, N will update the data in its cache and transfer this RREQ to the destination again. In this process, the destination may receive too much RREQ from the same intermediate nodes, thus, a great burden will add to the destination and cause the meaningless routing overhead as well as the delay. And what the node N do during the delay is that it should compare the RREQs that have received one by one, finally, choose the shortest one and transfer it to the destination node. Other than this, the node N will not transfer any data to the destination until the new route discovery is initiated.

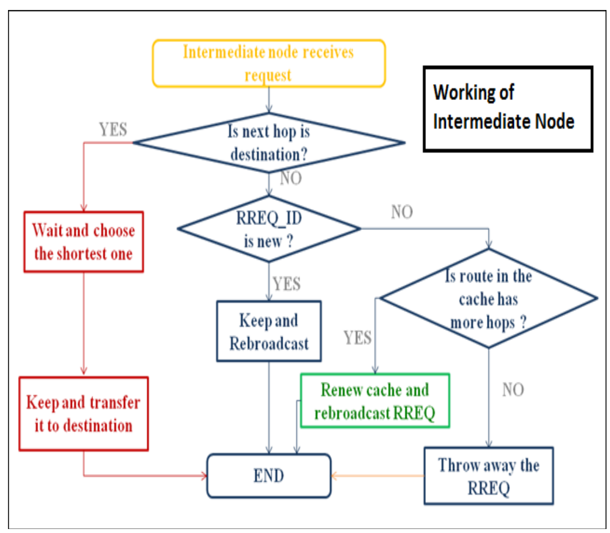

Fig 3: Processing of the intermediate nodes for RREQ in SMSR algorithm

The destination node will receive disjoint multiple routes during the delay and execute the multiple selecting algorithm, and then reply the RREP. The route discovery also can be explained by a simple topology chart with 16 nodes as shown in the Fig 4.

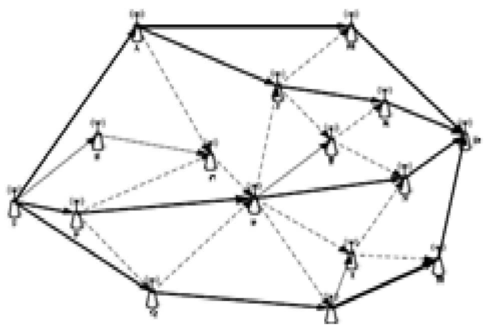

Fig 4: **Route discovery topology chart**

Suppose that the node S is the source node, the node D is the destination node, the real lines mean the routes that will be kept in the caches of the corresponding nodes, the broken lines mean the route that will be finally thrown away, and the thick real lines mean that will be received by the destination node D. For example consider the node P, once first receives the RREQ from the source node S, it stores the RREQ and rebroadcasts it to its next hops E, F and C. On the other hand, P will receive the RREQ of the node B in succession as it is the next hop of B. Then, P will carry out comparison, and finds that the hops in the RREQ from B is more than that in its cache kept from S, thus, P will throw away the new arrived RREQ; For example take the node N whose next hop is the destination node D, once it receives the RREQ of node I at the first time, it will not transfer to D immediately but just delays it. After a fixed random time, N will receive and compare the RREQ from E and F one by one. And it will select the F's RREQ at last for it is the shortest route will be observed. The conclusion drawn from the above analysis can be summarized as follows. Each route received by the destination node is disjoint and is the correspondingly shortest route. This will enhance the route reliability and the data delivery ratio, as well as reduce the difficulty of the selection for the destination node. A simple method for selecting multiple paths is proposed here.

First, the primary source route which is the route taken by the first query reaching the destination node is considered and is the main route for it. It also defines the shortest route between the source and the destination. Once it receives, the destination node responds by sending a route reply (RREP) message to the source immediately for reducing the delay by any possible means. Then, the destination node waits for a fixed time during which many RREQs from the different intermediate nodes will be received. But only M routes should be are kept as the spare route and reply RREPs. From Fig2, the forms of the routes in RREQs that have been received by the destination are shown as follows:

RREQ1 {S,A,M}; RREQ2 {S,A,J,K}; RREQ3 {S,P,F,N}; RREQ4 {S,Q,G,H}.

By this way, the number of the RREQs that are received by destination should be obviously far more than four in the large-scale mobile ad hoc networks. Suppose that the RREQ1 is the first one that arrives at D, it will be recognized as the main route. And the selection of the spare routes based on the above aggregation of the RREQs can be explained in the following manner.

1) *Select* a set of RREQs all of them have the first same intermediate node and make up of a new subset. For example, if the intermediate node A is the first same node of RREQ1 and RREQ2, thus, they are selected.

2 Select the RREQ which includes the shortest route (here we define the route that have the least hops in RREQ is the shortest route) from the new subset and add to the spare multiple routing table, erase the other RREQs in the subset at the same time.

3) If the nodes in one RREQ are not as the same as all of that in the other RREQs, directly add the RREQ to the spare multiple routing table. Otherwise, repeat the steps 1) &2) until there is no RREQ in the aggregation.

4) Select the shortest M routes from the spare multiple routing table and erase the others. But it's not the more the better for M because that too much routes will bring the high routing overhead for route maintenance when consequentially enhance the routing reliability at the same time.

4. Analysis

The Multiple routing algorithms are compared with the DSR protocol in NS2.

A. **simulation Environment**

For simulation purpose numbers of nodes are generated. Here 20, 25, 30 nodes are randomly placed in an area of 2km by 2km and compare in two groups. The simulation time is about 30ms. Nodes generally follow the mobility model with varying speeds in random waypoint.

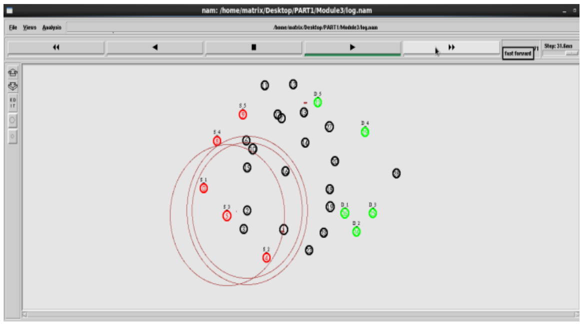

Fig 4.1: Implementing DSR routing protocol for topology of 30 nodes

Five pairs of source and destination figure 4.1 are chosen to evaluate performance parameters. Shortest path is selected for given pair of source and destination. Hop count is the metric used for the shortest path.

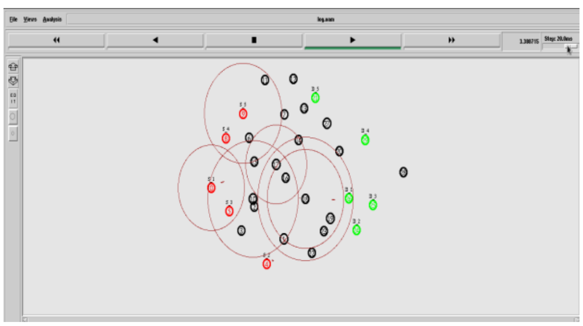

Fig.4.2: Implementing SMSR routing protocol for topology of 30 nodes

Five pairs of source and destination fig 4.2 are chosen to evaluate performance parameters for SMSR routing algorithm. Alternative paths are stored in cache memory as it is multiple path routing algorithms.

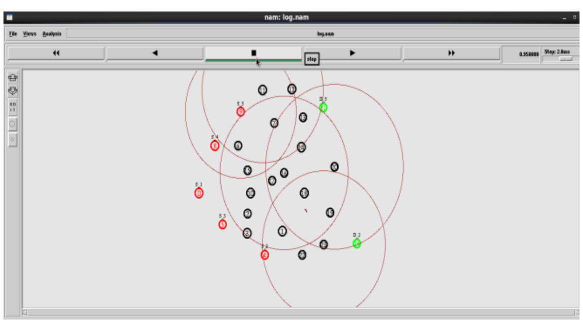

Fig 4.3: Implementing SMSR routing protocol for topology of 25 nodes

SMSR routing protocol is further implemented by changing number of nodes from 30 to 25 as shown in Fig 4.3.

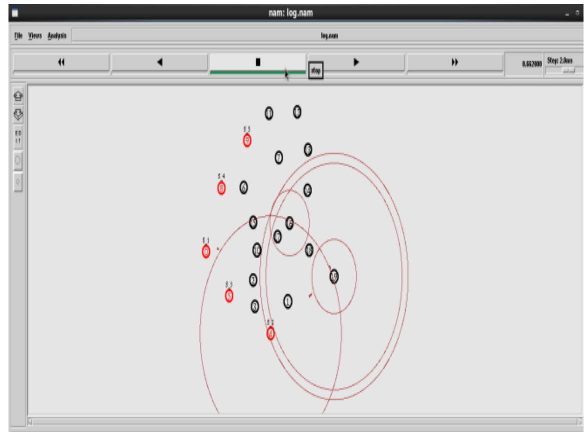

Fig 4.4: Implementing SMSR routing protocol for topology of 20 nodes

SMSR routing protocol is again further implemented by changing number of nodes from 25 to 20 as shown in fig 4.4

B. Performance metrics

Multiple routing algorithms are compared with DSR in the most important performance metrics as follows:

1) Packet Delivery Ratio (PDR) is defined as the rate of packets received to packets generated.

2) Average End to End Packet Delay: is defined as the average end to end delay encountered by each data packet.

3) Routing Overhead per Received Packet: is defined as the ratio of the total number of routing control packets generated or forwarded to the data packets received correctly at the destination. This includes route requests, route replies, and route errors.

C. simulation Results

Initially 30 nodes topology is used to simulate working of DSR and SMSR. Simulation is carried out for 30ms of the time. Nodes generally follow the random way point mobility model. The Trace files (log.tr file) of the respective protocols are analyzed using AWK script for calculating values of all parameters. These values are then compared to conclude.

Comparative Results for SMSR and DSR

Table 4.5: E2E delay for SMSR and DSR

Time (ms)	E2E delay for DSR (ms)	E2E delay for SMSR (ms)
5	0	0
15	1216.47	318.004
20	1348.13	307.282
25	1335.09	338.672
30	1369.8	455.79

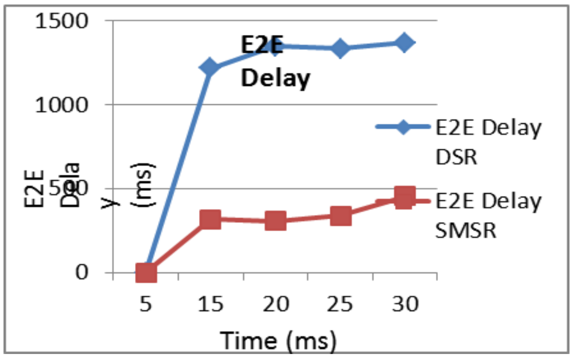

Figure 4.5: E2E delay for SMSR and DSR

E2E delay is encountered by each data packet. During route discovery, three routes are built in SMSR algorithm and the new route discovery will be initiated when all of them are invalid, but here is only one route in DSR. Obviously, the probability of the route rebuilding in SMSR should be less than that of DSR in the dynamic topology network. So E2E delay in SMSR algorithm is significantly improved than in DSR algorithm.

Table 4.6: PDR for SMSR and DSR

Time(ms)	DSR	SMSR
5	0.5	0.5
15	0.7876	0.8524
20	0.7882	0.8156
25	0.7925	0.8065
30	0.7895	0.8076

Table 4.7: Average E2E delay for SMSR and DSR

Routing Protocol	Average E2E delay
DSR	1369.8 ms
SMSR	455.79 ms

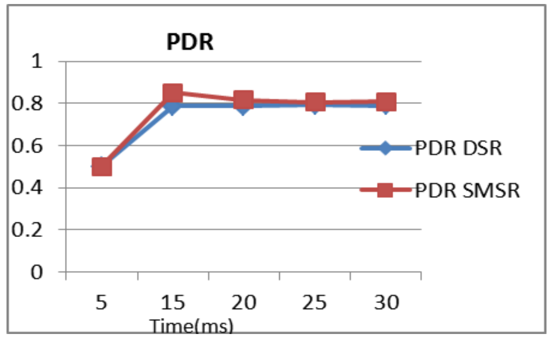

Figure 4.6: PDR for SMSR and DSR

PDR is rate of packets received to packets generated. SMSR algorithm is having multiple paths for given pair of source and destination. So if one of the paths fail, alternative path is available thus probability for increase in PDR whereas, in DSR probability of unavailability of the path giving rise to decrease in PDR. Therefore PDR for SMSR algorithm is improved than DSR.

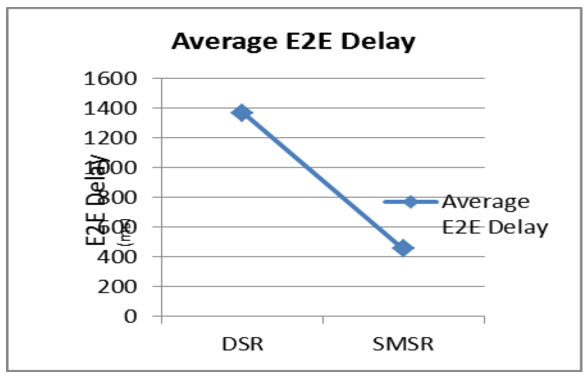

Figure 4.7: Average E2E delay for SMSR and DSR

5. Conclusion

The number of routes is formed between given pair of source and destination. RREQ whose RREP arrives first at source becomes the shortest path. The shortest of these routes is primary route. It is used mainly for data transfer. Next two shorter paths are secondary routes.

If primary path fails, then traffic automatically switches on to secondary path without giving rise to route discovery again. In doing so, the reliability of the route between the source and the destination will be enhanced. It decreases the traffic over the network as frequency of route discovery is reduced. Also the validity of the path increases. The packets loss rate and the network delay are reduced. The simulation results show that the new algorithm is better than DSR protocol. For the presented SMSR protocol, as number of nodes are increased E2E delay increases but PDR remains fairly constant.

Future Scope

Simulation results for real time system with greater than 30 nodes and more than 30 ms simulation time will be observed. Proposed routing protocol SMSR can be compared with other unipath routing protocols such as AODV.

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Dr. Kshama V Kulhalli, has Completed her B.E from Karnataka University, in 1984, Masters from BITS, Pilani in 1990, MBA in HR from YCMOU, and PhD in Electronics Engg. From Shivaji University in 2013, currently she is working as Vice Principal and Head IT Dept. in D.Y. Patil. College of Engg. & Technology. She is Teaching PG/UG students from last 30 years. She has more than 50 international /National papers publications to her credit and also guiding 18 PG and 2Research candidates.

Prajakta Rane completed her ME from D.Y.Patil college of Engg and Technology, in 2013 and currently working in Mumbai university Engg. College as an Assistant Professor.