Master Flow Routing Protocol for Ad-Hoc Networks

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Abstract

The network route information and frequent route discovery processes in MANETs generate considerable routing delay and overhead when on-demand routing protocols are employed. This paper proposes a practical route caching strategy to minimize routing delay and/or overhead by adding a new master routing table and modifying the local routing table of the nodes, for the network. The master table helps working nodes to choose the updated path for data transfer. The local table at nodes helps to find the congestion free link while maximizing the bandwidth utilization. Along with this, the new scheme also modifies the different packets (REQ, REP, and ERR) being used for path discovery & maintenance and master table updations. Calculated results show that the routing delay achieved by our route caching scheme is only marginally more than the theoretically determined minimum. Simulation in NS-2 demonstrates that the end-to-end delay from DSDV routing can be remarkably reduced by our scheme and reliable end to end delivery.

1. Introduction

In the next generation of wireless communication systems, there will be a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity, and can be conceived as applications of **Mobile Ad Hoc Networks[1]**. A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves, i.e., routing functionality will be incorporated into mobile nodes.**[2][3]**

The design of network protocols for these networks is a complex issue. Regardless of the application, MANETs need efficient distributed algorithms to determine network organization, link scheduling, and routing. While the shortest path (based on a given cost function) from a source to a destination in a static network is usually the optimal route, this idea is not easily extended to MANETs. Factors such as variable wireless link quality, propagation path loss, fading, multi-user interference, power expended, and topological changes, become relevant issues. A lapse in any of these requirements may degrade the performance and dependability of the network. The network should be able to adaptively alter the routing paths to alleviate any of these effects.**[8]**

2. The Proposed Master Flow Routing Scheme

The Master Flow Routing Protocol (MFRP) maintains a master routing table for the network. The master routing table is filled when the network is initialized, using this table the nodes searches for the path to appropriate destination node. Each node in the network maintains its own (local) routing table. The master table tells the path to travel for the data transfer from any node to any destination, with the minimum cost. The local table helps the packets to select the link based on low congestion. If some source wants to send data to some destination, it (data packet) travels through as prescribed by the master table. If, during transfer, there is some congestion, it's the responsibility of the intermediate node to search for the new path with the help of local table. It may be the case when there is some link failure during data transfer, then intermediate searches for the path to destination with the help of master table. The entries in master table are filled according to the Floyd-Warshall algorithm and the local tables are filled according to the Ford-Fulkerson algorithm. These tables helps source node to transfer maximum data to destination node, therefore utilizing maximum bandwidth.

2.1 Different Packets and Tables Used In the Network

Here we have defined the packets *(REQ, REP, and ERR)* necessary for finding & maintaining path and updating the master table. Along with this we have given the structures and fields of the different packets.

The tables are as followed:

Master table:

{Source ID, Destination ID, Cost, Path}

Local table:

{Destination ID, Next hop, Sequence Number, Flow Count}

The different packets are:

REQ: Request for data transfer from source to destination, with the given route by master table.

Type	Reserved	Hop Count
Sequence Number		
Source ID	Destination ID	
Master's Path	Cost	
Path Travelled	New Cost	

REP: Reply from destination after successful transmission of data.

Type	Reserved	Hop Count
Sequence Number		
Source ID	Destination ID	

ERR: Sent by an intermediate node to source node telling about the link failure, congestion or even unavailability of the next, thus again it consults the master table for the further path to destination.

Type	Reserved	Hop Count
Sequence Number		
INode ID	Source ID	
Description		

2.2. Route Discovery

The route discovery process is invoked by the master table when the network is initialized. In this process the classical Floyd Warshall Algorithm **[9]** is initialized. According to this the shortest distance is calculated by:

$$d^{(k)}_{ij} = w_{ij} \quad \text{if } k=0;$$
$$= \min\left(d^{(k-1)}_{ij},\ d^{(k-1)}_{ik} + d^{(k-1)}_{kj}\right) \quad \text{if } k>=1;$$

where $d^{(k)}_{ij}$ is the weight from node i to node j, and when k=0, a direct path from i to j with no intermediate node in between. Now the path to be traveled using this shortest path is calculated by:

When k=0, i.e. there is no intermediate node from source (i) to destination (j):

$$\pi^{(0)}_{ij} = \text{NIL} \quad \text{if } i=j \text{ or } w_{ij} = \infty,$$
$$= i \quad \text{if } i=j \text{ and } w_{ij} < \infty.$$

For k>=1, i.e. there is one or more than node in between:

$$\pi^{(k)}_{ij} = \pi^{(k-1)}_{ij} \quad \text{if } d^{(k-1)}_{ij} <= d^{(k-1)}_{ik} + d^{(k-1)}_{kj},$$
$$= \pi^{(k-1)}_{kj} \quad \text{if } d^{(k-1)}_{ij} > d^{(k-1)}_{ik} + d^{(k-1)}_{kj}$$

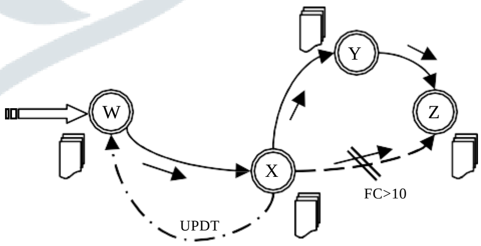
2.3 Route Maintenance

When the source node sends the data to the destination node via the path as described by the master routing table, it may be the case that the link might be broken, or there may be no node (node destruction), then it is the responsibility of the previous node to send the data to the destination node following some different route being described at that time.

This is done with the help of the local routing table of that particular node. The local table maintains information about the neighbor nodes and the link information depicting the flow count (link utilization).

Flow Count	Description
0	No Data Transfer – low utilization
1 <= FC < 3	Under Flow – Low Utilization
3 <= FC < 6	Average Flow – good utilization
7 <= FC < 9	Best Flow – best utilization
FC >= 10	Over Flow – congestion

The FC field in the local routing table is filled by the classical Ford-Fulkerson algorithm.



Now if the flow count (FC) of some link, to destination is 10, then it means the link is highly congested, therefore it finds another link to transfer the data, or if FC=0, this means that there is no link utilization, hence affecting the network efficiency. Thus more and more data should be transferred through this link so as to increase the efficiency of the network.

2.4. Master Table Updation

When the data is successfully received by the destination node, it sends a reply packet back to the source node. The destination node checks the cost of the packet traveled to that of those described by the master table.

if $Cost_{(Trav)}$ <= $Cost_{(Master)}$ then path is updated,
else its not updated.

3. Experiments and Simulation Results

The simulation of this protocol in NS2**[6]** has shown high percentage of packet delivery in MANETs as compared to DSDV and other protocols.

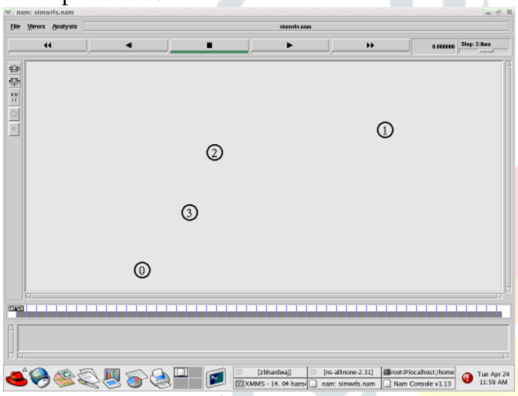


Fig: Before Transmission

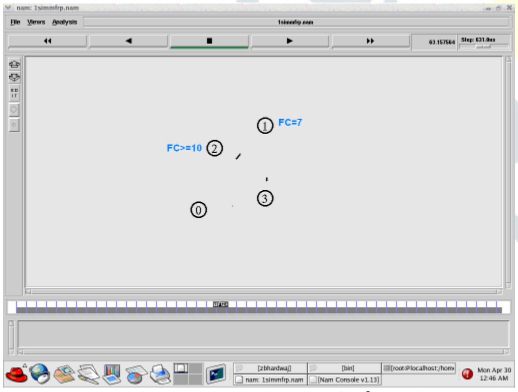


Fig: Transmission via 1 as FC of 2 >10

The new protocol achieves the target of better management of route repairs and thus reliable routes. It does not use cache concept as in DSR which creates overhead in route maintenance. It does not use height calculation and generation of directed acyclic graph. It has been designed to be robust to changes.

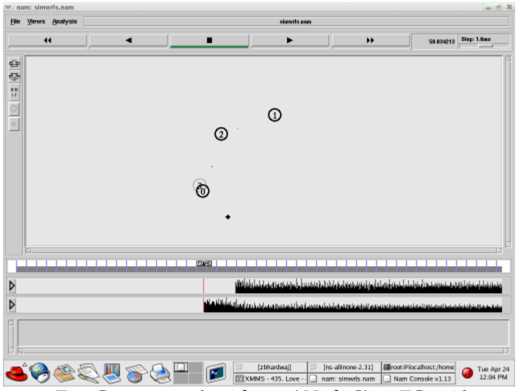


Fig: Congestion Avoidance (Node 3) as FC>=10

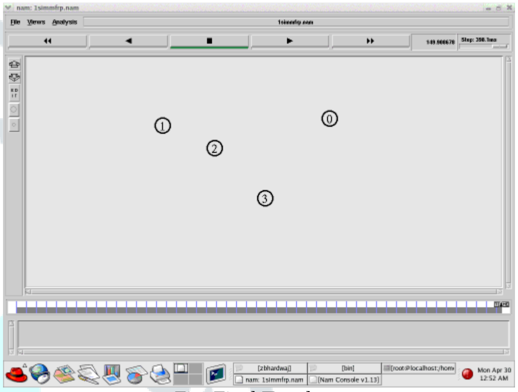


Fig: Final Topology

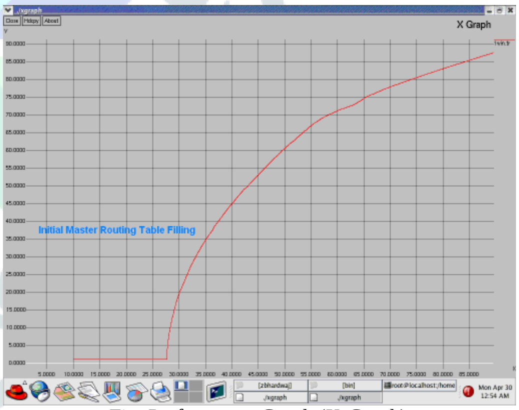


Fig: Performance Graph (X-Graph)

4. Summary

1. MFRP provides faster and reliable communication.
2. It thus utilizes link bandwidth and thus increases network efficiency.
3. Initial filling of Master Table is a drawback.
4. Consistent updations of both the tables increases the link and network utilization.

5. Future Scope

1. Here we are trying to overcome the drawback of initial Master Routing Table filling, while maintaining the basic concept of existing protocol.
2. Innovating new ideas to provide security for the communication.

6. Acknowledgments

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7. References

[1] Sanlin Xu, Kim Blackmore, Haley Jones - “Practical Scheme for Optimizing Route-Cache TTL in MANETs”.

[2] Panagiotis Papadimitatos and Zygmunt J Haas - “Securing Routing for MANETs”.

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[6] http://www.isi.edu/nsnam/

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[8] Mehran Abolhasan , Tadeusz Wysocki , Eryk Dutkiewicz – “A Review of Routing Protocols For Mobile Ad Hoc Networks”.

[9] Thomas Coreman, Charles Leiserson , and Ronald Rivest – “Introduction to Algorithms, 2nd Edition”