# Evaluation Criteria for Routing In Mobile Ad Hoc Networks

GJCST Computing Classification
C.2.5, C.2.m

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***Abstract-* Mobile Ad-hoc network typically have a dynamic topology, which will have profound effects on network characteristics. Network functions such as routing, address allocation, authentication, and authorization must be designed to cope with a dynamic and volatile network topology. Routing is a core problem in networks for delivering data from one node to another. Many routing algorithms have been proposed for MANET that belongs to different categories and with different criteria to improve the performance while reducing the overhead. In this paper we would like to exploit various characteristics and review those characteristics and their effect on performance of the proposed routing methods. In this paper, we have also tried to identify the issues that are to be considered while evaluating a routing algorithm for mobile ad hoc networks.**

## I INTRODUCTION

According to the definition of IEEE 802.11: A network composed solely of stations within mutual communication range of each other via the wireless medium (WM). An ad hoc network is typically created in a spontaneous manner. The principal distinguishing characteristic of an ad hoc network is its limited temporal and spatial extent. These limitations allow the act of creating and dissolving the ad hoc network to be sufficiently straightforward and convenient to be achievable by non-technical users of the network facilities. No specialized "technical skills" are required and little or no investment of time or additional resources is required beyond the stations that are to participate in the ad hoc network. The term ad hoc is often used as slang to refer to an independent basic service set (IBSS)[13].

In this paper we would like to exploit the requirements for routing protocols and survey the different routing strategies for Mobile Ad Hoc Networks. Section II categorizes the various routing strategies for MANET while Section III describes the issues for evaluating the routing protocols proposed for the Mobile Ad Hoc networks.

## II CHARACTERISTICS REVIEW OF CURRENT ROUTING ALGORITHMS

We shall now review the main characteristics of proposed routing algorithms, in light of desired qualitative and quantitative properties, and few additional characteristics.

### *A. Demand-Based Operation*

Routing algorithms can be classified as proactive or reactive. Proactive protocols maintain routing tables when nodes move, independently of traffic demand, and thus may Have unacceptable overhead when data traffic is considerably lower than mobility rate. The communication overhead involved in maintaining global information about the networks is not acceptable for networks whose bandwidth are battery power are severely limited.

***Reactive algorithms-***
Reactive algorithms are designing routes when they are needed, in order to minimize the communication overhead. They are adaptive to „sleep period" operation, since inactive nodes simply do not participate at the time the route is established. When requires the destination search will be initiated and the route will be computed for data transmission. The efficiency of destination search depends on the corresponding location update scheme. A quorum based, a home agent based, and a depth-first search based destination search and corresponding location update schemes are being developed. Other location update and destination search schemes may be used including an occasional flooding. In reactive routing, the communication overhead of routing algorithm is divided into the following components: location updates, destination searches (that are performed in accordance to location update scheme), and path creation (or reporting from destination back to source).

### *B. Distributed Operation*

We shall divide all distributed routing algorithms into localized and non-localized. Localized algorithms are distributed algorithms that resemble greedy algorithms, where simple local behavior achieves a desired global objective. In a localized routing algorithm each node makes decision to which neighbor to forward the message based solely on the location of itself, its neighboring nodes, and destination. While neighboring nodes may update each other location whenever an edge is broken or created, the accuracy of destination location is a serious problem. Localized routing algorithms that guaranty delivery show that localized algorithms can nearly match the performance of shortest path algorithms.

All non-localized routing algorithms proposed in literature are variations of shortest weighted path algorithm. Zone based approaches, combining shortest paths within a zone and inter-zonal destination searches or routing tables.

In zone based routing algorithm, nodes are divided into non-overlapping zones. One way of forming Zone is to use the location information to form the zones and operate based on location information. Another way is not to use location information of nodes but selects one node in each grid or zone, and these nodes serve as backbone for routing tasks. Each node only knows node connectivity within its own zone, and routing within zone is performed directly while inter-zone would be performed by using backbone node.

### *C. Location Information*

Most proposed routing algorithms do not use the location of nodes, that is their coordinates in two or three-dimensional space, in routing decisions. The distance between neighboring nodes can be estimated based on incoming signal strengths (if some control messages are sent using fixed power). Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors.
Alternatively, the location of nodes may be available directly by communicating with a satellite, using GPS (Global Positioning System), if nodes are equipped with a small low power GPS receiver. We believe that the advantages of using location information outweigh the cost of additional hardware, if any. The distance information, for instance, allows nodes to adjust their transmission powers and reduce transmission power accordingly. This enables using power, cost, and power-cost metrics and corresponding routing algorithms in order to minimize energy required per routing task, and to maximize the number of routing tasks that a network can perform. Routing tables that are updated by mobile software agents modeled on ants. Ants collect and disseminate location information about nodes.

### *D. Single-Path Vs. Multi-Path Strategies*

There exist several multi-path full message strategies, where each node on the path sends full message to several neighbors which are best choices for all possible destination positions. There is significant communication overhead, and lack of guaranteed delivery can make this approach inferior to even a simple flooding algorithm. Clever flooding algorithm may use about half of nodes only for retransmissions, which often matches the number of nodes participating in routing in this method. In addition, flooding guarantees delivery and requires no prior location updates for improved efficiency. Multi-path methods may be regarded as flooding that is restricted to the request zone, and as such can be used for geocasting (where a message is to be delivered to all nodes located within a region). Multi-path algorithm consisting of several single-paths is proposed.

### *E. Loop-Freedom*

Interestingly, this basic criterion was neglected in many papers. GEDIR and MFR algorithms are inherently loop-free. The proofs are based on the observation that distances of nodes toward destination are decreasing.

### *F. Memorization Of Past Traffic*

Most reported algorithms require some or all nodes to memorize past traffic, as part of current routing protocol, or to memorize previous best path for providing future path to the same destination. Solutions that require nodes to memorize route or particular information about past traffic are sensitive to node queue size, changes in node activity and node mobility while routing is ongoing. One form of such memorization are routing tables, which memorize last successful path to each destination.

## III PERFORMANCE EVALUATION ISSUES

The important issues for evaluating the routing protocols for MANET are as follows.

### *A. Delivery Rate*

Delivery rate is defined as the ratio of numbers of messages received by destination and sent by senders. The best methods by this metric are those that guarantee delivery, where message delivery is guaranteed assuming „reasonably‟ accurate destination and neighbor's location and no message collisions.

### *B. End-To-End Data Delay*

This is also referred to as latency, and is the time needed to deliver the message. Data delay can be divided into queuing delay and propagation delay. If queuing delay is ignored, propagation delay can be replaced by hop count, because of proportionality. Retransmissions can be included if MAC (medium access control) layer is used in experiments. Several papers suggested that it is more important to minimize the power needed per message, or the number of routing tasks network can perform before partitioning.

### *C. Communication Overhead*

It can be defined as the average number of control and data bits transmitted per data bits delivered. Control bits include the cost of location updates as preparation step, destination searches, and retransmission during routing process. However, this metric is rarely used in literature. In fact, most of proposed papers avoid measuring it altogether. The portion of ignored overhead may often be more significant than the measured one.

### *D. Performance On Static Networks*

Although the algorithm is designed with moving nodes in mind, static nodes are important special case to be verified. Some networks, such as sensor networks, are static most of time, and sometimes destination and neighbors information is accurate.

### E. MAC Layer Considerations

While initial experiments may ignore data link layer, for similar reasons (in the absence of message collisions, routing algorithms should have superb performance, e.g. to guaranty delivery), further experiments, even on static networks, should consider it. IEEE 802.11 is a standard for MAC specifications in wireless networks.

### F. Comparison With The Shortest Path Algorithm

There is notable tendency in literature to compare the performance of proposed routing algorithms with the worst possible solution, flooding. Even such comparison is not properly done, since improper flooding algorithms are used. If flooding is taken for comparison then the proper version of it should be used. Although some existing algorithm can also be taken for comparison, especially if it belongs to the same class with classification criteria, the ideal shortest path algorithm is certainly the ultimate goal, and one should verify how far from that goal the proposed algorithm is. If the cost of location updates for both proposed and shortest path algorithms is ignored, flooding rate (the ratio of the number of message transmissions and the shortest possible hop count between two nodes) can be used for fair comparison, especially for multi-path methods. Each transmission in multiple routes is counted, and message can be sent to all neighbors with one transmission.

### G. Generating Sparse And Dense Graphs

For experiments with static networks, random unit graphs should be generated. Each of nodes should select at random x and y coordinates. Sub-graphs can be used if obstacles are taken into account. The connectivity depends on the selected transmission radius. Since transmission radius for a given equipment is normally fixed or should be selected from few discrete values, most papers use fixed value of transmission radius and change the range of coordinates to evaluate graphs of different density. Ignoring graph density issue in performance evaluations is a single misleading point in the experimental design and interpretation of results.
Routing algorithms perform differently on sparse and dense graphs, thus it is the graph density that is a primary independent variable to be considered. The best measure of graph density is the average number of neighbors for each node. Generated graphs, which are disconnected, may or may not be eliminated.

### H. Node Mobility

Some papers use random movements at each simulation step in four or eight possible direction. Random walks tend to keep all nodes close to their initial positions, and thus analysis using this model is largely misleading. One possible analogous design is as follows. Each node generates a random number wait in interval [0..maxwait]. The node does not move for wait seconds. This is called station time. When this time expires, node chooses to move with a probability p. It generates new wait period if it decides not to move. Otherwise, it generates a random number travel in interval [0,maxtravel], and a new random position within the same square, in the second case. Node then moves from old position to new position along the line segment joining them at equal speed for the duration of travel seconds. Upon arriving at new location, node again chooses waiting period etc. This movement patterns do not cover the case of nodes moving more or less in the same direction, which may often be the case in military and rescue operations. An additional component should be added in experiments, moving with same speed and in same direction by all nodes.

#### *i.* **Simulator**

Several wireless networks simulators are used in literature. Two most widely used are Glomosym [Glom] and ns-2[ns-2]. Although it is desirable to have some kind of benchmark testing facility, the problem with these simulators is a painful learning curve. Several researchers that used it confirmed that it takes about one month of full time work to learn how to use these simulators. Thus they are convenient choice for long term projects (and long term grant holders), but not for researchers with limited human resources. The other drawback of using these simulators is that experiments with static nodes and important parameters (e.g. graph density) are easily ignored. Preliminary experiments with static nodes and even moving nodes can be obtained by a simplified design using any programming language (e.g. C or Java) and valuable conclusions can be made. This shall be done even if simulator is used afterwards. We agree, of course, that real simulations are necessary for a complete performance evaluation, if resources for doing that are available.

## IV CONCLUSION

Routing is a core problem in networks for delivering data from one node to another. Many routing algorithms have been proposed for MANET that belongs to different categories and with different criteria to improve the performance while reducing the overhead. In this paper we have exploited various characteristics that can be incorporated in routing algorithms and the way the characteristics effect the performance of routing in MANETs. Evaluation of routing protocols should not be limited to a particular issue like reduced overhead or increase in throughput as a particular routing protocol strategy would affect other performance factors but should be extended to include the mobility factors, MAC layer considerations etc. Thus in this paper we have tried to exploit all the issues to be evaluated for a Routing protocol.

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