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Survey Analysis of Routing Protocols and Mobility Models in MANETs

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Abstract

A Mobile ad hoc network (MANET) is an infrastructure less network. The nodes in this network are mobile. The topology in MANET keeps on changing. MANETs have its applications in various fields like military, sensor networks, video conferencing etc. This paper discusses about various MANET routing protocols such as Proactive, Reactive, Hybrid, their types, comparison of routing protocols, mobility models in MANET, performance matrices that evaluate the performance of MANET routing protocols and applications of MANET.

Keywords: *MANET, DSDV, WRP, GSR, FSP, OLSR, TBRPF, DSR, AODV, TORA, ZRP, End-to-End Delay, Throughput, Packet Delivery Ratio*

1. Introduction

MANET(Mobile Ad-hoc Network)is made up of three words *i.e.*, Mobile which means 'moveable', Ad-hoc which means 'temporary' and Network which means 'collection of nodes'. Thus MANET is infrastructure less network consisting of autonomous collection of mobile nodes that communicate with each other to exchange information. Through wireless connection, these mobile nodes as routers can constitute any network topology which can work independently and also can connect with the Internet or cellular wireless network [1].The topology of this network keeps on changing due to the mobility of nodes. MANETs are less secure networks so in order to overcome threats some security technologies are applied to the network. These networks are self organized and have limited bandwidth. In mobile ad hoc networks (MANETs), the efficiency of broadcasting protocol can dramatically affect the performance of the entire network [2].

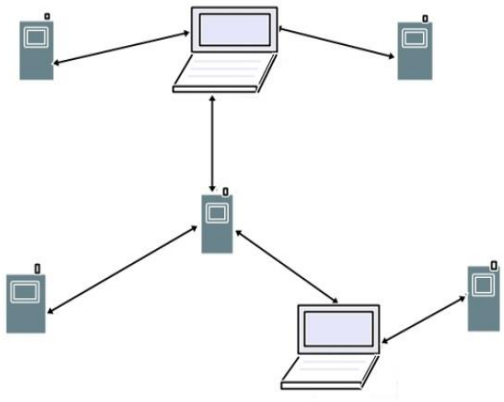

Figure 1. A Mobile ad hoc Network (MANET)

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2. Routing in MANETs

In an ad hoc network, all the nodes may not be within the transmission range of each other, so, nodes are required to forward network traffic on behalf of other nodes. Consider the scenario in Figure 2. If node S sends data to node D, which is three hops away, the data traffic will reach its destination only of A and B forward it. The process of forwarding network traffic from source to destination is termed routing [3].

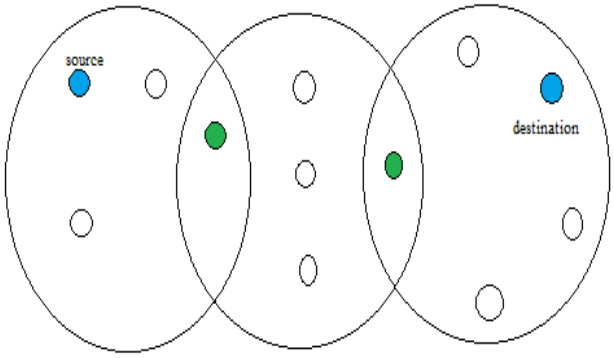

Figure 2. Multihoping Scenario

Routing in MANETs is done by routing protocols. Routing is used to transmit packet from source to destination in a network. Routing Protocols are classified as:

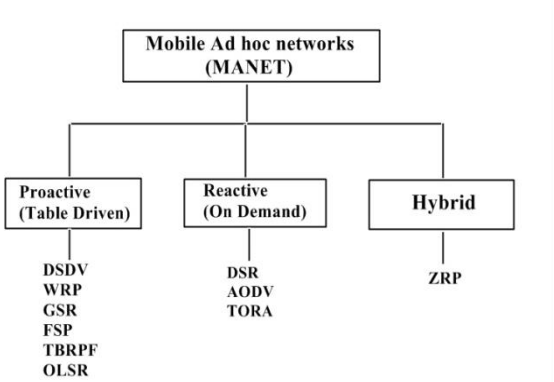

Figure 3. Classification of MANET

- Proactive (Table Driven) Routing Protocol.
- Reactive (On Demand) Routing Protocol.
- Hybrid (Both Proactive and Reactive) Routing Protocol.

2.1. Proactive Routing Protocol.

In Proactive routing protocol, each node in the network maintains a routing table and the information in the routing tables are updated periodically. This routing information is used by every node to store the location information of other nodes in the network and this information is used to move data among different nodes in the network. When a source node has to send a packet to the destination node, the route to that destination is

available immediately. This proactive routing protocol is also called table driven routing protocol.

The various types of reactive routing protocols are as follow:

- Destination Sequenced Distance Vector Routing (DSDV).
- Wireless Routing Protocol (WRP).
- Global State Routing (GSR).
- Fisheye State Routing Protocol (FSP).
- Optimized Link State Routing Protocol (OLSR).
- Topology Dissemination Based on Reuse Path Forwarding (TBRPF).

2.1.1. Destination Sequenced Distance Vector Routing (DSDV).

It is the table driven routing scheme for MANET based on Bellman-Ford Algorithm (shortest path routing algorithm to find a single path from source to destination).This algorithm solves the problem of routing loop problem.

In DSDV, each node in the network maintains its own routing table. The routing table consists of destination number of hops and sequence number generated by the destination. DSDV routing protocol requires that all the nodes in the network communicate the routing table to its neighbors. The communication can be multicasting or broadcasting. With this the neighbour nodes get to know about the current status of the node *i.e.*, any update made in the routing table due to the movement of node. The routing tables are sent to the neighbors through full dump or incremental way [4]. In full dump way the whole table is sent whereas in incremental way only the entries that require changes are sent.

2.1.2. Wireless Routing Protocol (WRP).

Wireless Routing Protocol (WRP) is similar to DSDV because it provides up-to-date information of the network but it differs from DSDV only in the way that DSDV maintains only one table whereas WRP maintains a set of topology tables. The topology tables are as follow:

- Distance Table.
- Routing Table.
- Link Cost Table.
- Message Retransmission List (MRL).

2.1.3. Global State Routing (GSR)

Global State Routing (GSR) is based on link state routing protocol. In this each node exchanges link state information with its neighbor nodes. Based on link state information, a global knowledge of the network topology is maintained. GSR is similar to DSDV but it avoids flooding of routing messages.

2.1.4. Fisheye State Routing Protocol (FSP)

Fisheye State Routing Protocol (FSP) is an improvement of GSR. It reduces the traffic of transmitting update messages. Each node has accurate information about its neighbour nodes. This is so because the transmitted update messages contain the information of the nearer nodes rather the information about all nodes in the network.

2.1.5. Topology Dissemination Based on Reuse Path Forwarding (TBRPF)

It is a link state proactive routing protocol. On the basis of partial topology in the topology table, each node in the network maintains a source tree to each destination. The

source tree is also called as shortest path tree [5]. To reduce overheads only a part of source tree is broadcasted to the neighbors. The partial source tree is called a reportable tree. TBRPF is best suited for dense networks.

2.1.6. Optimized Link State Routing Protocol (OLSR)

OLSR makes use of multipoint relays (MPRs) which act as intermediate routers in route discovery procedure. OLSR performs Packet forwarding, Neighbour sensing, Topology discovery procedures. OLSR uses four messages: Hello message, Topology control, Multiple Interface Declaration (MID), Host and Network Association (HNA) [5].

a) Advantages of Proactive routing protocols

- No route discovery procedure.
- Routing tables have up-to-date topology information.

b) Disadvantages of Proactive routing protocols

- Large bandwidth and power is required to maintain the routing tables.
- Maintenance of routing tables becomes difficult for large networks.

2.2. Reactive Routing Protocols

Reactive routing protocols follow a route determination procedure. If a source node has to send a packet to destination node, firstly the route to the destination node is determined and then a connection is established between these nodes. For route determination procedure, route request packets are flooded throughout the network.

Flooding is a reliable method of disseminating information over the network, however it uses bandwidth and creates network overhead, reactive routing broadcasts routing requests whenever a packet needs routing, this can cause delays in packet transmission as routes are calculated, but features very little control traffic overhead and has typically lower memory usage than proactive routing protocol, this increases the scalability of the protocol [6].

The various types of reactive routing protocols are as follow:

- Dynamic Source Routing (DSR)
- Ad hoc On Demand Vector Routing (AODV)
- Temporally Ordered Routing Algorithms (TORA)

2.2.1. Dynamic Source Routing (DSR)

Dynamic source routing (DSR) is based on source routing method. In this the nodes maintain a route cache. Route cache is updated when a new node is known. There are two phases with which routing are done in DSR [7]. These two phases are as follow:

- Route discovery.
- Route maintenance.

When a source node has to send a packet to the destination node, it first checks route to the destination in the route cache. If the route of the destination is present in the route cache then the source node sends the packet to the destination and if it is not present in the root cache it broadcasts a route request packet RREQ. The address includes the destination address, source address and unique identification number.

2.2.2. Ad hoc On Demand Vector Routing (AODV)

AODV is a distance vector routing protocol which determines route to the destination only on demand. It makes use of forwarding tables at each node. When a node wants to send the packet to destination, it broadcast a route request packet (RREQ) .The neighbour nodes broadcast this packet to other neighbour nodes and the process continues till it reaches the destination. While forwarding RREQ, a reverse path is established through which the destination node replies back by sending RREP packet. When a link breakage in a active route is detected, a RERR (route error) message is used to notify other nodes of the loss of the link.

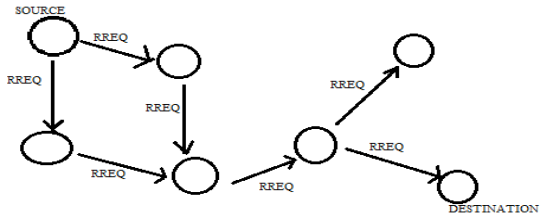

Figure 4. RREQ Message

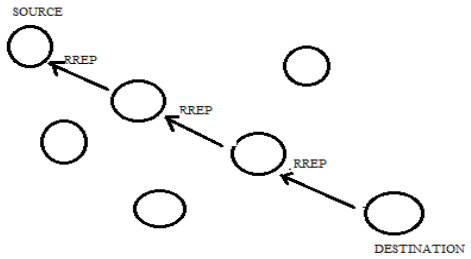

Figure 5. RREP Message

2.2.3. Temporally Ordered Routing Algorithms (TORA)

The key feature of TORA is its reaction to link failure. It erases invalid routes, searches for new routes and builds new routes in a single pass of the distributed algorithm.
TORA has three basic functions which are as follow:

- Route Creation
- Route Maintenance
- Route Erasure

Route Creation process converts an undirected network into a DAG (Directed Acyclic Graph) rooted at destination by assigning directions to the links. The purpose of Route Maintenance process is to reverse some of the links if link failures occur due to which some nodes lose all paths to destinations. This process reorients the network in the state where each node has a path to destination. When the network is partitioned, the Route Erasure process erases all paths in partitions which do not have the destination.

a) Advantages of Reactive routing protocols

- This protocol consumes less power.
- Less overhead are generated.

b) Disadvantages of Reactive routing protocols

- Route determination procedure is required.
- Sometimes it is time consuming to determine the routes.

2.3. Hybrid Routing Protocol

This protocol makes use of both proactive and reactive routing protocols. It is best suited for zone routing protocol in which zone neighbours are determined by proactive routing protocols and the routes between the nodes are determined by reactive routing protocols [8].

Type of Hybrid Routing Protocol is:

2.3.1. Zone Routing Protocol (ZRP)

ZRP combines the best properties of both proactive routing and reactive routing. As the name implies, zone routing protocol is based on the concept of zones. Each node has a separate routing zones and the overlapping of zones of neighbouring nodes is there.

A node that has a packet to send first checks whether the destination is within its local zone, in this case, the packet can be routed proactively, if the destination is outside the zone, then reactive routing is used [8].

a) Advantages of Zone routing protocols

- While using proactive routing, it reduces the control traffic produced by periodic flooding of routing information packets.
- It reduces the wastage of bandwidth and control overhead compared to reactive routing [9].

b) Disadvantages of Zone routing protocols

- The overlapping of routing zones may be large.

3. Comparison of Proactive and Reactive Routing Protocols

Table 1. Comparison of Proactive and Reactive Routing Protocols

S.No	Proactive Routing Protocol	Reactive Routing Protocol
1.	Route determination procedures are not required when a packet is sent from source to destination.	Route Determination procedures are required to determine route between source and destination.
2.	Network devices consume more power.	Network devices consume less power.
3.	Lot of overheads are generated.	Fewer overheads are generated.
4.	Less delay in sending the packets as the route information is immediately available.	More delay in sending the packet as route is to be determined between the nodes before sending the packet.
5.	Large bandwidth is required to update the tables.	Less bandwidth is required since there are no tables to update.

4. Mobility Models in MANETs

Mobility models are designed to evaluate the performance of ad-hoc networks. These mobility models are as follow:

- Random Walk Mobility Model
- Random Way Point Mobility Model
- Random Direction Mobility Model

4.1. Random Walk Mobility Model

This model represents the movement of the nodes in an unpredictable way. A node moves from its current location to a new one by randomly choosing Direction between [0,2pi] and Speed between [Min_{Speed}, Max_{Speed}].Direction and speed are both uniformly distributed.

A node which "crashes" against the boundary keeps on moving on an opposite direction between [0, pi] depending on the incoming one.

4.2. Random Way Point Mobility Model

In this model, at every instant, a node randomly chooses a destination (instead of direction) and moves towards that destination with the speed uniformly chosen from zero and maximum speed. After reaching the destination, the node halts for 'pause time' (time between changes in direction or speed) duration and chooses another destination and repeat this whole process till the end of simulation.

4.3. Random Direction Mobility Model

In this model, nodes select a destination (measured in degrees) to travel. Nodes start moving by choosing Direction between [0,2pi] and Speed between [Min_{Speed}, Max_{Speed}].

Nodes will travel till the bound is reached. On this position they'll stand for a pause time before leaving to a New-Direction [0, pi].

5. Traffic Model in MANETs

The traffic model is used to generate traffic on the network and which a set of applications that generates the packet both exponential and constant form when the simulation time starts with random destination or defined destination packet delivery[10]. MANETs supports different types of traffics and the most important and frequently used traffics are TCP, VBR and CBR traffics here VBR means Variable bit rate and CBR means Constant bit rate.

6. Performance Metrics in MANETs

Performance Metrics' for performance of MANETs routing protocols:

- End-to-End Delay
- Throughput
- Packet Delivery Ratio

6.1. Delay

The packet End-to-End delay is the time taken by data packet to transmit across the network from source to destination. It includes Transmission Delay, Propagation Delay, Processing Delay and Queuing Delay.

End-to-End delay is calculated as follow:

$$d_{end\text{-}end} = d_{trans} + d_{prop} + d_{proc} + d_{queu}$$

Where $d_{end-end}$ = End to end delay, d_{pro}=Propagating delay, d_{trans} = Transmission delay, d_{proc} = Processing delay, d_{queu} = Queuing Delay

6.2. Throughput

Throughput is defined as the ratio of the total data reaches to a receiver from the sender. Throughput is expressed as bytes or bits per second (bytes/sec or bits/sec). Throughput (bits/sec) is represented mathematically as follow:
*Throughput = (Number of delivered packet * Packet size * 8) / Total duration of simulation*

6.3. Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the source [11]. Packet Delivery Ratio is calculated as follow:
*Packet Delivery Ratio = (received packets/generated packets) * 100.*

7. Applications of MANETs

- **Military Scenarios**: Ad-Hoc networking allows the military to maintain an information network between the soldiers, vehicles, and military information head quarter.
- **Rescue Operations:** It provides Disaster recovery, means replacement of fixed infrastructure network in case of environmental disaster.
- **Data Networks**: MANETs provides support to the network for the exchange of data between mobile devices.
- **Device Networks**: Device Networks supports the wireless connections between various mobile devices so that they can communicate.
- **Free Internet Connection Sharing**: It also allow us to share the internet with other mobile devices.
- **Sensor Network**: It consists of devices that have capability of sensing, computation and wireless networking. Wireless sensor network combines the power of all three of them, like smoke detectors, electricity, gas and water meters.

8. Conclusion

In this paper, it is concluded that in MANET, Proactive routing uses excess bandwidth to maintain routing information, while reactive routing involves route request delays. Reactive routing protocol are better than Proactive Routing Protocols as in reactive routing protocols, tables are determined only on demand. Mobility Models such as Random Walk, Random Way and Random Direction Mobility Model evaluate the performance of ad-hoc networks and Performance matrices such as Delay, Throughput and Packet delivery ratio evaluate the performance of MANET routing protocols.

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