An Overview of MANET Routing Protocols

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----------ABSTRACT----------

Mobile ad hoc network (MANET) is a continuously self – configuring, infrastructure – less network of mobile devices connected without wires. Ad Hoc is a Latin word and it means "for this purpose". Mobile ad hoc networking is a means of communication which does not rely on any existing infrastructure such as dedicated routers, transceiver base stations or even cables. MANETs have been a challenging subject for research scientists and internet pioneers. A MANET is a type of ad hoc network that can change locations and configure itself on the fly. Because MANETs are mobile nodes, they use wireless connections to connect to various networks. This can be a standard Wi-Fi connection or another medium, such as cellular or satellite transmission. Some MANETs are restricted to a local area of wireless devices, while others may be connected to the internet. MANETs are not very secure because of its dynamic nature. This paper concentrates on routing techniques which is the most challenging issue due to the dynamic nature of ad hoc networks. There are different routing protocols proposed for MANET, which make it quite difficult to determine the suitable protocol for different network conditions. This paper provides an overview of different routing protocols proposed.

Keywords - **Ad hoc network, MANET, routing protocol, satellite transmission, wireless connection.**

1.INTRODUCTION

A Mobile ad hoc network is an autonomous system of mobile routers connected by wireless links. The routers are free to move randomly and organize themselves arbitrarily, thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a stand – alone fashion or may be connected to the larger internet.

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each device must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to internet. They may contain one or multiple and different transceivers between nodes. This results in a highly dynamic, autonomous topology.

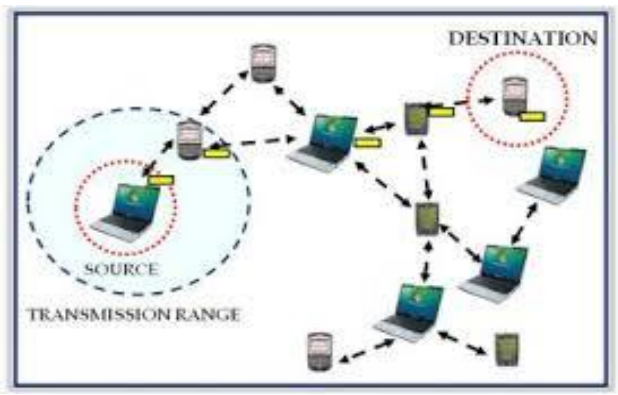


Fig 1: MANET routing to destination

MANET consists of peer – to – peer, self – forming, self – healing network in contrast to a mesh network that has a central controller.

MANETs are a kind of wireless ad hoc network that usually has a routable networking environment on the top of the link layer. Figure 1 shows the MANET routing to its destination.

2.CHARACTERISTICS OF MANET

- In MANET, each node has an autonomous behaviour (i.e) they act as both host and router.
- Multi-hop radio relaying – MANETs are capable of multi-hop routing when the source node and destination node are out of radio range for a message.
- Centralized firewall is not present because of its distributed nature of operation.
- The nodes can join or leave the network anytime, making the network topology dynamic in nature.
- Mobile nodes are characterized with less memory, power and light weight features.
- The reliability, efficiency, stability and capacity of wireless links are often inferior when compared with wired links. This shows the fluctuating bandwidth of wireless links.
- The spontaneous behaviour of the nodes, demand minimum human intervention to configure the network.
- All nodes have identical features with similar responsibilities and capabilities and hence it forms a completely symmetric environment.
- High user density and large level of user mobility.
- Nodal connectivity is intermittent.

3.MANET ROUTING PROTOCOLS

Routing protocols define a set of rules which govern the journey of message packets from source to destination in a network. There are different types of routing protocols in MANET, which are applied according to the network circumstances. Figure 2 shows the classification of routing protocols in MANET.

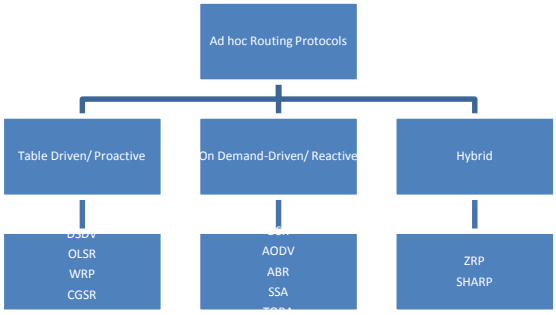


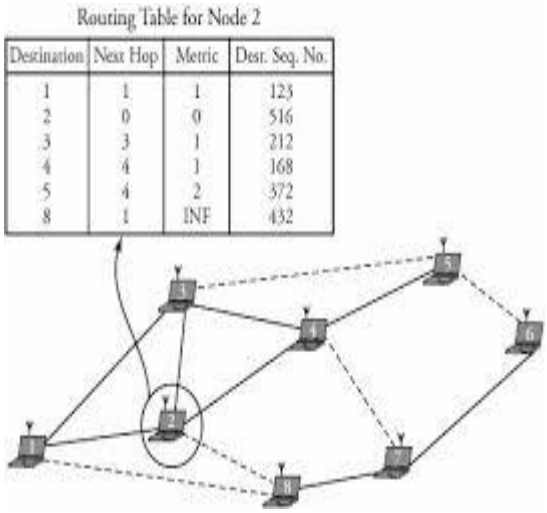
Fig 2: Classification of routing protocols in MANET

3.1 Proactive Routing Protocols/ Table Driven Protocols:

In proactive routing, every node maintains routing information to every other node in the network. The routing information is usually kept in a number of different tables. These tables are periodically updated. The difference between these protocols exists in the way the routing information is updated, detected and the type of information kept at each routing table. Proactive protocols are not suitable for large networks as they need to maintain node entries for each and every node in the routing table of every node. These protocols maintain different number of routing tables varying from protocol to protocol. There are various well known proactive routing protocols, example: DSDV, OLSR, WRP, etc.

3.1.1 Dynamic Destination – Sequenced Distance – Vector Routing Protocol (DSDV)

DSDV is developed based on Bellman-Ford routing algorithm with some modifications. Each mobile node in the network keeps a routing table in this protocol. Each of the routing table contains the list of all available destinations and the number of hops to each other. Each table entry is tagged with a sequence number, which is originated by the destination node. Periodic transmissions of updates of the routing tables help maintaining the topology information of the network. If there is any new significant change for the routing information, the updates are transmitted immediately, so that the routing information updates might either be periodic or event driven.


Routing Table for Node 2

Destination	Next Hop	Metric	Dest. Seq. No.
1	1	1	123
2	0	0	516
3	3	1	212
4	4	1	168
5	4	2	372
8	1	INF	432

Fig 3: Dynamic distance Sequenced Distance Vector Routing Protocol

DSDV protocol requires each mobile node in the network to advertise its own routing table to its current neighbours. The advertisement is done either by broadcasting or by multicasting. By the advertisements, the neighbouring nodes can know about the changes in the network by the movement of nodes. The routing updates could be sent in two ways: full dump and incremental. In the case of full dump, the entire routing table is sent to the neighbours, whereas in case of incremental update, only the entries that require changes are sent.

3.1.2 Optimized Link State Routing Protocol(OLSR)

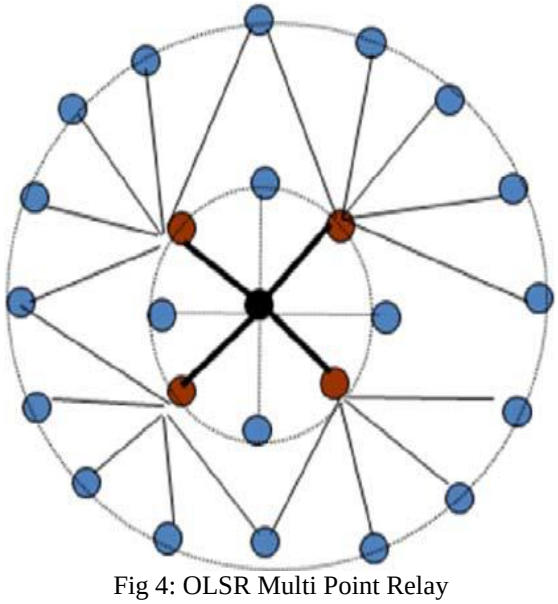


Fig 4: OLSR Multi Point Relay

OLSR is a proactive link state routing protocol that uses hello and Topology Control (TC) messages to discover and then disseminate link state information throughout the mobile ad hoc network. Individual nodes utilise this topology information to work out next hop destinations for all nodes in the network using the shortest hop forwarding paths. Being a proactive protocol, routes to all destinations within the network are known and maintained before using

it. Having the routes available within the standard routing table can be useful for some systems and network applications as there is no route discovery delay associated with finding a new route. Being a link state protocol, OLSR requires reasonably large amount of bandwidth and CPU power to compute optimal paths inside the network.

OLSR uses two kinds of control messages: Hello and Topology control (TC). Hello messages are used for finding the information about the link status and the host's neighbours. OLSR makes use of "Hello" messages to find its one hop neighbours and its two hop neighbours through their resources. The Multi Point Relay (MPR) selector set is constructed by the Hello message, which describes the neighbours having preferred this host to work as MPR and as of this information the host be able to evaluate its individual rest of the MPRs. The Hello messages are sent simply single hop away, but the TC messages are broadcasted throughout the whole network. TC messages are used for distributing information about personal advertised neighbours, which includes atleast the MPR selector list. The TC messages will be broadcasted occasionally and only the MPR hosts can forward the TC messages. Figure 4 shows an example of OLSR multi point relay.

3.1.3 Wireless Routing Protocol (WRP)

WRP belongs to a general class of shortest path calculating algorithms, that calculate the shortest path using information regarding the length and second – to – last hop of the shortest path to each destination. WRP minimises the number of cases where a temporary routing loop can occur. Each node requires four things for the purpose of routing:

- A distance table.
- A routing table.
- A link – cost table.
- A Message Retransmission List (MRL).

WRP uses periodic update message transmissions to the neighbours of a node. The nodes in the response list should send acknowledgements. If there is no change from the last update, the nodes send an idle Hello message in the response list to ensure connectivity. A node can decide whether to update its routing table after receiving an update message from a neighbour and always it looks for a better path using the new information. If a node gets a better path, it relays back that information to the original nodes so that they can update their tables. After receiving the acknowledgement, the original node updates its MRL. Thus, each time the consistency of the routing information is checked by each node in this protocol, which helps to eliminate routing loops and to find out the best solution for routing in the network.

3.1.4 Cluster Gateway Switch Routing Protocol (CGSR)

CGSR considers a clustered mobile wireless network instead of a flat network. For structuring the network into separate but interrelated groups, cluster heads are elected using cluster head selection algorithm. By forming several clusters, this protocol achieves a distributed processing mechanism in the network. The drawback of this protocol is the frequent change or selection of cluster heads might be resource hungry and it might affect the routing performance. CGSR uses DSDV protocol as the underlying routing scheme and hence has the same overhead as DSDV. However, it modifies DSDV by using a hierarchical cluster-head-to-gateway routing approach to route traffic from source to destination. Gateway nodes are nodes within the communication range of two or more cluster heads. A packet sent by a node is first sent to its cluster head and then the packet is sent from the cluster head to a gateway to another cluster head and so on until the cluster head of the destination node is reached. The packet is then transmitted to the destination from its own cluster head.

3.2 Reactive Routing Protocols/ Demand Routing Protocol

In reactive routing protocol, route is discovered whenever it is needed. Nodes initiate the route discovery on demand basis. Source node sees its route cache for the available route from source to destination, if the route is not available then it initiates the route discovery process. The on-demand routing protocols have two major components:

- *Route Discovery:* In this phase, the source node initiates the route discovery on demand basis. Source nodes consults its route cache for the available route from source to destination, otherwise if the route is not present it initiates route discovery. The source node in the packet includes the destination address of the node as well as the address of the intermediate nodes to the destination.
- *Route Maintenance:* Due to dynamic topology of the network cases of the route failure between the nodes arises due to link breakage etc, so route maintenance is done.

Reactive protocols have acknowledgement mechanism due to which route maintenance is possible. Reactive protocols add latency to the network due to the route discovery mechanism. Each intermediate node involved in the route discovery process adds latency. These protocols decrease the routing overhead, but at the cost of increased latency in the network. Hence, these protocols are suitable in the situations where low routing overhead is required. There are various well known reactive routing protocols present in MANET. For example: DSR, AODV, TORA and LMR.

3.2.1 Dynamic Source Routing Protocol(DSR)

Dynamic source routing (DSR) is based on the source route approach. In DSR, shown in Figure 5, the protocol is based on the link state algorithm, in which the source initiates route discovery on demand basis. The sender determines the route from source to destination and it includes the address of intermediate nodes to the route record in the packet. DSR was designed for multi hop networks for small diameters. It is a beaconless protocol in which no HELLO messages are exchanged between nodes to notify them of their neighbours in the network.

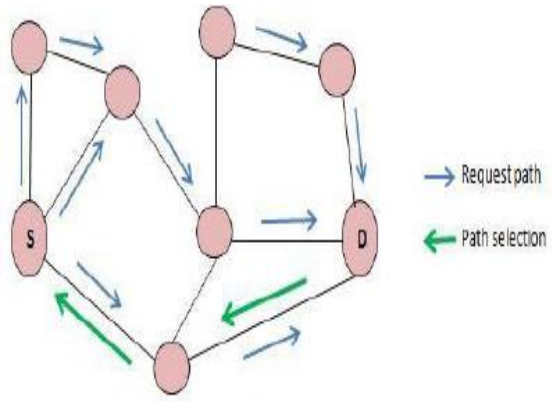


Fig 5: Dynamic Source Routing Protocol

3.2.2 Ad Hoc on- Demand Distance Vector Routing Protocol (AODV)

AODV is an enhancement of DSDV. But, AODV is a reactive routing protocol instead of proactive. By creating routes based on demand, it minimizes the number of broadcasts, which is not the case for DSDV. When any source node wants to send a packet to a destination, it broadcasts a route request (RREQ) packet. The neighbouring nodes in turn broadcast the packet to their neighbours and the process continues until the packet reaches the destination. During the process of forwarding the route request, intermediate nodes record the address of the neighbour from which the first copy of the broadcast packet is received. This record is stored in their route tables, which helps for establishing a reverse path. If additional copies of the same RREQ are received later, those packets are discarded. The reply is sent using the reverse path.

When a source node moves, it can reinitiate a route discovery process for route maintenance. If any intermediate node moves within a particular route, the neighbour of the drifted node can detect the link failure and sends a link failure notification to its upstream neighbour. This process continues until the failure notification reaches the source node. Based on the received information, the source might decide to re-initiate the route discovery phase. Figure 6 shows an example of AODV protocol.

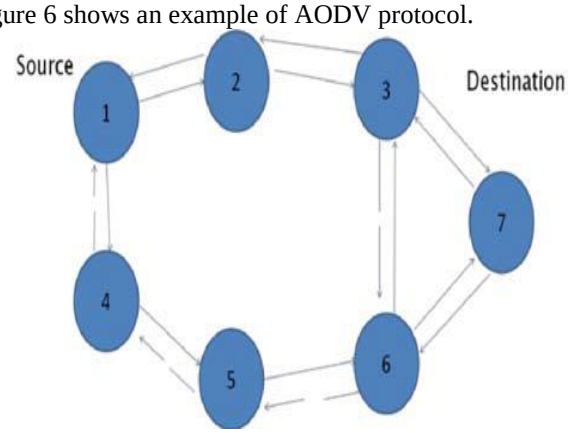


Fig 6: Ad hoc On-demand Distance Vector Routing Protocol

3.2.3 Associativity-Based Routing Protocol (ABR)

ABR protocol defines a new type of routing metric called "degree of association stability" for mobile ad hoc networks. In this routing protocol, a route is selected based on the degree of association stability of mobile nodes. Each node periodically generates beacon to announce its existence. Upon receiving the beacon message, a neighbour node updates its own associativity table. For each beacon received, the associativity tick of the receiving node with the beaconing node is increased. A high value of associativity tick for any particular beaconing node means that the node is relatively static. Associativity tick is reset when any neighbouring node moves out of the neighbourhood of any other node. Figure 7 shows an example of ABR

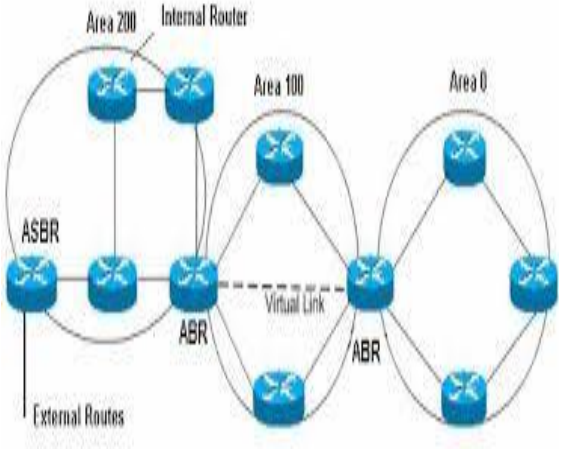


Fig 7: Associativity Based Routing Protocol

3.2.4 Signal Stability-Based Adaptive Routing Protocol (SSA)

SSA protocol focuses on obtaining the most stable routes through an ad hoc network. The protocol performs on demand route discovery based on signal strength and location stability. Weak and strong channels in the network are detected based on the signal strength. SSA can be divided into two cooperative protocols: the dynamic Routing Protocol (DRP) and the Static Routing Protocol (SRP). DRP uses two tables: Signal Stability Table (SST) and Routing Table (RT). SST stores the signal strengths of the neighbouring nodes obtained by periodic beacons from the link layer of each neighbouring node. These signal strengths are recorded as weak or strong. DRP receives all the transmissions and, after processing, it passes those to the SRP.

SRP passes the packet to the node's upper layer stack if it is the destination; otherwise, it looks for the destination in routing table and forwards the packet. If there is no entry in the routing table for that destination, it initiates the route-finding process. Route-request packets are forwarded to the neighbours using the strong channels. The destination, after getting the request, chooses the first arriving request packet and sends back the reply. The DRP reverses the selected route and sends a route-reply message back to the initiator of route request. The DRPs of the nodes along the path update their routing tables accordingly. In case of a link failure, the intermediate nodes send an error message to the

source indicating which channel has failed. The source in turn sends an erase message to inform all nodes about the broken link and initiates a new route-search process to find a new path to the destination.

3.2.5 Temporarily Ordered Routing Algorithm Protocol (TORA)

TORA is a reactive routing protocol with some proactive enhancements where a link between nodes is established creating a Directed Acyclic Graph (DAG) of the route from the source node to the destination. This protocol uses a link reversal model in route discovery. A route discovery query is broadcasted and propagated throughout the network until it reaches the destination or a node that has information about how to reach the destination. TORA defines a parameter, termed height. Height is a measure of the distance from the responding node to the required destination node. In the route discovery phase, this parameter is returned to the querying node.

As the query response propagates back, each intermediate node updates its TORA table with the route and height to the destination node. The source node then uses the height to select the best route toward the destination. This protocol has an interesting property that it frequently chooses the most convenient route, rather than the shortest route. For all these attempts, TORA tries to minimize the routing management traffic overhead.

3.3 Hybrid Routing Protocol

There is a trade-off between proactive and reactive protocols. Proactive protocols have large overhead and less latency while reactive protocols have less overhead and more latency. So a Hybrid protocol is presented to overcome the shortcomings of both proactive and reactive routing protocols. Hybrid routing protocol is combination of both proactive and reactive routing protocol. It uses the route discovery mechanism of reactive protocol and the table maintenance mechanism of proactive protocol so as to avoid latency and overhead problems in the network. Hybrid protocol is suitable for large networks where large numbers of nodes are present. This large network is divided into set of zones, where routing inside the zone is performed by using proactive approach and outside the zone routing is done using reactive approach. There are various popular hybrid routing protocols for MANET like ZRP, SHARP.

3.3.1 Zone Routing Protocol (ZRP)

ZRP is suitable for wide variety of MANETs, especially for the networks with large span and diverse mobility patterns. In this protocol, each node proactively maintains routes within a local region, which is termed as routing zone. Route creation is done using a query-reply mechanism. For creating different zones in the network, a node first has to know who its neighbours are. A neighbour is defined as a node with whom direct communication can be established, and that is within one hop transmission range of a node. Neighbour discovery information is used as a basis for Intra-Zone Routing Protocol (IARP).

Rather than blind broadcasting, ZRP uses a query control mechanism to reduce route query traffic by directing query messages outward from the query source and away from covered routing zones. A covered node is a node which belongs to the routing zone of a node that has received a route query. During the forwarding of the query packet, a node identifies whether it is coming from its neighbour or not. If yes, then it marks all of its known neighbouring nodes in its same zone as covered. The query is thus relayed till it reaches the destination. The destination in turn sends back a reply message via the reverse path and creates the route. Figure 8 shows an example of ZRP.

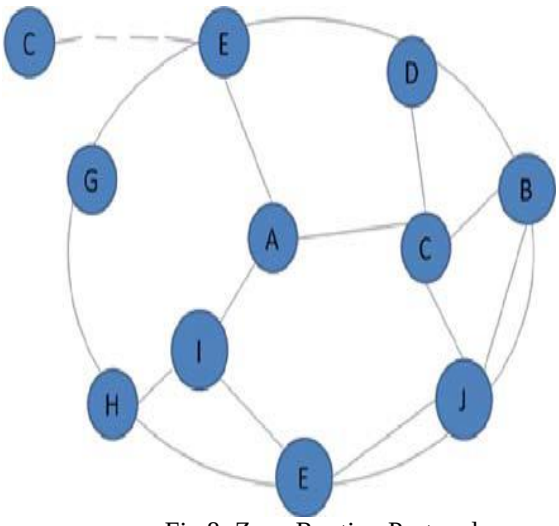


Fig 8: Zone Routing Protocol

3.3.2 Sharp Hybrid Adaptive Routing Protocol (SHARP)

SHARP adapts between reactive and proactive routing by dynamically varying the amount of routing information shared proactively. This protocol defines proactive zones around some nodes. The number of nodes in a particular proactive zone is determined by the node-specific zone radius. All nodes within the zone radius of a particular node become members of that particular proactive zone for that node. If for a given destination, a node is not present within a proactive zone, reactive routing mechanism is used to establish the route to that node. Proactive routing mechanism is used within the proactive zone. Nodes within the proactive zone maintain routes proactively only with respect to the central node. In this protocol, proactive zones are created automatically for frequently addressed destinations sought within the network. The proactive zones act as collectors of packets, which forward the packets efficiently to the destination, once the packets reach any node at the zone vicinity.

4.CHALLENGES FOR MANET

A MANET environment has to overcome certain issues of inefficiency. It includes:

- The wireless link characteristics are time-varying in nature - There are transmission impediments like fading, path loss, blockage and interference that add to the susceptible behaviour of wireless channels. The reliability of wireless transmission is resisted by different factors.
- Limited range of wireless transmission – The limited radio band results in reduced data rates

compared to the wireless networks. Hence optimal usage of bandwidth is necessary by keeping low overhead as possible.

- Packet losses due to errors in transmission - MANETs experience higher packet loss due to factors such as hidden terminals that results in collisions, wireless channel issues (high bit error rate (BER)), interference, and frequent breakage in paths caused by mobility of nodes, increased collisions due to the presence of hidden terminals and uni-directional links.
- Route changes due to mobility - The dynamic nature of network topology results in frequent path breaks.
- Frequent network partitions – The random movement of nodes often leads to partition of the network. This mostly affects the intermediate nodes.

5.CONCLUSION

A great development in the field of wireless networks (infrastructure based) and in the field of Mobile ad hoc network (infrastructure less network) can be seen. In this paper a number of routing protocols for MANET, which are broadly categorized as proactive and reactive and Hybrid protocols are discussed. There are various shortcomings in different routing protocols and it is difficult in choosing routing protocol for different situations as there is trade-off between various protocols. There are various challenges that have to be met, so these networks are going to have extensive use in the future.

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