ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 2, Issue 12, December 2017

A Survey of Several Routing Protocols for MANETs

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Abstract:-- **Mobile Ad hoc networks (MANET) are autonomously self organized networks without infrastructure support. Nodes in MANET normally have limited transmission ranges, Some nodes cannot communicate directly with each other. Hence, routing paths in mobile ad hoc networks potentially contain multiple hops, and every node in mobile ad hoc networks has the responsibility to act as a router. In proactive routing protocols, each node maintains routing information to every node in the network. But it is high in overhead and information is flooded in whole network. In reactive protocols reduce the overheads by maintaining information for active routes only. Hybrid protocol new generation of protocol was designed to increase the scalability and to reduce the route discovery overheads. Even though hybrid protocol suits for large networks, it complexity is increases i.e. High traffic and significant reduction in throughput when it expands in scale. In order to increase the scalability the route discovery and route maintenance must be controlled. Depends upon the network traffic and number of flows the routing protocol should be chosen. Hybrid protocol is association of the advantage of the both proactive and reactive routing protocol. To implement this, use sequence numbering in destination routing protocol to avoid the complexity in larger networks.**

Keywords: Ad Hoc; MANET; Node; Scalability; Proactive; Reactive; Hybrid Protocol

1. INTRODUCTION

MANET Stands for "Mobile Ad Hoc Network." A MANET is a type of ad hoc network that can change locations and configure itself on the fly. Because MANETS are mobile, they use wireless connections to connect to various networks. This can be a standard Wi-Fi connection, or another medium, such as a cellular or satellite transmission. Some MANETs are restricted to a local area of wireless devices (such as a group of laptop computers), while others may be connected to the Internet. For example, A VANET (Vehicular Ad Hoc Network), is a type of MANET that allows vehicles to communicate with roadside equipment. While the vehicles may not have a direct Internet connection, the wireless roadside equipment may be connected to the Internet, allowing data from the vehicles to be sent over the Internet. The vehicle data may be used to measure traffic conditions or keep track of trucking fleets. Because of the dynamic nature of MANETs, they are typically not very secure, so it is important to be cautious what data is sent over a MANET.

Mobile ad hoc network are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links. Mobile nodes are free to move randomly. May operate as standalone fashion or also can be connected to the larger internet.

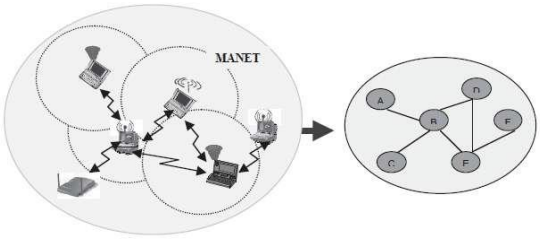

Fig. 1. Mobile Ad hoc Network

II. ROUTING IN MANETS

A Mobile Ad Hoc Network or spontaneous network is an infrastructure less, self-organized and multi-hop network with rapidly changing topology causing the wireless links to be broken and re-established on-the-fly [1]. A key issue is the necessity that the Routing Protocol must be able to respond rapidly to the topological changes in the network. Each node must be capable of acting as a router. As a result of limited bandwidth of nodes, the source and destination may have to communicate via intermediate nodes [2]. Major problems in routing are Asymmetric links, Routing Overhead, Interference, and Dynamic Topology. Routing in MANETs has been an active area of research and in recent years numerous protocols have been introduced for addressing the

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
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problems of routing, reviewed in later sections. These protocols are divided into two broad classes – Reactive and Proactive [3].

In Reactive or on demand RPs the routes are created only when they are needed. The application of this protocol can be seen in the Dynamic Source Routing Protocol (DSR) and the Ad-hoc On-demand Distance Vector Routing Protocol (AODV). Wherein Proactive or Table-driven RPs the nodes keep updating their routing tables by periodical messages. This can be seen in Optimized Link State Routing Protocol (OLSR) and Destination Sequenced Distance Vector Protocol (DSDV). All these protocols are quite insecure because attackers can easily obtain information about the network topology . In proactive routing protocols, each node maintains routing information to every node in the network. But it is high in overhead and information is flooded in whole network. In reactive protocols reduce the overheads by maintaining information for active routes only.

III. CLASSIFICATION OF ROUTING PROTOCOLS

We will discuss the classification of existing wireless ad hoc routing protocols, their characteristic features & types. The Routing Protocols for ad hoc wireless networks can be divided into three categories based on the routing information update mechanism. They could be Reactive (On-demand), Proactive (Table-driven) or Hybrid [6]-[15]. Figure 2 shows the three categories of Ad hoc RPs and various proposed Protocols under each category [7, 8, 9]. The table-driven ad hoc routing approach is similar to the connectionless approach of forwarding packets, with no regard to when and how frequently such routes are desired.

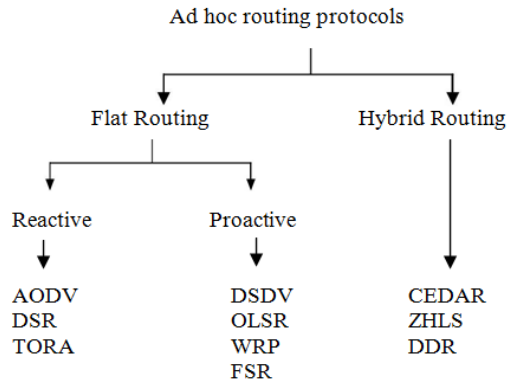

Fig. 2. Classification of Ad hoc Routing Protocols

This is not the case, however, for on-demand routing protocols. When a node using an on-demand protocol desires a route to a new destination, it will have to wait until such a route can be discovered.

A routing protocol is a protocol that specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network, the choice of the route being done by routing algorithms. Each router has a priori knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbors, and then throughout the network. This way, routers gain knowledge of the topology of the network.

A.STATIC ROUTING

Network administrators can create routing tables manually, but it is a tedious task. The only advantage is that the administrator knows the exact path data is taking to get to a destination, making static routing tables predictable and manageable. Static routing works best in small networks.

B.DYNAMIC ROUTING

A less tedious way to create a routing table is dynamically. Dynamic routing requires each device in a network to broadcast information about its location, which other devices use to update their routing tables. Frequent broadcasting keeps the tables up to date. Dynamic routing protocols use different algorithms to help routers refine path selection: interior, exterior, link state and distance vector, according to where they are in a network and what type of information they provide.

IV. PROACTIVE PROTOCOLS

In this type of routing protocol, each node in a network maintains one or more routing tables which are updated regularly. Each node sends a broadcast message to the entire network if there is a change in the network topology. However, it incurs additional overhead cost due to maintaining up-to-date information and as a result; throughput of the network may be affected but it provides the actual information to the availability of the network. Distance vector (DV) protocol, Destination Sequenced Distance Vector (DSDV) protocol, Wireless Routing protocol Fisheye

ISSN (Online) 2456 -1304

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State Routing (FSR) protocol are the examples of Proactive protocols.

DSDV is proposed by Perkins and Bhagwat. The Destination-Sequenced Distance-Vector (DSDV) [14] Routing protocol is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements such as making it loop-free. The distance vector routing is less robust than link state routing due to problems such as count to infinity and bouncing effect. In this, each device maintains a routing table containing entries for all the devices in the network. In order to keep the routing table completely updated at all the time each device periodically broadcasts routing message to its neighbor devices. When a neighbor device receives the broadcasted routing message and knows the current link cost to the device, it compares this value and the corresponding value stored in its routing table. If changes were found, it updates the value and re-computes the distance of the route which includes this link in the routing table.

B. OLSR

Clausen and Jacquet proposed the Optimized Link State Protocol, a point-to-point proactive protocol that employs an efficient link state packet forwarding mechanism called multipoint relaying [16, 17]. It optimizes the pure link state routing protocol. Optimizations are done in two ways: by reducing the size of the control packets and by reducing the number of links used for forwarding the link state packets. Here each node maintains the topology information about the network by periodically exchanging link-state messages among the other nodes. OLSR is based on the following three mechanisms: neighbor sensing, efficient flooding and computation of an optimal route using the shortest-path algorithm. Neighbor sensing is the detection of changes in the neighborhood of node. Each node determines an optimal route to every known destination using this topology information and stores this information in a routing table. The shortest path algorithm is then applied for computing the optimal path. Routes to every destination are immediately available when data transmission begins and remain valid for a specific period of time till the information is expired.

C. WRP

The Wireless Routing Protocol, as proposed by Murthy and Garcia-Luna-Aceves [18], is a table-based protocol similar to DSDV that inherits the properties of Bellman Ford Algorithm. The main goal is maintaining routing information among all nodes in the network regarding the shortest distance to every destination. Wireless routing protocols (WRP) is a loop free routing protocol. WRP is a path-finding algorithm with the exception of avoiding the count-to-infinity problem by forcing each node to perform consistency checks of predecessor information reported by all its neighbors. Each node in the network uses a set of four tables to maintain more accurate information: Distance table (DT), Routing table (RT), Link-cost table (LCT), Message retransmission list (MRL) table. In case of link failure between two nodes, the nodes send update messages to their neighbors. WRP belongs to the class of path-finding algorithms with an important exception. It counters the count-to-infinity problem by forcing each node to perform consistency checks of predecessor information reported by all its neighbors. This eliminates looping situations and enables faster route convergence when a link failure occurs.

D. STAR

The STAR protocol [19] is also based on the link state algorithm. Each router maintains source tree, which is a set of links containing the preferred paths to destinations. This protocol has significantly reduced the amount of routing overhead disseminated into the network by using a least overhead routing approach (LORA), to exchange routing information. The optimum routing (ORA) approach obtains the shortest path to the destination while LORA minimizes the packet overhead. Garcia–Luna–Aceves and Spohn propose STAR where each node maintains a source tree which contains preferred links to all possible destinations. Nearby source trees exchange information to maintain up-to-date tables. The routes are maintained in a routing table containing entries for the destination node and the next hop neighbor. The link state update messages are used to update changes of the routes in the source trees. Since these packets do not time out, no periodic messages are required.

E. FSR

Pei et al. propose the FSR protocol [20] which takes inspiration from the ‘‘fisheye ‘technique of graphic information compression proposed by Kleinrock and Stevens. When adapted to a routing table, this technique means that a node maintains accuracy distance and path quality information about its immediate vicinity, but the amount of detail retained decreases with the distance from the node.

ISSN (Online) 2456 -1304

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Each node considers a number of surrounding fish-eye scopes, areas which can be reached with 1, 2 hops. FSR reduces the size of the update messages by updating the network information for nearby nodes at a higher frequency than for the remote nodes, which lie outside the fisheye scope. This makes FSR more scalable to large networks than the protocols.

F. CGSR

The Cluster head Gateway Switch Routing protocol differs from the other protocols as it uses hierarchical network topology, instead of a flat topology. As proposed by Chiang, it organizes nodes into clusters, which coordinate among the members of each cluster entrusted to a special node named cluster head. Least Cluster Change (LCC) algorithm [21] is applied to dynamically elect a node as the cluster head. Each node must keep cluster member table where it stores the destination cluster head for each mobile node in the network. These cluster member tables are broadcast by each node periodically using the DSDV algorithm. CGSR is an extension of DSDV and hence uses it as the underlying routing scheme. It has the similar overhead as DSDV. However, it modifies DSDV by using a cluster (hierarchical) routing approach to route traffic from source to destination. CGSR improves the routing performance by routing packets through the cluster heads and gateways.

Summary

In proactive protocols the topological information is exchanged among all the nodes in a network. In contrast to source initiated routing, table driven routing has extensive precedents in the research done for routing in the wired domain. Also wired routing protocols have inspired their own classes of protocols in table driven ad hoc routing. One of these classes is the distance vector protocols where the nodes maintain only a local topology, and use the distributed Bellman-Ford algorithm to maintain the routing tables, the other class of protocols is the link state routing protocols, where the routers exchange full topology information, and then use a graph-theoretic shortest path algorithm (Dijkstra's) on the resulting graph. However, these protocols differ in the way routing information is updated and detected, the number of routing tables used, the type of information stored in each table and the changes that are periodically broadcasted in the network. This class of routing protocols has its own advantages and disadvantages. One of its main advantages is the fact that nodes can easily get routing information and it's easy to establish a session. The disadvantage is too much data stored by the nodes for route maintenance and it is slow to restructure when there is a failure in a particular node link. TABLE 1 shows the comparison of some of the existing proactive routing protocols.

Table 1: comparison of proactive routing protocols

Parameters	DSDV	WRP	OLSR
Route updates	Periodic	Periodic	Periodic
Loop free	Yes	Yes	Yes
Routing overhead	High	High	Low
Caching overhead	Medium	High	High
Throughput	Low	Low	Medium
Routing tables	2	4	4

V. REACTIVE PROTOCOLS

In this type of routing protocol, each node in a network discovers or maintains a route based on-demand. It floods a control message by global broadcast during discovering a route and when route is discovered then bandwidth is used for data transmission. The main advantage is that this protocol needs less touting information but the disadvantages are that it produces huge control packets due to route discovery during topology changes which occurs frequently in MANETs and it incurs higher latency. The examples of this type of protocol are Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV) and Associatively Based Routing (ABR) protocols.

The reactive or on-demand routing protocols are based on Query-Reply topology in which they do not attempt to continuously maintain the up-to-date topology of the network. When a route is desired, a procedure is invoked to find a route to the destination node. The major goal of on demand or reactive routing protocols is to minimize the network traffic overhead. These routing protocols are based on some type of "query-reply" dialog. They do not attempt to

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continuously maintain the up-to-date topology of the network. Rather, when the need arises, a reactive protocol

Invokes a procedure to find a route to the destination; such a procedure involves some sort of flooding the network with the route query. As such, such protocols are often also referred to as on demand. The common element in reactive protocols is the mechanism used for discovering routes. The source node emits a request message, requesting a route to the destination node. This message is flooded, i.e. relayed by all nodes in the network, until it reaches the destination. The path followed by the request message is recorded in the message, and returned to the sender by the destination, or by intermediate nodes with sufficient topological information, in a reply message. Thus multiple reply messages may result, yielding multiple paths - of which the shortest is to be used. Some examples of source initiated ad hoc routing protocols include the Dynamic Source Routing Protocol (DSR) [22], Ad Hoc On-Demand Distance Vector Routing Protocol (AODV) [23], and Temporally-Ordered Routing Algorithm (TORA) [24].

Table 2: comparison of reactive routing protocols

Parameters	AODV	DSR	TORA
Route Creation	By source	By source	Locally
Periodic updation	No	No	No
Performance Metrics	Speed	Shortness	Speed
Routing overhead	High	High	High
Caching overhead	Low	High	Medium
Throughput	High	Low	Low
Multipath	No	Yes	Yes
Route updation	Non-periodic	Non-periodic	High routing overhead

VI. HYBRID PROTOCOLS

Hybrid Routing Protocol (HRP) is a network routing protocol that combines Distance Vector Routing Protocol (DVRP) and Link State Routing Protocol (LSRP) features. HRP is used to determine optimal network destination routes and report network topology data modifications. Not all routing protocols fall into the categories defined above. For example, Cisco's proprietary EIGRP is sometimes described as a hybrid of the link-state and distance-vector protocols. Cisco describes EIGRP as "an enhanced distance-vector protocol … [that] calculates the shortest path to a network." The BGP exterior gateway protocol uses an algorithm called path vector, which means it keeps track of paths used and compares them to determine the best one.

A. Distance Vector (DV) Protocol

It is a proactive protocol that works on the principles of distance vector where each node in a network maintains a distance table that contains the shortest distance and the address of the next hop router. Initially, each node knows only the distance with the nodes that are directly connected and a distance vector is initialized with that distance. Initially, distance to all others nodes that are not directly connected are initialized to infinity. When a change occurs in the network, each node updates its directly connected neighbors to the least cost distance vector. This process continues until convergence.

The advantages of distant vector protocol are 1) No need for global broadcasting and 2) Short route acquisition delay since all information for each node are available in the routing table. The disadvantages are 1) Long convergence time which may cause counting to infinity problem for large networks, 2) Non-availability of alternative paths.

B.Wireless Routing Protocol (WRP)

It is an improved version of the distant vector protocol that eliminates the count-to-infinity problems and thereby decreasing the convergence time. It has some disadvantages also. It requires larger memory and greater processing. It is also not suitable large networks with mobility. However, in WRP, each node in a network maintains the following four tables:

•Link Cost Table: Each node contains cost and other information like identifier to the directly connected nodes. The cost of a broken link is identified by infinity.
•Distance Table: In this table, each node contains information to the nodes that are not directly connected.

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•Routing Table: It contains the shortest distance and the up-to-date information of all destinations.
•Message Retransmission List (MRL): Each node in a network sends a hello message to its neighbors and informs them that he is alive and waits for the acknowledgement (ACK) from its neighbors. If it does get any ACK from any neighbors within a certain time, then keeps this information to MRL list. Next time it will send update message to nodes only that did not reply to the hello message.

C. Dynamic Source Routing (DSR) Protocol

It is a reactive protocol that creates a route on demand using source routing protocol i.e. it requires a full series of paths to be established between source and destination nodes to transmit packets and each packet follows the same path. The major motivations of this protocol are to limit the bandwidth by avoiding the periodic table updates and long convergence time. The underline fact to this protocol is that it floods a route request message in the network to establish a route and it consists of two procedures: Route Discovery and Route Maintenance.

C.Route Discovery

As it is an on-demand routing protocol, so it looks up the routing during transmission of a packet. At the first phase, the transmitting node search its route cache to see whether there is a valid destination exists and if so, then the node starts transmitting to the destination node and the route discovery process end here. If there is no destination address then the node broadcasts the route request packet to reach the destination. When the destination node gets this packet, it returns the learned path to the source node.

D.Route Maintenance

It is a process of broadcasting a message by a node to all other nodes informing the network or node failure in a network. It provides an early detection of node or link failure since wireless networks utilize hop-to-hop acknowledge.

The advantage of this protocol are 1) Aware of existence of alternative paths that helps to find another path in case of node or link failure. 2) It avoids routing loops and 3) less maintenance overhead cost as it an on-demand routing protocol. On the other side, the disadvantages are 1) Long route acquisition delay for the route discovery which may not be acceptable in situations like the battle field. 2) It is not suitable for large number of nodes where speed may suffer and 3) it produced huge messaging overhead during busy times.

E.Ad-hoc On-demand Distance Vector (AODV) Protocol

It is a classical routing protocol for MANETs that compromise the trade-off problems like large packet header in reactive source protocol and large messaging overhead due to periodic updates in proactive protocols. It uses a distributed approach i.e. it keeps track of the neighbor nodes only and it does not establish a series of paths to reach the destination. It also uses route discovery and route maintenance mechanism like DSR.

F.Route Discovery

A source node send a broadcast message to its neighboring nodes if no route is available for the desired destination containing source address, source sequence number, destination address, destination sequence number, broadcast ID and hop count. Two pointers such as forward pointer and backward pointer are used during route discovery. Forward pointers keep track of the intermediate nodes while message being forwarded to destination node. Eventually, when route request message reached the destination node, it then uncast the reply message to the source via the intermediate nodes and the backward pointer keeps track of the nodes. The major feature of AODV that distinguish it from DSR is the destination sequence number which is used to verify the up-to-date path to the destination.

G.Route Maintenance

Three types of messages exchanged between source and destination such as route error message, hello message and time out message. Route error message ensures that this message will be broadcasted to all nodes because when a node observes a failed link, it will propagate this message to its upstream nodes towards source node only. Hello message ensures the forward and backward pointers from expiration. Time out message guarantees the deletion of link when there is no activity for a certain amount of time between source and the destination node.

Main advantages are 1) it is an efficient algorithm for mobile ad-hoc networks and it is scalable 2) it takes short time for convergence and is a loop free protocol and 3) messaging overhead to announce the link failure is less compared DSR.

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The main disadvantage is that it needs huge bandwidth to keep maintain periodic hello message.

Table 3: Comparison between three categories of Protocols

Parameters	Table-Driven (Proactive)	On-Demand (Reactive)	Hybrid
Storage Requirements	Higher	Dependent on no. of routes maintained or needed	Depends on size of each zone or cluster
Route Availability	Always Available	Computed as per need	Depends on location of destination
Periodic Route	Required Always	Not required	Used inside each zone
Updates Delay	Low	High	Low for local destinations and high for Interzone
Scalability	**100 nodes**	**> 100**	**> 1000**
Control Traffic	High	Low	Lower that other two types

VII. CONCLUSION

In this paper, we have presented and discussed the taxonomy of routing protocols in mobile ad hoc networks and provided comparisons between them. The protocols are divided into three main categories: (i) source-initiated (reactive or on-demand), (ii) table-driven (pro-active), (iii) hybrid protocols. For each of these classes, we reviewed and compared several representative protocols. While there are still many challenges facing Mobile ad hoc networks related to routing and security. Each routing protocol has unique features. Based on network environments, we have to choose the suitable routing protocol. The analysis of the different proposals has demonstrated that the inherent characteristics of ad hoc networks, such as lack of infrastructure and rapidly changing topologies, introduce additional difficulties to the already complicated problem of secure routing. The main differentiating factor between the protocols is the ways of finding and maintaining the routes between source destination pairs. The comparison we have presented between the routing protocols indicates that the design of a secure ad hoc routing protocol constitutes a challenging research problem against the existing security solutions. We hope that the taxonomy presented in this paper will be helpful and provide researchers a platform for choosing the right protocol for their work. At last we have provided the overall characteristic features of all routing protocols and described which protocols may perform best in large networks. Almost all the protocols we discussed in this paper have their own characteristic features and performance parameter combinations where they outperform their competitors. Still mobile ad hoc networks have posed a great challenge for the researchers due to changing topology and security attacks, and none of the protocols is fully secured and research is going on around the globe.

Hybrid protocol new generation of protocol was designed to increase the scalability and to reduce the route discovery overheads. Even though hybrid protocol suits for large networks, it complexity is increases i.e. High traffic and significant reduction in throughput when it expands in scale. In order to increase the scalability the route discovery and route maintenance must be controlled. Depends upon the network traffic and number of flows the routing protocol should be chosen. Hybrid protocol is association of the advantage of the both proactive and reactive routing protocol. Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the algorithm. The main contribution of the algorithm was to solve the routing loop problem. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present; else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently. To implement this, use sequence numbering in destination routing protocol to avoid the complexity in larger networks

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