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RESEARCH ARTICLE

A Comparative Study of Routing Protocols for Mobile Ad-Hoc Networks

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Abstract— Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes that dynamically form a network temporarily without any support of central management. Routing in Mobile ad hoc network is extremely challenging because of its limited bandwidth, battery constraints, routing overhead, asymmetric link, speed, scalability, packet loss and quality of services. The widely accepted existing routing protocols are designed to accommodate the needs of such self-organized networks. The protocol to be chosen must cover all states of a specified network and never is allowed to consume too much network resources by protocol overhead traffic. This paper deals with the classification of Mobile ad hoc routing protocols and also presents some specified protocols according to that classification.

Keywords-- Adhoc networks, Routing protocols, MANET, DSR, DSDV, AODV, hybrid

I. INTRODUCTION

Mobile ad hoc networks (MANETs) act as an effective communication in dynamic operation environments such as military operations, emergency operation for disaster recovery, and for missions like search and rescue. Also the lack of fixed infrastructure makes these networks attractive for several distributed applications like sensing and internet access to deprived communities [5]. Ad hoc networks don't have fixed routers; each node acts as a router and forwards traffic from other nodes. These nodes are connected in an arbitrary manner and because the nodes are highly mobile, the topology changes occur frequently [1]. The rate of change depends on the velocity of the nodes and the challenges are these devices are small and the available transmission power is limited. To form an efficient and effective MANET, there are numerous applicable protocols available which are designed to perform its task. The design and classification depends on what routing information is exchanged, when and how routes are computed, their network structure, communication model, routing strategy, and state information and so on but most of these are done depending on routing strategy and network structure. Various research communities working in the field of MANET are trying to adopt the protocols and technology in other applications as well. One of the important research areas in MANET is establishing and maintaining the ad hoc network with the use of routing protocols.

II. ROUTING PROTOCOLS

Routing is the process of selecting paths in a network for moving a packet of data from source to destination. A routing protocol composes of a routing algorithm with a set of rules that monitors the operations of the network [1]. The key issue in MANETs is that the routing protocols must be able to respond rapidly to topological changes of the network. Routing protocols are broadly classified into three types, table-driven, on-demand driven and hybrid protocols.

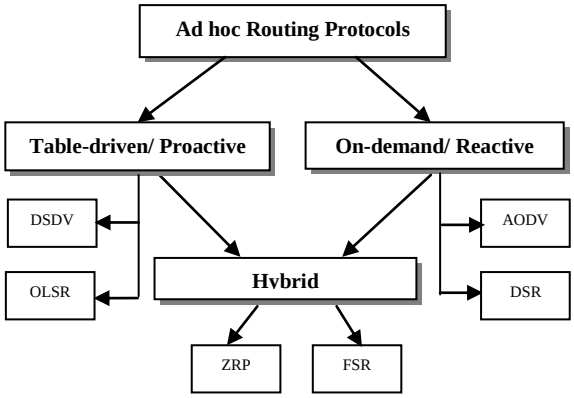

Figure 1: Classification of routing protocols

A. Proactive Protocols

In this type of routing protocol, each node in a network maintains one or more routing tables that are updated regularly which helps them to learn the topology of the network [5]. When a route is required to send data from source to destination, the route information is available immediately because each node sends a broadcast message to the entire network, if there is a change in the network topology. Since each node is required to maintain one or more tables to store up-to-date routing information, it incurs additional overhead cost [2]. These protocols have lower intermission because all the routes are maintained at all the times. DSDV (destination sequence distance vector), WRP (wireless routing protocol), GSR (global state routing), STAR (source tree adaptive routing), DREAM (distance routing effect algorithm for mobility) and OLSR (optimized link state routing protocol) are examples of Proactive protocols.

a) Destination Sequenced Distance Vector (DSDV) protocol

Developed by C. Perkins and P. Bhagwat, DSDV is based on bellman-ford shortest path algorithm with improvements such as including freedom from loops in routing table with the use of sequence numbers.

Bellman-Ford Equation (dynamic programming)
• Define
$dx(y) :=$ *cost of least-cost path from x to y*
• Then
$dx(y) = min \{c(x,v) + dv(y) \}$
where min is taken over all neighbors v of x

Within adhoc networks, advertisements may propagate along many paths. Sequence numbers help to apply the advertisements in correct order which helps in avoiding the loops [3]. The routing table stores information such as, the next hop towards the destination node, the metric, the sequence number of the last advertisement and the time at which the path has been installed first [7].Whenever there is a change in network topology, each mobile node advertises routing information. The route labeled with the highest sequence number is always used as it helps in identifying the stale routes from the new ones, thereby avoiding the formation of loops. DSDV is not suitable for highly dynamic networks as a new sequence number is needed every time the topology of the network changes [1].

Distance Vector Algorithm
• Dx(y) = estimate of least cost from x to y
• Distance vector: Dx = [Dx(y): y є N]
• Node x knows cost to each neighbor v: c(x,v)
• Node x maintains Dx = [Dx(y): y є N]
• Node x also maintains its neighbors' distance vectors
• For each neighbor v, x maintains
Dv = [Dv(y): y є N]

b) Optimized Link State Routing (OLSR) Protocol

Like other table driven protocols, OLSR also exchanges topology information with other nodes of the network regularly. It is an optimization over the classical link state protocol. This protocol does not require reliable transmission of control messages [6]. Multi point relays (MPR) are selected by each node from its set of neighbor nodes. Only these MPRs are responsible for forwarding control traffic, intended for diffusion into the entire network [3].

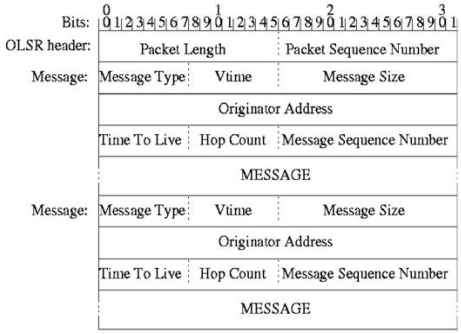

Figure 2: OLSR Packet Format

OLSR protocol is well suited for those applications which do not allow long delays in the transmission of the data packets. The major disadvantage of this protocol is that it must maintain the routing table for all the possible routes, thus when the number of the mobile hosts increases, the overhead from the control messages also increases [6].

Parameters	DSDV	OLSR
Multicast Routes	No	Yes
Route Updates	Periodic	Periodic
Distributed	Yes	Yes
QoS Support	No	Yes
Routes Maintained	Route table	Route table
Route Metric	Shortest path	Shortest path
Overhead	Low	High

Table 1: DSDV vs. OLSR

B. Reactive Protocols

In on-demand routing, as the name indicates routes are created as and when required rather than continuously maintaining up to date topology of network. It follows the technique of flooding a control message throughout the network while discovering a route [2]. It requires less routing information and focuses on minimizing the network traffic overhead but produces huge control packets during route discovery as topology changes occur frequently in MANET. Ad Hoc On-Demand Distance Vector Routing Protocol (AODV), Dynamic Source Routing Protocol (DSR) are examples of reactive protocols [5].

a) Ad Hoc On-Demand Distance Vector Routing (AODV) Protocol

AODV is capable of both unicast and multicast routing. AODV uses sequence numbers to ensure the freshness of routes and to prevent routing loop [4]. In AODV the source node and the intermediate nodes store the next-hop information for each data packet transmission whereas DSR uses source routing in which a data packet carries the complete path to be traversed. The major advantages of AODV are it is loop-free, self-starting, and scales to large numbers of mobile nodes [1].

In AODV, Route discovery is done when there is no proper route is available to the destination. This is initiated by sending a R.REQ packet into the network. This request has the following fields, source address, request id, source sequence number, destination address, destination sequence number, hop count [1]. On checking the source address and route id the request will be forwarded or replied with a R.REP message. If the route entry is not up to date it will be rebroadcasted with incremented hop count. Every R.REQ carries a time to live (TTL) which specifies the number of times it should be re broadcasted. Hence the predefined values will be incremented on retransmission [4].

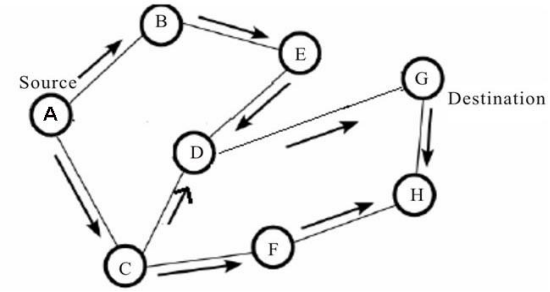

Figure 3: RREQ Broadcast

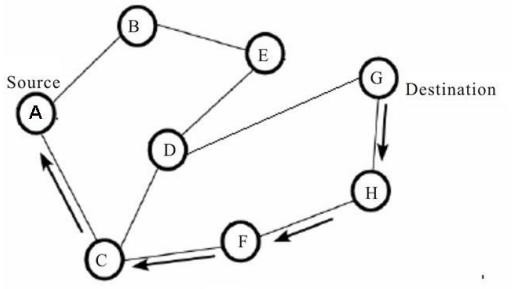

Figure 4: RREP Forward path

The drawbacks of this protocol are if the source sequence number is old and the intermediate nodes have a higher but not the latest destination sequence number, intermediate nodes can lead to inconsistent routes [6]. Also, multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead. Another drawback is the unnecessary consumption of bandwidth due to periodic beaconing and each node expects to periodically receive messages from each of its outgoing nodes.

b) Dynamic Source Routing (DSR) Protocol

DSR uses source routing where only source is responsible for providing information of whole path and intermediate node does not provide any information about destination. DSR is similar to AODV with RREQ and RREP messages and forms a route on-demand when a transmitting computer requests one [7]. The destination node generates a route reply message which includes the list of addresses received in the route request and transmits it back along this path to the source [1]. When a successful reception of a packet is not verified by a node, it tries to retransmit it for a finite number of times. If the problem still persists then the node generates a route error message that specifies the problematic link, transmitting it to the source node.

The advantage of DSR is that it allows the network to be self-organized and self-configured without any central administration and network setup. It differs from AODV by not maintaining periodic routing messages thus reduces bandwidth overhead and conserves battery power [7]. The problem with DSR is care must be taken to avoid collisions between route requests propagated by neighboring nodes. Other drawbacks include Network-wide flood, Reply storm problem and Stale cache problem in which an intermediate node may send Route Reply using a stale cached route, thus polluting other caches [4].

Parameters	AODV	DSR
Route Metric	Newest Route	Shortest path
Routes maintained in	Route table	Route cache
Overhead	High	High
Time Complexity (initialization)	O(2d)	O(2d)
Time Complexity (Post Failure)	O(2d)	O(2d) or O
Path Type	Single	Multiple
Loop free	Yes	Yes

Table 2: AODV vs. DSR

C. Hybrid Protocols

These protocols seek to incorporate the aspects of proactive and reactive protocols. It uses the route discovery mechanism of reactive protocol and the table maintenance mechanism of proactive protocol thereby overcoming the drawbacks like large overhead and latency [5]. Though it aims at eliminating the drawbacks, it has the disadvantage of the nodes that have high level topological information maintains more routing information, which leads to more memory and power consumption [2]. Hybrid protocol is suitable for large networks with large numbers of nodes. Some examples of Hybrid Routing Protocols include CEDAR, FSR, ZRP and SRP.

a) Fisheye State Routing (FSR) Protocol

This protocol uses the fisheye technique proposed by Kleinrock and Stevens in which the size of the information required is reduced to represent graphical data. . The eye of a fish captures with high detail the pixels near the focal point. The detail decreases as the distance from the focal point increases. FSR maintains a topology map at each node [8]. Based on the up to date information received from neighboring nodes, a link state table is maintained. These tables are exchanged periodically only with their local neighbors. The update messages sent between the nodes could consume a lot of bandwidth, when the size of the network becomes bigger. To overcome this problem, the sizes of these messages are reduced using routing scopes. Scope is a set of nodes that can reach each other in given number of hops. Figure 5 shows the scope of the node 4. Since there is no flooding, FSR significantly reduces the consumed bandwidth [8].

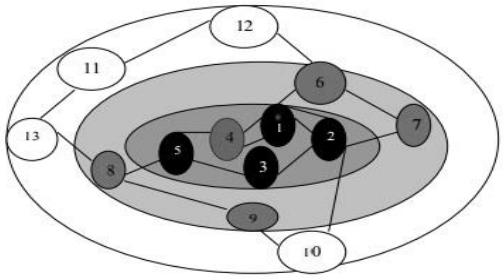

Figure 5: Scope of Fisheye

b) Zone Routing Protocol (ZRP)

ZRP is suitable for large area networks and route creation is done using a query-reply mechanism. It uses Intrazone and Interzone routing to provide flexible route discovery and route maintenance in the multiple ad hoc environments [9]. Through reactive routing protocol, Interzone routing is performed globally and through proactive routing protocol, intrazone routing is performed locally to maintain up-to-date route information [5].

A node must first identify its neighbors with whom direct communication can be established. This would help in the creation of different zones in the network. During the forwarding of the query packet, a node identifies whether it is coming from its neighbor or not using the route information. If so, then it marks all of its known neighboring nodes in its same zone as covered [9]. A covered node is a node which belongs to the routing zone of a node that has received a route query. The query is relayed till it reaches the destination and the destination in turn sends back a reply message via the reverse path and creates the route [5]. ZRP performs route discovery more efficiently as it reduces the network overhead caused by proactive routing and also by handling the network delay caused by reactive routing protocols [9].

Parameters	FSR	ZRP
Path type	Single	single
Route metric	Scope range	Shortest path
Route Storage	Routing tables	Intra and Inter zone tables
Multicast Capability	No	No
Complexity	Low	Medium
Multiple paths	Yes	Yes
Route Recovery	Notify source	Start repair at failure point

Table 3: FSR vs. ZRP

III. COMPARISON OF PROACTIVE, REACTIVE AND HYBRID PROTOCOLS

Parameters	Proactive	Reactive	Hybrid
Routing structure	Both flat and hierarchical	Flat	Hierarchical
Routing information	Stored in table	Doesn't store	Depends on requirement
Route availability	Always available	Determined when needed	Depends on destination location
Storage requirements	High	Lower than proactive	Depends on size of the cluster
Periodic route updates	Required	Not required	Required inside each zone
Traffic control volume	high	low	Lower than other two types

Delay level	Low	high	For local destinations small & high for interzone
Scalability	Up to 100 nodes	More than 100	More than 1000

Table 4: Comparison of Proactive, Reactive and Hybrid protocols

Protocols	**Advantages**	**Disadvantages**
Proactive	• Up to date routing information • Quick establishment of routes • Low delay level	• Possibility for loop formation • Requires large amount of resources
Reactive	• Routing load is reduced • No loop formation • Resources are considerably saved	• High delay level • Routes are not always up to date
Hybrid	• Scalability (>1000 nodes) • Up to date information within zones	• Inter zone routing latencies • More resources for large size zones

Table 5: Advantages and Disadvantages

IV. CONCLUSION & FUTURE WORK

In this paper, an attempt has been made to study and analyze six routing protocols (DSDV, OLSR, AODV, DSR, FSR & ZRP) and a comparison has been made between Proactive, Reactive and Hybrid protocols. It is a critical issue to select efficient and reliable protocol. FSR and ZRP are efficient in discovering and maintaining routes. DSDV and OLSR have faster connection times because routing information is already available when the first packet is sent. AODV performance is good considering its ability to maintain connection by periodic exchange of data's. DSR will perform better when the number of nodes is less. Efforts can be made in the future to optimize DSR so that it performs well with a larger network.

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