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Overview of Basic Routing Protocols in MANETs

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Abstract— ***A mobile ad-hoc network (MANET) is a self configured dynamic network comprising of mobile nodes, where each and every participating node voluntarily transmit the packets to some other node using wireless (radio signal) transmission. A ad hoc network do not have any centralized arbitrator or server. In MANET each and every mobile node is assumed to be moving with random speed in any random direction. Because of that there is no long term guaranteed path from any one node to other node. MANETs use DSDV, OLSR, AODV and DSR as their base routing protocols. These protocols have different behaviors with respect to wireless routing perspective.***

Index Terms- Mobile Ad hoc Network(MANET),Dynamic Sequence Distance Vector (DSDV), Optimized Link State Routing (OLSR), Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR)

I. Introduction

Ad hoc network is a network which has an independent existence where there is no existence of wireless infrastructure for networking, for a specific purpose. In this network every node transfer packet that flow to and from different usually multiple nodes using some routing algorithm to route different packets. MANET is a kind of Ad- Hoc network which involves mobile nodes i.e. they can change their location with time. Some of its major features are:

a) It is self-configuring network of mobile routers (and hosts connected to them) using wireless media.
b) Nodes transfer data packets irrespective of whether these belong to them or not.
c) Topology is dynamic as nodes are mobile so can join and leave network any time.
d) Limited Bandwidth and Power.

The MANETs are different from wired or cellular networks as MANETS have fast and unpredictable topology changes due to nodes mobility, no dedicated routers to do routing and every node works as a router and a host and changing channel capacity due to environmental effects. Also, due to the absence of base stations, MANETs use multi-hop approach to deliver data.

II. Routing in MANETs

Routing is the act of moving information across an internetwork from a source to a destination. Routing involves two basic activities- determining optimal routing paths and Transporting packets (packet switching). Optimality of the path can be described using various metrics like, Number of hops, traffic, etc. In Ad-hoc network each host node acts as specialized router itself. In mobile ad hoc networks the routing is mostly done with the help of routing tables. These tables are kept in the memory cache of these mobile nodes.
There are several kinds of routing protocols for wireless ad hoc networks. These routing protocols are categorized as reactive or proactive routing protocols. The ad hoc routing protocols using combination of both proactive and reactive merits, is called hybrid routing protocols.

Proactive routing protocols- In proactive routing scheme every node continuously maintains complete routing information of the network. This is achieved by flooding network periodically with network status information to find out any possible change in network topology. Examples of Proactive Routing Protocols are: Destination Sequenced Distance Vector Routing (DSDV), OLSR (Optimized Link State Routing). In Proactive routing protocols routes are readily available when there is any requirement to send packet to any other mobile node in the network, hence quick response to Application program. But consumes lots of network resources to maintain up-to-date status of network graph.

Reactive routing protocols- In Reactive routing protocols routes are discovered on demand basis. Every node in this routing protocol maintains information of only active paths to the destination nodes. A route search is needed for every new destination therefore the communication overhead is reduced at the expense of delay to search the route. Rapidly changing wireless network topology may break active route and cause subsequent route search. Examples of reactive protocols are: Ad hoc On-demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR). These are bandwidth efficient protocols. Less Network communication overhead is required in this protocol.

Hybrid routing protocols- There exist a number of routing protocols of globally reactive and locally proactive states. For Example: Zone Based Routing Protocol (ZRP).

III. Proactive routing protocols

In proactive routing (also called table-driven) every node continuously maintains complete routing information of the network by flooding network periodically with network status information to find out any possible change in network topology.

A. DSDV

DSDV is based on the distributed bellman ford algorithm. In DSDV, packets are transmitted between mobile nodes by using Routing Tables which are stored at mobile node. Each Routing Table, at each of the mobile node contain list of all available destinations and the number of hops to each. Each Route Table entry is tagged with a sequence number which is originated by the destination node. To achieve the consistency in the dynamically changing topology based network, every mobile node periodically transmits updates and Routing Tables are updated. Routing information is advertised by multicasting the packets which are transmitted periodically and incrementally as topological changes are detected.

DSDV is Modification of Distance Vector Algorithm. It works as in following steps:

1. Packets are transmitted by using "Route Table" maintained at each node.
2. To Maintain Route Table each node broadcasts its Route Table Entries.
3. When a node receive new routing information:
   - Entry with Highest (most recent) Sequence Number is used.
   - If Sequence Numbers are same, the entry with smallest metric is used.
4. The update packet starts out with a metric of one as each receiving neighbour is one metric away from the node.
5. The route information broadcast by each node contain: new Sequence Number, Destination's address, number of hops required to reach the destination, Destination Sequence Number.
6. On receiving the update packet, neighbour nodes update their routing table with incrementing the metric by one and retransmit the update packet to their neighbours.

Consider an ad hoc network as shown in figure1 below:

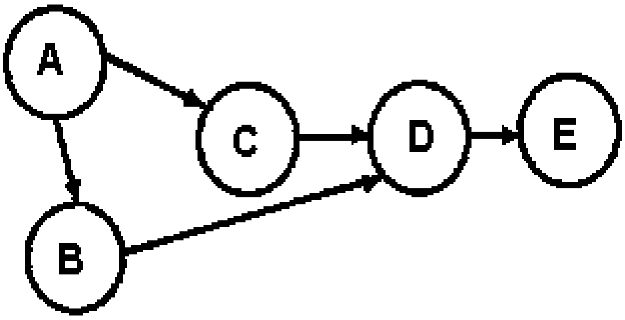

Figure 1 An example of an ad hoc network.

If we use DSDV routing algorithm on network as in figure1 the routing table generated at node A would be as in table I.

Table I
Route Table at Node A

Destination	Metric (Hop count)	Next hop	Sequence Number
a	0	a	S46_1
b	1	b	S16_4
c	1	c	S26_1
d	2	c	S71_6
e	3	c	S90_2

If the link A to B breaks in the above network, then new information packet with odd sequence number for node will get generated. The updated routing table at node A will be as shown in table II.

Table II
Updated Route Table at A

Destination	Metric (Hop count)	Next hop	Sequence Number
a	0	a	S46_1
b	∞	b	S85_1
c	1	c	S26_1
d	2	c	S71_6
e	3	c	S90_2

Analysis of DSDV routing protocol:

- In DSDV, Routing is achieved by using routing tables maintained at each node.
- Large routing overhead as Generation and maintenance of these routing tables is very complex.
- Uses only bidirectional links for information exchange.
- Suffers from count to infinity problem.
- As the number of nodes in the network grows , the size of the routing tables and the bandwidth required to update them also grows.
- Whenever the topology changes, DSDV is unstable until update packets propagate throughout the network, So not suitable for mobile networks.

B. OLSR

OLSR keeps track of routing table in order to provide a route if needed. In OLSR, all the nodes in the network do not broadcast the route packets. Just Multipoint Relay (MPR) nodes broadcast route packets. These MPR nodes is selected from the neighbour nodes of source node called multipoint relay selector set. Each node in the network keeps a list of MPR nodes. This MPR selector is obtained from HELLO packets sending between in neighbour nodes. These routes are built before any source node intends to send a message to a specified destination. Each and every node in the network keeps a routing table. This is the reason the routing overhead for OLSR is minimum than other reactive routing protocols and it provide a shortest route to the destination in the network. There is no need to build the new routes, as the existing in use route does not increase enough routing overhead. It reduces the route discovery delay. Nodes in the network send HELLO messages to their neighbors. These messages are sent at a predetermined interval in OLSR to determine the link status. A node chooses minimal number of MPR nodes, when symmetric connections are made. Symmetric connection is the one in which participating devices can send and receive message from each other. It broadcast topology control (TC) messages with information about link status at predetermined TC interval. TC messages also calculate the routing tables. In TC messages MPR node information are also included.

Analysis of OLSR routing protocol:

- OLSR minimizes the overhead from flooding of control traffic by using only MPRs, to retransmit control messages, which reduces the number of retransmissions required to flood a message to all nodes in the network.
- The protocol does not require reliable transmission of control messages: each node sends control messages periodically, and can therefore sustain a reasonable loss of some such messages.
- Each host periodic sends the updated topology information throughout the entire network, this increase the protocol's bandwidth usage.

IV. REACTIVE ROUTING PROTOCOLS

Reactive routing protocols are more popular routing algorithms and are also called “on-demand” protocols, as route discovery operation is performed only when a routing path is needed, and it is terminated when a route or no route has been found.

C. DSR

The DSR allow nodes to dynamically discover a source route across multiple network hops to any destination. It uses source routing: Each packet(in header) to be routed carries the complete, ordered list of nodes through which the packet pass. These routes are stored in node memory called direction cache. It provides an advantage that intermediate hops need not to maintain routing information in order to route the packets as packets already contain routing information. It does not require the periodic transmission of router advertisements or link status packets.DSR is broken down into three functional components: routing, route discovery and route maintenance.

Route Discovery

It determines path(s) for a communication between a source node and target node. Route discovery uses two messages i.e. route request (RREQ) and route reply (RREP). When a node need to send a message to some destination, it broadcast the RREQ packet in the network. The neighbour nodes in the broadcast range receive this RREQ message and add their own address to the packet header and rebroadcast it in the network until destination is reached. In the case if the message did not reached to the destination then the node which received the RREQ packet will look for any previously used route for the specific destination. Each node maintains its route cache which is kept in the memory for the discovered route. The node will check its route cache for the desired destination before rebroadcasting the RREQ message. By maintaining the route cache at every node in the network, memory overhead (by the route discovery procedure) can be reduced. If a route is found in that node route cache do not rebroadcast the RREQ in the whole network. So it will forward the RREQ message to the destination node. The first message reached to the destination has full information about the route. That node will send a RREP packet to the sender having complete route information.

Route Maintenance

If a node along the path of a packet detects an error, the node returns a route error (RERR) packet to the sender. When a route error packet is received, the hop in error is removed from any route caches and all routes which contain this hop are truncated. A route error packet can be returned to the sender by following ways:

In case of bidirectional links- reverse the route contained in the packet from the original host.

In case of unidirectional links- Salvage , Gratuitous route repair , Promiscuous listen methods are used.

Use of DSR makes the network completely self-organizing and self-configuring, as it do not require any existing network infrastructure or administration. Network nodes cooperate to forward packets for each other to allow communication over multiple hops between nodes not directly within wireless transmission range of one another. As nodes in the network move about or join or leave the network and as wireless transmission conditions such as sources of interference change, all routing is automatically determined and maintained by the DSR Routing Protocol. By including this source route in the header of each data packet, other nodes forwarding or overhearing any of these packets may also easily cache this routing information for future use.

Analysis of DSR routing protocol:

- Bandwidth overheads arises due to route discovery, route maintenance and packet header.
- DSR can make use of multiple paths.
- It does not send periodic packets.
- Paths are more stable when created as information is obtained from packet header come all way long source to destination.
- As node count increases, the detrimental effects of route discovery and maintenance can be expected to grow.

D. AODV

AODV is a Reactive Routing Protocol. Therefore, routes are determined only when needed. Whenever an AODV router or node receives a request to send a message, it checks its Routing Table for route existence. Each Routing Table entry consists of Destination Address, Next Hop Address, Destination SN and Hop Count. If a route exists, the router simply forwards the message to the next hop. Otherwise, it saves the message in a message queue and then it initiates a route request to determine a route. Upon receipt of the Routing information, it updates its Routing Table and sends the queued message(s).

AODV nodes use four types of messages: RREQ, RREP, RERR and HELLO. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance. HELLO messages is used to detect and monitor links to neighbors. If HELLO messages are used, each active node periodically broadcasts a HELLO message that all its neighbors receive. Because nodes periodically send HELLO messages, if a node fails to receive several HELLO messages from a neighbor, a link break is detected. When a source has data to transmit to an unknown destination, it broadcasts a RREQ for that destination. At each intermediate node, when a RREQ is received a route to the source is created. If the receiving node has not received this RREQ before, is not the destination and does not have a current route to the destination, it rebroadcasts the RREQ. If the receiving node is the destination or has a current route to the destination, it generates a RREP. The RREP is unicast in a hop-by-hop fashion to the source. As the RREP propagates, each intermediate node creates a route to the destination. When the source receives the RREP, it records the route to the destination and can begin sending data. If multiple RREPs are received by the source, the route with the shortest hop count is chosen.

Source Address	Request ID Source	Sequence Number	Destination Address	Destination Sequence Number	Hop Count

Figure2. Route Request (RREQ) Packet Field

A RREQ is identified by the pair source address and request ID, each time when the source node sends a new request and the request ID is incremented. After receiving of request message, each node checks the request ID and source address. The new RREQ is discarded if there is already RREQ packet with same pair of parameters. A node that has no route entry for the destination, it rebroadcasts the RREQ with incremented hop count parameter. A route reply (RREP) message is generated and sent back to source if a node has route with sequence number greater than or equal to that of RREQ. The format of the Route Reply message is as shown in figure 3.

Source Address	Destination Address	Destination Sequence Number	Hop Count	Life Time

Figure3. Route Reply Packet Field

AODV involves two steps: route discovery and route maintenance.
Route Discovery involves following steps:

1. When a node need to send a packet to some other node (destination) –Check routing table to determine if current route to the destination is available with it:
   i. If Yes, forward the packet to next hop node.
   ii. If No, initiate a route discovery process.
2. *Setup of Reverse Path*: Route discovery process starts with the generation of a Route Request (RREQ) packet by source node.
3. RREQ Packet has broadcast ID number, which gets incremented each time a source node uses RREQ. Also Broadcast ID and source IP address form a unique identifier for the RREQ.
4. Once an intermediate node receives a RREQ, the node sends route reply packet (RREP) for the source node in its route table
5. *Setup of Forward Path*: When RREQ reaches destination, a response is generated if its route table has:
   i. Unexpired entry for the destination (life time value).
   ii. Sequence number of destination at least as great as in RREQ (for loop prevention).
6. If both conditions are met & the IP address of the destination matches with that in RREQ:
   the node responds to RREQ by sending a RREP back using unicasting to the source using reverse path.
   Else, Node increments the hop count in RREQ and broadcasts to its neighbors.
7. Ultimately the RREQ will reach to the destination.

After Route has been discovered, comes Route maintenance phase which involve following steps:

1. Neighboring nodes periodically exchange hello message. Absence of hello message is used as an indication of link failure. Successive failures to receive several MAC-level acknowledgements may be used as an indication of link failure.
2. If a link to source node breaks, route discovery process is done again.
3. If link to intermediate nodes or the destination breaks, RERR is initiated by the nearest neighbor node to the break. It updates its own routing table by marking the break node invalid. It is propagated to all the affected nodes. RERR lists all the nodes affected by the link failure. When a node receives an RERR, it sets distance to the destination as infinity in the route table. When a source node receives an RERR, it restarts route discovery process to destination.

Analysis of AODV routing algorithm:

- AODV and DSR are very similar, but AODV mechanisms are easier to implement and to integrate with other mechanisms using other different routing protocols.
- AODV has better scalability and its header size on data packet is relative constant.
- AODV maintains only one route per destination. So if route is broken, a new route discovery initiated, which leads to more overheads, higher delays and high packet lost.
- It stores all usable routing information extracted from overhearing packets, hence lead to inconsistencies.
- AODV uses flooding as a broadcasting mechanism, which has many optimization and collision related problems.

V. Conclusion

The field of MANET is rapidly growing and changing and while there are still many challenges that need to be met. This paper totally speaks about working and description of Reactive and Proactive Protocols and every Protocol has its limitations and delimitations. Some time they may work better and sometime not. Four basic protocols were introduced and their basic functioning was described. Also the analysis of the protocols based on their routing processes was given. There are many issues that require further investigation like traffic control, power control and security besides performance metric like Packet Delivery Ratio, Throughput, Average End-to-End Delay and Normalized Routing Overhead. This paper compares the most commonly used routing algorithms .

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