An Overview of Route Discovery Mechanisms of Multicast Routing Protocols for MANETs

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Abstract— A Mobile Ad-hoc NETwork (MANET) is a self-organizing wireless network, which has no fixed infrastructure or central control station. A Major aspect of ad-hoc networks is that the nodes move randomly, which requires the routing protocols in ad-hoc network to quickly respond to the network topology change. In addition to that it should provide the various quality of services such as guaranteed delivery, security, reduced overhead etc. An efficient protocol must have the mechanism to maintain paths to other nodes and in most cases, if the routes are affected, it should be able to recover using an existing alternate path [1]. In this paper, we focused the various methodologies used for route discovery, route maintenance and route recovery process adopted in different routing protocols for MANETs. A comparative study based on simulation results is discussed

Keyword- MANET, Route Maintenance, Route Recovery

INTRODUCTION

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MANET is a collection of mobile devices that form a self-creating, self-organizing and self-administering wireless networks. Routing is an essential component of communication networks, which defines act of moving information from source node(s) to destination node(s) in an inter network. Efficient dynamic routing is a challenge in such a network. Ad-hoc routing protocols can be classified into two main categories: proactive (or table driven) protocols and reactive (or source initiated) protocols.

Proactive protocols are also called as Table driven protocols since they maintain the up to date routing information even before it is needed. Routes information is maintained in the form of routing tables and is periodically updated from each node to every other node as the network topology changes. The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth.

Source Initiated Protocols are also called as reactive protocols. The routing information or routing activity is not necessary to maintain at the network nodes if there is no communication. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. Some form of route maintenance procedure is used to maintain the routes. These protocols tend to use less bandwidth for maintaining the route tables at every node. However, the latency drastically increases, leading to long delays before a communication can start. This is because a route to the destination has to be acquired first[3].

To limit the impact of this delay, most protocols will use a route cache for once established routes. The advantage of on- demand routing protocols lies in the fact that the wireless channel (a scarce resource) does not need to carry a lot of routing overhead data for routes, that are not even used. The routing mechanisms will vary in different protocols based on the factors like mobility of nodes, expected quality of services, area of application, resources availability etc. In this paper, a framework of various routing mechanisms in different routing protocols like AODV, MAODV, DSR, HA-MAODV were discussed and the preliminary simulation results were produced.

II RELATED WORK

A. Adhoc - On Demand Distance Vector (AODV)

AODV routing protocol uses mobile nodes to identify routes fastly to reach new destinations and does not require nodes to maintain routes to destinations. It is loop-free and avoids "counting to infinity" problem.

The operation of AODV comprises of two main processes i.e. route discovery and route maintenance. Each node in the network maintains a routing table with the routing information entries such as Destination IP Address, Prefix Size Destination Sequence Number Next Hop IP Address Lifetime (expiration or deletion time of the route) Hop Count (number of hops to reach the destination) Network Interface Other state and routing flags (e.g., valid, invalid)

The route discovery process generates route request / route reply query cycle. When a node has a data to send then it broadcasts a route request (RREQ) packet across the network. The RREQ contains the following fields such as source-address, destination-address, destination-sequence and hop-count. The nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables.

A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. The RREP contains the following fields such as Destination- address, Destination-sequence number and lifetime. Otherwise, it rebroadcasts the RREQ. Once the source node receives the RREP, it may begin to forward data packets to the destination.

If there are any link or node failures, then the node in the upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s). In order to enable this reporting mechanism, each node keeps a ``precursor list'', containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination. After receiving the RERR, if the source node still desires the route, it can reinitiate route discovery. On-demand routing protocol which is widely developed in adhoc networks because of its effectiveness and efficiency.

The various desirable factors which make AODV as effective & efficient routing protocol for MANETS are

✓ *Efficient bandwidth Utilization:*

In AODV, all the routes are obtained by on-demand basis only. So the utilization of available bandwidth is less. The nodes that are not in the active path do not maintain the routing information. Also if a node does not receive any RREP message from all of its neighbors, it deletes the routing information from the routing table. All the stale cached routes are getting refreshed using counter for reuse.

✓ Simple and Effective:

The route discovery process of AODV is simple. Each and every node will take part in finding the optimal path between source and destination. The routing table maintained at every node is updated always with the optimal and recent paths, if exists.

✓ Counting To Infinity Problems:

It avoids counting to infinity problems. It maintains loop free routes by discarding the data with Same broadcast id.

✓ Well suited for dynamic networks:

When ever there is a change in the topology of the network due to the mobility of nodes or due to the broken links, the intermediate node which identifies the broken path will propagate an RERR message throughout the network and in turn the source will reinitiate the route discovery process.

The various issues related with AODV are

✓ Open Network

In route discovery processes, every node must be aware each other's broadcast messages. Network is open to all which may broadcast some messages that can be misused for insider attacks including route disruption, route invasion, node isolation, and resource consumption.

✓ Lack of route Maintenance

> In the case of any route failures in data transmission due to mobility or broken links, the Node will not reuse the routing information, up to which is correct. Instead the source will get the failure notice and reinitiate the route discovery process. The routing information is always obtained on demand, including a common case traffic.

> In the route discovery process, the RREQ will include the addresses of all the nodes through which it is passing and it carries all this information all its way which adds some overhead to bandwidth.

✓ No reply for reply loss message

It is based on single route reply message. The lost of route reply message may cause waste of performance. The node will reinitiate the route discovery process.

The process of sending the same data to multiple recipients is called multicasting. Multicasting plays an important role for communication in a MANET. It can reduce the consumptions of network bandwidth. MAODV protocol which is an enhanced version of AODV supports multicast traffic.

Multicast routes can be generated during route discovery process using Route Request (RREQ) and Route Reply (RREP) messages as shown in Fig1.



Fig.1. Route Discovery in MAODV

Whenever a node has a data to send, it initiates the route discovery mechanism to discover the routes to the desired multicast group. Every multicast group has a sequence number. When a node has a data to send, it broadcast the RREQ message thorough the network. Only a member of the desired multicast group may respond to join-RREQ. Every multicast group has a sequence number. The nodes forwarding RREQ and RREP record the path backwards to the source of packet,

Each node has three tables namely Unicast Route Table, Multicast Route Table and Group Leader Table. Unicast Route Table has an address of the next hop to which the message is to be forwarded. Multicast Route Table has the address of the next hops for the tree structure of the each multicast group.

The group member that first constructs the tree is the group leader for that tree, which is responsible for maintaining the group tree by periodically broadcasting Group Hello (GRPH). If a member node wishes to terminate its group membership, that node has to ask for the termination to the group. Then its membership will be terminated.

B. Dynamic Source Routing (DSR)

It allows nodes to dynamically discover a source route across multiple network hops to any destination in the ad hoc network. Unlike AODV, in DSR the intermediate nodes do not maintain routing information in order to route the pockets they receive. This protocol comprises of three components namely routing, route discovery and route maintenance.

Routing of packets is performed as follows. The node which has a data to send will dynamically discover a source route. Each packet will carry in its header the complete list of nodes through which the data must pass to reach the destination. There is no periodic transmission of router advertisements, link status, updating of routing information etc. But in the packet header, the complete source route from a source node to a desired destination is available. This source route can be cached by the intermediate nodes for future use.

If the source route is not available, the node will initiate a route discovery process. The source node will broadcast a route request message to all of its neighbors. Each route request is identified with a unique id number generated by source node. It contains the details of source and destination. Also it contains a record of addresses of each intermediate nodes through which the data has been forwarded. At the source node, the route record is empty.

Nodes forward route requests if they are not the destination node and they are not already listed as a hop in the route record. Otherwise, if the route request reaches the destination the destination node returns a route reply packet to the source node with the full source to destination path listed. Each node will maintain a cache of recently received route requests to avoid the duplication.

Further, when a node receives a route request for which it has a route to the destination in its cache, the node will returns the route reply to the source node with full concatenation of the route record in the header of the data and the cached route leading to the destination.

Route maintenance can also be performed using end-to-end acknowledgments rather than the hop-by-hop acknowledgments [5]. If a node along the path of a packet detects an error, the node returns a route error packet to the sender. The route error packet contains the addresses of the nodes at both ends of the hop in error. When a route error packet is received or overheard, the hop in error is removed from any route caches and all routes which contain this hop must be truncated at that point.

The various factors which enhance and degrade the performance of this protocol are

Route discovery with reduced overhead

 \succ In DSR, each sender will select and control the routes in routing its pockets which will balance the load among other nodes.

 \succ A single route discovery may yield many routes to the destination, All routes are get cached. So the intermediate nodes can utilize the route cache information

> When a node overhears a packet not addressed to it, it checks whether it has an optimized route in its cache. If so, the node sends a reply to the source with this new route which will further enhance the source routing

Lack of Route Maintenance

√

 \succ The header of the packet will carry the routing information through all the intermediate nodes till to reach the destination. It will cause a remarkable overhead as the path length increases.

 \succ In a highly mobile network, the intermediate-node replies are very likely to be invalid, which will result in wastages of time and bandwidth.

C. History aware on Multicast Ad Hoc on Demand Distance Vector Routing (HM-AODV)

It is an improved version of MAODV. It provides multiple paths in consideration of session history from source to destination. A session history includes the details about how many times and how much duration a node is involved in communication sessions between mobile nodes in a network. A node with high session history will be in low movement whereas the nodes with low session history are in high movement. Always the nodes with high session history are preferable, because the mobility of the nodes will be low.

At each node the session history should be maintained. During route discovery process, a route query message transports to a destination the session histories of nodes through which it goes so that the destination can determine a route in consideration for its session history [6]. Each node keeps the record of active session and past session information.

Active session information gives the information about communication sessions in which the node is currently involved. It contains the start time, source node address and destination node address of the active communication sessions. Past session information gives the information about in which the node was involved in times past. It contains the start time and session duration of the past communication session and the number of past sessions recorded. To obtain the useful session history, the past session information that is maintained during more than a given period is eliminated.

The number of active sessions that a node can maintain simultaneously is restricted to a certain number. If the number of active sessions gets to limit, the node cannot participate in a route discovery. To prevent a node from being continuously excluded from a route discovery process, the application is suspended for a specific period of time so that the node can be involved in a route.

In case of link failure, the node which detects the failure will notify its upstream node using RERR packet and destroys its route information. The node which receives the RERR packet looks for a redundant path. If exists, it replaces the next hop of its route table with the next hop for the redundant path. Then it drops the RERR packet [2].

Also if RERR packet is originated from a node on a redundant path, it discards the RERR packet and does not forward any longer. It removes its redundant path information. Further if a node cannot find a redundant path, it reinitiates a route discovery procedure.

The various factors which influences the working of this protocol are

 \succ It avoids the failure of nodes and links to some extent, since each and every node will have a detailed session history.

> The packet delivery ratio is comparatively high.

 \succ The overhead can be controlled by avoiding the route re-transmission by correctly choosing the durations, values for the history degree in the network.

 \succ The weak point in history awareness is that if the nodes in a network do not have enough session history information, history aware may be ineffective.

III PERFORMANCE EVALUATION

A. Performance of AODV:

A simulation is done in network simulator (NS2) to evaluate the performance of AODV[8][9] on the basis of various parameters such as throughput, PDR (Packet Delivery Ratio), Routing Overhead, End-End delay, Packet drop.

Throughput:

It is a measure of packets that are successfully delivered to a final destination sent from the sender. The throughput is usually measured in no of data packets per time slots. It shows how effectively the requests are handled.

Packet Delivery Ratio:

The packet delivery ratio is defined as the ratio between the number of packets sent by the constant bit rate sources and the number of received packets by the constant bit rate sinks at destination. It is a measure of reliability. If PDR is more, network and data transfer is more reliable.

Routing Overhead:

It is the number of packet generated by routing protocol during the transmission such as routing information, error correcting and operational instructions etc. The generation of an important overhead will decrease the protocol performance

End-End Delay:

The time difference between the CBR packet sent and received is called End-End delay. There are possible delays at the MAC and propagation and transfer times. It describes the packet delivery time. The lower the End-End delay the better the application performance.

1) *Observations:* It is observed from the simulation that, the throughput of AODV increases dramatically with increasing pause time. At low pause time (high mobility) the network topology will change frequently, more broken links will occur and the discovery process will be needed more. As a consequence, there will be a greater routing overhead and packets will be dropped resulting in more delay and less throughput as shown in fig 2.

The path to a destination is retrieved only on on-demand basis. Some delay will be introduced route discovery process. Further the packets are stay in the send buffer till the route is discovered in order to be sent to the destination on that route. End-End delay increases as the waiting time increases as shown in the Fig 3.



Fig.2.

From the fig 4, it is clear that AODV produces better packet delivery Ratio. It tries to guarantee that the packets will be delivered to the destination by delay compromising. The PDF increases in respect of pause time. This is because when the nodes are not moving too much the routing status becomes relatively stable and as a result a path finding process is not required.

Further, in AODV the routing overhead will decrease with increasing pause time because at high pause time the mobility of the nodes will be low as shown in Fig 5.



Fig 5.

B. Performance of DSR:

A simulation is done in network simulator (NS2) [9] to evaluate the performance of DSR on the basis of various parameters such as throughput, PDR (Packet Delivery Ratio), Routing Overhead.

1) Observations:

It is observed that in DSR protocol will produce better PDR similar to AODV with increasing pause time as shown in the fig 6.From the Fig 7, the routing overhead will decreases with increased pause time. In the high pause time the mobility of the nodes are low.



Fig. 6.



Fig 7.

It is clear from the fig 8 that, DSR is purely reactive in nature and its path finding is very effective for which its throughput is high However DSR suffers with scalability issue. Its performance at fast moving scenario and at dense network is the major issue of concern. In our case the network density was low for which it gives better packet delivery ratio but we suspect its performance in term of throughput may degrade when the node density will increase.



Fig 8.

C. Performance of HA-MAODV:

A simulation is done in network simulator (NS2)[7] to evaluate the performance of HA-MAODV on the basis of various parameters such as Routing Overhead and latency

Latency:

It is the measure of time from the source sending a packet to the destination receiving it.











From the Fig 9 and Fig 10, it is inferred that the routing overhead increases as the mobility of the nodes increases. The overhead can be controlled by correctly choosing the durations values for the history degree in the network. Also the latency degrades with high mobility. Similar to DSR, HA-MAOD suffers with scalability issue.

IV. CONCLUSION

The task of finding and maintaining routes is nontrivial in mobile adhoc network. The mobility causes frequent unpredictable topological changes. A path that was considered to be optimal will not be optimal after a while. The factors that affect the routing process are link capacity, link and node capability, network density, etc. Also, the simulation results show that there is no one protocol is having better performance. Each protocol is suitable for some applications. An efficient routing protocol should be selected that suits the desired task.

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