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Proactive and Reactive Routing Protocols in Multihop Mobile Ad hoc Network

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Abstract—Mobile Ad hoc Network (MANET) allows portable devices to establish communication independent of a central infrastructure. The wireless links in this network are highly error prone and can go down frequently due to mobility of nodes. Therefore, routing in MANET is a critical task due to highly dynamic environment. Efficient Routing Protocols will make MANET reliable. Mainly protocols are of three kind i.e. Proactive, Reactive and hybrid. But, we will discuss Proactive and Reactive Protocols. Several Routing Protocols for MANET are Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV), Destination Sequence Distance Vector (DSDV) and Temporally Ordered Routing Algorithm (TORA). This paper provides an overview of these protocols by presenting their characteristics, functionality, benefitsand then their comparative analysis parameters. Depending on parameters one can compare the performance of Routing Protocols. The objective is to make observation about the working and performance metrics of these protocols. Security and Power are major issues while designing Routing Protocol. Because of air as a transmission medium for wireless networks, so there must be security for data and devices are mobile, hence battery should have long life. This paper presents the survey of Proactive and Reactive Routing Protocols in MANET.

Keywords— Ad hoc On-demand Distance Vector, Dynamic Sequence Distance Vector, Dynamic Source Routing, Temporally Ordered Routing Algorithm and Mobile Ad hoc Network.

I. INTRODUCTION

In MANET [1] mobile nodes communicate with each other using multihop wireless links without infrastructure. Every node in the network act as a router as well as packet forwarding agency for other nodes. A central challenge in the design of MANET is the development of dynamic routing protocols that can efficiently find routes between two communicating nodes. In MANET nodes moves randomly, therefore the network may experience sudden and unpredictable change in topology. Nodes in MANET normally have limited transmission ranges, therefore some nodes cannot communicate directly to other nodes and those are beyond the limit of range of mobile node. So many protocols have been proposed for MANETs for achieving the efficient routing. Every protocol uses a new searching methodology for new route or modifying a known route, when hosts move. Energy consumption in MANET is very critical issue. Because, mobile devices have limited battery power and processing power. In MANET, Routing Protocols can be divided into three categories: Proac- tive Routing Protocols or Table Driven Routing Protocols, Reactive Protocols or Demand Routing Protocols and Hybrid Routing Protocols. Proactive Routing Protocols contain consistent and up-to-date routing information to all nodes which is maintained at each node. Reactive Protocols the routes are created, when required, when source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination.

II. TERMINOLOGY

If there are only two nodes that want to communicate with each other and are located very closely to each other, then no specific Routing Protocols or Routing decisions are necessary. On the other hand, if there are a number of mobile hosts wishing to communicate beyond the limit of transmission range, then the Routing Protocols come into play because in this case, some critical decisions have to be made such as which is the optimal route from the source to the destination which is very important because, the mobile nodes operate on some kind of battery power. Thus it becomes necessary to transfer the data with the minimal delay so as to waste less power. There may also be some kind of compression involved which could be provided by the protocol so as to waste less bandwidth. In addition to this, Quality of Service support is also needed so that the least packet drop can be obtained. The other factors which need to be considered while choosing a protocol for MANET are as follows:

A. Multicasting

This is the ability to send packets to multiple nodes at once. This is similar to broadcasting except the fact that the broadcasting is done to all the nodes in the network. This is important as it takes less time to transfer data to multiple nodes.

Loop Free

A path taken by a packet never transits the same intermediate node twice before it arrives at the destination. To improve the overall, we want the routing protocol to guarantee that the routes supplied are loop-free. This avoids waste of bandwidth or CPU consumption.

B. Multiple Routes

If one route gets broken due to some disaster, then the data could be sent through some other route. Thus the protocol should allow creating multiple routes.

C. Distributed Operation

The protocol should be distributed. It should not be dependent on a centralized node.

III. Routing Protocols

Routing Protocol [2] is needed whenever a packet needs to be transmitted to a destination via number of nodes and numerous Routing Protocols have been proposed for such kind of network. These Protocols find a route for packet delivery and deliver the packet to the correct destination. The studies on various aspects of Routing Protocols have been an active area of research for many years. Basically, Routing Protocols can be broadly classified into three types as Table Driven Protocols or Proactive Protocols, On-Demand Protocols or Reactive Protocols and Hybrid Protocols. But, here we are discussing only Proactive and Reactive Protocols.

A. Table Driven or Proactive Protocols

In Proactive or Table-Driven Routing Protocols, each node continuously maintains up-to-date routes to every other node in the network. Routing information is periodically transmitted throughout the network in order to maintain Routing Table consistency. Thus, if a route has already existed before traffic arrives, transmission occurs without delay. Otherwise, traffic packets should wait in queue until the node receives routing information corresponding to its destination. However, for highly dynamic network topology, the Proactive schemes require a significant amount of resources to keep routing information up-to-date and reliable. Certain Proactive Routing Protocols are DSDV, Wireless Routing Protocol (WRP), Global State Routing (GSR) and Cluster-head Gateway Switch Routing (CGSR).

B. On Demand or Reactive Protocols

In Reactive Protocols, a node initiates a route discovery throughout the network, only when it wants to send packets to its destination. For this purpose, a node initiates a route discovery process through the network. This process is completed once a route is determined or all possible permutations have been examined. Once a route has been established, it is maintained by a route maintenance process until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. In Reactive schemes, nodes maintain the routes to active destinations. A route search is needed for every unknown destination. Therefore, theoretically the communication overhead is reduced at expense of delay due to route research. Some Reactive Protocols are Cluster Based Routing Protocol (CBRP), AODV, DSR, TORA, Associativity-Based Routing (ABR), Signal Stability Routing (SSR) and Location Aided Routing (LAR).

IV. DSDV

DSDV [3]-[4] is based on the bellman ford algorithm and developed by Charles E. Perkins and PravinBhagwat in 1994. 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 (SN) 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. Consider Node A wants to send a data to Node C as shown in Fig. 1, but Node C is not in the coverage area of Node A. Node A and Node C are in the range of Node B. Hence, Node A has to forward packet to Node B and Routing Table of Node B comes into picture, it will act as routing agency for forwarding packet from Node A to Node C.

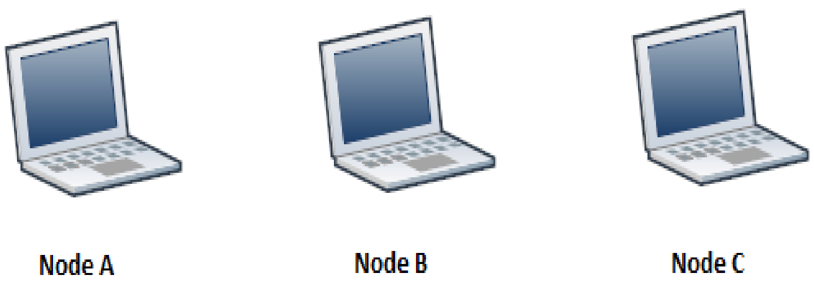

Fig. 1.Mobile Ad hoc Network

Routing Table contains Destination IP address, Next Hop, Number of Hops, SN and Install Time. Routing Table of Node B is as shown in Table I.

TABLE I

ROUTING TABLE FOR NODE B

Destination	Next Hop	Number of Hops	SN	Install Time
A	A	0	A46	1000
B	B	1	B36	1200
C	B	2	C28	1500

Consider MH_4 (Mobile Host 4) in Fig. 2. Table II shows a possible structure of the Forwarding Table which is maintained at MH_4. Suppose the address of each Mobile Host is represented as MH_i. Suppose further that all Sequence Numbers are denoted SN_MH_i (Sequence Number by Mobile Host i), where MH_i specifies the Host that created the SN. Also suppose that there are entries for all other Mobile Hosts, with sequence numbers SN_MH_i, before MH_1 moves away from MH_2. The install time field helps determine when to delete stale routes. With our protocol, the deletion of stale routes should rarely occur, since the detection of link breakages should propagate through the Ad hoc Network immediately.

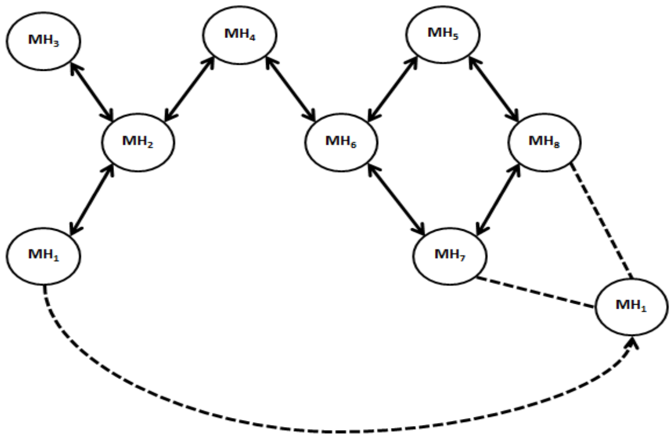

Fig. 2. Movement in an Ad hoc network

Nevertheless, we expect to continue to monitor for the existence of stale routes and take appropriate action.

From Table II, we can conclude that all the Hosts became available to MH_4 at about the same time, since its install time for most of them is about the same. One could also conclude that none of the link between the Hosts is broken, because all of the SN fields have times with even digits in the units place. Table III shows the structure of the Advertised Route Table by MH_4.In order to maintain Routing Table consistency, Routing updates are periodically forwarded throughout the network. Two types of updates can be employed, full dump and incremental. A full dump sends the entire Routing Table to theneighbours and requires multiple Network Protocol Data Units (NPDUs).Incremental updates are smaller and are used to transmit those entries from the Routing Table which have changed since the last full dump update.When a network is stable, incremental updates are forwarded and full dump are usually infrequent. On the other hand, full dumps will be more frequent in a fast moving network.

TABLE II

STRUCTURE OF THE MH_4 FORWARDING TABLE

DestinationAddress	Next Hop	Hop Count	SN	Install Time
MH_1	MH_2	2	$S406\_MH_1$	$T1\_MH_4$
MH_2	MH_2	1	$S128\_MH_2$	$T1\_MH_4$
MH_3	MH_2	2	$S564\_MH_3$	$T1\_MH_4$
MH_4	MH_4	0	$S710\_MH_4$	$T1\_MH_4$
MH_5	MH_6	2	$S392\_MH_5$	$T2\_MH_4$
MH_6	MH_6	1	$S076\_MH_6$	$T1\_MH_4$
MH_7	MH_6	2	$S128\_MH_7$	$T2\_MH_4$
MH_8	MH_6	3	$S050\_MH_8$	$T2\_MH_4$

TABLE III
ADVERTISED ROUTE TABLE BY MH_4

Destination	**Hop Count**	**SN**
MH_1	2	S406_ MH_1
MH_2	1	S128_ MH_2
MH_3	2	S564_ MH_3
MH_4	0	S710_ MH_4
MH_5	2	S392_ MH_5
MH_6	1	S076_ MH_6
MH_7	2	S128_ MH_7
MH_8	3	S050_ MH_8

In addition to the Routing Table information, each route update packet contains a distinct SN assigned by the transmitter. The route labeled with the most recent i.e. highest SN is used. The shortest route is chosen if any two routes have the same SN.

V. AODV

AODV [5] 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 to communicate among each other. 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. The following sections describe route determination and route maintenance in greater detail. HELLO messages may be used to detect and monitor links to neighbours. If HELLO messages are used, each active node periodically broadcasts a HELLO message that all its neighbours receive. Because nodes periodically send HELLO messages, if a node fails to receive several HELLO messages from a neighbour, 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.

A. RREQ

Type	J	R	G	D	U	Reserved	Hop Count
RREQ ID							
Destination IP Address							
Destination Sequence Number							
Originator IP Address							
Originator Sequence Number							

Fig. 3. RREQ

The format of the RREQ message is illustrated in Fig. 3 and contain the following fields: Type is 1, J is Join flag reserved for multicast, R is Repair flag reserved for multicast, G is Gratuitous RREP flag indicates whether a gratuitous RREP should be unicast to the node specified in the Destination IP Address field, D is Destination only flag indicates only the destination may respond to this RREQ, U is Unknown Sequence Number indicates the Destination Sequence Number is unknown, Reserved set as 0 i.e. ignored on reception, Hop Count the number of hops from the Originator IP Address to the node handling the request, RREQ ID is Sequence Number uniquely identifying the particular RREQ when taken in conjunction with the originating node's IP address, Destination IP Address is the IPaddress of the destination for which a route is desired, Destination Sequence Number is the latest Sequence Number received in the past by the Originator for any route towards the Destination, Originator IP Address is the IP address of thenode which originated the Route Request, Originator Sequence Number is the current Sequence Number to be used in the route entry pointing towards the originator of the route request.

B. RREP

Type	R	A	Reserved	Prefix Size	Hop Count
RREQ ID					
Destination IP Address					
Destination Sequence Number					
Originator IP Address					
Originator Sequence Number					
Lifetime					

Fig. 4. RREP

The format of the Route Reply message is illustrated in Fig.4 and contains the following fields: Type is 2 for RREP, A is Acknowledgment required, Prefix Size if nonzero the 5-bit Prefix Size specifies that the indicated next hop may be used for any nodes with the same routing prefix as the requested destination, Lifetime is the time in milliseconds for which nodes receiving the RREP consider the route to be valid and all other fields are same as in RREQ packet format.

VI. DSR

The DSR [6] Protocol is a simple and efficient Routing Protocol designed specifically for use in multihop wireless Ad hoc Networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no 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. Because the number or sequence of intermediate hops needed to reach any destination may change at any time, the resulting network topology may be quite rich and rapidly changing. The DSR Protocol allows nodes to dynamically discover a source route across multiple network hops to any destination in the Ad hoc network. Each data packet sent then carries in its header the complete, ordered list of nodes through which the packet must pass, allowing packet routing to be trivially loop-free and avoiding the need for up-to-date routing information in the intermediate nodes through which thepacket is forwarded. 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. While designing DSR, we needed to create a routing protocol that had very low overhead yet was able to react quickly to changes in the network, providing highly Reactive service to help ensure successful delivery ofdata packets in spite of node movement or other changes in network conditions.

VII. TORA

TORA [7] is a highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal and invented by Vincent Park and M. Scott Corson from University of Maryland. TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It finds multiple routes from a source node to a destination node. The main feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes maintain routing information about adjacent nodes. The protocol has three basic functions: Route creation, Route maintenance and Route erasure. TORA has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. In the event of network partitions the protocol is able to detect the partition and erase all invalid routes. To initiate a route, the node broadcasts a QUERY packet to its neighbours. This QUERY is rebroadcasted through the network until it reaches the destination or an intermediate node that has route to the destination. The recipient of the QUERY packet then broadcast the UPDATE packet which lists its height with respect to the destination.

VIII. PERFORMANCE MEASURING PARAMETER (METRIC)

The performance is measured on the basis of some parameters [8]-[11] which are described as follows:

A. Packet Delivery Ratio (PDR)

It is the percentage of ratio between the number of packets sent by sources and the number of received packets at the sinks or destination.

$$PDR = \frac{\sum \text{Number of packets received at destination}}{\sum \text{Number of packets sent by source}} * 100$$

B. Average End-to-End Delay

Average End-to-End Delay signifies how long it will take a packet to travel from source to destination node. It includes delays due to route discovery, queuing, propagation delay and transfer time. This metric is useful in understanding the delay caused while discovering path from source to destination.

$$\text{Average End-to-End Delay} = \frac{\sum e}{P}$$

Where,

$e = T_d - T_s$,
T_d = Time when packet received at destination,
T_s = Time when packet created by source,
P = Total Packets.

C. Throughput

Throughput is the ratio of number of packets sent and total number of packets. It describes the average rate of successful message delivery over a communication channel. Throughput measures the efficiency of the system.

D. Packet Loss Ratio

Packet loss ratio defines the number of packets that are dropped or lost due to congestion in the network.

E. Routing Packet Overhead (RPO)

RPO is the total number of transmissions routing packets transmitted during the simulation. For packets sent over multiple hops, each transmission of the packet counts as one transmission.

F. Normalized Routing Load

The sum of the routing control messages such as RREQ, RREP, RERR and HELLO.

IX. CONCLUSIONS

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. Many of the research paper have been focused on performance metric for comparing the performance of Routing Protocols. Performance metric like Packet Delivery Ratio, Throughput, Average End-to-End Delay and Normalized Routing Overhead. For simulation of Routing Protocols in MANET mostly used simulation tools are ns-2, NetSim, GloMoSim and Qualnet. There are many issues that require further investigation like traffic control, power control and security. In case of security, due to the broadcast nature of the wireless node security becomes more difficult. Further research is needed to investigate how to stop an intruder from joining an on going session or stop a node from receiving packets from other sessions. The field of MANET is rapidly growing and changing and while there are still many challenges that need to be met.

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