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A Survey of Routing Protocol in MANET

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***Abstract*—Mobile Ad Hoc Network (MANET) is collection of multi-hop wireless mobile nodes that communicate with each other without centralized control or established infrastructure. The wireless links in MANET are error prone and can go down frequently due to less infrastructure, interference and mobility of nodes. Therefore, in MANET routing is a critical task due to highly dynamic environment. Later on, many routing protocols have been proposed for mobile ad hoc networks and prominent among them are DSR, AODV, TORA and NCPR. This research paper provides an overview of these protocols by presenting their limitations, benefits, functionality and characteristics and then makes their comparative analysis so to analyze their performance. The objective is to know about how the performance of these protocols can be improved.**

***Index Terms*—AODV, DSR, MANET, TORA, NCPR**

I. INTRODUCTION

The wireless network can be classified into two types: Infrastructure or Infrastructureless. In Infrastructure wireless networks, while communicating the mobile node can move, the base stations are fixed and as the node goes out of the range of a base station later it goes into the range of another base station.

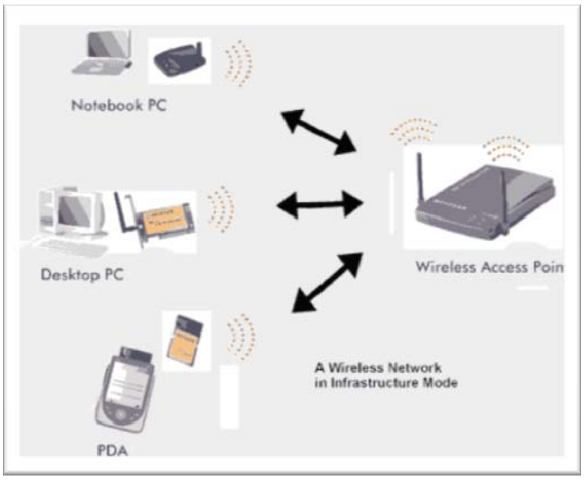

Fig. 1: Infrastructured Wireless Networks

The fig.1 is an example of Infrastructure wireless network. In Infrastructureless network, while communicating the mobile node can move, there are no fixed base stations and all the nodes can act as routers in the network. The mobile nodes in the Ad Hoc network dynamically establish routing among themselves to form their own network. The example of Infrastructureless network can be shown as in fig. 2.

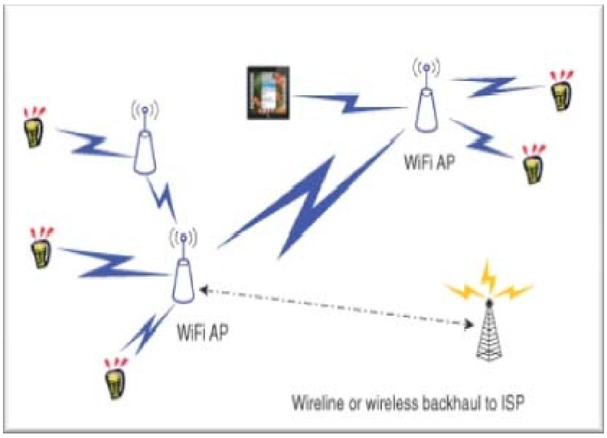

Fig. 2: Infrastructureless or Ad Hoc Wireless Networks

A Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes forming a temporary/short-lived network without any fixed infrastructure where all nodes are free to move about arbitrarily and where all the nodes configure themselves. In MANET, each node acts as router and host & even the topology of network may also change rapidly. The challenges in MANET are as follows:

1) Unicast routing
2) Multicast routing
3) Dynamic network topology
4) Speed
5) Scalability
6) Frequency of updates or Network overhead
7) Mobile agent based routing
8) Energy efficient or Power aware routing
9) Quality of Service
10) Secure routing

The key challenges faced at different layers of MANET are shown in Fig. 3. It represents layered structure and approach to ad hoc networks.

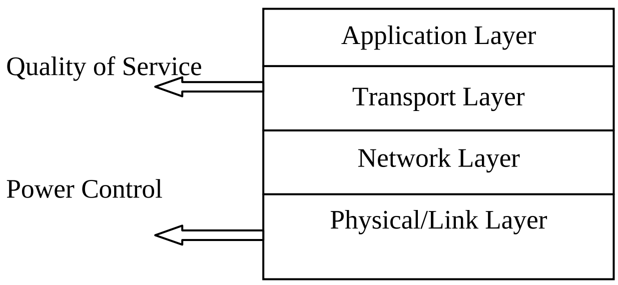

Fig.3: MANET Challenges

II. ROUTING PROTOCOLS

A routing protocol 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 adhoc networks. To find a route for packet delivery and deliver the packet to the correct destination these protocols are used. The studies on many functionality of routing protocols have been an active area of research for many years. Basically, routing protocols can be classified into two types as (a) Table Driven Protocols or Proactive Protocols and (b) On-Demand Protocols or Reactive Protocols.

Table Driven or Proactive Protocols: In Table Driven routing protocols each node maintains one or more tables containing routing information to every other node in the network. All nodes updating these tables to maintain latest view of the network. Some of the table driven or proactive protocols are listed as follows: DSDV [1], [2], DBF [3], GSR [10], WRP [7] and ZRP [11], [6].

On Demand or Reactive Protocols: In these protocols, routes are created. While a transmission starts from source to destination, the route discovery procedure is invoked. The route remains valid until the route is no longer needed. Some of the on demand routing protocols are listed as follows: DSR [8], [9], AODV [4], [5], TORA [13], [12] and NCPR [14], [15].

The emphasis in this research paper is concentrated on the survey and comparison of various On Demand/Reactive Protocols such as DSR, AODV, TORA and NCPR as these are best suited for Ad Hoc Networks. The next sub-section describes the basic features of these protocols.

III. DYNAMIC SOURCE ROUTING

Dynamic Source Routing (DSR)[8,9] is an Ad Hoc routing protocol which is based on the theory of source-based routing. DSR is source-initiated rather than hop-by-hop. This protocol is designed for multi-hop wireless adhoc networks of mobile nodes. DSR protocol does not need any existing network infrastructure or administration and it allows the Network to be completely self-organizing and self-configuring. DSR Protocol is composed of two essential parts of route discovery and route maintenance. Each node store recently discovered paths by maintaining a cache. While a node sends a packet to some node, in the cache it first checks its entry. If the path is available, then it transmits the packet and also attaches its source address on the packet by using that available path. If the path is not there in the cache or the entry in cache is expired, the route request packet is broadcasted by the sender to all of its neighbors asking for a path to the destination. Till the route is discovered the sender will waits. The sender can perform other tasks such as sending/forwarding other packets during waiting time. If the route request packet arrives to the nodes, it checks from their neighbor whether the destination is known or unknown. If the given route information is known, then it sends back a route reply packet to the destination otherwise it broadcasts the same route request packet. The required packets will be transmitted by the sender on the discovered route when the route is discovered. The age information of the entry is maintained in the node, so it is useful to know whether the cache is fresh or not. It first checks whether the packet is belongs to it or not when a data packet is received by any intermediate node. If it is meant for itself (i.e. the intermediate node is the destination), then the corresponding packet is received otherwise the same will be forwarded using the path attached on the data packet. So in Adhoc network, anytime the link may fail. Therefore, route maintenance process will constantly monitor and if there is any failure in the path it will also notify the nodes. By this, the nodes will change the entries of their route cache.

Benefits and Limitations of DSR

One of the main benefit of DSR protocol is that there is no need to keep routing table so as to route a given data packet as the entire route is contained in the packet header. The limitations of DSR protocol is not scalable to large networks and even requires significantly more processing resources than most other protocols. Each node must spend lot of time to process any control data it receives to obtain the routing information, even if it is not the intended recipient.

IV. ADOV (AD HOC ON DEMAND DISTANCE VECTOR)

AODV [4,5] is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSR and DSDV. It works to minimize the requirement of system-wide broadcasts to its extreme. The routes from every node to every other node in the network cannot be maintained rather they are discovered as and when needed & are maintained only as long as they are required. The algorithm used by AODV for establishment of unicast routes are explained below.

A. Route Discovery

When a node wants to send a data packet to a destination node, it checks to ensure whether there is a current route to that destination node or not by using the entries in route table. The data packet is forwarded to the appropriate next hop toward the destination if it is in route table. The route discovery process is initiated if it is not in route table. AODV starts a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its current sequence number, the destination's IP address, broadcast ID, the destination's last sequence number and its IP address. The broadcast ID is incremented each time the source node sends RREQ. The sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. By using RREQ message the requests are sent and the information in connection with creation of a route is sent back in RREP message. The node sets up a reverse route entry for the source node in its route table to process the RREQ. This is useful to know how to forward a RREP to the source. A lifetime is embedding with the reverse route entry and if this entry is not used the route information is deleted within this lifetime. The source node is allowed to broadcast again using route discovery mechanism if the RREQ is lost during transmission.

B. Expanding Neighbors Search Technique

The source node broadcasts the RREQ packet to its neighbours which in turn forwards the same to their neighbors. Specifically in case of large network, network-wide broadcasts of RREQ control are needed and to control the same; the source node uses an expanding ring search technique. In this expanding ring search technique, the source node sets the Time to Live (TTL) value of the RREQ to a starting value. The next RREQ is broadcasted with a TTL value increased by an increment value if there is no reply within the discovery period. Until a threshold value is reached, after the RREQ is broadcasted the entire network the process of incrementing TTL value continues.

C. Setting up of Forward Path

When the destination node or an intermediate node with a route to the destination receives the RREQ, the RREP is created and then it unicast the RREP towards the source node using the node from which it received the RREQ as the next hop. When RREP is received by an intermediate node and routed back along the reverse path, in its routing table it sets up a forward path entry to destination. If a route from source to the destination has been established and then the source node can begin the data transmission.

D. Route Maintenance

A route discovered between a source node and destination node is maintained by the source node is needed. If the source node moves during an active session, the source node can reinitiate route discovery mechanism to establish a new route to destination. If the destination node or if some intermediate node moves, the node upstream of the break sends Route Error (RERR) message to the affected active upstream nodes. Obviously these nodes propagate the RERR to their predecessor nodes. Until the source node is reached the process gets continued. When Route Error (RERR) is received by the source node, it will neither stop sending the data nor reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

E. Benefits and Limitations of AODV

The benefits of AODV protocol are that it favours the least congested route instead of the shortest route and it also supports both unicast and multicast packet transmissions even for nodes in constant movement. AODV responds quickly to the topological changes that affects the active routes. AODV does not engage any additional overheads on data packets as it does not make use of source routing. The limitations of AODV protocol are as follows, it expects/requires that the nodes in the broadcast medium can detect each other broadcasts. There is a possibility to that a valid route is expired and the determination of a reasonable expiry time is difficult. The reason is that the nodes are mobile and their sending rates may differ widely and can change dynamically from node to node. As the size of network grows the various performance and metrics begin decreasing. For various kinds of attacks AODV is vulnerable as it based on the assumption that all nodes must cooperate and without their cooperation no route can be established.

V. TORA (TEMPORARY ORDERED ROUTING PROTOCOL)

TORA [12, 13] is a distributed highly adaptive routing protocol designed to operate in a dynamic multi-hop network. TORA uses an arbitrary height parameter to determine the direction of link between any two nodes for a given destination. Multiple routes exist for a given destination but none of them are necessarily the shortest route only. To start a route, the node broadcasts a QUERY packet to its neighbor nodes. Through the network the QUERY is rebroadcasted until it reaches the destination or an intermediate node that has a route to the destination. The receiver of the QUERY packet broadcasts the UPDATE packet which lists its height with respect to the destination. If this packet propagates in the network, each node which receives the UPDATE packets sets its height of a value greater than the height of the neighbor from which the UPDATE has been received. It leads to creating a series of directed links from the original sender of the QUERY packet to the node that initially generated the UPDATE packet. When this problem has been discovered by a node that the route to a destination is no longer valid, then it will adjust the value of its height so that it became a local maximum with respect to its neighbours and then transmits an UPDATE packet. If these nodes have no neighbor of finite value of its height with respect to the destination, then it attempts to discover a new route as described above. If a node finds a network partition, then the node generates a CLEAR packet that results in reset of routing over the ad hoc network.

A. Benefits and Limitations of TORA

One of the benefits of TORA is that the multiple routes between any source destination pair are supported by TORA. The failure or removal of any nodes is quickly resolved without source intervention by switching to an alternate route. The limitations of TORA are as follows: It depends on synchronized clocks among nodes in the adhoc network. The dependence of TORA on intermediate lower layers for certain functionality presumes that the neighbor discovery, link status sensing, in order packet delivery and address resolution are all available. To run the Internet MANET Encapsulation Protocol at the layer immediately below TORA is the solution. It makes the overhead for TORA difficult to separate from that imposed by the lower layer.

B. 3.0 Performance Metrics

There are number of qualitative and quantitative metrics that can be used to compare reactive routing protocols. Most of the already available routing protocols ensure the qualitative metrics. The following quantitative metrics have been considered to make the comparative study of these routing protocols through simulation.

1) Routing overhead: This metric describes how many routing packets for route discovery and route maintenance need to be sent so as to propagate the data packets.

2) Average Delay: It represents average end-to-end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination.

3) Throughput: This metric represents the total number of bits forwarded to higher layers per second. In other words it is defined as the total amount of data a receiver actually receives from sender divided by the time taken by the receiver to obtain the last packet. It is measured in bps.

4) Media Access Delay: The time a node takes to access media for starting the packet transmission is called as media access delay. For each packet the delay is recorded when it is sent to the physical layer for the first time.

5) Packet Delivery Ratio: The ratio between the amount of incoming data packets and actually received data packets.

6) Path optimality: It can be defined as the difference between the path actually taken and the best possible path for a packet to reach its destination.

VI. NCPR (NEIGHBOR COVERAGE PROBABILISTIC REBROADCAST)

To effectively exploit the neighbor coverage knowledge [14, 15], a novel rebroadcast delay is needed to determine the rebroadcast order, and then obtain a more accurate additional coverage ratio. To keep the network connectivity and to reduce the redundant retransmissions, a metric named connectivity factor is needed to determine how many neighbors should receive the RREQ packets. By combining the additional coverage ratio and the connectivity factor, rebroadcast probability is introduced, which can be used to reduce the number of rebroadcasts of the RREQ packet and to improve the routing performance.

A. Rebroadcast Delay

The rebroadcast delay is to determine the forwarding order. The node with many common neighbors with the previous node has the lower delay. When these nodes rebroadcast a packet, then this fact is known by more common neighbors. So these rebroadcast delay enables the information about the nodes which have transmitted the packet to more neighbors. When a node n_i receives an RREQ packet from its previous node S, then it use the neighbor list in the RREQ packet to estimate how many its neighbors have not been covered by the RREQ packet . If node n_i has more neighbors uncovered by the RREQ packet from S, i.e., if node n_i rebroadcasts the RREQ packet, then the RREQ packet can reach many additional neighbor nodes. To effectively exploit the neighbor coverage knowledge, it should be spread as quickly as possible. When node S sends an RREQ packet to all its neighbors $n_{i,\ i}$ = 1, 2 …receive and process the RREQ packet. The node n_k has the largest number of common neighbors with node S, then node n_k has the lowest delay. Once the node n_k rebroadcasts the RREQ packet, many nodes are available to receive the RREQ. Rebroadcast of the RREQ packet by node n_k depends on its rebroadcast probability calculated in the next subsection. The main work of this rebroadcast delay is not to rebroadcast the RREQ packet to many nodes, but to spread the neighbor coverage knowledge more quickly.

B. Rebroadcast Probability

The scheme considers the information about the local node density, connectivity metric and uncovered neighbors to calculate the rebroadcast probability. This probability is composed of two parts: a) additional coverage ratio, b) connectivity factor. The node with a larger rebroadcast delay may listen to RREQ packets from the nodes which have lowered one. We do not need to adjust the rebroadcast delay because the rebroadcast delay is used to determine the order of disseminating neighbor coverage knowledge. If the timer of the node n_i's rebroadcast delay expires, then the node gets the final uncovered neighbor set. The node belongs to the final uncovered neighbor set are the nodes that need to receive and process the RREQ packet. To use the final uncovered neighbor set to set the rebroadcast probability. The nodes which are covered needs to receive and process the RREQ packet. More nodes will be covered by this rebroadcast.

VI. COMPARISON OF AODV, DSR AND NCPR

Features	AODV	DSR	NCPR
Routing Overhead	High	Less than AODV	No routing overhead
Mechanism	Combination of DSR and DSDV	Source Routing	AODV
Higher-mobility performance	Medium	Low	High
Latency time	High	Low	High
End to End Delay	High	Average	Low

VII. CONCLUSION

In this survey paper, the concentration is made on the comparative study and performance analysis of various Ondemand/reactive routing protocols (DSR, AODV, TORA and NCPR) on the basis of above mentioned performance metrics. NCPR performs much better in packet delivery. The results indicate that AODV keeps on improving with denser mediums and at faster speeds. The evaluation predicts that in spite of slightly more overhead in some cases DSR and AODV outperforms NCPR in all cases. NCPR is still better in Route updation and maintenance process. It has been further concluded that due to the dynamically changing topology and decentralized characteristics, security, infrastructure less and power awareness is hard to achieve in mobile ad hoc networks. The security and power awareness mechanisms should be built-in features for all sorts of applications based on ad hoc network.

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