On Demand Routing Protocols in MANET

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***Abstract*— A Mobile Ad Hoc Network (MANET) is a network consisting of a set of mobile hosts capable of communicating with each other without the assistance of base stations. The dynamic topology of a mobile ad hoc network poses a real challenge in the design of a MANET routing protocol. Over the last 10 years, a variety of routing protocols have been developed and their performance simulations are made by network researchers. An efficient approach is to consider routing algorithms in which network connectivity is determined in the process of establishing routes. The shortest path (based on a given cost function) from a source to a destination in a static network is usually the optimal route, this idea is not easily extended to MANET. Factors such as power expended, variable wireless link quality, propagation path loss, fading, multi-user interference, and topological changes, become relevant issues. The network should be able to adaptively alter routing paths to alleviate any of these effects. Hence, Performance is an interesting issue for different protocols. This paper describes some special characteristics of ad hoc on-demand routing protocols like DSR, AODV, and TORA, with their working and performance measurements of these protocols.**

***Keywords*— Mobile Ad-Hoc Network, DSR, AODV, TORA.**

I. Introduction

Mobile Ad-hoc Network (MANET) is a network where autonomous mobile nodes with wireless interfaces construct a temporary wireless network. In mobile ad hoc networks there are no dedicated routers. Each node operates as a router and transmits packets between source and destination. The node within the transmission range of the source node and is not the destination node, accepts the packet sent by the source and forwards it along the route to the destination node.

A number of MANET routing protocols have been proposed in the last decade. These protocols can be classified according to the routing strategy that they follow to discover route to the destination. These protocols perform variously depending on type of traffic, number of nodes, rate of mobility, etc. Over the last 10 years,

various MANET routing protocols have been developed by network researchers and designers primarily to improve the MANET performance with respect to establishing correct and efficient routes between a pair of nodes for packet delivery [1]. Examples of popular MANET routing protocols are: Ad Hoc On-Demand Distance Vector (AODV) [7], Dynamic Source Routing (DSR) [8], and Temporally Ordered Routing Algorithm (TORA) [9].

Conventional routing protocols such as AODV, DSR and OLSR use minimum hop count or shortest path as the main metric for path selection. However, networks that require high Quality of Service (QoS) needs to consider several criteria's that could affect the quality of the chosen path in packet forwarding process [4].

Limited resources in MANETs made a very challenging problem that is represented in designing of an efficient and reliable routing strategy [2]. Transferring real-time traffic over MANETs is a big challenge due to the high requirements of bandwidth, time delay, and latency for such traffic [3]. This requires the offering of guaranteed service quality.

The rest of this paper is organized as follows. Section II briefly describes the ad-hoc on-demand routing protocols. Section III discusses the most important on-demand routing protocols. Section IV presents a comparative study of various protocols. Section V represents a conclusion of the paper.

II. On Demand or Reactive Protocols

On-demand routing protocols were designed with the aim of reducing control overhead, thus increasing bandwidth and conserving power at the mobile stations. These protocols limit the amount of bandwidth consumed by maintaining routes to only those destinations for which a source has data traffic.

Some of the existing on demand routing protocols are: AODV [7], DSR [8] and TORA [9].The emphasis in this research paper is concentrated on the survey and comparison of various On Demand/Reactive Protocols such as DSR, AODV and TORA as these are best suited for Ad Hoc Networks.

III. Some Important On-Demand Routing Protocols

A. AODV Protocol

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is a modification of the DSDV algorithm. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes.

AODV builds routes using a route request / route reply query cycle.

1) Route Discovery: When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet the network.

Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables. In addition to the source node's IP address, current sequence number, and broadcast ID, the RREQ also contains the most recent sequence number for the destination of which the source node is aware. 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. If this is the case, it unicasts a RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it.

2) Route Reply: As the RREP propagates back to the source, nodes set up forward pointers to the destination. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and begin using the better route.

3) Route Maintenance: As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically travelling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s). After receiving the RERR, if the source node still desires the route, it can reinitiate route discovery.

B. DSR Protocol

The Dynamic Source Routing protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration.

DSR has been implemented by numerous groups, and deployed on several test beds. Networks using the DSR protocol have been connected to the Internet. DSR can interoperate with Mobile IP, and nodes using Mobile IP and DSR have seamlessly migrated between WLANs, cellular data services, and DSR mobile ad hoc networks.

The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network.

1) Route Discovery: When anode wishes to establish a route, or issues a Route Request to all of its neighbours. Each neighbour rebroadcasts this Request, adding its own address in the header of the packet.

2) Route Maintenance: When the Request is received by the destination or by a node with a route to the destination; a Route Reply is generated and sent back to the sender along with the addresses accumulated in the Request header. The responsibility for assessing the status of a route falls to each node in the route. Each must insure that packets successfully cross the link to the next node. If it doesn’t receive an acknowledgement, it reports the error back to the source, and leaves it to the source to establish a new route. While this process could use up a lot of bandwidth, DSR gives each node a route cache for them to use aggressively to reduce the number of control messages sent. If it has a cache entry for any destination request received, it uses the cached copy rather than forward the request. In addition, it promiscuously listens to other control messages for additional routing data to add to the cache. DSR has the advantage that no routing tables must be kept to route a given packet, since the entire route is contained in the packet header. The caching of any initiated or overheard routing data can significantly reduce the number of control messages being sent, reducing overhead. Using only triggered updates furthers that same goal.

All aspects of the protocol operate entirely on-demand, allowing the routing packet overhead of DSR to scale automatically to only that needed to react to changes in the routes currently in use.

The protocol allows multiple routes to any destination and allows each sender to select and control the routes used in routing its packets, for example for use in load balancing or for increased robustness. Other advantages of the DSR protocol include easily guaranteed loop-free routing, support for use in networks containing unidirectional links, use of only "soft state" in routing, and very rapid recovery when routes in the network change. The DSR protocol is designed mainly for mobile ad hoc networks of up to about two hundred nodes, and is designed to work well with even very high rates of mobility.

C. TORA Protocol

The Temporally-Ordered Routing Algorithm (TORA) is an algorithm for routing data across Wireless Mesh Networks or networks. Temporally-Ordered Routing Algorithm (TORA) is a distributed protocol designed to be highly adaptive so it can operate in a dynamic network. For a given destination, TORA uses a somewhat arbitrary ‘height’ parameter to determine the direction of a link between any two nodes. As a consequence of this multiple routes are often present for a given destination, but none of them are necessarily the shortest route.

TORA does not use a shortest path solution, an approach which is unusual for routing algorithms of this type. TORA builds and maintains a Directed Acyclic Graph rooted at a destination. No two nodes may have the same height. Information may flow from nodes with higher heights to nodes with lower heights.

The key design concept of TORA is localization of control messages to a very small set of nodes near the occurrence of a topological change. To accomplish this, nodes need to maintain the routing information about adjacent (one hop) nodes. The protocol performs three basic functions: Route creation, Route maintenance, Route erasure.

1) Route Creation: For a node to initiate a route, it broadcasts a Query to its neighbours. This is rebroadcast through the network until it reaches the destination, or a node that has a route to the destination.

2) Route Maintenance: This node replies with an Update that contains its height with respect to the destination, which is propagated back to the sender. Each node receiving the Update sets its own height to one greater than that of the neighbour that sent it. This forms a series of directed links from the sender to the destination in order of decreasing height. When a node discovers link failure, it sets its own height higher than that of its neighbours, and issues an Update to that effect reversing the direction of the link between them.

3) Route Erasure: If it finds that it has no downstream neighbours, the destination is presumed lost, and it issues a Clear packet to remove the invalid links from the rest of the network.

An advantage to TORA is that it supports multiple routes to any source/destination pair. Failure or removal of one node is quickly resolved without source intervention by switching to an alternate route.

Unfortunately, there are drawbacks to TORA as well. The most glaring being that it relies on synchronized clocks among nodes in the network. While external time sources are present (GPS for example), it makes the hardware to support it more costly, and introduces a single point of failure if the time source became unavailable. TORA also relies on intermediate lower layers for certain functionality. It assumes, for example, that link status sensing, neighbour discovery, in-order packet delivery, and address resolution are all readily available. The solution is to run the Internet MANET Encapsulation Protocol (IMEP) at the layer immediately below TORA. This makes the overhead for this protocol difficult to separate from that imposed by the required lower layer.

IV. COMPARATIVE STUDY OF VARIOUS PROTOCOLS

This paper describes on-demand routing protocol as well as expose some of the protocol's basic characteristics and parameters through tabular study.

Quantitative Metrics for Performance Evaluation:

The following is a list of quantitative metrics that can be used to assess the performance of any routing protocol.

- End–to-End delay.
- End–to-End throughput.
- Routing Acquisition Time.
- Route latency (delay).
- Overhead cost (packets/bandwidth/energy).
- Percentage out of order Delivery.
- Packet Delivery Ratio.
- Remaining Power of node.
- Effect of node Mobility.
- Effect of node Density.
- Effect of packet Length.
- Effect of Link Stability.

TABLEI. COMPARATIVE STUDY OF THREE PROTOCOLS

Protocols / parameters	**On Demand Routing Protocols**		
	AODV	***DSR***	***TORA***
Protocol type	Distance vector	Source routing	Link reversal
Route maintained in	Route table	Route cache	Route table
Loop free	Yes	Yes	Yes
Routing philosophy	Flat	Flat	Flat
Multicast capability	Yes	No	No
Periodic broadcast	Yes	No	Yes
Multiple route possible	No	Yes	Yes
Route cache/table expiration timer	Yes	No	No
Require sequence data	Yes	No	Yes
Route reconfiguration methodology	Erase route and notify source	Erase route and notify source	Link reversal and route repair

V. CONCLUSION

The field of ad-hoc mobile networks is rapidly growing and changing and while it is not clear that any particular algorithm or class of algorithm is the best for all environment , each protocol has definite advantages and disadvantages , and is well suited for certain situations. The Efficient routing protocols can provide significant benefits to mobile ad hoc networks, in terms of both performance and reliability. Many routing protocols for such networks have been proposed so far. Amongst the most popular ones are Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing Protocol (DSR), and Temporally-Ordered Routing Algorithm (TORA).

The set of applications for MANETs is diverse, ranging from small, static networks that are constrained by power sources, to large-scale, mobile, highly dynamic networks. It is unlikely that a single routing protocol will be optimal for all scenarios.A lot of research has been carried out to utilize more reliable links in making end-to-end routes to avoid frequent route failures and realize higher packet delivery ratio. However, these approaches mainly consider the availability of a link over time and depend on link history which is difficult to acquire in highly dynamic systems. Some protocols focused on selecting the path depending on the QoS metrics such as delay, bandwidth, and battery power, but few of them focused on finding the suitable end-to-end routes that are capable of transporting different sizes of the application data packets [5].

To provide an optimum MANET routing solution, we are currently implementing an efficient MANET routing protocol with focus on the quantitative performance evaluation metric given in this paper like Link stability, effect of packet length, node density and mobility, and a future paper will report the projected performance.

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