

# A Study of Asynchronous Routing Protocols in Peer to Peer Networks

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

**Keywords**—AODV, DSR, MANET, TORA

## I. INTRODUCTION

A mobile ad hoc network (MANET) is a self-organizing and self configuring multihop wireless network, where the network structure changes dynamically due to member mobility. Ad hoc wireless network are self creating and self organizing and self administrating. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably.

In ad hoc network each node acts both as a host and a router which forwards the data intended for some other node. An ad hoc network might consist of several home-computing devices, including laptops, cellular phones, and so on. Each node will be able to communicate directly with any other node that resides within its transmission range. The wireless network can be classified into two types: Infrastructure or Infrastructure less.

**In Infrastructure wireless** networks, the mobile node can move while communicating, the base stations are fixed and as the node goes out of the

range of a base station, it gets into the range of another base station.

**In Infrastructure less or Ad Hoc wireless network**, the mobile node can move while communicating, there are no fixed base stations and all the nodes in the network act as routers. The mobile nodes in the Ad Hoc network dynamically establish routing among themselves to form their own network 'on the fly'. An ad hoc network might consist of several home computing devices, including laptops, cellular phones and so on. Each node will be able to communicate directly with any other node that resides within its transmission range.

## Routing approaches in Mobile Ad Hoc Network

In ad hoc mobile networks, routes are mainly multi hop because of the limited radio propagation range and topology changes frequently and unpredictably since each network host moves randomly. Therefore, routing is an integral part of ad hoc communications.

Routing is to find and maintain routes between nodes in a dynamic topology with possibly uni-directional links, using minimum resources.

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 both as a router and a host & even the topology of network may also change rapidly. Some of the challenges in MANET include:

- 1) Unicast routing
- 2) Multicast routing
- 3) Dynamic network topology
- 4) Speed
- 5) Frequency of updates or Network overhead
- 6) Scalability
- 7) Mobile agent based routing

- 8) Quality of Service
- 9) Energy efficient/Power aware routing
- 10) Secure routing

The key challenges faced at different layers of MANET are shown in Fig.1. It represents layered structure and approach to ad hoc networks.

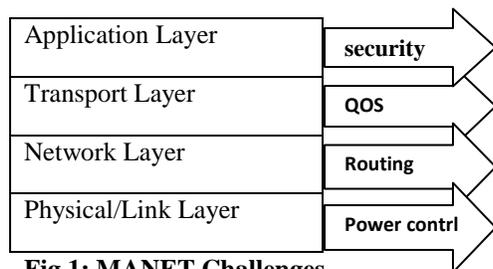


Fig.1: MANET Challenges

## 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 ad hoc networks. 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. Many protocols have been suggested keeping applications and type of network in view. Basically, routing protocols can be broadly 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:

#### Table-driven or Proactive Protocols:

Proactive routing protocols attempt to maintain consistent, up-to-date routing information between every pair of nodes in the network by propagating, proactively, route updates at fixed intervals. Representative proactive protocols include: Destination-Sequenced Distance- Vector (DSDV) routing, Clustered Gateway Switch Routing (CGSR), Wireless Routing Protocol (WRP), Optimized Link State Routing (OLSR) and *The Fisheye State Routing (FSR)*.

**On Demand or Reactive Protocols:** In these protocols, routes are created as and when required. When a transmission occurs from source to destination, it invokes the route discovery procedure. The route remains valid till destination is achieved or until the route is no longer needed. Some of the

existing on demand routing protocols are: DSR [8], [9], AODV [4], [5] and TORA [26], [27].

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. The next sub-section describes the basic features of these protocols.

### DYNAMIC SOURCE ROUTING [8, 9]

Dynamic Source Routing protocol is a reactive protocol i.e. it determines the proper route only when a packet needs to be forwarded. The node floods the network with a route-request and builds the required route from the responses it receives. DSR allows the network to be completely self-configuring without the need for any existing network infrastructure or administration. The DSR protocol is composed of two main mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network. All aspects of protocol operate entirely on-demand allowing routing packet overhead of DSR to scale up automatically.

**Route Discovery:** When a source node *S* wishes to send a packet to the destination node *D*, it obtains a route to *D*. This is called Route Discovery. Route Discovery is used only when *S* attempts to send a packet to *D* and has no information on a route to *D*.

**Route Maintenance:** When there is a change in the network topology, the existing routes can no longer be used. In such a scenario, the source *S* can use an alternative route to the destination *D*, if it knows one, or invoke Route Discovery. This is called Route Maintenance

### Benefits and Limitations of DSR

The **advantage** is route maintenance in this protocol is fast and simple. In case of a fatal error in the data-link layer, a route-error packet is generated from a failing node. When the route-error packet is received, the failing node is removed from its route cache, and all routes containing that node are truncated. The limitations of DSR protocol is that this is not scalable to large networks and even requires significantly more processing resources than most other protocols. Basically, In order to obtain the routing information, each node must spend lot of time to process any control data it receives, even if it is not the intended recipient. The flowchart [17] for DSR Protocol is given below:

## **ADOV (AD HOC ON DEMAND DISTANCE VECTOR) [4], [5]**

AODV is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is derived from DSDV and DSR it combines the advantages of both protocols. Its route discovery procedure is similar to DSR. It aims to minimize the requirement of system-wide broadcasts to its extreme. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed & are maintained only as long as they are required.

The key steps of 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, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID.

The broadcast ID is incremented each time the source node initiates RREQ. Basically, 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. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbors and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

### ***B. Ring Search Technique is Expanding***

The source node broadcasts the RREQ packet to its neighbors which in turn forwards the

same to their neighbors and so forth. Especially, in case of large network, there is a need to control network-wide broadcasts of RREQ and to control the same; the source node uses an expanding ring search technique. In this technique, the source node sets the Time to Live (TTL) value of the RREQ to an initial start value. If there is no reply within the discovery period, the next RREQ is broadcasted with a TTL value increased by an increment value. The process of incrementing TTL value continues until a threshold value is reached, after which the RREQ is broadcasted across the entire network.

### ***C. Forward path is setting***

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

### ***D. Route Maintenance***

A route discovered between a source node and destination node is maintained as long as needed by the source node. Since there is movement of nodes in mobile ad hoc network and if the source node moves during an active session, it can reinitiate route discovery mechanism to establish a new route to destination.

Conversely, if the destination node or some intermediate node moves, the node upstream of the break initiates Route Error (RERR) message to the affected active upstream neighbors/nodes. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

### ***E. Benefits and Limitations of AODV***

The **advantage** of AODV is it reduces control overhead. The connection setup delay is lower and provide loop free Routing. Periodic beaconing leads to unnecessary bandwidth consumption. It has high route discovery latency for

large network (Scalability problem). Delay caused by route discovery process.

The limitation of AODV protocol is that it expects/requires that the nodes in the broadcast medium can detect each others' broadcasts. It is also possible that a valid route is expired and the determination of a reasonable expiry time is difficult. The reason behind this is that the nodes are mobile and their sending rates may differ widely and can change dynamically from node to node. In addition, as the size of network grows, various performance metrics begin decreasing. AODV is vulnerable to various kinds of attacks as it based on the assumption that all nodes must cooperate and without their cooperation no route can be established.

### **TORA(TEMPORARY ORDERED ROUTING ROUTING PROTOCOL) [26],[27]**

Temporally Ordered Routing Algorithm (TORA) is a uniform, destination-based, reactive protocol. A destination-oriented directed acyclic graph is built for each destination. If connectivity changes result in a node losing its entire outbound links, the node "reverses" the direction of some or its entire inbound links. Consequently, multiple routes often exist for a given destination but none of them are necessarily the shortest route. To initiate a route, the node broadcasts a QUERY packet to its neighbors. The request is rebroadcast until it reaches the destination, which is de need to have zero height with respect to itself. The destination broadcasts an update message, indicating its height. Each node that receives the update message updates its height to be one higher than the height in the update message and broadcasts an update message indicating its new height.

The updates must be broadcast reliably and ordered by a synchronized clock or logical timestamp in order to prevent long-lived loops. A route failure is propagated only when a node loses its last downstream link. TORA distinguishes nodes whose height already reflects a link reversal ("reflected"). Again reliable, ordered broadcast is required in order to prevent long-lived routing loops. The destination is the only node with no outgoing link. The maintenance of DAG provides loop free communication to the destination. The flowchart [17] for TORA Protocol is given below:

#### **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 this protocol. This provides good reliability and possible QoS extension support by

selecting paths with particular characteristics and that can support pre-specified QoS constraints.

Good in dense networks. But it is not scalable by any means. Paths may not be the shortest. Therefore, failure or removal of any of the nodes is quickly resolved without source intervention by switching to an alternate route.

TORA is also not free from limitations. One of them is that it depends on synchronized clocks among nodes in the ad hoc network. The dependence of this protocol on intermediate lower layers for certain functionality presumes that the link status sensing, neighbor discovery, in order packet delivery and address resolution are all readily available. The solution is to run the Internet MANET Encapsulation Protocol at the layer immediately below TORA. This will make the overhead for this protocol difficult to separate from that imposed by the lower layer.

#### **B. Performance Metrics**

There are number of qualitative and quantitative metrics that can be used to compare reactive routing protocols. Most of the existing routing protocols ensure the qualitative metrics. Therefore, the following different 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:** This metric 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. It is measured in seconds.

3) **Throughput:** This metric represents the total number of bits forwarded to higher layers per second. It is measured in bps. It can also be 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.

4) **Media Access Delay:** The time a node takes to access media for starting the packet transmission is called as media access delay. The delay is recorded for each packet 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:** This metric can be defined as the difference between the path actually taken and the best possible path for a packet to reach its destination.

### Comparison of DSR, AODV and TORA

As reactive routing protocols for mobile ad hoc networks, DSR, AODV and TORA are proposed to reduce the control traffic overhead and improve scalability. In the appendix, their main differences are listed. DSR exploits source routing and routing information caching. A data packet in DSR carries the routing information needed in its route record field. DSR uses flooding in the route discovery phase. AODV has less traffic overhead and is more scalable because of the size limitation of route record field in DSR data packets. Both DSR and TORA support unidirectional links and multiple routing paths, but AODV doesn't.

In contrast to DSR and TORA, nodes using AODV periodically exchange hello messages with their neighbors to monitor link disconnections. This incurs extra control traffic overhead. AODV uses sequence numbers to avoid formation of route loops. Because DSR is based on source routing, a loop can be avoided by checking addresses in route record field of data packets.

A loop-free property can be guaranteed in TORA. However, TORA has an extra requirement that all nodes must have synchronized clocks [13]. When the number of source nodes is large, the performance of TORA decreases. The general result was that DSR performs better than AODV when number of nodes is small, lower load and /or mobility, and AODV outperforms DSR in more demanding situations.

<i>Parameter</i>	<i>Table Driven(proactive)</i>	<i>Demand Driven(Reactive)</i>
<i>Routing structure</i>	<i>Flat and hierarchical structure</i>	<i>Mostly flat</i>
<i>Bandwidth requirement</i>	<i>High</i>	<i>Low</i>
<i>Power requirement</i>	<i>High</i>	<i>Low</i>
<i>Route acquisition Delay</i>	<i>Low</i>	<i>Higher</i>
<i>Control overhead</i>	<i>High</i>	<i>Low</i>
<i>Communication Overhead</i>	<i>High</i>	<i>Low</i>
<i>Scalability</i>	<i>Upto hundred nodes</i>	<i>Upto few hundreds</i>
<i>Topology dissemination</i>	<i>Periodical</i>	<i>On-demand</i>

<i>On Demand</i>	<i>TORA</i>	<i>DSR</i>	<i>AODV</i>
<i>Routing Structure</i>	<i>Flat</i>	<i>Flat</i>	<i>Flat</i>
<i>Overall complexity</i>	<i>High</i>	<i>Medium</i>	<i>Medium</i>
<i>Frequency of update transmission</i>	<i>Event Driven</i>	<i>Event Driven</i>	<i>Event Driven</i>
<i>Updates transmitted to</i>	<i>Neighbors</i>	<i>Source</i>	<i>Source</i>
<i>Overhead</i>	<i>Medium</i>	<i>Medium</i>	<i>Low</i>
<i>Loop free</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Utilize hello messages</i>	<i>No</i>	<i>No</i>	<i>Yes</i>
<i>Multiple Route support</i>	<i>Yes</i>	<i>Yes</i>	<i>No</i>
<i>Routing metric</i>	<i>Shortest Path</i>	<i>Shortest Path</i>	<i>Freshest &amp; Shortest Path</i>

### Conclusion

In this research paper has been made to on the comparative study and performance analysis of various on demand/reactive routing protocols (DSR, AODV and TORA) on the basis of above mentioned performance metrics based on significant QoS parameter like throughput, bandwidth, time complexity, Power requirement, Route acquisition delay, Control overhead, Routing Structure, Communication Overhead, Scalability etc.

The results after analysis have reflected in Table I and Table II. The first table is description of

parameters selected with respect to low mobility and lower traffic. It has been observed that the performance of all protocols studied was almost stable in sparse medium with low traffic. TORA performs much better in packet delivery owing to selection of better routes using acyclic graph. Table II is evaluation of same parameters with increasing speed and providing more nodes. The results indicate that AODV keeps on improving with denser mediums and at faster speeds. The design of the protocols are driven by specific goals and requirements based on respective assumptions about

the network properties or application area. Therefore, it is extremely important that these networks should be able to provide efficient quality of service (QoS) that can meet the vendor requirements. To provide efficient quality of service in mobile ad-hoc networks, there is a solid need to establish new architectures and services for routine network controls.

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