A Quantitative Study and Comparison of AODV, OLSR and TORA Routing Protocols in MANET

Tamilarasan-Santhamurthy

Department of Information Technology, LITAM,
Dullipala (village), Sattenpalli (Mandal), Guntur, Andhra Pradesh, 522412, India

Abstract

Mobile Ad-Hoc Network (MANET) is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Most of the proposed MANET protocols do not address security issues. In MANETs routing algorithm is necessary to find specific routes between source and destination. The primary goal of any ad-hoc network routing protocol is to meet the challenges of the dynamically changing topology and establish an efficient route between any two nodes with minimum routing overhead and bandwidth consumption. The existing routing security is not enough for routing protocols. An ad-hoc network environment introduces new challenges that are not present in fixed networks. A several protocols are introduced for improving the routing mechanism to find route between any source and destination host across the network. In this paper present a logical survey on routing protocols and compare the performance of AODV, OLSR and TORA

Keywords: *AODV, OLSR, TORA, MANET, Routing*

1. Introduction

A MANET is a collection of mobile nodes that can communicate with each other without the use of predefined infrastructure or centralized administration. Due to self-organize and rapidly deploy capability, MANET can be applied to different applications including battlefield communications, emergency relief scenarios, law enforcement, public meeting, virtual class room and other security-sensitive computing environments. There are 15 major issues and sub-issues involving in MANET such as routing, multicasting/broadcasting, location service, clustering, mobility management, TCP/UDP, IP addressing, multiple access, radio interface, bandwidth management, power management, security, fault tolerance, QoS/multimedia, and standards/products. Currently, the routing, power management, bandwidth management, radio interface, and security are hot topics in MANET research. The routing protocol is required whenever the source needs to transmit and delivers the packets to the destination. Many routing protocols have been proposed for mobile ad hoc network. In this paper we present a number of ways of classification or categorization of these routing protocols and the performance comparison of an AODV, OLSR and TORA routing protocols.

2. Routing Protocol

MANET protocols are used to create routes between multiple nodes in mobile ad-hoc networks. IETF (Internet Engineering Task Force) MANET working group is responsible to analyze the problems in the ad-hoc networks and to observe their performance. There are different reasons for designing and classifying routing protocols for wireless ad-hoc networks. The MANET protocols are classified into three huge groups, namely Proactive (Table-Driven), Reactive (On-Demand) routing protocol and hybrid routing protocols. The following figure shows the classification of protocols [3].

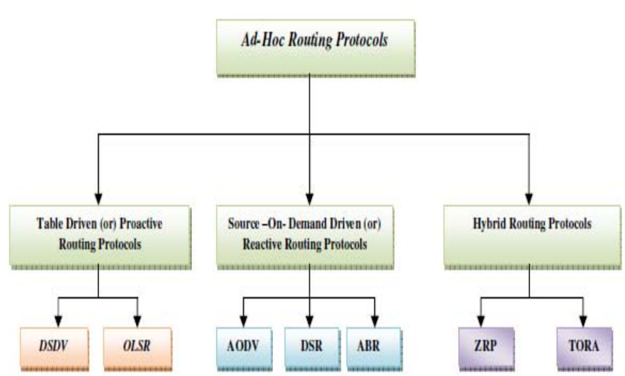

Fig.1: Different type of routing protocols in wireless Ad-hoc network

Proactive (Table-Driven) routing protocol: - In proactive routing protocol perform reliable and up-to-date routing information to all the nodes is maintained at each node.
Reactive (On-Demand) routing protocol: - This type of protocols find route on demand by flooding the network with Route Request packets.

2.1. Proactive vs. Reactive Routing

Proactive methods determine the routes to various nodes in the network in advance, so that the route is already present whenever needed. Route Discovery overheads are larger in such schemes as one has to discover all routes. Examples of such schemes are the conventional routing schemes, Destination Sequenced Distance Vector (DSDV).Reactive methods determine the route when needed. Therefore they have smaller Route Discovery overheads. Examples for such schemes are Ad Hoc On-Demand Distance Vector (AODV) routing protocol.

2.2. Single-Path vs. Multi-Path

There are several decisive factors for comparing single-path routing and multi-path routing in ad-hoc networks. First, the overhead of route discovery in multi-path routing is much more than that of single-path routing. On the other hand, the frequency of route discovery is much less in a network which uses multi-path routing, since the system can still operate even if one or a few of the multiple paths between a source and a destination fail. Second, it is commonly believed that using multi-path routing results in a higher throughput. Third, multi-path networks are fault tolerant when dynamic routing is used, and some routing protocols, such as OSPF (Open Shortest Path First), can balance the load of network traffic across multiple paths with the same metric value.

2.3. Proactive vs. Source Initiated

A proactive (Table-Driven) routing protocols are maintaining up-to-date information of both source and destination nodes. It is not only maintained a single node's information, it can maintain information of each and every nodes across the network. The changes in network topology are then propagated in the entire network by means of updates. Some protocols are used to discover routes when they have demands for data transmission between any source nodes to any destination nodes in network, such protocol as DSDV(.Destination Sequenced Distance Vector) routing protocol. These processes are called initiated on-demand routing. Examples include DSR (Dynamic Source Routing) and AODV (Ad-hoc On Demand Distance Vector) routing protocols [3].

3. Ad-hoc on demand Vector Protocol (AODV)

AODV combines some properties of both DSR and DSDV. It uses route discovery process to cope with routes on-demand basis. It uses routing tables for maintaining route information. It is reactive protocol; it doesn't need to maintain routes to nodes that are not communicating. AODV handles route discovery process with Route Request (RREQ) messages. RREQ message is broadcasted to neighbor nodes. The message floods through the network until the desired destination or a node knowing fresh route is reached. Sequence numbers are used to guarantee loop freedom. RREQ message cause bypassed node to allocate route table entries for reverse route. The destination node uncast a Route Reply (RREP) back to the source node. Node transmitting a RREP message creates routing table entries for forward route [2] [5] and [7]. Figure (Fig.2) shows, AODV routing protocol with RREQ and RREP message.

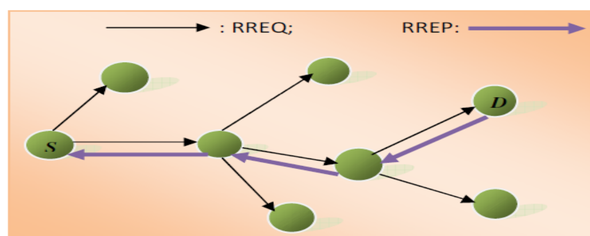

Fig. 2: AODV routing protocol with RREQ and RREP message

For route maintenance nodes periodically send HELLO messages to neighbour nodes. If a node fails to receive three consecutive HELLO messages from a neighbour, it concludes that link to that specific node is down. A node that detects a broken link sends a Route Error (RERR) message to any upstream node. When a node receives a RERR message it will indicate a new source discovery process. Figure (Fig.3) shows AODV routing protocol with RERR message.

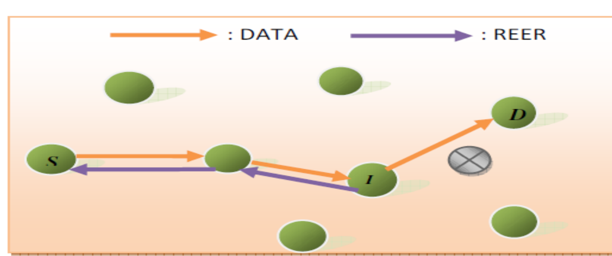

Fig.3: AODV routing protocol with RERR message

Advantages:

- Routes are established on demand and destination sequence numbers are used to find the latest route to the destination.
- Lower delay for connection setup.

Disadvantage:

- AODV doesn't allow handling unidirectional links.
- Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead.
- Periodic beaconing leads to unnecessary bandwidth consumption.

4. Optimized Link State Routing Protocol (OLSR)

OLSR is a proactive routing protocol for mobile ad hoc networks. The protocol inherits the stability of the link state algorithm and has the advantage of having routes immediately available when needed due to its proactive nature. OLSR minimizes the overhead caused by flooding of control traffic by using only selected nodes, called Multi-Point Relays (MPR), to retransmit control messages. This technique significantly reduces the number of retransmissions required to flood a message to all nodes in the network. Upon receiving an update message, the node determines the routes (sequence of hops) toward its known nodes. Each node selects its MPRs from the set of its neighbors saved in the Neighbor list. The set covers nodes with a distance of two hops. The idea is that whenever the node broadcasts the message, only the nodes included in its MPR set are responsible for broadcasting the message [5] [6].
OLSR uses HELLO and TC messages. The Topology Control (TC) messages for continuous maintain of the routes to all destinations in the network, the protocol is very efficient for traffic patterns where a large subset of nodes is communicating with another large subset of nodes, and where the [source, destination] pairs change over time. The HELLO messages are exchanged periodically among neighbor nodes, to detect the identity of neighbors and to signal MPR selection. The protocol is particularly suited for large and dense networks, as the optimization is done by using MPRs which work well in this context. The larger and more dense a network, the more optimization can be achieved as compared to the classic link state algorithm. OLSR uses hop-by-hop routing, i.e., each node uses its local information to route packets [5].

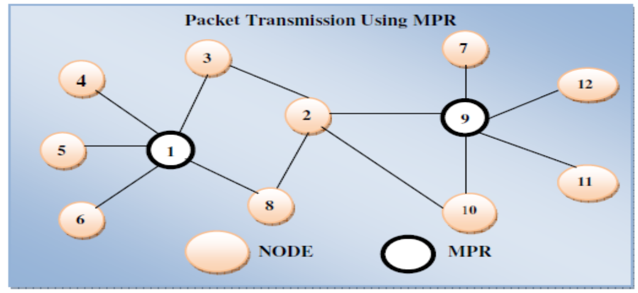

Fig.4: Packet Transmission Using MPR

Advantages:

- OLSR does not need central administrative system to handle its routing process.
- The link is reliable for the control messages, since the messages are sent periodically and the delivery does not have to be sequential.
- OLSR is suitable for high density networks.
- It does not allow long delays in the transmission of packets.

Disadvantages:

- OLSR protocol periodically sends the updated topology information throughout the entire network.
- It allows high protocol bandwidth usage.

5. Temporary Ordered Routing Algorithm (TORA)

The Temporally Ordered Routing Algorithm (TORA) is a highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal. 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 can suffer from unbounded worst-case convergence time for very stressful scenarios. 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.

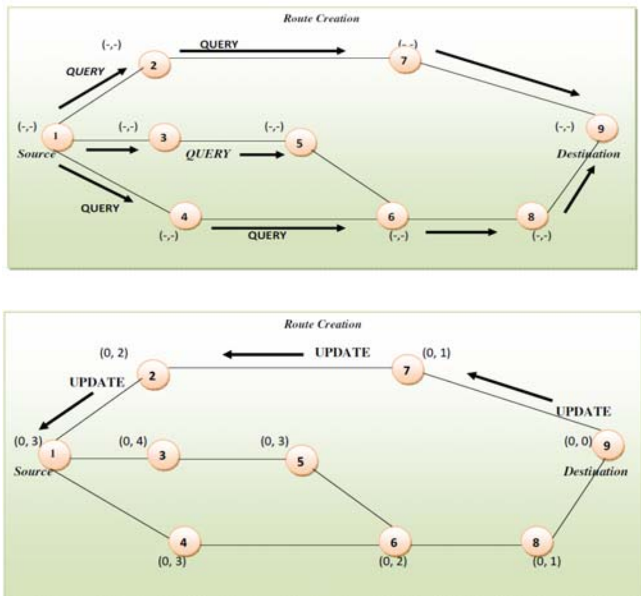

Fig.4: Route Creation

The figure shows, source node (1) broadcasts QUERY to its neighbor's node. Node (6) does not propagate QUERY from node (5) as it has already seen and propagated QUERY message from node (4). A source node (1) may have received a UPDATE each from node (2), it retains that height. When a node detects a network partition, it will generate a CLEAR packet that results in reset of routing over the ad-hoc network. The establishment of the route mechanism based on the Direct Acyclic Group (DAG). Using DAG mechanism, we can ensure that all the routes are loop free. Packets move from the source node having the highest height to the destination node with the lowest height like top-down approach.

Advantages:

- TORA supports multiple routes between source and destination. Hence, failure or removal of any of the nodes quickly resolved without source intervention by switching to an alternate route to improve congestion.
- TORA does not require a periodic update, consequently communication overhead and bandwidth utilization is minimized.
- TORA provides the supports of link status sensing and neighbor delivery, reliable, in-order control packet delivery and security authentication.

Disadvantages:

- 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. This 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.

6. Comparative Study of Ad Hoc Routing Protocols

6.1. Metrics for Performance Comparison

MANET has number of qualitative and quantitative metrics that can be used to compare ad hoc routing protocols. The table-I illustrates the comparison of OLSR, AODV and TORA routing protocols. This paper has been considered the following metrics to evaluate the performance of ad hoc network routing protocols.

- Packet delivery ratio: The ratio of the data packets delivered to the destinations to those generated by the CBR sources.
- Optimal path length: It is the ratio of total forwarding times to the total number of received packets.
- Optimal path length: It is the ratio of total forwarding times to the total number of received packets.
- Average end to end delay: This is the difference between sending time of a packet and receiving time of a packet. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer tirnes.
- 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.

Table 1. Comparison of ad-hoc routing protocols

SL. NO	***Performance Constraints***	***OLSR***	***AODV***	***TORA***
1.	Multi-cost Routes	No	No	Yes
2.	Distributed Environment	Yes	Yes	Yes
3.	Unidirectional Link	Yes	No	Yes
4.	Multicast	Yes	Yes	No
5.	Periodic Broadcast	Yes	Yes	Yes
6.	QoS Support	Yes	No	Yes
7.	Routes Information Maintained in	Route Table	Route Table	Route Table(Adjacent nodes on-hop knowledge
8.	Reactive	No	Yes	Yes
9.	Proactive	Yes	No	Yes
10.	Hybrid	No	No	Yes
11.	Provide Loop-Free Routers	Yes	Yes	Yes
12.	Scalability	Yes	Yes	Yes
13.	Route Reconfiguration	Control Messages sent in advance to increase the reactivenes	Erase Route notify source	Link reversed route repair
14	Routing Philosophy	Flat	Flat	Flat
15.	Route Optimization	Yes	Yes	Yes
16.	Protocol Type	Link State scheme	Distance Vector	Link Reversed
17.	Message Overhead	Minimum	Larger	Moderate
18.	Protocol Suite	Large and Dense networks	Dynamic Self-Starting networks	Large and Dense networks
19.	Summary	Control messages for link sensing, Neighbor (MPR) Detection, Multiple Interface Detection, Route Calculation	Route Discover, Expanding Ring, Search, Setting Forward Path.	Link Reversal, Route Discovery, Route Update Packets.

Table. 2. Routing performance in low mobility

Low Mobility and Low traffic					
Sl. No	***Protocol***	***End-to-End Delay***	***Packet Delivery Ratio***	***Route Over head***	***Path Optimality***
1.	OLSR	Low	High	Low	Good
2.	AODV	Average	High	Low	Average
3.	TORA	Low	High	Average	Good

Table.3. Routing performance in high mobility

High Mobility and High traffic					
Sl. No	***Protocol***	***End-to-End Delay***	***Packet Delivery Ratio***	***Route Over head***	***Path Optimality***
1.	OLSR	Low	Average	Average	Good
2.	AODV	Average	Average	Average	Average
3.	TORA	High	Low	Average	Good

7. Conclusion

In this article, we presents the comparative study and performance analysis of three mobile ad hoc routing protocols (OLSR, AODV and TORA) on the basis of end-to-end delay, packet delivery ratio, media access delay, path optimality, routing overhead performance metrics. The quantitative study of these routing protocols shows that OLSR is more competent in high density networks with highly sporadic traffic. OLSR requires that it continuously have some bandwidth in order to receive the topology updates messages. AODV keeps on improving in packet delivery ratio with dense networks. The performance of all protocols 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. It has been concluded that performance of TORA is better for dense networks. The AODV is better for moderately dense networks where as the OLSR performs well in sparse networks. The future work suggested that the effort will be made to enhance ad hoc network routing protocol by tackling core issues.

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Authors

S. Tamilarasan, M.E.
Associate professor cum Head of Department, Loyola institute of Technology and management,
Dullipala (village), Sattenapalli (Mandal), Guntur, Andhra Pradesh, India.
Specialization:
Mobile computing, Advanced Data Structure, Design and Analysis of algorithm, Computer networks