Volume 1, No.1, March – April 2012
International Journal of Science and Applied Information Technology
Available Online at www.warse.ijatcse.current

An Analysis and Comparison of Multi-Hop Ad-Hoc wireless Routing Protocols for Mobile Node

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ABSTRACT

A Mobile Ad-Hoc Network (MANET) is a group of wireless nodes and distributed throughout the network. In MANET each node using the multi hops wireless links without an infrastructure or centralized administration. Now days, a variety of routing protocols targeted specifically at this environment have been developed and some performance simulations are made. Depending upon the requirement, the nodes in wireless network can change its topology dynamically and arbitrary establish routes between source and destination. The important task of wireless routing protocol is to face 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. 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, DSR and TORA.

Keywords: AODV, DSR, TORA, MANET, Routing

1. INTRODUCTION

A mobile ad-hoc network (MANET) is a self-configuring networks and emerging technology of mobile routers. The mobile router is associated with hosts or nodes and connected by wireless links. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Connections are possible over multiple nodes (multi-hop ad hoc network). 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, 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, DSR and TORA routing protocols.

2. ROUTING PROTOCOLS

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 criteria 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.

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.

Hybrid Routing Protocol: - The advantages of Reactive and Proactive protocols are combined and a new protocol is created. This routing scenario is known as Hybrid Routing Protocol (HRP). Thus in this the performance is improved by finding the rout faster. Zone Routing Protocol (ZRP) and Temporally- Ordered Routing Algorithm (TORA) are coming under this category [1].

The Major classifications of Routing Protocols are given below:

- Proactive Routing Protocol (PRP)
- Reactive Routing Protocol (RRP)
- Hybrid Routing Protocol (HRP)

Under these major classifications, there are sub classifications of Protocols as shown in Figure 1.

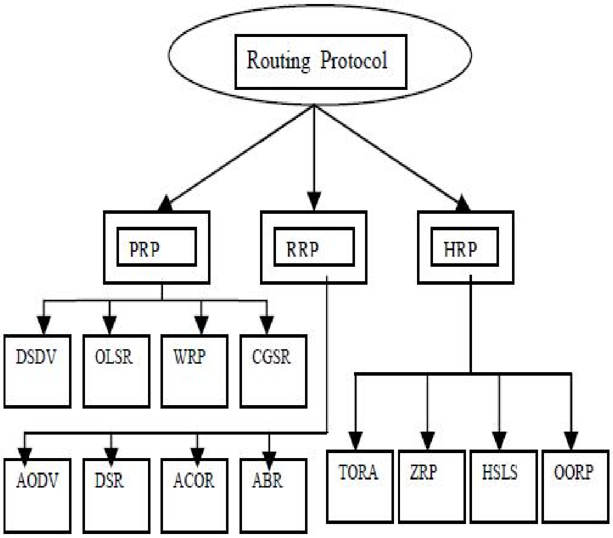

Figure 1: Different routing protocols

2.1. Proactive vs. Reactive Routing

In proactive methods, routes of the various nodes are discovered 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).

In reactive methods, the routes are determined when needed. These methods 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 criteria 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. AD-HOC DEMAND VECTOR PROTOCOLS

AODV is a reactive (on-demand) routing protocol which suite for Mobile Ad-Hoc Network (MANET). AODV combines some property of both DSR and DSDV routing protocols. It uses route discovery process to cope with routes on demand basis. It uses routing tables for maintaining route information. 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 [6]. Figure 2 shows AODV routing protocol with RREQ and RREP message.

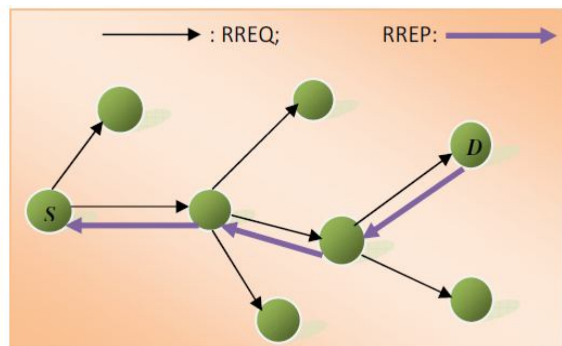

Figure 2: AODV routing protocol with RREQ and RREP message

For route maintenance nodes periodically send HELLO messages to neighbor nodes. If a node fails to receive three consecutive HELLO messages from a neighbor, 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 3 shows AODV routing protocol with RERR message [2] [5] and [6].

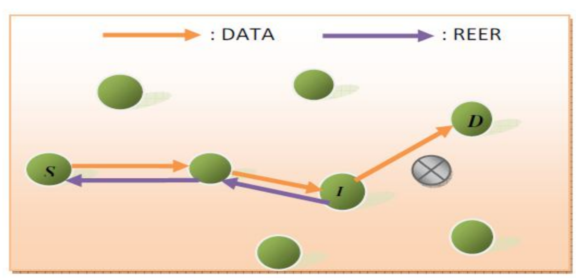

Figure 3: AODV routing protocol with RERR message

4. 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.

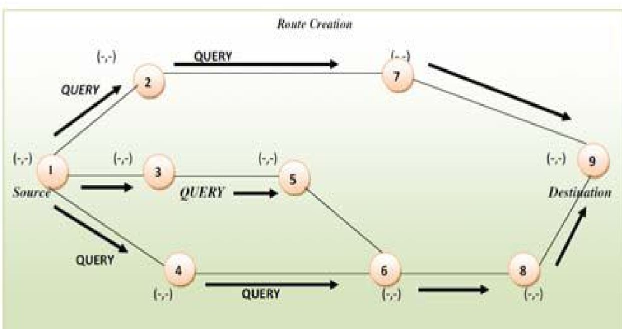

Figure 4.a: Route Creation

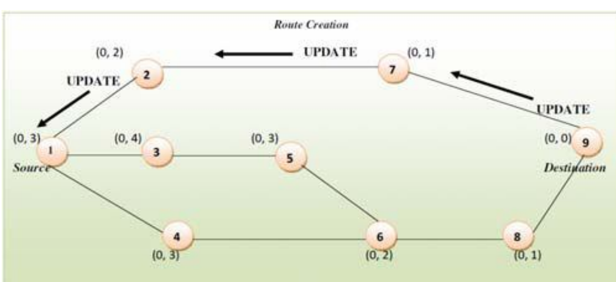

Figure 4.b: Route Creation

The Figures 4.a and 4.b 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 [9] [10].

5. DYNAMIC SOURECE ROUTING (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks and is based on a method known as source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache [6]. The data packets carry the source route in the packet header. DSR is on demand, which reduces the bandwidth use especially in situations where the mobility is low. It is a simple and efficient routing protocol for use in ad-hoc networks. It has two important phases, route discovery and route maintenance [14]. When a node in the ad-hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route. Route discovery works by flooding the network with Route REQuest (RREQ) packets. Each node receiving a RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed so far. The RREP routes are itself back to the source by traversing this path backwards. The route carried back by the RREP packet is cached at the source for future use. If any link on a source route is broken, the source node is notified using a Route ERRor (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source, if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use. Creation of route record in DSR is shown in Figure 5 and building of the route record during route discovery is shown in Figure 6. Several additional optimizations have been proposed such as,

Salvaging: An intermediate node can use an alternate route from its own cache, when a data packet meets a failed link on its source route.

Gratuitous route repair: A source node receiving a RERR packet piggybacks the RERR in the following RREQ.

This helps clean up the caches of other nodes in the network that may have the failed link in one of the cached source routes.

Promiscuous listening: When a node overhears a packet not addressed to it, it checks if the packet could be routed via itself to gain a shorter route. If so, the node sends a gratuitous RREP to the source of the route with this new, better route. Aside from this, promiscuous listening helps a node to learn different routes without directly participating in the routing process [14] [19].

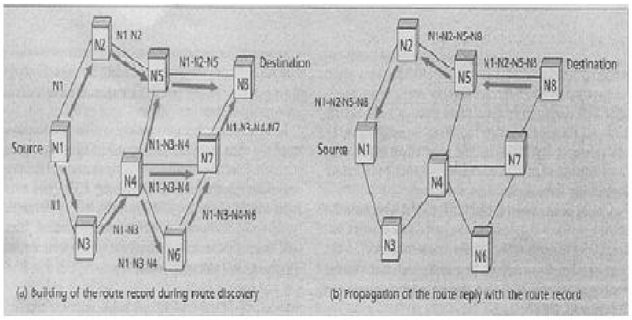

Figure 5: Creation of the route record in DSR

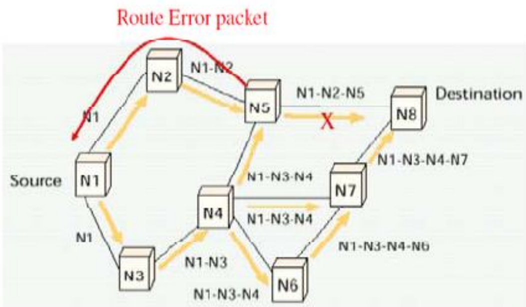

Figure 6: Building of the route record during route discovery

6. COMPARATIVE STUDY OF AD HOC ROUTING PROTOCOLS

MANET has number of qualitative and quantitative metrics that can be used to compare ad hoc routing protocols. The Table 1, Table 2 and Table 3 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 times.
- 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: Routing Performance in Low Mobility

Low Mobility and Low Traffic				
Protocol	***End-to-End Delay***	***Packet Delivery Ratio***	***Path Optimality***	***Routing Overhead***
AODV	Average	Average	High	Average
DSR	Low	Average	Average	Good
TORA	Low	High	Good	Average

Table 2: Routing Performance in High Mobility

High Mobility and High Traffic				
Protocol	***End-to-End Delay***	***Packet Delivery Ratio***	***Path Optimality***	***Routing Overhead***
AODV	Average	High	Good	Average
DSR	Average	Low	Good	Low
TORA	Low	High	Good	Average

Table 3: Comparison of Ad Hoc Routing Protocols

Sl.No	***Protocol Property***	***AODV***	***DSR***	***TORA***
1.	Multi-Cost Routes	NO	YES	YES
2.	Distributed	YES	YES	YES
3.	Unidirectional Link	NO	YES	YES
4.	Multicast	YES	NO	NO
5.	Periodic Broadcast	YES	NO	YES
6.	QoS Support	NO	NO	YES
7.	Routes Information Maintained in	Route Table	Route Cache	Adjacent Routers(One-Hop-Knowledge)
8.	Reactive	YES	YES	YES
9.	Provide Loop-Free Routers	YES	YES	YES
10	Route Optimization	YES	YES	YES
11.	Scalability	YES	YES	YES
12.	Route Reconfiguration	Erase Route Notify Source	Erase Route Notify Source	Link Reversed Route Repair
13.	Proactive	NO	NO	YES
14.	Routing Philosophy	FLAT	FLAT	FLAT

7. CONCLUSION

In this paper, we present the comparative study and performance analysis of three mobile ad hoc routing protocols (AODV, DSR, and TORA) on the basis of end-to-end delay, packet delivery ratio, media access delay, path optimality, routing overhead performance metrics. AODV has the efficient performance in all rounds of metrics. DSR is suitable for networks with moderate mobility rate. It has low overhead that makes it suitable for low bandwidth and low power networks. TORA is suitable for operation in large mobile networks. This networks having dense population of nodes. The major benefit is its excellent support for multiple routes and multicasting.

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