ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

Simulation Based Analysis of AODV, DSR, ZRP Routing Protocols

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Abstract*— A Mobile Ad hoc Network (MANETs) is a kind of wireless ad-hoc network which allows mobile computer users for wireless communication to set up a short lived network for communication needs during movement. The mobile nodes are free to move randomly, thus making the network topology dynamic. Each node operates as a router to forward packets and also acts as an end system. Therefore routing is one of the most concerned areas in these networks. Normal routing protocols which work well in fixed networks do not show the same performance in Mobile Ad Hoc Networks because the requirements differ in the two scenarios. In wireless networks, routing protocols should be more dynamic so that they quickly respond to topological changes which occur frequently in these networks. Various routing protocols have been designed which aims at establishment of correct and efficient routes between a pair of mobile nodes. This study is a comparison of three routing protocols proposed for mobile ad-hoc networks. The protocols are: Ad-hoc On demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Zone Routing Protocol (ZRP). The performances of the protocols are analyzed in terms of throughput, average end-to-end delay and normalized routing load, which shall provide an insight about the sensitivity of the protocols. Simulation based analysis of the protocols have been carried out by using NS-2, an open source simulator.

Index Terms—**AODV, DSR, MANET, NS-2, ZRP.**

I. INTRODUCTION

A Mobile Ad-Hoc Network (MANET) is a collection of wireless mobile nodes without any centralized access point or centralized administration of the mobile networks. Data transmission between two nodes requires multiple hops as nodes transmission range is limited in Mobile Ad hoc networks (MANET's)[7]. In recent years, the mobile computing popularity has increased tremendously. People are getting used to the advantages of having frequent and convenient internet access. So more network functionality is taken by number of laptop users. To allow mobile computers with wireless communication devices to set up a short lived network just for the communication needs for the moment is called as adhoc network [2]. Conventional wireless networks are often connected to a wired network so that the ATM (Asynchronous Transfer Mode) or Internet connections can be extended to mobile users. This kind of wireless network requires a fixed wire line backbone infrastructure. All mobile hosts in a communication cell can reach a base station on the wire line network in one-hop radio transmission. In parallel with the conventional wireless networks, another type of model, based on radio to radio multi-hopping, has neither fixed base stations nor a wired backbone infrastructure. In some application environments, such as battlefield communications, disaster recovery etc., the wired network is not available and multi-hop wireless networks provide the only feasible means for communication and information access. It is also expected to play an important role in civilian forums such as campus recreation, conferences, and electronic classrooms etc. The wireless mobile computing devices can perform critical network topology functions that are normally the job of the routers within the internet infrastructure [4]. There are many kinds of protocols available which are supported by network infrastructure. Each node in an ad hoc network, if it volunteers to carry traffic, participates in the formation of the network topology. Since the topology of Ad hoc network is dynamic in nature, design of suitable routing protocol is essential to adapt the dynamic behavior of the network. Further that node density and pause time will have significant effect in the performance of the any routing policy due to the fact that an increase in node density will tend to increase the hop count thus changing the topology significantly [5]. The topology of the ad-hoc network depends on the transmission power of the nodes and the location of the mobile nodes, which may change from time to time. One of the main problems in ad-hoc networking is the efficient delivery of data packets to the mobile nodes where the topology is not pre-determined nor does the network have centralized control [10]. Hence, due to the frequently changing topology, routing in ad-hoc networks can be viewed as a challenge. This paper makes an attempt to analyze the performance of three most popular Ad hoc routing protocols, viz. AODV, DSR and ZRP. In AODV, DSR and ZRP in the fact they belong to two different routing families. AODV and DSR are from reactive routing family where routes are only generated on demand, in order to reduce routing loads [2]. Where as ZRP is a hybrid routing protocol which effectively combines the best features of both proactive and reactive routing protocols. The key concept employed in this protocol is to use a proactive routing scheme within a limited zone in the neighborhood of every node, and use a reactive routing scheme for nodes beyond this zone. ZRP consists of the Intra Zone Routing Protocol (IARP),

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

which is proactive in nature and the Inter Zone Routing Protocol (IERP), which is reactive in nature [9]. The rest of this paper is organized as follows: In the next section, brief overviews of the routing protocols have been discussed. Section 3 discusses the simulation environment in which both the protocols have been tested. Section 4 includes analysis of the performance of the protocols under a varying node density environment with respect to performance metrics such as throughput, average end-to-end delay and normalized routing load. Section 5 provides conclusion, limitation and future work.

II. OVERVIEW OF THE PROTOCOL

A. Ad hoc On Demand Distance Vector (AODV):

Ad hoc On Demand Distance Vector Routing Protocol (AODV) is a reactive routing protocol designed for Ad hoc wireless network and it is capable of both unicast as well as multicast routing. It provides communication between mobile nodes with minimal control overhead and minimal route acquisition latency [2]. In AODV, each node maintains a routing table which is used to store destination and next hop IP addresses as well as destination sequence numbers [3]. Each entry in the routing table has a destination address, next hop, precursor nodes list, lifetime, and distance to destination. To initiate a route discovery process a node creates a route request (RREQ) packet. The packet contains the source node's IP address as well as the destination's IP address. The RREQ contains a broadcast ID, which is incremented each time the source node initiates a RREQ [1]. The broadcast ID and the IP address of the source node form a unique identifier for the RREQ. The source node then broadcasts the packet and waits for a reply. When an intermediate node receives a RREQ, it checks to see if it has seen it before using the source and broadcast ID's of the packet. If it has seen the packet previously, it discards it. Otherwise it processes the RREQ packet [8]. To process the packet the node sets up a reverse route entry for the source node in its route table which contains the ID of the neighbor through which it received the RREQ packet. In this way, the node knows how to forward a route reply packet (RREP) to the source if it receives one later. When a node receives the RREQ, it determines if indeed it is the indicated destination and, if not, if it has a route to respond to the RREQ. If either of those conditions is true, then it unicasts a route reply (RREP) message back to the source [1]. If both conditions are false, i.e. if it does not have a route and it is not the indicated destination, it then broadcasts the packet to its neighbors. Ultimately, the destination node will always be able to respond to the RREQ message. When an intermediate node receives the RREP, it sets up a forward path entry to the destination in its routing table. This entry contains the IP address of the destination, the IP address of the neighbor from which the RREP arrived, and the hop count or distance to the destination. After processing the RREP packet, the node forwards it toward the source. The node can later update its routing information if it discovers a better route. Dynamic Source Routing (DSR) DSR is one of the most well known routing algorithms for ad hoc wireless networks.DSR allows the network to be completely self-organizing and self configuring, without the need for any existing network infrastructure. The Dynamic Source Routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source routes in the ad hoc networks [2]. DSR uses source routing, which allows packet routing to be loop free. It increases its efficiency by allowing nodes that are either forwarding route discovery requests or overhearing packets through promiscuous listening mode to cache the routing information for future use [2]. DSR is also 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. The main algorithm works in the following manner. A node that desires communication with another node first searches its route cache to see if it already has a route to the destination. If it does not, it then initiates a route discovery mechanism. This is done by sending a Route Request message [9]. When the node gets this route request message, it searches its own cache to see if it has a route to the destination. If it does not, it then appends its id to the packet and forwards the packet to the next node; this continues until either a node with a route to the destination is encountered (i.e. has a route in its own cache) or the destination receives the packet. In that case, the node sends a route reply packet which has a list of all of the nodes that forwarded the packet to reach the destination [2]. This constitutes the routing information needed by the source, which can then send its data packets to the destination using this newly discovered route. Although DSR can support relatively rapid rates of mobility, it is assumed that the mobility is not so high as to make flooding the only possible way to exchange packets between nodes.

B. Zone Routing Protocol (ZRP)

Zone Routing Protocol allows efficient and fast route discovery .ZRP requires a small amount of routing information to be maintained at each node and the cost in wireless resources for maintaining routing information of inactive routes is low[2]. Zone routing protocol is a hybrid routing protocol which effectively combines the best features of both proactive and reactive routing protocols [11]. The key concept employed in this protocol is to use a proactive routing. Proactive routing uses excess bandwidth to maintain routing information, while reactive routing involves long route request delays [10]. Reactive routing also inefficiently floods the entire network for route determination. It acts as a proactive protocol in the neighborhoods of a node (IntrA-zone Routing Protocol, IARP) locally and a reactive protocol for routing between neighborhoods (IntEr-zone Routing Protocol, IERP) globally. The local neighborhoods are called zones, which are different for each node[10. Each node may be within multiple overlapping zones and each zone may be of a different size. The size of a zone is not

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

determined by the geographical measurement but is determined by a radius of length p, where p is the number of hops to the perimeter of the zone.

III. SIMULATION METHODOLOGY

Simulation based study using Network Simulator NS-2[6] has been used to compare three protocols viz. AODV, DSR and ZRP under varying node density assuming that the size of network, maximum speed of nodes and transmission rate are fixed. Tables 1 and 2 summarize the parameters used in the communication and movement models for simulation.

A. Communication Model

The simulator assumes constant bit rate (CBR) traffic with a transmission rate of 8 packets per second. The number of nodes varies from 25 to 100 in the denomination of 25, 50, 75,100.

Table 1. Parameters of Communication Model

Parameter	Value
Traffic	CBR
No.of nodes	25,50,75,100
Transmission rate	8packets/sec

B. Movement Model

The realistic mobility pattern of the mobile nodes, the simulation assumes a Random Waypoint Model, where a node is allowed to move in any direction arbitrarily [8, 10]. The nodes select any random destination in the 500 X 500 space and moves to that destination at a speed distributed uniformly between 1 and nodes maximum speed (assumed to be 20 meter per second). Upon reaching the destination, the node pauses for fixed time, selects another destination, and proceeds there as discussed above. This behavior repeats throughout the duration of the simulation (1200 seconds)[11]. Meanwhile, number of nodes has been varied to compare the performance of the protocols for low as well as high density environment.

Table II. Parameters of Movement Model

Parameter	Value
Simulator	NS-2
Simulation time	1200 seconds
Area of the network	500 m x 500 m
Number of nodes	25,50,75,100
Pause time	10 seconds
Maximum speed of nodes	20 meters per second
Mobility Model	Random waypoint

C. Performance Metrics

Three performance metrics have been measured for the protocols:

- **Throughput**: Throughput is the number of packet that is passing through the channel in a particular unit of time. This performance metric shows the total number of packets that have been successfully delivered from source node to destination node [8]. Factors that affect throughput include frequent topology changes, unreliable communication, limited bandwidth and limited energy.

$$Throughput = \frac{Received\_Packet\_Size}{Time\_to\_Send}$$

- **Average End-to-End Delay:** A specific packet is transmitting from source to destination node and calculates the difference between send times and received times[9]. This metric describes the packet delivery time. Delays due to route discovery, queuing, propagation and transfer time are included metric.

$$Avg\_End\_to\_End\_Delay = \frac{\sum_i^n (CBR\_Sent\_Time - CBR\_Recv\_Time)}{\sum_i^n CBR\_Recv}$$

- **Normalized Routing Load**: Normalized Routing Load is the ratio of total number of routing packet received and total number of data packets received [8].

$$Normalized\_Routing\_Load = \frac{Number\_of\_Routing\_Pkts\_Recvd}{Number\_of\_Data\_Pkts\_Recvd}$$

IV. SIMULATION RESULT AND ANALYSIS

Figures 1, 2 and 3 represent the performance analysis in terms of throughput, average end-to-end delay and normalized routing load respectively. In all the cases the node density varies from 25 to 100.

A. Throughput

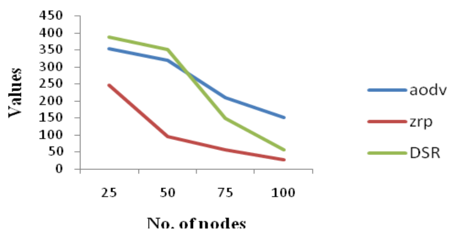

Fig 1 (a): Throughput

The simulation result as indicated in Figure 1(a) indicates that the throughput of AODV, DSR and ZRP decreases as the node density increases. Higher node density increases the number of control and data packets in the network and thus the throughput of the network is low for higher density. The proactive nature of IARP of ZRP is responsible for generating more number of control packets in dense network and thus produces less through put.

B. End to end delay

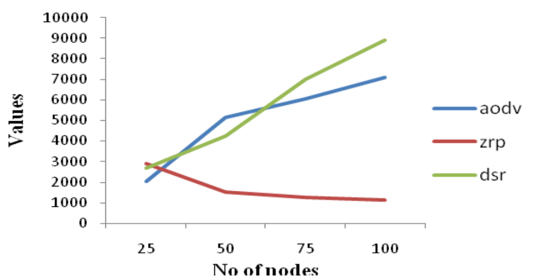

Fig 1 (b): Average end to end delay

Figure 1(b) depicts that the delay increases with the increase of node density for AODV and DSR. The possible reason for such behavior is the presence of more number of nodes between source and destination which effects in

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

increase of hop count thus resulting in increased average end-to-end delay [10]. However, in ZRP, higher node density increases the number of neighbor nodes inside a zone. So, for ZRP, the hop count between source node and destination node decreases with the increase of node density and average end-to-end delay decreases.

C. Routing load

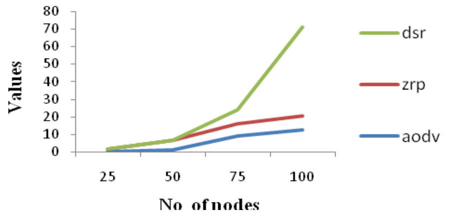

Fig 1 (c): Normalized routing load

The simulation result of figure 1 (c) indicates that that there is a rise in normalized routing load whenever there is an increase in node density. In high node density, the number of control packets is high due to more route discovery and more control packets produces more routing load in the network.

V. CONCLUSION

The performance evaluation of the routing protocols AODV, DSR and ZRP has been done with respect to metrics throughput, average end-to-end delay and normalized routing load under varying node density. From the result analysis, it has been observed that in high node density the performance of the protocols in terms of throughput decreases significantly .In case of the average end to end delay the performance of AODV and DSR protocols decreases significantly as average end to end delay increases as number of nodes increases. But for ZRP end to end delay decreases accordingly. Due to increase of node density in the network causes more number of control packets in the network for route establishment between a pair of source and destination nodes. In normalized routing load the performance of the protocols AODV and ZRP decreases in terms of node density. But for DSR normalized routing load increases drastically as density of nodes increases. This is the cause of performance degradation of the routing protocols in high node density [8] . It has been observed that in low node density the performance of AODV and ZRP is better than DSR. The current work has been limited with fixed simulation area (500x500m) with CBR traffic and node density is up to 100 nodes. In Current work, only three performance metrics have been considered to analyze the performance of AODV,DSR and ZRP. Inclusion of other performance metrics will provide in depth comparison of these protocols which may provide an insight on the realistic behavior of the protocols under more challenging environment.

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