Simulation Based Comparative Analysis of AODV, TORA and DSR Protocols

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Abstract: A mobile ad hoc network (MANET) consists of mobile nodes, connected by wireless links. The mobile nodes can receive and forward the data packets as a router, which make routing a critical issue in MANET's. In MANET's, different routing protocols are used to establish the route and data transfer takes place from source to destination through those routes. In this paper work, an attempt has been made to compare the performance of three on-demand routing protocols for MANETs: Ad hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) protocols, and Temporally Ordered Routing Algorithm (TORA) with respect to five performance metrics: Packet Delivery Ratio (PDR), Throughput, Normalized Routing Overheads, Error rate and MAC Collision rate. The performance differentials are analyzed using varying number of nodes. These simulations are carried out using the MATLAB. Simulation results show that the overall performance of AODV is better than TORA and DSR for all the observed parameters for the specified simulation environment.

Key words: Reactive routing protocols, AODV, TORA, DSR, MANET's

1. Introduction

The aim of the communication system is to exchange the data between the source and destination, but MANET's are different from the structured communication systems as these networks don't have any fixed infrastructure. It is a decentralized autonomous wireless system which consists of free nodes. MANET is a self configurable wireless network. The nodes within the network are free to move anywhere anytime that means the topology of the MANET is ever changing [1]. All the nodes of MANET are capable to receive and to transmit the messages. If the source and destination nodes are directly within the range of each other they can communicate directly (single-hop) otherwise the nodes between the source and destination node can forward the data (multi-hop)[2]. In case of multi hoping, each intermediate node acts as router. The ability of self configuration of these nodes makes them more suitable for urgently required network connection like tactical networks (Military Communication and operations, automated battle fields), emergency services (search and rescue operations, disaster recovery, policing and firefighting), commercial and civilian environment (business, sports stadiums), education (universities and campus setting, virtual classrooms), entertainment (multi user games, outdoor internet access, robotic pet) and sensor networks (home applications) etc [3]. But whatever may be the required application efficient and reliable routing is the main requirement [18].

To do communication if the source and destination are in the direct range of each other then they can communicate directly but if not then routing protocols are needed to transfer the data packet from source to destination via intermediate node that are acting as router. So the biggest challenge of MANET is the design and implementation of routing protocol that may be able to transfer maximum data packets with minimum overheads. The available routing protocols are categorized as Reactive routing protocols, Proactive routing

protocols and Hybrid routing protocols. We have reviewed and discussed various reactive protocols [17] in our work and analyzed the performance of these protocols on the basis of performance parameters.
The rest of the paper is organized as follows: Section II give the details of various categories of routing protocols Section III presents overview of the reactive protocols i;e AODV, TORA and DSR. Section IV provides the simulation environment and performance metrics are described in Section V and then the results are presented in Section VI. Finally Section VII concludes the paper.

1. Routing protocols

A. **Reactive routing protocols**: These are the protocols in which route is traced only and only when they are required. When any of the nodes has data to send then and only then routes are discovered by route discovery process [12]. That route remains valid only for the duration of communication. In reactive routing protocols, to discover the route they broadcast a Route Request (RREQ) packet in the network and that request packet is multi time replicated in the network until it find the destination. It will lead to broadcast storm problem [4] and particularly in dense networks it increase the MAC collision rate and reduce the packet delivery ratio. As the route discovery is needed prior to each data transmission so latency is also high [11] [13].

B. **Proactive routing protocols**: In these routing protocols, the paths to the destination are computed automatically and independently at the start up and maintained by using a periodic route update process [15]. The tables contain the information about nodes to maintain the latest view of network. As the nodes move away from one another then the network topology changes which propagate update messages throughout the network in order to maintain consistent and up-to-date routing information about the whole network. These routing protocols differ in the method by which the topology change information is distributed across the network and the number of necessary routing-related tables [16].

C. **Hybrid routing protocols**: Proactive or reactive protocols alone work well within limited region of network setting but the combinations of proactive and reactive protocols, called as hybrid routing protocol, can work very well for any particular network. It may work as for any nearby routes (for example, maximum two hops) are kept up-to-date proactively, while far-away routes are set up reactively. Both proactive and reactive routing protocols prove to be inefficient under these circumstances. Hybrid routing protocol combines the advantages of the proactive and reactive approaches. Hybrid protocols include: SHARP, ZHLS routing protocols [9] [10].

2. Overview of reactive protocols

Ad Hoc on demand distance vector (AODV) routing protocol:

AODV [7] is capable of both uni-cast and multicast routing. 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. It is loop-free, self-starting, and scales to large numbers of mobile nodes [8]. AODV construct routes using a route request / route reply query cycle. The algorithm used by AODV to establish a uni-cast route is as follows:

A. Route Discovery:

When a source node wishes a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet across 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. The receiving node checks if it has a route to the desired node. If a route exists and the sequence number for this is higher than the supplied number a new route is found. The node generate the route reply (RREP), 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. For active route i;e if data packets periodically exchanged between source and the destination along that path the route remain continued and maintained. Once the source stops sending data packets, the links will time out and finally be deleted from the intermediate node routing tables.

B. Route maintenance:

If source node moves during the data transmission and need the link for more data transmission then it can reinitiate the route discovery process and find a new route to destination. If a link failed, either because of the movement of intermediate node or destination node, the node upstream of the break propagates a route error (RERR) message to the source node to notify it that the destination is unreachable for that moment, and on receiving the RERR, if the source node still want to establish the route, it can reinitiate route discovery.

Dynamic Source Routing (DSR)

The Dynamic Source Routing protocol (DSR) [6] is a plain and competent routing protocol designed specifically for use in multi-hop wireless Adhoc networks. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration [12] [13]. 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. An advantage of DSR is that nodes can store multiple routes in their route cache, which means that the source node can check its route cache for a valid route before initiating route discovery and if a valid route is found there is no need for route discovery [5]. For low mobility networks it save lots of effort to discover routes. Since they routes stored in the route cache will be valid longer. Another advantage of DSR is that it does not require any periodic beaconing, therefore nodes can enter sleep node to conserve their power.

Temporary Ordered Routing Algorithm (TORA)

Temporally-Ordered Routing Algorithm (TORA) is a distributed protocol designed to be highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal [14]. 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 shortest route. The protocol has three basic functions: Route creation, Route maintenance and Route erasure. 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.

2. Simulation environment

To verify the results through the simulation using MATLAB, the simulation parameters are as per table 1. The traffic sources are CBR (continuous bit rate). The source-destination pairs are stretch randomly over the network. The mobility model uses 'random waypoint model' in a rectangular filed of 2500m x 2500m with 150 nodes. During the simulation, one randomly selected node start the data transmission to randomly selected node. By all the protocols, route has been discovered and data transmission takes place. Speed of the nodes and transmission range of any particular node is fixed for simulation. Due to the random movement of nodes, the topology is ever changing. That's why different protocols perform differently in the same environment.

Table 1: Simulation Parameters

Simulation Parameter	Values
Simulator	MATLAB R2010a
Channel Type	Wireless Channel
Area	2500*2500 m2
Transmission Range	500 m
Packet size	100
Speed	5 m/s
Pause time	0 sec
MAC type	Mac 802_11
Antenna model	Omni Antenna
Routing Protocol	AODV/TORA /DSR

3. Performance analysis

(a) **MAC Collision Rate**: MAC collision rate is the number of data packet collisions occurring at MAC layer in a network over a specified period of time. It indicates the rate at which data packets collide or are lost in collisions. It is measured as a percentage of the data packets successfully sent out.

Normalized routing overhead: It is the ratio of total packet size of control packets (including the RREQ, RREP, RERR and Hello) to the total packet size of data packets delivered to the destination.

(b) **Packet delivery ratio**: It is the ratio of number of data packet successfully received by the CBR (constant bit rate) destination to the number of data packet generated by the CBR source. It measures the loss rate by transport protocols. Mathematically, it can be expressed as:

$$PDR = \frac{\sum(\text{ all the packets received by destination})}{\sum(\text{all the packets sent by source})} \text{……..(i)}$$

(c) **Error rate**: It is the rate at which error may occur in the transmitted data packets. More error means the higher losses in data packets and more retransmissions are required which increase the overheads and reduce the throughput.

Average Throughput: Throughput is defined as the total number of packets delivered over the total simulation time. Mathematically, it can be defined by equation (ii) as:

$$\text{Throughput} = \frac{\text{N}}{1000} \text{…….(ii)}$$

Where N is the number of bits received successfully by all destinations. And average of the total throughput is called as average throughput.

4. Results and discussions

Figure 1 shows the MAC collision rate for AODV, TORA and DSR, under same simulation environment. For more dense environments the collisions are high, and with AODV the minimum value is 0 and maximum is 0.37 with the average of 0.077. The average value is .605 and 22.30 for TORA and DSR respectively.

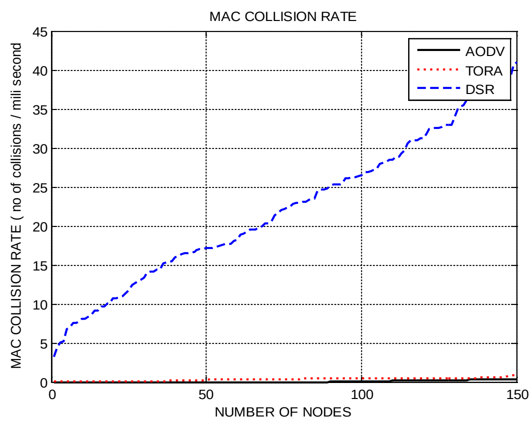

Figure 1: MAC collision rate vs Number of Nodes

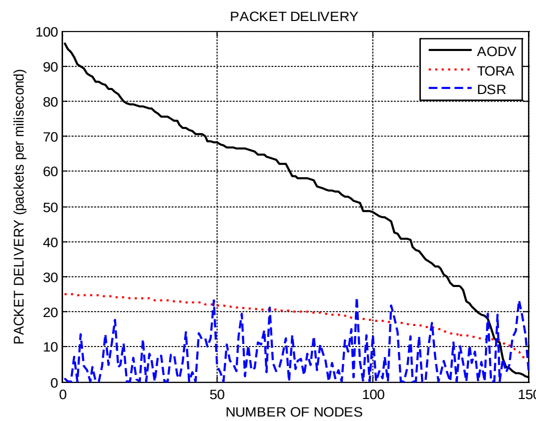

Figure 2: Packet delivery vs Number of Nodes

Figure 2 compares the packet delivery ratio of three protocols. For AODV it is always better than TORA and DSR. It remains 93.02% on an average with minima 27.43 and maxima 99.86 for AODV in comparison to TORA and DSR in it is 19.87% and 6.55% respectively. This result indicates that the AODV protocol is the more efficient among the three protocols.

Normalized routing overheads are shown in figure 3. AODV has lowest routing overheads as compared with TORA and DSR. In AODV, average routing overheads are 0.006 where as for TORA and DSR average routing overheads are 0.151 and 10.04.

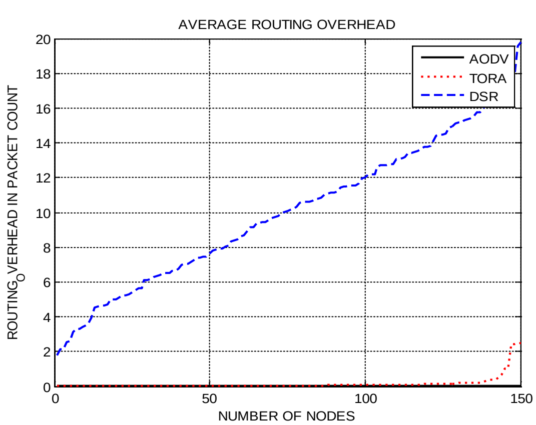

Figure 3: Average routing overheads vs Number of nodes

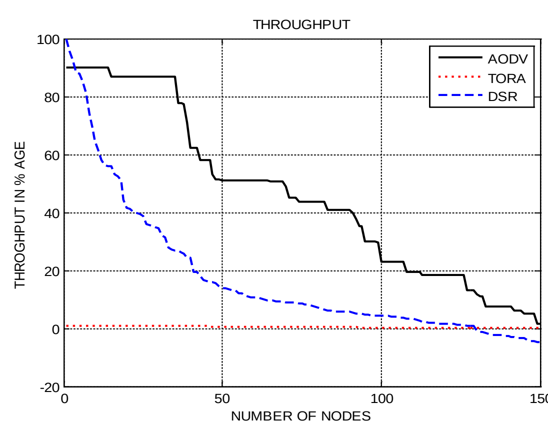

Figure 4: Throughput vs Number of nodes

Figure 4 compare the throughput of AODV, TORA and DSR protocols. The Average throughput of AODV is 46.04% that is much higher than the TORA and DSR. The average throughput of TORA and DSR is 0.49% and 17.36%.

In figure 5, error rate for AODV, TORA and DSR is shown. The average error rate for AODV is 0.0145 that is lower than TORA and DSR. Error rate for TORA is 0.164 and for DSR it is 3.611.

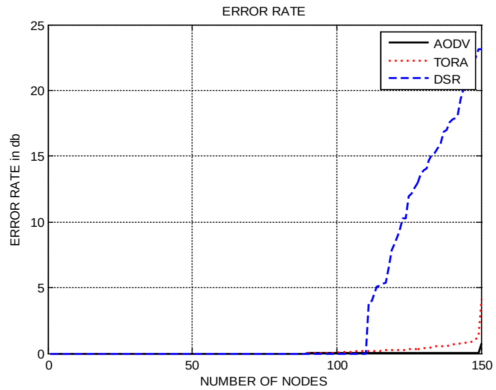

Figure 5: Error rate vs Number of nodes

5. Conclusion

In this paper the performance of AODV is compared with TORA and DSR on the basis of packet delivery ratio, normalized routing overheads, Throughput, error rate and MAC collision rate by using Matlab. From the simulation results it is clear that for the same simulation environment protocols behave differently. This is because of their way of working. The performance of AODV protocols is better than TORA and DSR for all the observed parameters.

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