Comparing Packet Delivery Ratio of Reactive Protocols with respect to Simulation Time, Packet size and Mobility

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Abstract

A key issue in MANETs is the necessity that the routing protocols must be able to respond rapidly to topological changes in the network. At the same time, due to the limited bandwidth available through mobile radio interfaces, it is essential that the network traffic, generated by the routing protocols should be kept at a minimum. Several protocols exist, addressing the problems of routing in mobile ad-hoc networks. MANET routing protocols are designed to adaptively cater to dynamic changes in topology while maximizing the throughput and packet delivery ratio, and minimizing delay, aggregate good put, average jitter and minimum packet loss. In this paper a simulative study on MANET routing protocols aims to determine its packet delivery ratio performance with respect to simulation time, packet size & mobility.

1 INTRODUCTION

Reactive Routing Protocol (RRP) is a bandwidth-efficient on-demand routing protocol for MANETs. In this protocol the originator node initiates the route search process, whenever it needs to send data packets to a target node. Thus the need for a route triggers the process of route search, hence the name Reactive Routing Protocol. RRP is intended to be implemented in the network layer of mobile nodes i.e. in the layer 3 of ISO OSI reference model. Route Discovery and Route Maintenance functions of the protocol are described next.

1.1 Route Discovery

RRP is different from other suggested on-demand routing protocols, by the way it uses the Incremental Search Method (ISM), thus making it more bandwidth-efficient and reducing the number of links traversed for the same routes discovered as compared to a broadcast based method.

In the Incremental Search Method of RRP, each node maintains a list of its immediate neighbors i.e. the nodes that have direct communication link with source node. In addition to the address of neighbor nodes, source node also records the link cost to this neighbor and the time of neighbor discovery in its neighbor list. The neighbor list is maintained by periodically sending 'Echo' packets by each node and the node receiving this packet will respond back immediately. Measurement of the round-trip time and dividing it by two gives the link cost to this neighbor. The neighbor list is used not just for route discovery but also for route maintenance and can be used for other optimizations to the protocol.

Under the Incremental Search Method, whenever an originator node needs to send data packets to a target node and it has a valid route to target node in its routing tables or neighbor list, it can proceed with the data transfer to that node through this route. If originator node could not find a valid route to target node, then the source node would send a route discovery packet with an incremented value of Dis_Identification Number for this target node to each of its neighbors from the neighbor list. Originator Address, Target Address and Dis_Identification Number uniquely identify a route discovery packet.

Each node that receives a route discovery packet would look for a route to target node in its routing tables and neighbor list. In case a node finds a route to target node then it would send a route verification packet to target node so that it could reply with a route confirmation packet back to the source node. This is done to ensure that this route is valid and is not broken. If no route confirmation packet is received by source node within a certain timeout period associated with each sending of route verification packet, then it can presume that this route is not valid anymore. A route discovery process might return more than one route from originator to target in which case the originator would keep most optimal route in its Active Routing Table and other routes in its Passive Routing Table. The Passive Routing Table helps in expediting future route discoveries or when the route in Active Routing Table gets broken. The major advantage of this method that source node and other intermediate nodes know the routes to several other nodes in the network apart from target node through their temporary routing tables, thereby reducing the routing overhead for future route discoveries and adding more to the bandwidth efficiency of RRP.

1.2 Route Maintenance

RRP uses Surroundings Repair Method (SRM), for the detection of link breaks and repair of an existing route. To implement Surroundings Repair Method each node keeps record of next hop and next to next hop for each target entry in its routing tables. This method works both proactively and reactively.

In the proactive approach, each node when it detects a change in its neighbor list in the way that its link to an old neighbor node is now broken, it initiates Surroundings Repair Method for those routes in its Active Routing Table that use as their next hop. In the reactive approach, when the source node is unable to forward data packets to node target node due to a break in its link to target node, it initiates Surroundings Repair Method for all those routes in its Active Routing Table that use as their next hop.

The advantage of Surroundings Repair Method is that if a route is repaired successfully the overhead incurred in sending a route invalid packet back to the originator node and in initiating the new route search by the originator node is saved. Thus the overall bandwidth efficiency of MANET is improved by using Surroundings Repair Method.

Examples of reactive protocols are Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), and Associativity-Based Routing (ABR).

2 Overview of Reactive Protocols (AODV, DSR, and TORA)

2.1 Ad hoc On-demand Distance Vector Routing (AODV)

AODV belongs to the class of Distance Vector Routing Protocols (DV). In a DV every node knows its neighbours and the costs to reach them. Ad hoc On Demand Distance Vector (AODV) is a reactive routing protocol which initiates a route discovery process only when it has data packets to transmit and it does not have any route path towards the destination node, that is, route discovery in AODV is called as on-demand. A new route maintenance algorithm to avoid route breaks because each intermediate node on an active route detects the danger of a link break to an upstream node and re-establishes a new route before a route break. This algorithm is based on AODV (Ad-hoc On-demand Distance Vector routing protocol) is presented in [ABM12].

A routing protocol for Bluetooth scatter nets that customizes the Ad hoc On-Demand Distance Vector (AODV) routing protocol by making it power-aware and suitable for scatter nets. It enhances the AODV flooding mechanism by excluding all non-bridge slaves from taking part in the AODV route discovery process. In addition, it improves the AODV route discovery phase by considering the hop count, the predicated node's power, and the average traffic intensity for each node as metrics for best route selection. By removing HELLO packets, the protocol reduces the control packets overhead and the power consumption in network devices. Simulation results show that the implemented protocol achieved considerable improvements over other enhanced AODV protocols by increasing the data delivery ratio by 10.78%, reducing the average end-to-end delay by 8.11%, and reducing the average energy consumption by 7.92%.

AODV is composed of three mechanisms: Route Discovery process, Route message generation and Route maintenance. The significant feature of AODV is whenever a route is available from source to destination, it does not add any overhead to the packets. However, route discovery process is only initiated when routes are not used and/or they expired and consequently discarded. This strategy reduces the effects of stale routes as well as the need for route maintenance for unused routes. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication. AODV uses a broadcast route discovery algorithm and then the unicast route reply message.

2.2 Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing. It is a routing protocol for wireless mesh networks. It is similar to AODV in that it forms a route on-demand when a transmitting node requests one. However, it uses source routing instead of relying on the routing table at each intermediate device. Determining source routes requires accumulating the address of each device between the source and destination during route discovery. The accumulated path information is cached by nodes processing the route discovery packets. The learned paths are used to route packets. To accomplish source routing, the routed packets contain the address of each device the packet will traverse. This may result in high overhead for long paths or large addresses, like IPv6. To avoid using source routing, DSR optionally defines a flow id option that allows packets to be forwarded on a hop-by-hop basis.

Hence it is designed specially for use in multihop ad hoc networks of mobile nodes. It allows the network to be completely self-organizing and self-configuring and does not need any existing network infrastructure or administration. DSR is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the network. DSR has a unique advantage by virtue of source routing. As the route is part of the packet itself, routing loops, either short – lived or long – lived, cannot be formed as they can be immediately detected and eliminated. This property opens up the protocol to a variety of useful optimizations.

A protocol for routing packets between wireless mobile hosts in an ad hoc network. Unlike routing protocols using distance vector or link state algorithms, this protocol uses dynamic source routing which adapts quickly to routing changes when host movement is frequent, yet requires little or no overhead during periods in which hosts move less frequently. Based on results from a packet-level simulation of mobile hosts operating in an ad hoc network, the protocol performs well over a variety of environmental conditions such as host density and movement rates. For all but the highest rates of host movement simulated, the overhead of the protocol is quite low, falling to just 1% of total data packets transmitted for moderate movement rates in a network of 24 mobile hosts. In all cases, the difference in length between the routes used and the optimal route lengths is negligible, and in most cases, route lengths are on average within a factor of 1.02 of optimal as presented by [DAD12].

2.3 Temporally 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. It is an algorithm for routing data across Wireless Mesh Networks or Mobile ad hoc networks. The TORA attempts to achieve a high degree of scalability using a "flat", non-hierarchical routing algorithm. In its operation the algorithm attempts to suppress, to the greatest extent possible, the generation of far-reaching control message propagation. TORA builds and maintains a

Directed Acyclic Graph (DAG) rooted at a destination. No two nodes may have the same height. Information may flow from nodes with higher heights to nodes with lower heights. Information can therefore be thought of as a fluid that may only flow downhill. By maintaining a set of totally ordered heights at all times, TORA achieves loop-free multipath routing, as information cannot 'flow uphill' and so cross back on itself.

TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It 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. The protocol has three basic functions: Route creation, Route maintenance and Route erasure.

3 Packet Delivery Ratio

3.1 Performance Metrics

Efficient routing protocols can provide significant benefits to mobile ad hoc networks in terms of both performance and reliability. Different performance metrics are used in the evaluation of routing protocols. They represent different characteristics of the overall network performance to achieve the required quality of service (Qos). Describe a number of quantitative metrics that can be used for evaluating the performance of MANET routing protocols. In this report, we have used packet delivery ratio metric for evaluating and used in our comparisons to study their effect on the overall network performance.

The simulation was conducted using ns2 simulator and compared AODV, DSR and TORA protocols. The general ideas as of previous study of simulation were followed. In simulation, we first generate scenario files considering the area of 1050m*600m. And divided them into three different categories as under.

1. Scenario files for varying Simulation Time and keeping no of nodes (42), Speed (10m/s) and pause time (100 sec) constant (25files).
2. Scenario files for varying Packet Size and keeping no of nodes (42) and Speed (10m/s) keeping Pause time (2 sec) constant (25 files).
3. Scenario files for Varying Mobility Speed and keeping No of Nodes (42), Pause Time constant. (25 files).

After generating the scenario files we generated traffic files using cbrgen utility of ns2. The no of maximum connections were mentioned as no of nodes for a particular file and data communication rate was defined as packets per second. Before starting the simulation it was ensured that the computer system was having a good processing speed and large storage capacity as 120 trace files were generated and each file was of the capacity in the range of 1gigabyte to 50 gigabytes. Tcl script was run over to generate the trace files for various protocols. Also it was very time consuming as some simulation took approximate 15-20 hours to generate a single trace file especially in case of higher number of nodes. After analyzing these 120 trace files with awk script we concluded the results for various parameters to be calculated and plotted the graph as in the next section. Every simulation was done for 600 seconds (10 minutes).

3.2 Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio between the number of packets transmitted by a CBR traffic source and the number of packets received by a CBR traffic sink. It can be obtained from the total number of data packets arrived at destinations divided by the total data packets sent from sources. It measures the loss rate as seen by transport protocols and as such, it characterises both the correctness and efficiency of ad hoc routing protocols. It represents the maximum throughput that the network can achieve. The performance is better when the packet delivery ratio is nearer to one.

Packet Delay Ratio = Σ Number of packets receive / Σ Number of packets send

4 Comparison of Performance Metrics

The performance of reactive protocols AODV, DSR, & TORA presented individually in the above sections. The comparison of above protocols with respect to metrics is considered based on the sample Simulation Time (20 sec), the Packet Size (625 bytes) and Mobility (15 m/s). Their results are shown and discussed with the following table and bar graphs.

4.1 Comparison of Packet Delivery Ratio with respect to Simulation Time

Below Table 1 shows the comparison of Reactive protocols and their Performance metrics values with respect to the simulation time 20sec.

Table 1: Simulation time (20 sec)

Performance metrics	AODV	DSR	TORA
Packet Delivery Ratio	0.9949	0.9795	0.2963

End to End Delay	55.4052	353.319	878.451
Throughput	324.73	382.85	516.202
Route overhead	0.230	0.438	2.62209
Energy Consumption	59.3181	54.7829	108

The X-Graphs Shown in figure 1 represents Packet Delivery Ratio of AODV, DSR & TORA with respect to Simulation Time. The graphs illustrate the results of Packet Delivery Ratio with Simulation Time, taking Simulation Time along the X-axis and Packet Delivery Ratio along the Y-axis. In the graph lines and bars in green colour represents AODV, red colour represents DSR and blue color represents TROA.

AODV is best among three protocols. DSR performs better where the PDR decreases as the simulation time increases. On the other hand the performance of TORA is poor. In view of packet delivery ratio, reliability of AODV and DSR protocols are greater than TORA.

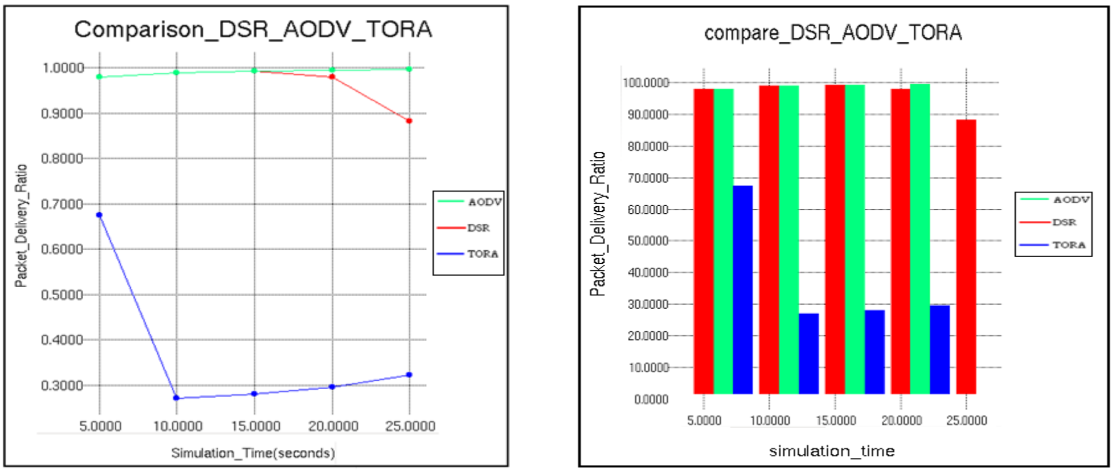

Figure 1: Packet Delivery Ratio Vs Simulation Time for AODV, DSR and TORA

4.2 Comparison of Packet Delivery Ratio with respect to Packet size

Below Table 2 shows the comparison of Reactive protocols and their Performance metrics values with respect to the Packet Size (625 bytes).

Table 2: Packet size (625)

Performance Metrics	AODV	DSR	TORA
Packet Delivery Ratio	0.9896	0.9792	0.3125
End to End Delay	55.7085	589.462	382.678
Throughput	332.27	436.05	536.700
Route overhead	0.232	0.752	2.33085
Energy Consumption	38.73264	40.7255	97.534

The X-Graphs Shown in figure 2 represents Packet Delivery Ratio and AODV, DSR & TORA with respect to Packet Size. This graph illustrates the results of Packet Delivery Ratio with Packet Size, taking Packet Size along the X-axis and Packet Delivery Ratio along the Y-axis. In the graph lines and bars in green colour represents AODV, red colour represents DSR and blue color represents TROA.

AODV is best among three protocols. DSR performs better where the PDR decreases as the packet size increases. On the other hand the performance of TORA is poor. In view of packet delivery ratio, reliability of AODV and DSR protocols is greater than TORA.

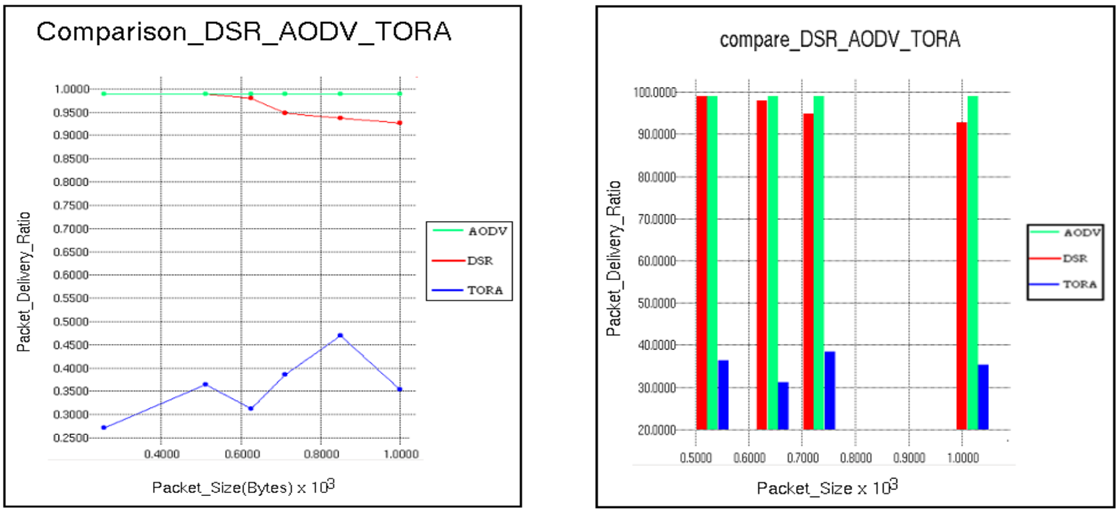

Figure 2: Packet Delivery Ratio Vs Packet Size for AODV, DSR and TORA

4.3 Comparison of Packet Delivery Ratio with respect to Mobility

Below Table 3 shows the comparison of Reactive protocols and their Performance metrics values with respect to the Mobility 15m/s.

Table 3: Mobility (15)

Performance Metrics	**AODV**	**DSR**	**TORA**
Packet Delivery Ratio	0.9896	0.9896	0.2604
End to End Delay	56.0337	60.2794	404.678
Throughput	332.38	320.94	427.8090
Route overhead	0.232	0.317	3.43
Energy Consumption	39.7197	37.9564	97.4329

The X-Graphs Shown in figure 3 represents Packet Delivery Ratio and AODV, DSR & TORA with respect to Mobility. This graph illustrates the results of Packet Delivery Ratio with Mobility, taking Mobility along the X-axis and Packet Delivery Ratio along the Y-axis. In the graph lines and bars in green colour represents AODV, red colour represents DSR and blue color represents TROA.

This graph shows the comparison of PDR with respect to mobility of nodes / speed in m/s. AODV & DSR performance is comparable. AODV shows a slight decrease in high mobility of nodes. DSR performs best during high mobility. On the other hand the performance of TORA is poor. PDR decreases as the mobility increases. In view of packet delivery ratio, reliability of AODV and DSR protocols is greater than TORA.

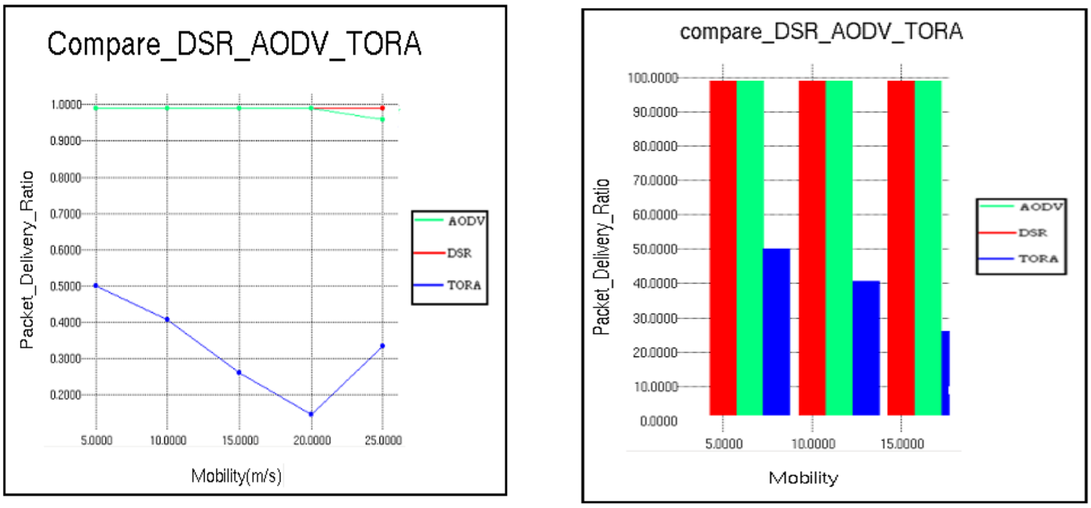

Figure 3: Packet Delivery Ratio Vs Mobility for AODV, DSR and TORA

5 CONCLUSION

This paper discusses the comparison of the packet delivery ratio metric of reactive routing protocol represented by AODV, DSR & TORA. Based on experimental results obtained, in view of packet delivery ratio, reliability of AODV and DSR protocols are greater than TORA.

DSR is preferable for moderate traffic with moderate mobility. For the robust scenario where mobility is high, nodes are dense, the amount of traffic is more, and AODV performs better among all studied routing protocols. Thus from the simulation results, it can be concluded that AODV performs optimally well not the best. Though there are some disadvantages of this protocol, it is robust for use in mobile ad hoc networks. Our future work will include the study of other performance metrics with respect to simulation time, packet size and mobility.

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