# Performance Analysis of Reactive Routing Protocols in Mobile Ad hoc Networks

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**Abstract:**
Ad hoc networks are characterized by multi-hop wireless connectivity, frequently changing network topology and the need for efficient dynamic routing protocols plays an important role. In this paper we compare the performance of three on-demand routing Protocols for mobile Ad-hoc network (MANET) networks: Dynamic Source Routing (DSR), Ad Hoc On-demand distance Vector Routing (AODV) and Temporarily Ordered Routing Algorithm (TORA) in by varying the size of the networks. The performance metrics selected to make the performance differences are Total Traffic Received, Traffic Load, Throughput, Number of Hops per Route and Route Discovery Time. AODV shows a Considerable better performance over the others for any number of nodes. TORA and DSR show moderate performance for minimum number of nodes, where in the case of large networks, DSR shows some performance rather than TORA.
***Keywords:*** *Ad hoc, AODV, DSR, TORA, OPNET.*

## 1. Introduction

MANET (Mobile ad hoc network) is a temporary self organizing system formed by a Collection of nodes, which are connected with wireless links. In the network, nodes may be disappeared or new nodes may be appeared over the time due to node mobility. In the recent years, many researchers are contributing to the improvement of the performance of routing protocols in MANET. IETF (Internet Engineering Task Force) created a working group in 1996 to deal with the MANET research [1]. The idea of such networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes. Figure.1 shows an example of an ad hoc network, where there are numerous combinations of transmission areas for different nodes. From the source node to the destination node, there can be different paths of connection at a given point of time. But each node usually has a limited area of transmission as shown in Figure 1 by the oval circle around each node. A source can only transmit data to node *B* but *B* can transmit data either to *C* or *D*. It is a challenging task to choose a really good route to establish the connection between a source and a destination so that they can roam around and transmit robust communication.

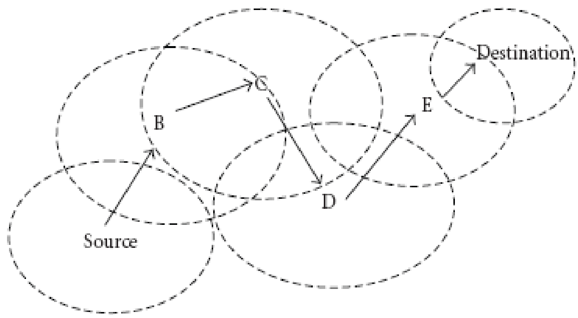


Fig. 1 Mobile Ad-hoc Network

In this paper we evaluate the performance of three on-demand routing protocols for mobile Ad-hoc network (MANET): Dynamic Source Routing (DSR), Ad Hoc On-demand distance Vector Routing (AODV) and Temporarily Ordered Routing Algorithm (TORA) by varying the size of the networks. The performance metrics selected to make the performance evaluations are Total Traffic Received, Traffic Load, Throughput, Number of Hops per Route and Route Discovery Time. This analysis was done using the MANET model in OPNET simulator [2]. OPNET Simulator is the industry's leading simulator specialized for network research and development. It allows to design and study communication networks, devices, protocols, and applications with great flexibility. This paper is organized as follows. Section 2 presents the mobile ad hoc routing protocols categories. Section 3 gives the overview of AODV, DSR and TORA protocols. Simulation environment and performance metrics are described in Section 4 and simulation results and analysis are presented in Section 5. Finally section 6 summarizes the paper.

## 2. Routing Protocols in Ad Hoc Networks

There are many ways to classify the MANET routing protocols. Depends on how the protocols handle the packet to deliver from source to destination, most of the protocol classifications are made as [3].

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### 2.1 Proactive Routing

These types of protocols are called *table driven protocol*. In the routing, the route is predefined. Packets are transferred to that predefined route. In this scheme, packet forwarding is faster but routing overhead is greater because one has to define all of the routes before transferring the packets. Proactive protocols have lower latency because all routes are maintained at all the times.
Examples of proactive are DSDV (Destination Sequenced Distance Vector), OLSR (Optimized Link State Routing).

### 2.2 Reactive Routing

These types of protocols are called *On Demand Routing Protocol*. In the routing, the routes are not predefined. A node calls for route discovery to find out a new route when needed. This route discovery mechanism is based on *flooding* algorithm which employs on the technique, a node just broadcasts the packet to all of its neighbors and intermediate nodes just forward the packet to their neighbors. This is a repetitive technique until reaches to destination; *reactive* techniques have smaller routing *overheads* but higher *latency* because a route from node A to node B will be found only when A wants to send to B. Examples of Reactive are DSR, AODV, TORA.

### 2.3 Hybrid Routing

Hybrid protocols are the combinations of reactive and proactive protocols. It takes advantages of these two protocols and as a result, routes are found very fast in the routing zone. ZRP (Zone Routing Protocol) is an example of Hybrid protocol.

## 3. Overview of AODV, DSR and TORA

Every routing protocol has its own merits and demerits, none of them can be claimed as absolutely better than others. We have selected the three reactive routing protocols – AODV, DSR and TORA for evaluation [4], [5].

### 3.1 Ad hoc On Demand Distance Vector (AODV)

In AODV [6][7] routing information is maintained in routing tables at nodes. Every mobile node keeps a next-hop routing table, which contains the destinations to which it currently has a route. A routing table entry expires if it has not been used or reactivated for a pre-specified expiration time. In AODV, when a source node wants to send packets to the destination but no route is available, it initiates a route discovery operation. In the route discovery operation, the source broadcasts route request (RREQ) packets. A RREQ includes addresses of the source and the destination, the broadcast ID, which is used as its identifier, the last seen sequence number of the destination as well as the source node's sequence number. Sequence numbers are important to ensure loop-free and up-to-date routes. To reduce the flooding overhead, a node discards RREQs that it has seen before and the expanding ring search algorithm is used in route discovery operation. The RREQ starts with a small TTL (Time-To-Live) value. If the destination is not found, the TTL is increased in following RREQs.

### 3.2 Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) [8] utilizes source routing algorithm. In source routing algorithm, each data packet contains complete routing information to reach its dissemination. Additionally, in DSR each node uses caching technology to maintain route information that it has learnt. When a source node wants to send a packet, it firstly consults its route cache. If the required route is available, the source node includes the routing information inside the data packet before sending it. Otherwise, the source node initiates a route discovery operation by broadcasting route request packets. A route request packet contains addresses of both the source and the destination and a unique number to identify the request. Receiving a route request packet, a node checks its route cache. If the node doesn't have routing information for the requested destination, it appends its own address to the route record field of the route request packet. Then, the request packet is forwarded to its neighbors. When the route request packet reaches the destination, a route reply packet is generated. When the route reply packet is generated by the destination, it comprises addresses of nodes that have been traversed by the route request packet.

### 3.3 Temporarily Ordered Routing Algorithm (TORA)

TORA [9], [10] is a distributed routing protocol based on a "link reversal" algorithm. It is designed to discover routes on demand, provide multiple routes to a destination, establish routes quickly, and minimize communication overhead by localizing algorithmic reaction to topological changes when possible. Route optimality (shortest-path routing) is considered of secondary importance, and longer routes are often used to avoid the overhead of discovering newer routes.
The actions taken by TORA can be described in terms of water flowing downhill towards a destination node through a network of tubes that models the routing state of the real network. The tubes represent links between nodes in the network, the junctions of tubes represent the nodes, and the water in the tubes represents the packets flowing towards the destination. Each node has a height with

respect to the destination that is computed by the routing protocol. If a tube between nodes **A** and **B** becomes blocked such that water can no longer flow through it, the height of **A** is set to a height greater than that of any of its remaining neighbors, such that water will now flow back out of **A** (and towards the other nodes that had been routing packets to the destination via **A**).

## 4. Simulation Environment

It is very difficult to estimate the performance of a proposed network in real life and as a result, many network simulators have been proposed to design and simulate networks in many perspectives. In the paper, simulation is performed on OPNET simulator [2]. In the simulation, a 500 x 500 meters square geographical area is selected with varying number of MANET workstations where 30% of the total nodes are source-destination pairs. One third of the total nodes in any scenario are mobile nodes, moving according to Random Waypoint Mobility Model [11]. A predefined trajectory “manet_down_left” is used in every network. Each mobile node waits for 260 seconds and starts moving along the path defined in the trajectory. The rest of the nodes are stationary nodes. Many different networks of small size like 20, 50 nodes and large size like 150,200 nodes are made to make the different scenarios. Sources start traffic generations exponentially at 100 seconds and continue till the end of the simulations.

The performance metrics selected to make the performance differences are:

1. Total Traffic Received
2. Traffic Load
3. Throughput
4. Route Discovery Time
5. Number of Hops per Route

## 5. Simulation Results and Analysis

The simulation results are shown in the following section and comparison between the three protocols are performed by varying numbers of nodes on the basis of the above-mentioned metrics.

### 5.1 Total Traffic Received

Based on MANET Traffic Received between the protocols for different network sizes, the following figures show packets received per second. For 20 nodes, after 8-10 minutes, the figure 2 shows, AODV and DSR receiving almost the same number of packets where TORA receiving almost the half of them. The packet receiving performance of AODV and DSR increases exponentially as increasing the number of nodes. For 150 nodes, the figure 3 show, the performance curves for DSR is downward after 5 minutes simulation but for AODV, the curve is upward.

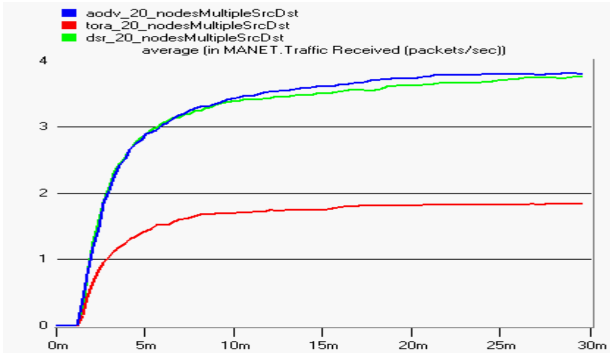

Fig. 2 Total Traffic Received for 20 nodes

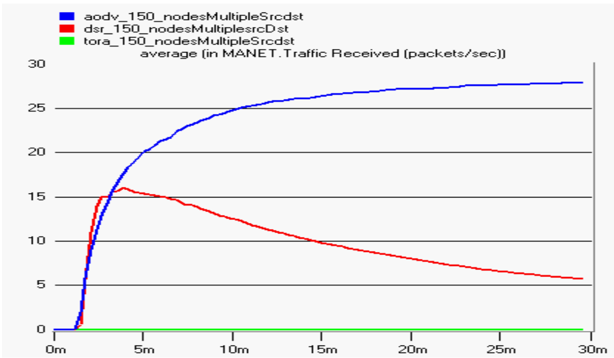

Fig. 3 Total Traffic Received for 150 nodes

### 5.2 Traffic Load and Throughput

Based on Wireless LAN Load and Throughput, the following figures show that, for different number of nodes, loads are varying compared to each other. For 150 nodes, load for DSR network increased alarmingly. For any load, AODV is showing a considerable good performance.

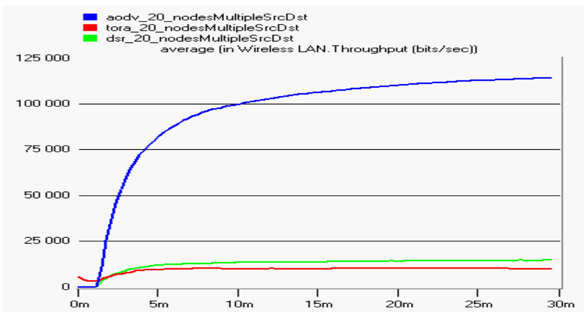

Fig. 4 Wireless LAN load for 20 nodes

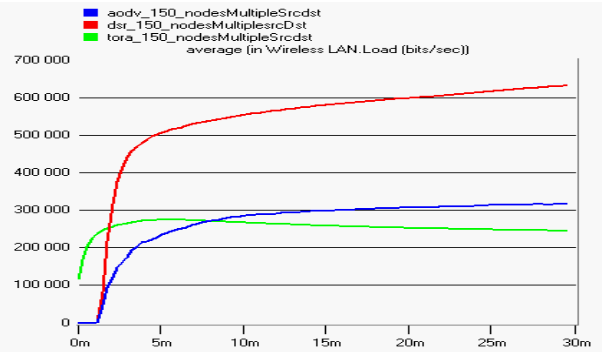

Fig. 5 Wireless LAN load for 150 nodes

For a small network such as 20 nodes network, AODV has a good throughput compared to DSR and TORA. For a large network such as 150 nodes or 200 nodes, TORA has a minimum throughput where AODV is performing well.

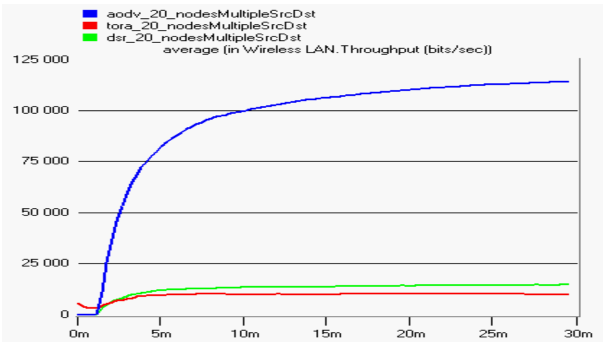

Fig. 6 Wireless LAN Throughput for 20 nodes

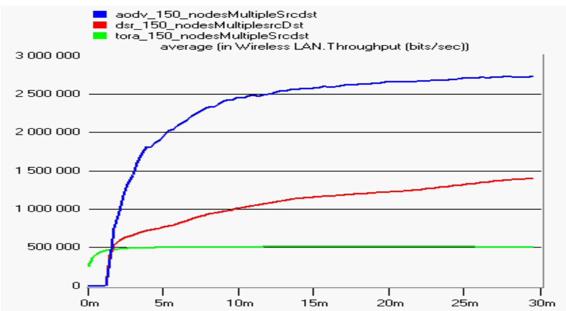

Fig. 7 Wireless LAN Throughput for 150 nodes

## 5.3 Route Discovery Time and Number of Hops between AODV and DSR

Based on number of hops required and route discovery time between AODV and DSR, the following figures show that for any number of nodes, AODV performing better than DSR. For 150 nodes, route discovery time ranging from 2.5 seconds to 3.8 seconds for DSR throughout the simulation and that's why DSR needs more hops than AODV in every route. AODV has an excellent performance, taking less route discovery time and less number of hops per route.

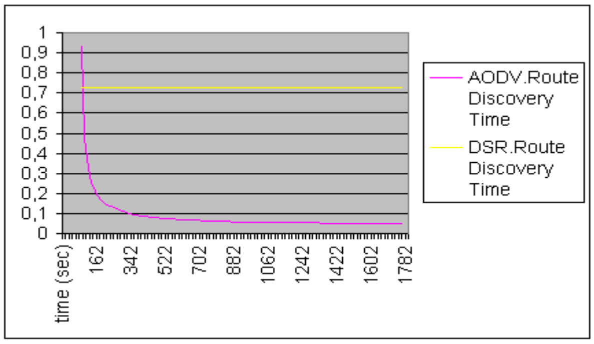

Fig. 8 Route Discovery Time for 50 nodes

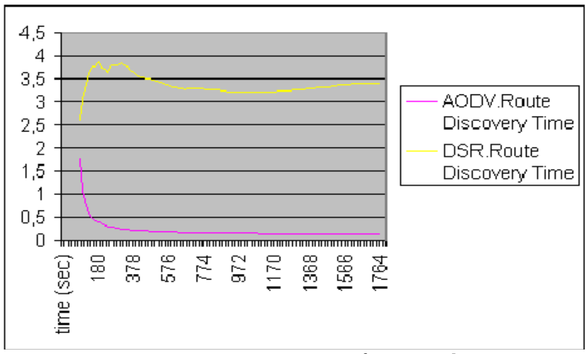

Fig. 9 Route Discovery Time for 150 nodes

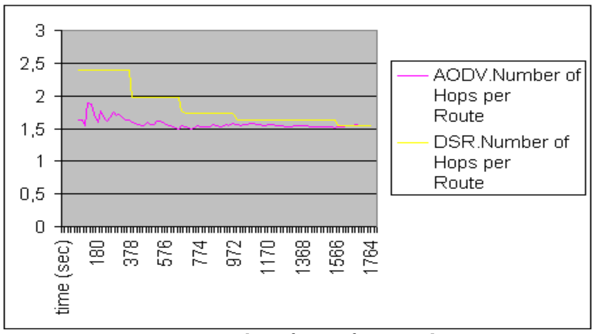

Fig. 10 Number of Hops for 50 nodes

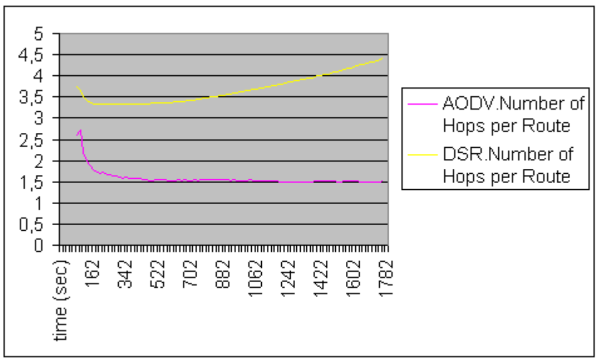

Fig. 11 Number of Hops for 150 nodes

## 6. Conclusion

The OPNET simulator provides only AODV, DSR and TORA MANET models, which are the most commonly used models in Ad hoc routing. In the paper, the performance difference is made between three protocols for different number of nodes In the paper, detail analysis of the behavior of protocols based on some important metrics such as traffic sent and received, route discovery time and number of hops per route, load and throughput is performed. The network load is selected for small size like 20, 50nodes and large size 150, 200 nodes in which one third are mobile nodes and the rest of them are stationary nodes. Multiple sources and destinations are used in every scenario. AODV and DSR receive traffics for any number of nodes but TORA creates a lot of loads in large networks like 150, 200 nodes and cannot receive considerable traffics. As a result, AODV and DSR have better performance than TORA for maximum as well as minimum number of nodes. But above of all, AODV is showing the best performance over the others in every respect.

Only Random Waypoint Mobility Model is used in this paper due to the limitation of OPNET simulator. Therefore in future different mobility models with varying mobility of nodes should be measured along with different security issues.

### References

[1] Internet Engineering Task Force (IETF) Mobile Ad Hoc Networks (MANET) Working Group Charter, Chaired by Joseph Macker and Scott Corson, http://www.ietf.org/html.Charters/manet charter.html

[2] Network Simulator, OPNET Modeler 10.5, available at http://www.opnet.com/

[3] Ankur Khetrapal, “Routing Techniques for Mobile ad hoc Networks: a quantitative and qualitative analysis”, Proceedings of International Conference on Wireless Networks (ICWN' 06)

[4] Elizabeth M. Royer and C.-K. Toh, “A Review of Current Routing Protocols for Ad- Hoc Mobile Wireless Networks”, IEEE Personal Communications Magazine, April 1999, pp. 46-55.

[5] A. Boukerche, “A performance comparison of routing protocols for ad hoc networks”, in proceedings 15th International Symposium on Parallel and distributed Processing, April 2001, pp. 1940-1946.

[6] Ian Chakeres and Elizabeth Belding-Royer, “AODV Implementation Design and Performance Evaluation”, International Journal of Wireless and Mobile Computing, Issue 2/3, 2005.

[7] C. E. Perkins and E. M. Royer, “Ad Hoc On-demand Distance Vector Routing,” In Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, February 1999, pp. 90-100.

[8] D. B. Johnson and D. A. Maltz, “Dynamic Source Routing in Ad-Hoc Ad hoc Networks," Mobile Computing, ed. T. Imielinski and H. Korth, Kluwer Academic Publishers, 1996, pp. 153 181.

[9] V. D. Park, M. S. Corson, “A Performance Comparison of TORA and Ideal Link State Routing”, Proceedings of IEEE Symposium on Computers and Communication, June 1998.

[10] V. Park, S. Corson, “Temporally-Ordered Routing Algorithm (TORA) Version 1”, Internet draft, IETF MANET working group, http://tools.ietf.org/id/draft-ietf-manet-tora-spec-04.txt, July 2001.

[11] W. Navidi and T. Camp, “Stationary Distributions for the Random Waypoint Mobility Model”, Technical Report MCS-03-04, the Colorado School of Mines, April 2003

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