



Reactive Routing in MANETs: A Performance Evaluation

Jaspreet Singh¹, C.S. Rai²

¹Research Scholar-USICT, ²Professor and Director- USICT and Research & Consultancy
University School of Information Technology, Guru Gobind Singh Indraprastha University
Dwarka Sector-14 C, New Delhi, India

Abstract: An ad-hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any existing infrastructure or centralized administration. Routing is the process of communication established for exchange of messages. The process of routing is central to any application for ad hoc networks. This paper brings about a performance comparison between three existing reactive routing protocols: AODV, DSR and LAR1. These three protocols exhibit different levels of processing requirements and overheads. Our study is different from existing studies as we are concentrating only on reactive routing methods, while most other studies compare reactive with proactive methods. Also, we are comparing the behavior of protocols vis-à-vis different mobility patterns, which we define as a combination of varying three parameters: pause time, minimum speed and maximum speed of movement. High mobility is marked by rapid movement and constantly changing topology, which has its own challenges. The goal of this study is to bring out adaptability of existing routing solutions with respect to varying network characteristics and see their suitability.

Keywords: QoS, MANET, routing protocols, Comparison, Performance Evaluation

I. Introduction

Mobile Ad-hoc networks (MANETs) are self organizing, infrastructure-less and multi-hop packet forwarding networks. There is no concept of fixed base station. So, each node in the network acts as a router to forward the packets to the next node. Ad-hoc networks are self-adaptable and capable of handling topology changes and malfunctions in nodes [6].

Routing is the process of communication established for exchange of messages. The process of routing is central to any application for ad hoc networks. Since the path is continuously changing, routing is the first process for any activity. Ad hoc networks are multi-hop networks. The key challenge in mobile ad hoc networks is to route the packets with low overheads even in dynamic conditions of node mobility, limited channel bandwidth and limited battery life of nodes. In general routing algorithms fall into one of two categories: Reactive algorithms: Here, routes are established, only when they are required, they are not readily available and Proactive algorithms: Here, regular information is exchanged between the neighbors. This information is maintained in form of tables and routes are readily available to all destinations. This also calls for more overheads, as many of these routes may not be used at all times.

The rest of this paper is organized as follows: Section II presents the simulation environment and performance metrics, Section III presents simulation results and its analysis and finally Section IV concludes the paper.

II. RELATED STUDY

Manickam et al. [2] compares three MANET Routing protocols: DSDV, AODV and DSR. It concludes that DSR is preferable for moderate traffic with moderate mobility while DSDV produces low end-to-end delay compared to other protocols, due to its proactive nature. Ehsan et al. [3] compares four different types of routing protocols: DSDV, DSR, AODV and TORA. While DSDV is a proactive protocol, others are reactive in nature. It concludes that DSR outperforms all other three. DSR generates less routing load than AODV. While AODV suffers from higher end to end delays, TORA has very high routing overhead and DSDV has a low packet delivery fraction at high mobility. Bouhorma et al. [4] compares two routing protocols: AODV and DSR and concludes that while DSR scales well in small networks with low node speeds, AODV performs better and exhibits higher packet delivery ratio even at higher mobility. Baraković et al. [5], compares performances of three routing protocols: DSDV DSR and AODV. It concludes that under low mobility scenarios, all three protocols show similar results, while under high load conditions or high mobility, AODV performs pretty well.

DSDV depicts a low packet delivery fraction while DSR shows overall low performance of higher Normalized Routing Load and higher delay.

III. SIMULATION ENVIRONMENT AND PERFORMANCE METRICS

We have used Glomosim 2.03 simulator for studying the behavior of these routing protocols. Global Mobile Information System Simulator (GloMoSim) is a parallel discrete-event simulator which provides a scalable network environment [1]. For our comparison purpose, we simulate the running behavior of three existing reactive routing protocols: AODV, DSR and LAR1.

A. Fixed Parameters

Field Size: A field of size 800m X 1000 m has been selected for node movement.

Traffic Type: We have used Constant Bit Rate traffic. CBR offers a fixed traffic pattern, generating it continuously at designated rate, unlike TCP. Such constant traffic rate may be generated by applications such as audio, video or other fixed forms of data. For our study, the traffic generation rate has been fixed at four packets per second. The size of each data packet is 512 Bytes.

Mobility Model: We use the Random Waypoint Model for movement of nodes. In Random Waypoint model, a node randomly selects a target point and moves in that direction with a speed chosen randomly between a minimum and a maximum speed. After reaching the target, node waits at that point for certain specified time called the pause-time and then moves again.

These parameters are summarized as below:

Table 1: Parameters used for the simulation

Parameter Name	Value
Environment Size	800m X 1000m
Mobility Model	Random Waypoint
Traffic type	Constant Bit Rate
Packet size	512 Bytes
Packet Rate	4 packet /s
MAC-Protocol	802.11
Radio Transmission Power	15 dB
Simulation Time	100 sec

B. Variable Parameters

We compare the performance of above protocols vis-à-vis type of mobility and also number of nodes. We take into account three different mobility patterns: low, medium and high mobility. A low mobility is characterized with fairly static network topology, while a high mobility is marked by constant changing topology. In our experimental setup, we define mobility by varying speed of movement and also pause time between two movements. We define mobility as follows:

Low Mobility: Speed between 0 and 5 m/sec and pause time of 25 sec.

Medium Mobility: Speed between 5 and 15 m/sec and pause time of 10 sec.

High Mobility: Speed between 15 and 25 m/sec and pause time of 1sec.

Number of nodes: We repeat the simulation by varying number of nodes as 10, 25, 50 and 100. The node density directly affects the routing behavior. The more the number of nodes, more will be the number of packets to be sent and received. The behaviour of a protocol will vary as the number of nodes increases.

C. Performance Metrics

The metrics being used to evaluate the performance of routing protocols in this paper are: average end-to-end delay, Packet Delivery Fraction and throughput of the network.

Average end-to-end delay: The end-to-end delay of a packet represents the time it takes to route a packet from source to the destination. This delay consists of propagation delay, queuing delay, and transmission delay introduced by network components. The average end-to-end delay is the average of end-to-end delay of all the packets which are successfully delivered. The end to end delay is important because most applications need a small latency to deliver usable results. It shows the suitability of the protocol for these applications.

Packet delivery fraction: The packet delivery ratio is defined as the ratio between the number of packets received by the destination to the number of packets sent by the source. It describes percentage of the packets which reach the destination. A high percentage is desirable and reflects the reliability of the network.

Throughput: Throughput of a network is defined as the number of packets received by destination per unit time. A higher throughput reflects a higher efficiency of the network. However, a higher throughput may result in longer end to end delays.

IV. SIMULATION RESULTS AND ANALYSIS

A. Comparative Analysis of MANET protocols as a function of mobility

1) *Average end to end delay:* The trend shows that end to end delay decreases, as mobility increases from low to medium, and then increases again, as mobility increases again from medium to high. AODV is least affected by mobility pattern, while DSR is most affected. This proves that moderate mobility is better than a static network and it reduces end to end delay. However, high mobility leads to frequent topology changes and greater delays. AODV shows a fairly constant delay, irrespective of speed of movement and the pause time. DSR, in contrast, depicts a high delay when mobility is less. This delay decreases as mobility increases from low to medium and then again increases, as mobility increases from medium to high. We attribute the reason for this to the fact that at low mobility, if nodes are far apart, then end to end delay is more. However, as mobility increases, the probability of nodes coming within transmission range increases, during the transmission interval. This leads to lower delays and higher delivery ratio. However, as mobility increases further, the network topology changes very fast. As a result, the available routes obsolete out very fast, leading to frequent route discoveries. Hence the overheads increase and therefore, average end to end delay increases very fast.

Fig 1: Average end to end delay versus mobility

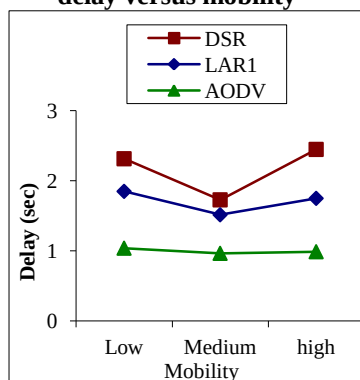


Fig 2: Packet delivery fraction versus mobility

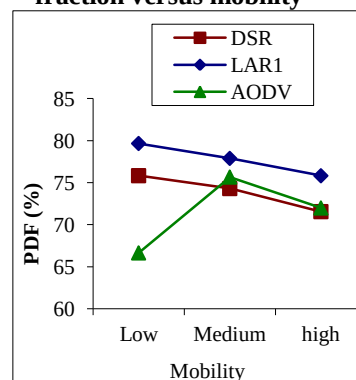
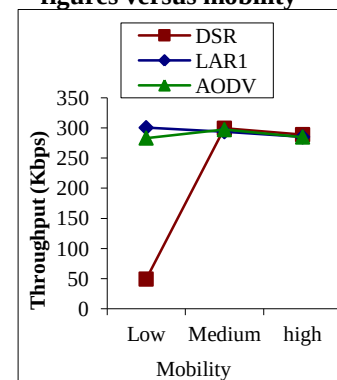


Fig 3: Average throughput figures versus mobility



2) *Packet delivery fraction:* The trend clearly shows that packet delivery fraction decreases with higher mobility. This result is as per expectation. Higher mobility leads to frequent topology changes and routes become obsolete. Hence many packets are dropped in the process. LAR1 shows better packet delivery fraction than other two. This is probably due to accurate prediction of destination location. This expected location is helpful in targeted broadcast. A noted exception is this behavior is AODV at low mobility. Packet delivery fraction for AODV is particularly less at low mobility. This fraction however improves and becomes comparable to DSR at medium mobility and then it decreases again at high mobility, which is natural. This lower packet delivery fraction for AODV at low mobility may be attributed to the fact that network is quite static. Hence two nodes, which are unable to send packets across to each other, will keep dropping packets, as the network is static. However, when the mobility increases, chances are that such nodes may move closer to each other, within the transmission interval and paths may get established. But when mobility increases further, from medium to high, the network becomes highly dynamic and frequent path breaks occur. This leads to high packet dropout ratio. The reason why DSR and LAR1 are able to have high packet delivery ratio for low mobility is due to their path optimization features. DSR runs in promiscuous mode and listens to all Route Replies and Route Requests, to update its path information. LAR1 uses GPS information to find approximate location of destination. For fairly static network, there is hardly any change and therefore, packet delivery ratio is high.

3) *Average Throughput:* Throughput is the number of packets received by destination per unit time. The graph shows that throughput of LAR1 and AODV exhibits a fairly constant rate, irrespective of mobility. The effect of mobility on their throughput is minimum. Because the traffic pattern and traffic density remains the same between low and high mobility, there is not much variation in packets received per unit time. A noted exception to this trend is the behavior of DSR at low mobility. However, this throughput improves significantly and becomes equal for DSR, AODV and LAR1, at medium and high mobility.

B. Comparative Analysis of MANET protocols as a function of number of nodes

Fig 4: Average end to end delay Vs No. of nodes

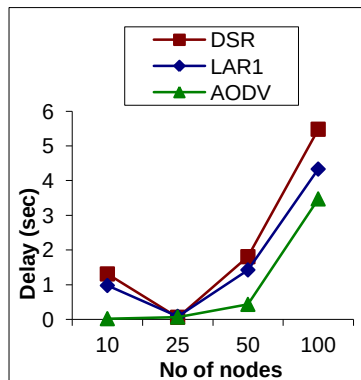


Fig 5: PDF Vs No. of nodes

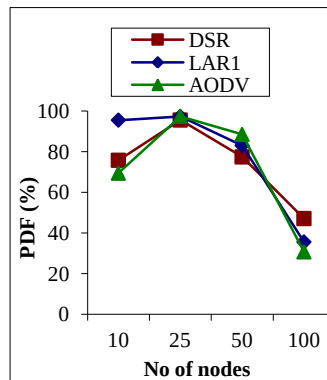
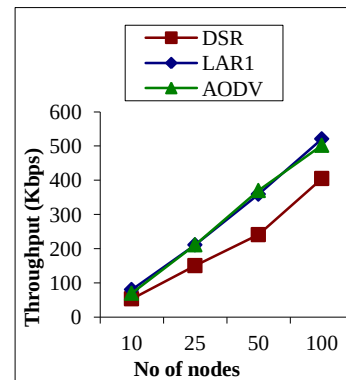


Fig 6: Avg. throughput Vs No. of nodes



1) *Average end to end delay*: The end to end delay as a function of number of nodes, clearly shows that there is a non-linear increase in the delay with increase in nodes. As the number of nodes increase, the number of nodes in the transmission range also increases. This increases overall traffic and number of packets handled by a node per unit time increases manifold. Therefore, there is a significant increase in Route Requests, Route Replies and data packets generated. This leads to appreciable increase in queuing and transmission delays, as more requests are lined up at each node. This in turn automatically pushes the end to end delay, as nodes increase. The trend shows that end to end delay decreases slightly, as number of nodes increase from 10 to 25. This is due to the fact that for 10 nodes, nodes are sparse and far spread out. Hence many packets time-out and reach their destination late. However, as nodes increase to 25 and node density becomes desirable, paths become easily available and queuing delays are also manageable. Here the network exhibits best end to end delays. With further increase in number of nodes, the number of messages increases non-linearly. This affects the end to end delays and it increases beyond this point. It increases moderately from 25 to 50 nodes and then significantly, as nodes increase from 50 to 100.

From the data we can find that average delay is almost same for all three protocols, when number of nodes are 25. However, for 50 nodes, AODV clearly outperforms DSR and LAR1. LAR1 has the highest average end to end delay for 50 nodes. This performance is maintained, as nodes increase from 50 to 100 and DSR exhibits highest end to end delay. The graph clearly shows that AODV clearly outperforms DSR and LAR1. AODV being a simple algorithm, the delay here is minimum. However, LAR1 and DSR have significant overheads, which cannot be overlooked. These overheads are due to more processing required, to optimize the routes.

2) *Packet delivery fraction*: The trend here is that PDF decreases with increasing number of nodes. Initially, when nodes increase from 10 to 25, PDF increases slightly, due to easy availability of routes between source and destination. However, as nodes increase further to 50 and 100, there is a decrease in PDF. This decrease is quite natural. With more nodes in the transmission range, there is an explosion in number of Route Requests, Route Replies and even data messages. Many of these messages time out, due to increased queuing and processing delays. Hence, it results in overall reduced PDF. This decrease is more marked as nodes increase from 50 to 100 than from 25 to 50. It clearly means that network degradation starts with increasing node density and it becomes significant when network size increases to 100 and beyond. Of the three protocols, LAR1 exhibits highest PDF, when nodes are 10, but becomes comparable to other two when nodes increase to 25 and 50. At 100 nodes, DSR has slightly better PDF than AODV and LAR1.

3) *Average Throughput*: The trend clearly shows that average throughput grow linearly with increasing number of nodes. This is depicted by all the three protocols. It can be attributed to the fact that as the nodes increase, so does the number of packets generated by them. When overall volume of traffic increases, more traffic is handled by every node and every link per unit time. This pushes up the throughput of the system. Therefore, we can say that bigger network is good, if throughput is the only parameter. However, higher throughput has to be seen in context of higher PDF and end to end delay, and not in isolation. Both LAR1 and AODV exhibit comparable throughput and DSR exhibits lowest throughput, of the three.

V. CONCLUSION

The metrics like end to end delay, throughput and packet delivery fraction are not mutually exclusive, but are overlapping. The improvement of one may lead to degradation of another. For example, though throughput of

the system may improve, the end to end delay might actually increase. Therefore, the selection of protocol should be on the basis of actual requirement. AODV has lowest end to end delay, than its counterparts. This is due to its simplicity and low overheads. DSR, on the other hand, has highest delays. This is due to its promiscuous mode of operation. LAR1 exhibits highest PDF than other two. This actually means that if we can calculate approximate location of target, it might actually help in increasing PDF. In terms of throughput, both AODV and LAR1 exhibit fairly better throughput than their counterparts. From above results, we can easily conclude that no single solution is apt for all situations and all types of networks. Each solution has its own strengths and weaknesses. These results are summarized in the table below.

Table 2: A Comparison of various aspects of AODV, DSR and LAR1

	AODV	DSR	LAR1
Nature	Reactive	Reactive	Reactive
No. of Paths	Single path	Multi-path	Single path
Address field in Data packets	Packet contains only next-hop information	Packet contains entire path	Packet contains only next-hop information
Multiple paths information	Only single path	Only source has multiple paths to destination	Only single path
Load Balancing	No	No	No
Adaptability to network load	Not adaptable	Not adaptable	Not adaptable
Categorization of paths	No	No	No
Network signal monitoring	Not present	Not present	Not present
End to End Delay	Lowest	Highest	Moderate
PDF	Moderate	Low for Low Mobility	Highest
Throughput	Comparable to LAR1	Low for Low Mobility	Highest

VI. References

- [1] Jorge Nuevo, "A Comprehensive GloMoSim Tutorial", March 2004.
- [2] P. Manickam, T. Guru Baskar, M. Girija, D. Manimegalai, "Performance Comparisons Of Routing Protocols In Mobile Ad Hoc Networks", *IJWMN* Vol. 3(1), 2011.
- [3] Humaira Ehsan' and Zartash Afzal Uzmi, "Performance Comparison Of Ad Hoc Wireless Network Routing Protocols", *IEEE INMIC* 2004.
- [4] Mohammed Bouhorma, H. Bentaouit and A. Boudhir, "Performance Comparison of Ad-hoc Routing Protocols AODV and DSR", *IEEE Multimedia Computing and Systems*, 2009.
- [5] Sabina Baraković, Suad Kasapović, and Jasmina Baraković, "Comparison of MANET Routing Protocols in Different Traffic and Mobility Models", *Telfor Journal*, Vol. 2, No. 1, 2010.
- [6] C. Sivaram murthy, B. S. Manoj, *Adhoc wireless networks: Architectures, and protocols*, Pearson Education, 2004.
- [7] S. Corson and J. Macker, "Mobile Ad-hoc networking: Routing protocol performances and evaluation considerations", In *RFC* 2501, 1999.
- [8] C. Toh, "Challenges in MANET", *IEEE Communication*, 2001.
- [9] E. M. Royer and C. K. Toh, "A review of current routing protocols for Ad-hoc mobile wireless networks", *IEEE Personal Communications*, 6(2), Apr. 1999.
- [10] Subir Kumar Sarkar, T. G. Basavaraju, C. Puttamadappa, "Ad Hoc Mobile Wireless Networks: Principles, Protocols, and Applications", *CRC Press*, 2007.