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A Simulative Comparison of AODV and DSR On-Demand Routing Protocols for Mobile Ad-Hoc Networks

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ABSTRACT

Background: Mobile Ad-hoc NETwork is a collection of two or more mobile nodes that has no infrastructure support, and every mobile node can work as a router. In MANET mobile nodes can move arbitrarily, consequently the system topology changes in random manner. Practically, in order to allow mobile nodes to communicate with each other, a routing protocol is desired to discover routes between nodes, and determines how information is transmitted from a source node to a destination node. Basically, MANET routing protocols are classified into two categories: On-demand and Table-driven. On-demand protocols are utilized whenever a communication is needed. The most widely researched on-demand MANET protocols: DSR (Dynamic Source Routing protocol) and AODV (Ad hoc On-demand Distance Vector protocol). **Objective:** The main aim of this paper is to simulation based analysis of DSR and AODV protocols on the basis of different performance metrics which are packet delivery fraction (PDF), routing overheads (RO), and end-to-end delay. The simulation is performed through the simulation tool Global Mobile Simulator due to its open source simplicity and free availability. **Results:** in considered mobility scenarios, AODV gives better PDF than DSR, while DSR gives better RO and End-to-End delay in most mobility scenarios. **Conclusion:** In this article, an effort has been made to concentrate on the comparative study of well known on-demand protocols (AODV and DSR). Consequently, a single MANET routing protocol cannot accomplish best in all circumstances. Therefore, the preference of MANET routing protocol should be done carefully according to the conditions of the definite application.

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INTRODUCTION

Mobile Ad hoc Network (MANET) is created by mobile nodes which communicate with each other without necessarily using any infrastructure requirements such as that presented by base stations (Sarkar *et al*., 2013; Jing *et al*., 2013). In MANETs, each mobile node works as a host where applications can reside, also as a router so that it can send, receive and forward packets for other nodes in the network. However, because of the limited transmission range of mobile nodes, more than one hop may be needed to send and receive data across the network (Labiod, 2008). In order to facilitate communication within the network, a routing protocol is used to discover paths between nodes. Nodal mobility can cause unpredictable topology changes in MANETs (Jing *et al*., 2013; Goyal *et al*., 2011). Therefore, a highly adaptive routing policy is required to deal with the dynamic topology. The major aim of such a MANET routing protocol is a valid and efficient path between a pair of mobile nodes.

Numerous classes of routing protocols for MANETs have been proposed. They can be classified into two categories (Sarkar *et al*., 2013; Labiod, 2008; Tyagi and Chauhan, 2007): On-Demand and Table-Driven. A number of different on-demand protocols have been designed to improve the performance of on-demand routing. They try to discover a route to destination only when it is desired by source. In order to avoid the need for such a route discovery to be performed before each data packet is sent, such routing protocols must cache routes previously discovered. The Dynamic Source Routing (DSR) (Johnson *et al*., 2003) and Ad hoc On-demand Distance Vector routing (AODV) (Perkins *et al*., 2011) are the most popular on-demand protocols.

Review of AODV and DSR:

1. Dynamic Source Routing (DSR):

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The DSR (Johnson *et al*., 2001; David *et al*., 2001; David and Johnson, 1994; Garrido and Marandin, 2007) forms a route on-demand when a transmitter requests one. However, DSR utilizes Source-Routing technique instead of relying on the routing table at each intermediate mobile node. DSR is based on source routing. It has only two major phases which are Route Discovery and Route Maintenance. To return the Route REPly (R.REP) packet, the destination must have a route to the source. If the route is in the Destination Node's route cache, the route would be used. Otherwise, the node will reverse the route based on the route record in the R.REP header. In the case of failure data forwarding, the Route Maintenance scheme is started whereby the Route ERRor (R.ERR) packets are generated at a node. The failure link will be removed from the route cache; all routes containing the failure link are truncated at that point. Then, the source recalls the route discovery scheme (Yadav and Pankaj, 2013; Sandhu, 2013).

DSR aims to limit the bandwidth that consumed by control packets in MANETs by eliminating the periodic update packets that needed in the table-driven approach (Lu, 2010). The key difference between DSR and the other reactive routing protocols is that it is beacon-less, therefore it does not need periodic Hello-Packet transmissions, which are utilized by a node to inform its neighbor nodes of its presence (Narendra and Yadav, 2009). The essential method of DSR during the route discovery scheme is to set up a route by flooding Route REQuest (R.REQ) messages in the network. The destination node, on receiving a R.REQ, responds by sending a R.REP back to the source, which carries the route traversed by the R.REQ received.

DSR employs a reactive (on-demand) approach which eliminates the need to periodically flood the network with table update packets which are required in a table-driven approach (Narendra and Yadav, 2009). In this approach, a route is established only when it is needed. The middle nodes also employ the route cache information efficiently to decrease the overhead. The drawback of DSR is that the route maintenance scheme does not locally repair failure links. Broken route cache information could also outcome in inconsistencies during the route discovery scheme (Sundaram *et al*., 2013). In addition, considerable overhead is involved due to the source-routing mechanism. This overhead is immediately proportional to the route length (Gangwar and Krishan, 2012).

2. Ad-hoc On-demand Distance Vector Routing (AODV):

The AODV is an on-demand protocol (Perkins *et al*., 2011); it establishes a route to a destination only on demand. In AODV, the MANET stays silent until a connection process is required. At that point the AODV node that needs a connection propagates a R.REQ packet for connection (Bhadauria and Singh, 2013). Other AODV nodes forward this R.REQ packet, and record the sender node, creating an explosion of temporary routes back to the destination node. When a node receives such a R.REQ packet and already has a route to the intended destination node, it sends a R.REP packet towards to the source node. The source node then starts utilizing the shortest route that has the least number of hops toward the destination. However, in case of a link failure, a route error (R.ERR) packet is sent back to the destination node, and the route discovery repeats.

In AODV, much of the complexity is to decrease the total number of control packets to conserve the capacity of the MANET (Bhadauria and Singh, 2013). Another such attribute is that the R.REQ packet has a "time to live" number that limits how many times they can be resend. Another such feature is that if a R.REQ fails, another R.REQ may not be sent until twice as much time has passed as the timeout of the prior R.REQ.

The major advantage of AODV is that routes are created on-demand and destination sequence numbers are employed to discover the latest route to the destination (Morshed *et al*., 2009). One of the disadvantages of AODV is that middle nodes can lead to broken routes if the source sequence number is very old and the middle nodes have a higher but not the most recent destination sequence number, consequently having broken routes (Singh *et al*., 2012). Also many R.REP packets in answer to a single R.REP packet can lead to serious routing overhead. One more disadvantage of AODV is that the periodic beaconing leads to redundant bandwidth consumption (Yadav and Pankaj, 2013).

Simulation Based Analysis:

This section described the simulation tool, network topology, Simulation parameters and simulation results. The performances of on-demand (AODV and DSR) routing protocols are evaluated on the basis of three performance metrics mentioned bellow.

1. Simulation Environment:

In this paper the simulation of AODV and DSR routing protocols is done by using Global Mobile Simulation (GloMoSim) software. For all the simulations carried, a total of 5 simulation runs have been carried out for each performance metric and the simulation results are discussed below.

2. Performance Metrics:

In this section, we utilize the following performance metrics (Buchegger and Le, 2002; Tang and Wei, 2008):

a) Packet delivery ratio: the ratio of the data packets delivered to the destination to those generated by the sources.
b) Routing overhead ratio: the ratio of the total number of routing packets transmitted to the number of data packets received. This metric is an important as it measures the scalability of the protocol.
c) End-to-End Delay: the average elapsed time to send a packet from source to destination.

3. Simulation Parameters:

In this section, we report the results of the simulation experiments for DSR and AODV protocols. The simulation parameters are summarized in Table (1).

Table 1: Simulation Parameters.

Parameter	Value
Simulation-Time	900 sec
Terrain-Dimensions	2200m x 600m
Number-of-Nodes	50 mobile nodes
Pause Time	0, 300,600 and 900 sec
Routing-Protocol	DSR / AODV
Data traffic - CBR	4 UDP packets a second
Packet Size	512 bytes
Nodes speed	0-10 m/s

4. Simulation Results:

The simulation results are shown in the following section in the form of comparative graphs. In this paper an attempt has been made to compare the performance of two well known on-demand routing protocols AODV, and DSR according to above mentioned topology as shown in Table (1).

Packet Delivery Ratio (PDF):

Analyzing packet delivery ratio, we come to the conclusion that AODV routing protocol outperforms DSR protocol (Fig. 3.1) in all mobility environments except low mobility when (Pause Time=900). Basically, with increasing of mobility broken links occur very often, which leads to increase the broken routes in DSR’s route caches. In this case, nodes may utilize that cached broken routes in future. Therefore, source nodes may fail to deliver their data packets to intended destination nodes which increase the number of dropped data packets. That is the main cause why contribution to DSR’s packet delivery ratio comes from increased number of dropped data packets. In contrast, in AODV for any network topology change the route discovery mechanism has to be applied, and the routing table updated frequently. That is the major cause why broken links do not contribute very much to AODV’s packet delivery ratio. Practically, in AODV a great contribution comes from the periodic update of routing tables. However, in most considered mobility scenarios, AODV protocol gives more packet delivery ratio than DSR protocol.

Routing Overhead (RO):

Analyzing routing overhead, we come to the conclusion that DSR routing protocol outperforms AODV protocol (Fig. 3.2) in all cases. Basically, with increasing of mobility broken links occur very often. Broken links start route discoveries in AODV, because sources have just one route per destination in their routing table. Therefore, frequency of route discovery in AODV is immediately proportional to number of broken links. That is the main cause why contribution to AODV’s routing overhead appears from route request packets. In contrast, the response of DSR to broken links is moderate and calls route discovery process less often in comparison. The main reason is lots of cached routes at each DSR node, and source node does not apply the route discovery process until all cached routes fail. That is the major cause why route request packets do not contribute very much to DSR’s routing overhead. Practically, in DSR a great contribution comes from route reply packets. Nevertheless, in all considered mobility scenarios, DSR protocol causes significantly less routing overhead than AODV protocol.

End-To-End Delay:

Analyzing average end to end delay, we come to the conclusion that DSR routing protocol outperforms AODV protocol (Fig. 3.3) in all cases expect when (Pause Time=0). Basically, in AODV for any network topology change the route discovery mechanism has to be applied and nodes have to send route request packets, because it is on-demand routing protocol that has no available route when required. In addition, because of inefficient route repair of AODV, the end-to-end delay is the largest. In contrast, DSR routing protocol stores routes to all destinations in its route cache for future use, despite of topology changes. However, DSR protocol has the best performances compared to AODV in all mobility scenarios expect when (Pause Time=0), as DSR doesn’t depend on periodical updates, and utilizes route caching and source routing, in addition to caches multiple routes per destination.

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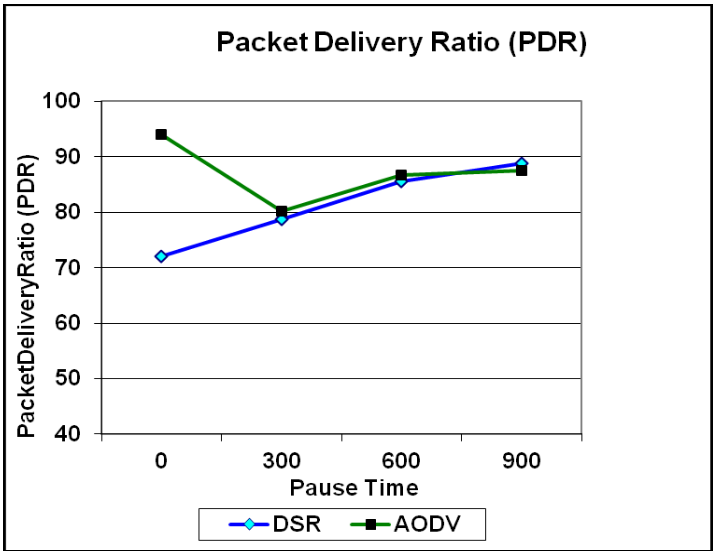

Fig. 3.1: Packet Delivery Ratio vs. Pause Time.

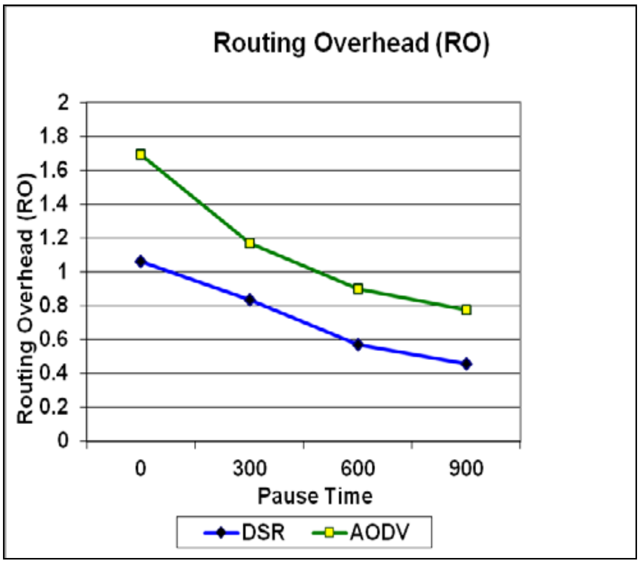

Fig. 3.2: Routing Overhead vs. Pause Time.

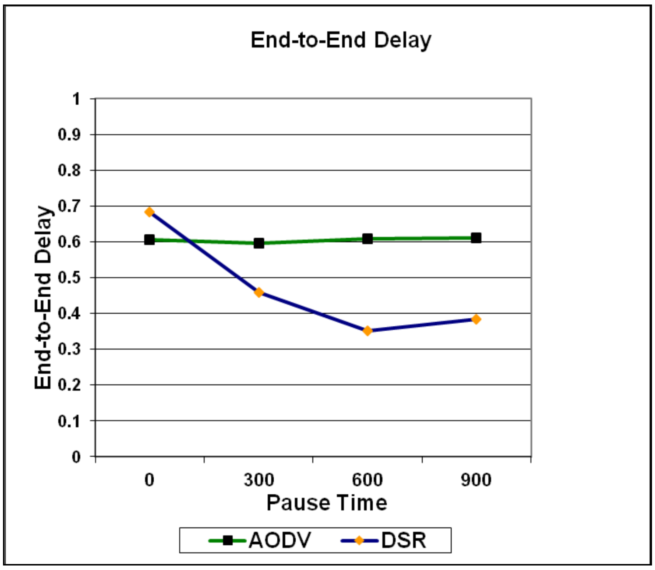

Fig. 3.3: Routing Overhead vs. Pause Time.

Conclusion:

This paper explained the classification of MANET routing protocols according to the routing approach. We discussed some significant features of the most popular on-demand routing protocols. In this article, an effort has been made to concentrate on the comparative study of well known on-demand protocols (AODV and DSR). In considered mobility scenarios, AODV gives better PDF than DSR, while DSR gives better RO and End-to-End delay in most mobility scenarios. As a result, a single MANET routing protocol cannot accomplish best in all circumstances. Therefore, the preference of MANET routing protocol should be done carefully according to the conditions of the definite application. The focus of the research in our future work is to present an extension of the existing popular on-demand routing protocols which will be superior in terms of packet delivery ratio, routing overhead and end-to-end delay.

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