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Comparison of AODV and DSR on the basis of performance matrices in MANET a Survey

Prachi Mishra, Neelesh Gupta
Truba Inst. of Engg. & Information Technology

Abstract*—This MANETs are being widely studied and it is the technology that is attracting a large variety of applications. Routing in MANETs is considered a challenging task due to the unpredictable changes in the network topology, resulting from the random and frequent movement of the nodes and due to the absence of any centralized control. Efficient routing protocols can provide significant benefits to mobile ad hoc networks in terms of both performance and reliability. In this paper, we evaluate the performance of two reactive routing protocols, Ad hoc On demand Distance Vector (AODV) and Dynamic Source Routing (DSR). The major goal of this study is to analyze the performance of well known MANETs routing protocol in random mobility case. Hence it becomes important to study the impact of mobility on the performance of these routing protocols. The performance is analyzed with respect to performance matrices like Average End-to-End Delay, Normalized Routing Load (NRL), Packet Delivery Fraction (PDF), and Throughput and also measures the performance of TCP and UDP packets. Analysis results verify that AODV gives better performance as compared to DSR.

***Index Terms*—MANET, Routing protocols, AODV, DSR.**

I. INTRODUCTION

Mobile networks can be classified into infrastructure networks and Mobile Ad Hoc Networks (MANET) according to their dependence on fixed infrastructures [1]. In an infrastructure mobile network, mobile nodes have wired access points (or base stations) within their transmission range. In contrast, Mobile Ad Hoc networks are autonomously self-organized networks without support of infrastructure. In a Mobile Ad Hoc Network, nodes move arbitrarily, therefore the network may experience rapid and unpredictable topology changes. Routing paths in MANETs potentially contain multiple hops, and every node in MANET has the responsibility to act as a router. Routing in MANET [2, 3] has been a challenging task ever since the wireless networks came into existence. The major reason for this is the constant change in network topology because of high degree of node mobility. A number of protocols have been developed to accomplish this task. Elizabeth Royer and Chai-KeongToh wrote “A Review of Current Routing Protocols for ad hoc Mobile Wireless Networks” [3] in 1999, ad hoc networks have made significant progress. Many new classes of protocol have been developed, expanding the two main classes considered in [3]. Routing is the process of selecting paths in a network along which to send data packets. An ad hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad-hoc network. In ad hoc networks, nodes do not start out familiar with the topology of their networks; instead, they have to discover it. The basic idea is that a new node may announce its presence and should listen for announcements broadcast by its neighbors. Each node learns about nearby nodes and how to reach them, and may announce that it can reach them too. The routing process usually directs forwarding on the basis of routing tables which maintain a record of the routes to various network destinations. Thus, constructing routing tables, which are held in the router's memory [2, 4] and the route establishment and data delivery are perform on the basis of routing table.

A.Classification of routing protocols

There are mainly three types of Routing protocols used in MANET

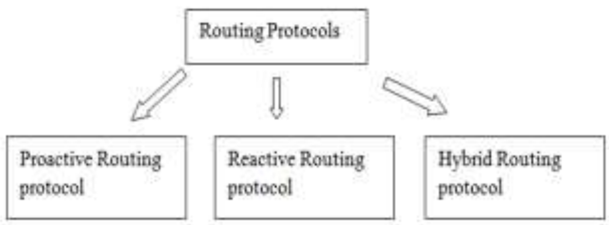

Fig 1: Classification of routing protocols

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A. *Proactive Routing Protocol (Table Driven)*

It periodically updates the routing table. Proactive protocols continuously learn the topology of the network by exchanging topological information among the network nodes. When there is a need for a route to a destination then the route information is available immediately. And if the network topology changes too frequently the cost of maintaining the network might be very high. But if the network activity is low then the information about actual topology might even not be used e.g. Optimized Link State Routing (OLSR), Dynamic Destination-Sequenced Distance-Vector Routing Protocol (DSDV) , Cluster-head Gateway Switch Routing (CGSR) Fish-eye State Routing (FSR).

B. *Reactive Routing Protocol (On Demand)*

The reactive routing protocols are based on some sort of query-reply dialog. These protocols proceed for establishing route(s) to the destination only when the need arises. It does not periodically update the routing table e.g. Ad-hoc On-demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), Associativity Based Routing (ABR).

II. OVERVIEW OF AODV AND DSR

A. *AD HOC On-Demand Distance Vector (AODV)*

It allows mobile nodes to quickly obtain routes for new destinations, and it does not require nodes to maintain routes to destinations that are not in active communication [24, 26]. When a source has data to transmit to an unknown destination, it broadcasts a Route Request (RREQ) for that destination. If the receiving node is the destination or has a current route to the destination, it generates a Route Reply (RREP). AODV routing protocol allows mobile nodes to respond link breakages and changes in network topology in a timely manner. If data is flowing and a link break is detected, a Route Error (RERR) is sent to the source of the data in a hop-by-hop fashion. Each node in the network maintains a route table entry for each destination in its route table, which contains:-

- Number of hops (Hop count)
- Destination sequence number
- Destination IP address
- Active neighbors for this route
- Lifetime (Expiration time of the route)
- Next hop

a. *Route discovery and Route maintenance*

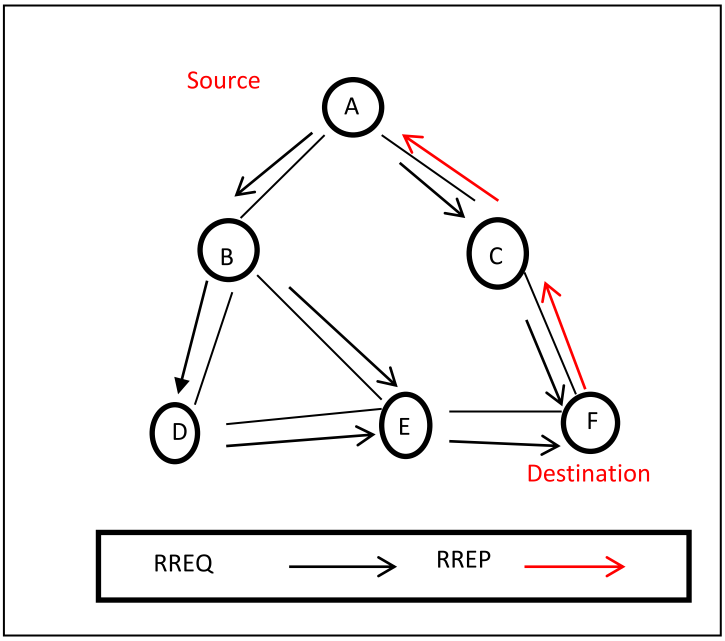

Fig 2: Route discovery & maintenance

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When a node called the source node has data to send to another node in the network, called the destination the source looks in its routing table to find a route to the destination. If there is no such route or the route is marked as invalid by an appropriate flag, the source propagates a RREQ message to its neighboring nodes. The source node before sending the RREQ message increments the RREQ ID by one and the source sequence number in the message header. In this manner, each RREQ message is uniquely identified by combining the above numbers with the source IP address. Any intermediate node that receives an RREQ message takes one of the following three actions: Firstly, the intermediate node discards the RREQ message if it has previously received the same RREQ message. If the intermediate node has a valid route to the destination node then it reverses a RREP message back to the source node. If the intermediate node does not have a valid route to the destination then it further broadcasts the message to its neighboring nodes. The destination node, which finally receives the RREQ message increments the destination sequence number and reverses an RREP message back to the source node. Once the source node receives the RREP message, it updates its routing table with the fresh route. Figure 2 shows the route discovery process from source node A to destination node F.

The route maintenance process in AODV is simple. When the link in the path between node A and node F breaks, the upstream node that is affected by the break, in this case node C generates and broadcasts a RERR message. The message ends up in source node A. Upon receiving the REER message, node A will generate a new RREQ.

b. Advantages and Disadvantages of AODV

The two main advantages of AODV are its reactive nature, which reduces the routing overhead in the network and the use of destination sequence numbers that helps in avoiding loops[29,25]. A disadvantage of this protocol is that intermediate nodes can lead to inconsistent routes if the sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number. The overhead of control message can be introduced when every intermediate node originates a RREP message to satisfy a route discovery request if it has avalid route to the destination causing a RREP messages storm. Another disadvantage of AODV is that the propagation of periodic HELLO messages from a node to maintain connectivity with its neighboring nodes will lead to bandwidth consumption. AODV are well suited for large networks.

B. DYNAMIC SOURCE ROUTING (DSR)

Dynamic source Routing (DSR) is a reactive routing protocol that uses source routing to send packets. It is reactive like AODV which means that it only requests a route when it needs one and does not require that the nodes maintain routes to destinations that are not communicating. It uses source routing which means that the source must know the complete hop sequence to destination. The route discovery process is initiated only if the desired route cannot be found in the route cache. [27, 23, 28].

a. Route Discovery

Each node in the network maintains a route cache in which it caches the routes it has learned. When a node wants to send a data packet to another node in the network, it first looks in its route cache to find a route to the destination. If such a route exists source node attaches to the packet header the complete route to the destination and forwards the packet to the next node. Then that node checks the packet header and forwards the packet to the next node. The procedure terminates when the packet reaches the destination. If the source node cannot find a route to the destination in its route Cache then it initiates a route discovery process that is it broadcasts a route request (RREQ) to its neighboring nodes and add a unique request ID to prevent other nodes from transmitting the same request. Each of the neighboring nodes checks in its Route Cache and if it finds such a route then it sends a Route Reply (RREP) message back to the source node with the complete path to the destination or else the destination node is obliged to do this task. AODV also uses these two mechanisms [24].

b. Route Maintenance

In route maintenance, source node detects another route towards the destination if the network topology change or existing link breaks. Each node transmitting the packets which confirm the packets are received by the next node through the source route. If confirmation is not received, this node receives ROUTE ERROR (RERR)[24] message to the source node. Here link is broken. DSR has additional route maintenance features to improve its functionality. A packet salvaging mechanism includes the actions taken by any intermediate node when a link-break event is detected. Then the intermediate node after sending the Route Error (RERR) message may search in its own route cache to find new route to the destination. When such a route exists, the intermediate node replaces the original source route on the packet with the new route and marks the packet as salvaged to prevent unnecessary retransmissions of the same packet by other nodes, and forwards the packet to the new next node. An automatic route shortening mechanism starts when any node in a route from a source to a destination detects that there is a shorter path than the one indicated in the packet header from that node to the destination then node replaces the original source route with the new one and sends a Route Reply message back to the source node to update its route cache [23].

c. Advantages and disadvantages of DSR

The main advantage of DSR is the absence of any periodic control messages that would take over a portion of the available bandwidth. The intermediate node utilizes the route cache information efficiently to reduce the control overhead. DSR has information of multiple routes. The route discovery and maintenance optimization techniques further eliminate the propagation and dissemination of control messages. DSR does not employ any local repair of a broken link and as any intermediate node can respond with a RR EP message to a RERR message based on its route cache there is a possibility for unstable routes in the network[26,28]. DSR was designed for a network with a limited number of nodes. The networks with high mobility will cause frequent link breaks that results in high routing overhead.

III. PERFORMANCE METRICS

There is various performance metrics that can be used to evaluate the performance of ad-hoc routing protocol [27, 26]. This metrics play a significant role while comparing two different protocols or ad-hoc routing protocols in terms of speed, number of packets sent, area, density, pause time etc. Few performance metrics are briefly discussed below:

Packet Delivery Ratio: It is the number of packet received by the destination out of all the generated packets by the source.

Average end-to-end Delay: It is the average delay time incurred when data packets are sent from the source to the destination.

- ***Throughput*:** It is the average rate of successful packet delivery per unit time.
- ***Average Jitter*:** It is the time variation between packets arriving due to congestion, timing and route changes etc.
- ***Routing Load*:** It is the ratio of control packets propagated by a node to the number of packets successfully delivered to the destination in the network.
- ***Mobility*:** Ad-hoc routing protocols are mobile in nature. The performance of ad-hoc nodes greatly depend on the mobility pattern and environment the nodes are deployed in.
-

IV. LITERATURE SURVEY

In [12], OPNET 14.5 was used for simulation. The simulation study for MANET network under five routing protocols AODV, DSR, OLSR, TORA and GRP were deployed using FTP traffic analyzing. These protocols were tested with three QOS parameters. From their analysis, the OLSR outperforms others in both delay and throughput.

Khan et al. [13] conclude that when the MANET setup for a small amount of time, then AODV is better because of low initial packet loss. DSR is not prefers because of its packet loss. On the other hand if we have to use the MANET for a longer duration so we can use both protocols, because after sometimes both have the same behavior. AODV have very good packet receiving ratio in comparison to DSR. At the end, they concluded that the combined performance of both AODV and DSR routing protocol could be the best solution for routing in MANET.

In [14], Bindra et al. evaluate the performance of AODV and DSR routing protocol for a scenario of Group Mobility Model such as military battlefield. They used Reference Point Group Mobility (RPGM) Model for their scenario. They concluded that in Group mobility model with CBR traffic sources, AODV is better than DSR but when TCP traffic used, DSR perform better in stressful situation like high load or high mobility. DSR routing load is always less than AODV in all type of traffic. Average end-to-end delay of AODV is less than DSR in both type of traffic. Over all the performance of AODV is better than DSR in CBR traffic and real time delivery of data. But DSR perform better in TCP traffic under limitation of bandwidth.

In [15], Barakovic et al. compared performances of three routing protocols: DSDV, AODV and DSR. They analyzed these routings with different load and mobility scenarios with Network Simulator version 2 (NS-2). They concluded that in low mobility and low load scenarios, all three protocols react in a similar way, but when mobility or load is increasing, DSR outperforms AODV and DSDV.

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Karthikeyan Bhagavan and Carl A Gunter [16] demonstrated the simulation analysis of Ad hoc On-demand Distance Vector (AODV) routing protocols for packet radio networks. The integrated system version consisting of a network simulator and logic based –checker for traces of events which corrects the network simulation properties has been demonstrated and showed its flexibility to improve the turn-around time in debugging.

Srdjankrco, marjnadupcinor [17] overcomed the problem of affecting the neighbor detection algorithm of the AODV protocol by significantly deteriorates network performance. All routes are established over good quality links as good neighbors only are kept in routing tables. This improves the parameters such as data throughput, decrease delays and overall user performance.

Vincent W.S.Wong [18] compared the performance of Load Balancing (LB) AODV protocol with both the original AODV and gossip based routing protocols. LB AODV delivers more data packets to the gateway and decreases the end to end delay of packets. Vincent W.S. Wong considered a mobile Ad hoc wireless access network in which the mobile nodes can access the Internet via one or more stationary gateway nodes and controlled the on-demand routing overhead by Load Balancing(LB) AODV routing protocol.

Z. Fan [19] developed a reactive routing algorithm for multirate ad hoc wireless networks which enhances the AODV protocol results in higher throughput over traditional adhoc routing protocols. The Medium Access Control (MAC) delay protocol is a very useful metric to identify congestion hot spots and measure the link interference in an adhoc network. This MAC delay protocol outperforms the old protocol mainly in low mobility scenarios. The significance of the routing protocol is to find the least cost path from the source to the destination.
Nianjun Zhou and Huaming Wu [20] presented a mathematical and simulative framework for quantifying the overhead of reactive routing protocols such as dynamic source routing and ad hoc on-demand distance vector routing in wireless topology networks. The effect of traffic on routing has been studied and the result is possible to design infinite reactive routing protocol for variable.

L. Raja et al [22] presented in their paper work a comparison of four Reactive (on-demand) routing protocols for MANETs: - Ad hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) protocols, Temporally Ordered Routing Algorithm (TORA) and Associativity Based Routing (ABR) protocol. They provided descriptions of several routing scheme proposed for mobile ad hoc networks, classification of these schemes according the routing strategy i.e. table driven and on demand and presented a comparisons of these categories of routing protocols. Reactive protocols were introduced and their core architecture was described.
Amit N. Thakare [26] gave a comparative analysis on his paper for two prominent on demand reactive routing protocols (AODV, DSR). The performance differentials were analyzed using varying simulation time. These simulations were carried out using the ns-2 network simulator. The results presented in this work illustrated the importance in carefully evaluating and implementing routing protocols in an ad hoc environment. AODV have very good packet receiving ratio in comparison to DSR.This paper concluded that AODV and DSR are very similar, but AODV mechanisms are easier to implement and to integrate with other mechanisms using other different routing protocols.

Salujaritu and Nisha[24]compared AODV and DSR on basis of four performance metrics- packet delivery ratio, throughput, routing load and end-to-end delay by varying number of nodes, pause time and simulation time and analyzed that AODV performs better than DSR. In DSR, packet delivery ratio is high only when the nodes are less but when nodes increase, the packet delivery ratio goes down. the pause time was varied from 2 sec to 10 sec where mobility is also described as high mobility (the nodes have less or zero pause time) and low mobility (higher pause time that is nodes are holding a position for more time).

Satveer Kaur[25] had studied the impact of mobility by changing the path in random direction, packet loss, Packet Delivery Ratio. In the first metric: packet loss, both protocols gives same performance. In metric Packet Delivery Ratio, DSR gives the better performance than AODV. In metric throughput, DSR gives better performance instead of AODV. In metric Aggregate good put, DSR successfully submit the more number of bits into the network. If we consider the above mentioned metrics, then we analyze that DSR gives better performance than AODV.

Vinaykumar Sharma [28] provided an overview of AODV & DSR reactive routing protocols explained in his literature. He also provided a performance comparison between them and suggest which protocol may perform

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best in varying number of nodes, and concluded that AODV performs well with varying network size.

Asad Amir Pirzada [29] analyzed the performance of these protocols in a hybrid wireless mesh network, where static mesh routers and mobile clients collaborate to implement network functionality such as routing and packet forwarding. Based on extensive simulations, we present a comparative analysis covering performance metrics such as packet loss, latency and path optimality.

Ashok N. Kanthe [23] that throughput of AODV protocol is better than DSR protocol as the nodes are increasing/adding to network. Packet drop rate and end-to end delay of AODV protocol is less than DSR protocol as the nodes are increasing. Efficiency achieved by the AODV protocol is higher than DSR protocol in mobile ad hoc networks. These routing protocols are compared in terms of throughput, packet drop rate and end-to-end delay. AODV performs better for 80 nodes and DSR performs better for 20 nodes. Hence the AODV protocol is scalable than DSR.

V. COMPARATIVE ANALYSIS

Qualitative measures based comparison:

Table 1: Qualitative comparison

Parameters	DSR	AODV
Protocol Type	Source Routing	Distance Vector & Source Routing
Multiple Routes	Yes	No
Route Maintained	Route Cache	Route table
Routing Metric	Short Path	Fresh & Short Path
Route Computation	Reactive	Reactive
Loop Free	Yes	Yes
Route Cache	Yes	No
Hello Message	No	Yes
Sequence Number	No	Yes

Quantitative measures based comparison:

Table 2: Quantitative comparison

	No. of Nodes	DSR	AODV
End To End Delay (ms)	10	18	12
	20	33	11
	30	10	12
	40	33	15
Packet Delivery Ratio (%)	10	95	95
	20	99	99
	30	99	99
	40	99	99
Throughput (Kbps)	10	86	89
	20	93	93
	30	93	93
	40	93	93
Overhead (%)	10	0	0
	20	0	2
	30	0	2
	40	1	5

In given tables 1 and 2,the comparison between AODV and DSR is shown with respective values for qualitative

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and quantitative measures. [28]

VI. CONCLUSION

In this survey it was found thatPerformances of routing protocol depend on the scenario in which the location of the nodes, speed of the nodes, number of connections of nodes and traffic in between nodes are varied, are compared interms of throughput, packet drop rate and end-to-end delay. AODV and DSR protocols outperformed each other in different scenarios. Most often DSR protocol was preferred in small network and less mobility while AODV performed better when node density and mobility is high. The combination of these protocols could be the better solution adapting to the changing environment and scenarios. More detailed comparison between DSR and AODV considering test-bed environment can be done in future.

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