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Performance Comparison of AODV and DSR Routing Protocols in Mobile Ad- hoc Networks: A Survey

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***Abstract*— A mobile Ad-Hoc network is a collection of autonomous wireless nodes without any fixed infrastructure and centralized administration. This paper presents a survey with an objective to compare Ad-Hoc routing protocols AODV and DSR taking into consideration different network parameters performed using simulation, emulation and real world experiments. Various researchers over time have analyzed the performance of AODV and DSR routing protocols based on the different test parameter and environment. AODV and DSR have been mostly studied through simulation, while fewer implementations of these protocols have been done on real network test-bed. The objective of this survey is to review the AODV and DSR protocols based on the performance metrics such as mobility pattern, packet delivery ratio, average end to end delay, throughput, packet drop, node density and in different test environments.**

***Index Terms*— AODV, DSR, MANET, PDR.**

I. INTRODUCTION

Ad-hoc Networks are wireless multi-hop packet networks without any fixed infrastructure. The main motive of wireless network is to maintain connectivity between nodes in a mobile environment. Most research in the ad-hoc network has been performed using simulation software and test-bed environment. With the presence of mobility and lack of static network nodes various routing protocols has been proposed to adapt to the changes in the environment. Also each node in a wireless ad-hoc network functions both as host and a router, and the control of the network transmission are distributed amongst the mobile nodes without any centralized control [3]. The topology changes due to mobility of nodes. Hence, there is need of efficient routing protocols to allow nodes to communicate over multi-hop paths which consists of several links. Compared to wired network, mobile network have unique characteristics. In mobile network node mobility may cause frequent change in network topology, which is rare in wired network. In contrast to the stable link capacity of wired network, wireless link capacity continuously varies because of the impacts from transmission power, receiver sensitivity, noise, fading and interference. Additionally, wireless mobile network have high error rate, power restrictions and bandwidth limitation [1]. Active research work for mobile ad-hoc network is carried out mainly in field of medium access control, routing, resource management, power control and security. Because of the importance of routing protocols in dynamic multi-hop networks, a lot of mobile ad-hoc network routing protocols have been proposed in last few years. The testing of ad-hoc networking protocols using test-bed provides the researchers with the opportunity to validate theories in practice and check the behavior of protocol in real world environment. In the modern world mobility has become increasingly important and ad-hoc network routing protocols is distinguished based on how routing information is acquired and maintained by mobile nodes.

Mobile ad hoc network routing protocols can be divided into proactive, reactive and hybrid [17] [19] [29]. A proactive routing protocol is also called "table driven" routing protocol. Using a proactive routing protocol, nodes in a mobile ad hoc network continuously evaluate routes to all reachable nodes and attempt to maintain consistent, up-to-date routing information [19]. Therefore, a source node can get a routing path immediately if it needs one. The Wireless Routing Protocol (WRP), the Destination Sequence Distance Vector (DSDV) and the Fisheye State Routing (FSR) are examples of proactive routing protocols. In proactive routing protocol, all nodes need to maintain a consistent view of the network topology. When a network topology changes, respective updates must be propagated throughout the network to notify the change. The Dynamic Source Routing (DSR) and Ad hoc on-demand Distance Vector routing (AODV) protocol are examples for reactive routing protocol. Hybrid routing protocols are proposed to combine the merits of both proactive and reactive routing protocols and overcome their

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shortcomings [17]. The Zone Routing Protocol (ZRP) , Zone-based Hierarchical Link State routing (ZHLS) and Hybrid Ad hoc Routing Protocol (HARP) are examples of hybrid routing protocols for mobile ad hoc networks.

II. OVERVIEW OF AODV

Ad-hoc on-demand distance vector (AODV) routing protocol is a reactive protocol even though it still uses characteristics of a proactive protocol. AODV uses the concept of route discovery and route maintenance of DSR and the concept of sequence number's and sending of periodic beacon's from DSDV [3]. AODV uses three types of control messages. They are Route Request (RREQ), Route Reply (RREP) and Route Error (RERR) messages [5].

When a route does not exist between two nodes i.e., when a route to new destination is required a node initiates the route discovery process. Route discovery involves flooding of RREQ messages to its neighbor to find the destination node [4] [6]. Route discovery process can also be initiated if the link has expired or broken. An intermediate node receiving the RREQ is required to first setup a reverse path to the source node. It uses sequence number and broadcast ID for loop free routing. When the destination receives a route RREQ, It responds with a RREP message containing the number of hops and latest destination sequence number. RREP is routed back to the source node using the reverse path and forward path to the destination is established. A time to live is associated with each reverse route entry. If no packets are sent over this route within the lifetime it will be removed from the routing table [19] [17] [18]. In route maintenance phase each node uses hello packets to check for the link. When a link failure is detected by a node it sends a route error (RRER) messages to its upstream neighbors on the current route. These error messages propagate to the source node. Intermediate nodes' receiving a RERR updates their routing table. The source node after receiving RERR starts the route discovery process again [19] [17] [18].

III. OVERVIEW OF DSR

The key feature of DSR is source routing [2] [18] [16]. The source or the sender knows the complete hop-by-hop route to the destination. These routes are stored in route cache. It uses a route discovery process to dynamically determine the unknown route. It does not use periodic hello message unlike AODV. RREQ and RRER message is used to discover the route similar to AODV. Source node broadcast the RREQ message and the receiving neighbor node adds its address to source address and rebroadcast the RREQ message if it does not have the information for destination node. If route to the destination node is known they send a route reply packet to the source node. Every node also maintains a cache where the route information is stored [16]. The advantage of DSR is that it can store multiple routes in their route cache [20]. If any link on a source route is broken, a node that identifies the break and sends a route error (RERR) packet to the source node. On receiving the RERR packet, the source node updates its route information by removing the link from its cache. A new discovery process will be started to find the viable route [5].

IV. PERFORMANCE METRICS

There is various performance metrics that can be used to evaluate the performance of ad-hoc routing protocol. 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.

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V. LITERATURE SURVEY

In recent years, several researchers have studied and analyzed various ad-hoc Routing Protocols taking into consideration different metrics as basis for performance evaluation. They have used different simulators and real-world environment for the same.

Kapan Lego et al. [1] studied and compared the performance of DSDV, AODV and DSR routing protocols for ad hoc networks using ns-2 simulations on different pause times. In this paper, it was conveyed that with pause time set to 0 the packet delivery ratio of AODV and DSR were almost same with 97% to 99%. With increase in pause time to 200, the packet delivery ratio of AODV and DSR reached 100% approximately. DSR performed well with low end to end delay for 0 pause time. Overall performance of DSR was found to be better than AODV.

Samir R. Das [2] et al. compared and analyzed the performance of AODV and DSR using random way point mobility model with variable pause time using ns-2 simulator and found that DSR outperformed AODV in delay and throughput on less stressful situation i.e., with small number of nodes and lower load and mobility while AODV out performed DSR in more load, high mobility. They also found that DSR low throughput and delay was due to aggressive use of caching and stale routes.

Bijan Paul et al. [3] studied the behavior of AODV and DSR over TCP and CBR (Constant Bit Rate) connection with varying speed and node density using random waypoint mobility model and ns-2 simulator. They found that in low density with low speed the packet delivery ratio (PDR) of TCP and CBR connection for both protocols is high while end to end delay (E-To-E) is high for TCP connection but low for CBR. With high speed PDR for AODV using TCP is average but high for DSR. In high density with low speed, PDR of TCP and CBR connection for AODV was average but high for DSR. If the speed was high the PDR for AODV and DSR using CBR was low, but using TCP AODV performed average and DSR performs high. Performance of both AODV and DSR outperformed each other based on the different traffic pattern.

Monika et al. [4] performed simulation of AODV and DSR for Vehicular Ad-hoc network with and without RSU (Road Side Unit) using Estinet Simulator and found that throughput was highest for AODV compared to DSR. Though number of packets dropped was high in case of AODV, but they were mostly control packets. They also found that performance of network was better in presence of RSU. They concluded that AODV is better than DSR.

Amit N. Thakare et al. [5] analyzed the performance of AODV and DSR in ns-2 simulator using Random Waypoint mobility model. They analyzed that packet loss of DSR is high for a small amount of time compared to AODV while it's almost same for greater amount of time. Ratio of packet received was high for AODV compared to DSR. They also found that AODV suffers packet loss, delays and overhead as AODV maintains only one route per destination. DSR was more stable in this aspect due to multiple paths and absence of periodic packet broadcast as in the case of AODV.

Muazzam Ali khan Khattak et al [6] analyzed different performance parameters of AODV, DSR and DSDV protocol in ns-2 simulator by varying the node density and mobility using UDP and TCP traffic. They found that all protocols performed well under TCP packet while packet delivery ratio was low in case of UDP due to no retransmission. Further they concluded that DSDV was poor protocol in mobility environment due to low coverage time.

Davesh et al. [7] analyzed the performance of AODV and DSR routing protocols using ns2 simulator and omni directional antenna. They found that packet delivery ratio is very high in case of AODV initially but it decreases substantially if the simulation node increases. DSR shows better delay performance than other reactive protocols due to fast route discovery process. It was concluded that AODV performs best because it provides almost identical result in both scenario and DSR suits for network in which mobile nodes move at moderate speed.

Sapna S. Kaushik et al. [8] compared the performance of AODV and DSR protocol in ns-2 simulator using various performance metrics and found that DSR performs well when the number of nodes is less as the load will be less and performance declines with increase in number of nodes due to more traffic in network. AODV performance decreases and remains constant as the number of node increases. DSR performs well when number of nodes is less but slightly underperforms with increase in the number of nodes. The packet dropped is much less compared to the performance of AODV.

V.K.Taksande et al. [9] used chain topology to compare the performance of AODV and DSR using ns-2 simulator keeping the network speed and pause time constant and varying the network size i.e. number of mobile nodes. They found that DSR protocols have better performance than AODV in terms of packet generated. It was observed that DSR performed well for small number of nodes up to 10 numbers, but for more numbers of nodes i.e. more than 10 nodes, the performance of AODV protocol have better performance than DSR. DSR protocol outperformed AODV protocol in terms of number of packets dropped and AODV protocol have better performance over DSR

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protocol in term of packet delivery ratio. For average end-to -end delay it was observed that up to 10 numbers of nodes, AODV protocol have better performance but above 10 numbers of nodes DSR have performs better compared to AODV protocol while transmitting data packets from source to destination.
Rajesh Deshmukh et al. [10] evaluated the performance of AODV and DSR by varying the network size from 100-150 nodes using ns-2 simulator and random waypoint mobility with constant pause time of 10s. It was found that packet delivery ratio performance of ADOV improved gradually as the number of nodes increases. AODV performed much better than DSR when the number of nodes exceeds 135 nodes, while DSR shows a big drop in the PDR. DSR performed better in terms of routing overhead below 140 nodes but AODV performance increase with number of nodes increased beyond 140. It was concluded that AODV performs better on larger number of nodes with given scenario while whereas DSR performs better on lesser number of nodes with the same scenario.
Md. Sohidul Islam et al. [11] studied and analyzed the performance of AODV and DSR protocols using ns-2 simulator and different simulation delays. It was found that AODV has higher throughput than the DSR because of loop free and fresh routes. Also AODV performed better in higher mobility. While DSR was better protocol in case of number of packets dropped due to no periodic updates. Number of packets received in case of AODV is lower with increase in propagation delay compared to DSR. It was finally concluded DSR outperformed AODV.
Devendra Singh et al. [12] used Random Waypoint Model to compare the performance of AODV and DSR using OPNET simulator taking throughput, load and delay as the performance metrics. They found that throughput of AODV is high in large network while DSR throughput is high in small network. AODV has lower delay compared to DSR. DSR load is low in case of small size network as compared to large size networks. It was concluded that DSR is preferable for small size network while AODV is best suited for medium size network.
Prem Chand et al. [13] studied the performance of AODV and DSR routing protocol using Qualnet simulator and random way point mobility model. Simulation result indicated that DSR exhibits more intermediate nodes compared to AODV due to source routing nature of DSR. And also DSR has no mechanism to determine the freshness of routes or to replace the stale routes. Also AODV has more RREQ and RERP packets making it more efficient as compared to DSR.
Jahangir khan [14] used Quality of service to compare the performance of AODV and DSR using OPNET simulator. The traffic sent and received by DSR protocol is greater than AODV protocols. AODV delay is high compared to DSR.
Pradish Dadhania et al. [15] compared the performance of AODV and DSR using ns-2 simulator and found that end-to-end delay is high initially in case of AODV and DSR routing protocols and decreases with increase in the number of nodes.
Josip Lorincz et al. [21] analyzed the performance of AODV and DSR based on the FTP throughput comparison in multi-hop static environment. They developed the test-bed using AODV-UU and DSR-UU. (UU- Uppsala University) in Linux based user space implementation. They found that DSR-UU throughput was higher and had less relative deviation than AODV-UU. Variation was possibly due to shorter route timeout settings in AODV-UU and also due to DSR source based routing. They also found that though DSR route caching has advantage in case of link breakage but DSR-UU takes more time to reroute because of source routing.
Rajiv Misra et al. [22] compared the performance of AODV and DSR based on constrained situation (Congestion) using Glomosim simulator. They found that DSR outperformed AODV in constrained situation. There was 30% reduction in performance for AODV and 10 % reduction in DSR as compared to the normal situation. DSR ability to store more than one route per destination and route caching provided better result than AODV during congestion. They also proposed a local route repair algorithm for AODV that takes the route through the destination using lightly load neighbor thereby reducing local congestion and thus reducing the packet drop during congestion. The same was simulated and found to be better.
Mehdi Barati et al. [23] analyzed and compared the performance of AODV and DSR routing protocols using ns-2 simulator based on energy consumption. Random Way Point mobility model was considered with number of nodes ranging from 10 to 100 with various topology sizes. They studied the routing energy consumption by varying the traffic pattern, mobility pattern, node number and area size. They found that increase in energy consumption for AODV was more than DSR in low traffic while DSR energy consumption was high in high traffic. Less energy was required for DSR in terms of varying mobility pattern compared to AODV due to its route caching behavior thus requiring less route discovery. Also DSR performed better in low and high load. AODV consumed more energy than the DSR with reference to area, as more space is there, more routing function is required. They also concluded that energy consumption increase was mainly due to increase in the control packets.

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Richa Agarwal et al. [24] studied the effect of wormhole attack on AODV and DSR routing protocols using Qualnet simulator using various node density, random way point mobility model in an area of 1500*1500 m2. They found that for a steady wormhole link there is no effect on the functioning of these protocols because the link behaves as a high speed directional link for routing messages. With the increase in length of obstructive links the performance of DSR degrades more compared to AODV.

Lawal Bello et al. [25] proposed a technique to evaluate the effect of ambient noise and path loss have on received signal strength of mobile node in MANET environment using OPNET simulator. They found that ambient noise could be calculated by the equation

$$An = RW*K \qquad (1)$$

Where An is the ambient noise, RW is the receiving bandwidth and K is the constant ambient noise level which is given as 1.0E-26. Similarly they came up with path loss model given by the equation.

$$PL = \lambda 2 / (4\Omega D)2 \qquad (2)$$

Where PL is the path loss, Lambda is wavelength and D is propagation distance. Proposed technique resulted in decrease in end-to-end delay and routing load and higher throughput for AODV and DSR. AODV performed well in low mobility but performance decreased with high mobility. DSR performed well in both low and high mobility.

Asma Tuteja et al. [26] studied and compared the performance of AODV and DSR routing protocols using ns-2 simulator. Overall performance of AODV decreased with the increase in packet size. In case of DSR routing overhead increased with increasing packet size subsequently throughput decreased with increasing packet size. DSR was the best performer compared to AODV protocol.

Koushik Majumder et al. [27] analyzed the performance of AODV and DSR in hybrid network that is a combination of wired and wireless ad-hoc network. The simulation was carried out using ns-2 simulator and varying pause time with different number of sources. Base station acted as a gateway between wired and wireless networks. Mobility model used was random way point. They found that PDR (Packet Delivery Ratio) was almost same for AODV and DSR. With decrease in mobility and increase in pause time PDR also increased for both the protocols. AODV had less end-to-end delay compared to that of DSR; which was mainly due to source routing nature of DSR and stale route. With increasing mobility and decrease in pause time delay also increased. DSR was found to be better in case of normalized routing load mainly due to route discovery process for AODV as it maintains only one route to the destination and in case of link breakage it needs to initiate route discovery process thereby increasing the number of control packets.

Shaily Mittal et al. [28] compared the performance of AODV and DSR routing protocols using Qualnet simulator and varying pause time in random way point mobility model. They found that AODV and DSR performed better in terms of Packet Delivery Ratio. Average hop count remained constant for DSR while for AODV the hop count increased continuously. AODV has low end-to-end delay compared to DSR.

Mohammed Bouhorma et al. [29] studied and compared the performance of AODV and DSR routing protocols using ns-2 simulator and random way point mobility model and varying number of nodes. They found that AODV Packet delivery Ratio was higher compared to DSR and end-to-end delay for DSR with varied pause time was less compared to that of AODV. As mobility increased AODV performed better.

VI. COMPARATIVE ANALYSIS

This section analyzes the comparative performance of AODV and DSR based on the various performance metrics as described in Table 1. It also highlights the various similarities that a protocol exhibits even with different simulation parameter and environment taken in consideration. From the table it can be viewed that AODV packet delivery ratio is high compared to DSR in most of the cases [5] [8] [9] [10] [29]. Similarly DSR has less end-to-end delay in most of the cases [1] [29]. Also there are situation in which some researchers found AODV to be better [1] while some found DSR to be better than AODV [4] but that greatly depends on the parameters and the environment used for the simulation.

Table 1. Comparative Analysis of AODV and DSR routing protocols

Simulator/ Test-bed	End–to-End Delay/Load/ PDR/Mobility/ Throughput/ No. of Packets Dropped Observations (DSR)	End–to-End Delay/Load/PDR/Mobility/ Throughput/ No. of Packets Dropped Observations (AODV)

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ns-2	• Low end-to-end delay [1] [2] [9]. • Outperformed AODV in delay[2][7] and throughput in less stressful situation [2] [8] • Packet loss high for small amount of time and more stable [5] • Better then AODV when no of nodes are less [8] [9] [10]. • Packets dropped are less [8] [9] [11]. • Better in terms of routing overhead for less number of nodes [10]. • Energy consumption is high in high traffic [23]. • Better in low and high load [23]. • Routing overhead increases and throughput decreases with increasing packet size [26] • Better then AODV in case of normalized routing load [27].	• Low end-to-end delay [27]. • Outperformed DSR in more load and high mobility with better throughput [2] [11] [29]. • Better Packet Delivery Ratio [5] [8] [9] [10] [29] • High PDR initially but decreases with increase in number node. • Packets dropped high [8]. • Better then DSR when number of nodes increases [8] [9] [10]. • Better in terms of routing overhead for greater number of nodes [10]. • Energy consumption high then DSR in low traffic [23] • performance decrease with increase in packet size [26]
Opnet	• Throughput high in small network and better for small size networks [12]. • PDR better then AODV [14]. • Performs well in both low and high mobility [25].	• Throughput high in large network, it has low end-to-end delay and better for medium sized networks [12]. • Performs well in low mobility while there was decrease in performance with high mobility [25].
Qualnet	• Exhibited more intermediate node compared to AODV [13]. • In case of worm whole attack with the increase in length of obstructive links the performance of DSR degrades more compared to that of AODV [24].	• Low end-to-end delay [28].
Glomosim	• Outperformed AODV in constrained situation (congestion) [22].	• decrease in performance is higher as compared to DSR in congestion [22]
Estinet	• Throughput less than that of AODV [4].	• Throughput higher then DSR, no of packets dropped is high [4].
Test-bed	• Takes more time to re-route [21].	• Throughput less then DSR [21].

VII. CONCLUSION

In this survey it was found that 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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