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Simulation Based Performance Evaluation of Routing Protocols for Mobile Ad-hocNetworks (MANET)

Shivlal Mewada
Institute of Computer Science
Vikram University, Ujjain

Umesh Kumar Singh
Institute of Computer Science
Vikram University, Ujjain

Pradeep Kumar Sharma
Department of Computer Science
Govt. Holkar Science College, Indore

***Abstract*— A Mobile Ad-Hoc Network (MANET) is characterized by dynamic nature without any physical infrastructure and centralizes access point. Routing in Ad-hoc networks is a challenging due to mobility of nodes. In this paper, we presents simulation based performance evaluation of DSR and AODV routing protocols for MANET, a detailed simulation based performance analysis has been carried out of Ad- Hoc On-Demand Distance Vector, Dynamic Source Routing based on different network scenario of network size, node mobility and pause time. Performance matrix includes parameters like average End-to-End delay and packet delivery ratio using NS-2 as network simulator.**

***Keywords*— Mobile Ad-Hoc Network, DSR, AODV**

I. Introduction

A mobile ad hoc network is a collection of wireless mobile nodes that dynamically establishes the network in the absence of fixed infrastructure [1]. One of the distinctive features of MANET is, each node must be able to act as a router to find out the optimal path to forward a packet. As nodes may be mobile, entering and leaving the network, the topology of the network will change continuously. MANETs provide an emerging technology for civilian and military applications. One of the important research areas in MANET is establishing and maintaining the ad hoc network through the use of routing protocols. Though there are so many routing protocols available, this paper considers AODV and DSR for performance comparisons due to pause time. These protocols are analyzed based on the important metrics such as throughput, packet delivery ratio and average end-to-end delay.

Most of the research study shows that DSR and AODV are performing well depend upon the environment, among the reactive protocols. In the case of proactive, OLSR protocols are performing well. The performance of different proactive, reactive and hybrid protocols have analyzed by different researchers. The comparative analysis of DSR [2], AODV [3], is proposed in this paper since no such analysis is available in the literature.

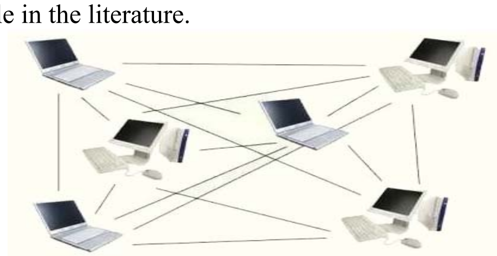

Figure 1: MANET

Corresponding Author: Shivlal Mewada, Member of *IEEE, IACSIT, IAENG*
shiv.mewada@gmail.com

The organization of the paper is as follows: Section 2 presents the related work. A mobile ad-hoc network is discussed in section 3. Overview of the routing protocols is discussed in section 4. Performances of AODV and DSR are discussed in sections 5. Experimental Setup and Simulation Parameters are discussed in section 6. Performance Metrics and Simulation results analysis is provided in section 7. Section 8 concludes the paper.

II. Related Work

Most recently, Ashish K. et al [4] evaluated AODV, FSR and ZRP for Scalable Networks. They performed simulations with the following two different scenarios for the performance evaluation of AODV, FSR and ZRP routing protocol. Network designed using random waypoint mobility model with different pause time. Network designed using random waypoint mobility model with variable number of nodes.

Performance of AODV, FSR and ZRP routing protocol is evaluated with respect to four performance metrics such as average end to end delay, packet delivery ratio and throughput. AODV shows best performance when compared with FSR and ZRP in terms of packet delivery ratio and throughput. AODV delivers more than 60 percent of all CBR packets when network is presented as a function of pause time and delivers more than 80 percent of all CBR packets when network is presented as a number of nodes.

Sree Ranga Raju, et al [5] compared the performance of DSR, AODV. Ayyaswamy Kathirvel, et al [6] compared the performance of DSR, AODV, FSR and ZRP with respect to propagation model. Reactive routing protocols (AODV and DSR) have got good packet delivery ratio. When compared with proactive and hybrid routing protocols, hybrid routing protocol have got next higher packet delivery ratio. Similarly reactive routing protocols have got less delay.

III. Mobile Ad Hoc Network

A MANET topology can also be defined as a dynamic (arbitrary) multi-hop graph G = (N, L), where N is a finite set of mobile nodes (MNs) and L is a set of edges which represent wireless links. A link (i, j) Є L exists if and only if the distance between two mobile nodes is less or equal than a fixed radius r as shown. This r represents the radio transmission range that depends on wireless channel characteristics including transmission power. Accordingly, the neighborhood of a node x is defined by the set of nodes that are inside a circle (assume that MNs are moving in a two-dimensional plane) with center at x and radius r, and it is denoted by:

$$N_r(x) = N_x = \{n_f \mid d(x, n_f) \leq r, x \neq n_f, \forall j \in N, j \leq |N|\}$$

Where x is an arbitrary node in graph G and d is a distance function [7].

A path (route) from node i to node j, denoted by Rij is a sequence of nodes Rij=(i,n_1, n_2,…,n_k, j) where (i,n_1), (n_k,j) and (n_y,n_{y+1}) for $1\leq y \leq k-1$ are links. A simple path from i to j is a sequence of nodes with no node being repeated more than once. Due to the mobility of the nodes, the set of paths (wireless links) between any pair of nodes and distances is changing over time. New links can be established and existing links can vanish.

IV. Overview Of ROUTING PROTOCOLS

In mobile ad hoc networks, routing protocol can be classified in three categories [8];

1. Proactive routing protocol or table-driven routing protocols,
2. Reactive routing protocol on-demand routing protocols. and
3. Hybrid protocol routing protocol.

Proactive (Table-Driven): The pro-active routing protocols are the same as current Internet routing protocols such as the Routing Information Protocol, Distance-Vector, Open Shortest Path First and link-state. They attempt to maintain consistent, up-to-date routing information of the whole network. Each node has to maintain one or more tables to store routing information, and response to changes in network topology by broadcasting and propagating. Some of the existing pro-active ad hoc routing protocols are: Destination Sequenced Distance-Vector, Wireless Routing Protocol, Cluster head Gateway Switch Routing, Global State Routing, Fisheye State Routing, Hierarchical State Routing, Zone based Hierarchical Link State and Source Tree Adaptive Routing.

Reactive (Source-Initiated On-Demand Driven): These protocols try to eliminate the conventional routing tables and consequently reduce the need for updating these tables to track changes in the network topology. When a source requires to a destination, it has to establish a route by route discovery procedure, maintain it by some form of route maintenance procedure until either the route is no longer desired or it becomes inaccessible, and finally tear down it by route deletion procedure. In pro-active routing protocols, routes are always available (regardless of need), with the consumption of signaling traffic and power. On the other hand, being more efficient at signaling and power consumption, re-active protocols suffer longer delay while route discovery. Both categories of routing protocols have been improving g to be more scalable, secure, and to support higher quality of service. Some reactive protocols are Cluster Based Routing Protocol (CBRP), Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), Signal Stability Routing (SSR) and Location Aided Routing (LAR).

V. Performance of DSR and AODV Routing Protocol

Dynamic Source Routing: The Dynamic Source Routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source routes in the ad hoc networks. Route Discovery: Is the mechanism by which a source node to send a packet to a destination node, obtains a source route to the destination. Route discovery is used only when the source node attempts to send a packet to a destination and does not already know a route to that destination. Route Maintenance: Is the mechanism by which a node to send a packet to a destination is able to detect, while using a source route to the destination, if the network topology has changed. If this is the case then it must no longer use this route to the destination because a link along the route broken. Route maintenance for this route is used only when the source node is actually sending packets to the destination. A source puts the entire routing path in the data packet, and the packet is sent through the intermediate nodes specified in the path, If the source does not have a routing path to the destination, then it performs a route discovery by flooding the network with a route request (RREQ) packet. Any node that has a path to the destination in question can reply to the RREQ packet by sending a route reply (RREP) packet. The reply is sent using the route recorded in the RREQ packet.

The responsibility for assessing the status of a route falls to each node in the route. Each must insure that packets successfully cross the link to the next node. If it doesn't receive an acknowledgement, it reports the error back to the source, and leaves it to the source to establish a new route. While this process could use up a lot of bandwidth, DSR gives each node a route cache for them to use aggressively to reduce the number of control messages sent. If it has a cache entry for any destination request received, it uses the cached copy rather than forward the request. In addition, it promiscuously listens to other control messages for additional routing data to add to the cache.

Ad Hoc on-Demand Distance-Vector Protocol (AODV): The Ad Hoc On-Demand Distance-Vector Protocol (AODV) is a distance vector routing for mobile ad-hoc networks. AODV is an on-demand routing approach, i.e. there are no periodical exchanges of routing information. The protocol consists of two phases:

i) Route Discovery

ii) Route Maintenance.

A node wishing to communicate with another node first seeks for a route in its routing table. If it finds path, the communication starts immediately, otherwise the node initiates a route discovery phase. The route discovery process consists of a route-request message (RREQ) which is broadcasted. If a node has a valid route to the destination, it replies to the route-request with a route-reply (RREP) message. Additionally, the replying node creates a so called reverse route entry in its routing table, which contains the address of the source node, the number of hops to the source, and the next hop's address, i.e. the address of the node from which the message was received. A lifetime is associated with each reverse route entry, i.e. if the route entry is not used within the lifetime it will be removed. The second phase of the protocol is called route maintenance. It is performed by the source node and can be subdivided into: i) source node moves: source node initiates a new route discovery process, ii) destination or an intermediate node moves: a route error message (RERR) is sent to the source node. Intermediate nodes receiving a RERR update their routing table by setting the distance of the destination to infinity. If the source node receives a RERR it will initiate a new route discovery. To prevent global broadcast messages AODV introduces a local connectivity management. This is done by periodical exchanges of so called HELLO messages, which are small RREP packets containing a node's address and additional information

Each AODV router is essentially a state machine that processes incoming requests from the SWANS network entity. When the network entity needs to send a message to another node, it calls upon AODV to determine the next-hop.

Whenever an AODV router receives a request to send a message, it checks its routing table to see if a route exists. Each routing table entry consists of the following fields:

- Destination address
- Next hop address
- Destination sequence number
- Hop count

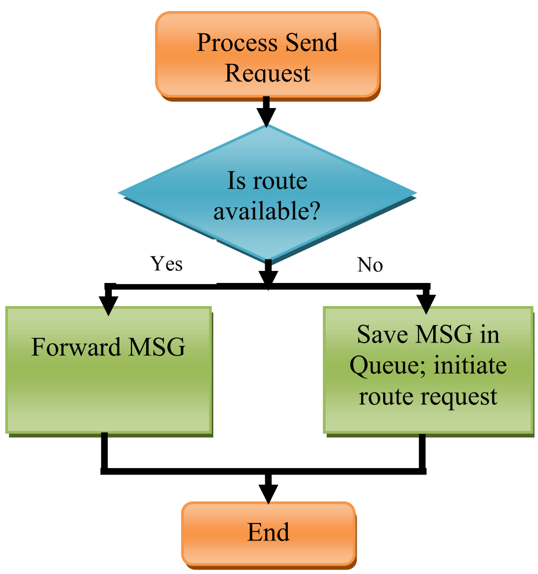

Fig. 2 Flow chart for Route discovery

If a route exists, the router simply forwards the message to the next hop. Otherwise, it saves the message in a message queue, and then it initiates a route request to determine a route. The flow chart as shown in figure 2 illustrates this process: Upon receipt of the routing information, it updates its routing table and sends the queued message(s). AODV nodes use four types of messages to communicate among each other. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance.

VI. Experimental Setup And Simulation Parameters

The experimental setup is used for performance evaluation of the DSR and AODV routing protocols. It measures the ability of protocols to adapt to the dynamic network topology changes while continuing to successfully deliver data packets from source to their destinations. In order to measure this ability, different scenarios are generated by varying the number of nodes. We use following scenario generation commands for generating scenario file for 50 nodes:

./setdest –v 1 –n 50 –p 2.0 –M 10.0 -t 200 -x 500 -y 500.

Similarly, for connection pattern generation we use, cbrgen.tcl file. By using following commands the connection pattern is generated:

ns cbrgen.tcl -type cbr -nn 50 -seed 1.0 -mc 16 –rate 4.0;

The trace file is created by each run and is analyzed using a variety of scripts, particularly one called file *. tr that counts the number of successfully delivered packets and the length of the paths taken by the packets, as well as additional information about the internal functioning of each scripts executed. This trace file is further analyzed with AWK file and Microsoft Excel is used to produce the graphs [9].
Simulations are run by considering DSR and AODV routing protocol. In order to get realistic performance, the results are averaged for a number of scenarios. We tried to measure the protocols performance on a particular terrain area of 500m x 500m from real life scenario at a speed of 10 m/s. The simulation time was taken to be of 200 seconds for Constant Bit Rate (CBR) traffic type with a packet size of 512 Byte. Also, we have considered nodes with Omni-Antenna and Two Ray Ground Radio Propagation method. Simulation parameters are appended in Table-1.

Parameter	Value
Channel	Channel/Wireless Channel
Propagation model	Propagation/Two Ray Ground
Antenna	Antenna/Omni Antenna
Simulator	NS-2
No of Nodes	50
Routing Protocols	DSR and AODV
MAC Layer	802.11 IEEE
Simulation Time	200 Second
Simulation Area	500 X 500
Transmission Range	250m
Node Movement Model	Random Waypoint
Traffic Type	CBR (UDP)
Data Payload	512 Bytes/Packet

Table 1: Simulation Parameters

VII. Performance Metrics and Simulation Results

The following performance metrics are considered for evaluation:

- Packet Delivery Fraction
- Average end-to-end delay

Packet Delivery Fraction (PDF): It is the ratio of the data packets delivered to the destinations to those generated by the sources.

Packet Delivery Fraction (PDF) = Total Packets Delivered to destination / Total Packets Generated. Mathematically, it can be expressed as:

$$P = \frac{1}{c}\sum_{f=1}^{e}\frac{Rf}{Nf}$$

Where, P is the fraction of successfully delivered packets, C is the total number of flow or connections, f is the unique flow id serving as index, Rf is the count of packets received from flow f and Nf is the count of packets transmitted to f.

Average end-to-end delay: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. It can be defined as:

$$D = \frac{1}{N}\sum_{i=1}^{s} \mathrm{Ri} - \mathrm{Si}$$

Where N is the number of successfully received packets, i is unique packet identifier, Ri is time at which a packet with unique id i is received, Si is time at which a packet with unique id i is sent and D is measured in ms. It should be less for high performance.

Node: 50, Pause Time: 2.0 Sec., Max Speed: 10 m/s.

Routing protocols	Total Packets Sent	Total Packets Revives	Packet Delivery Ratio
AODV	8827	7535	0.853631
DSR	8877	8865	0.998648

Table.2 Packet Delivery Fraction with varying number of Nodes.

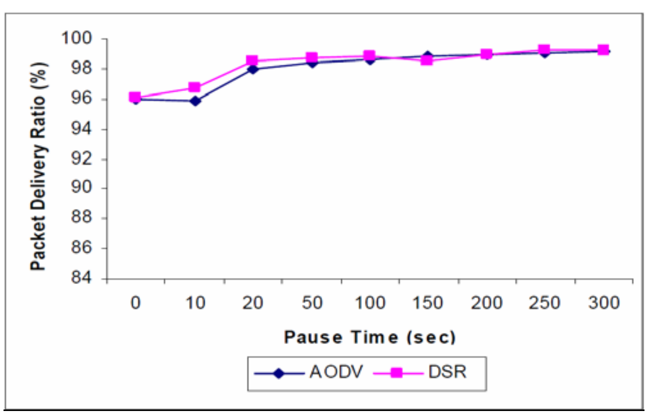

Figure 3: Packet delivery fraction vs. Pause time for 50-node model with 10 sources

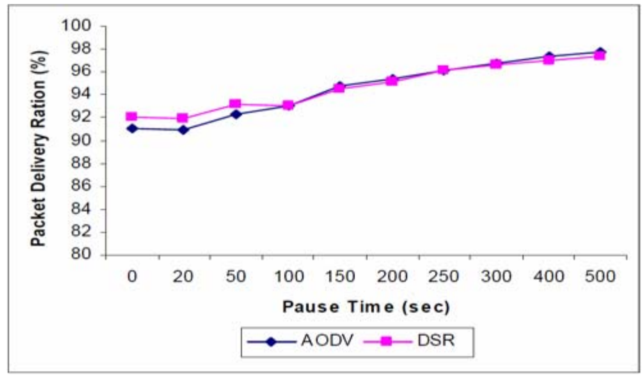

Figure 4: Packet delivery fraction vs. Pause time for 50-node model with 20 sources

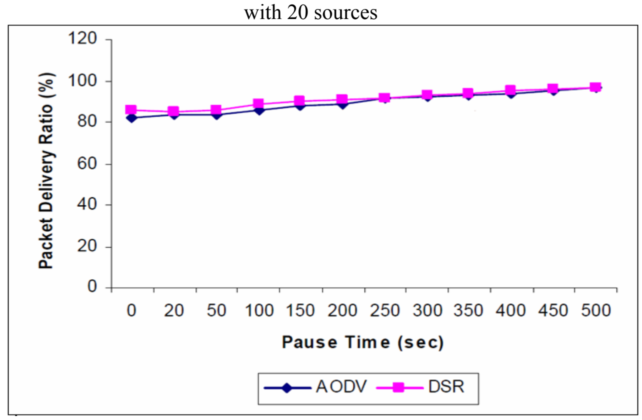

Figure 5: Packet delivery fraction vs. Pause time for 50-node model with 50 sources.

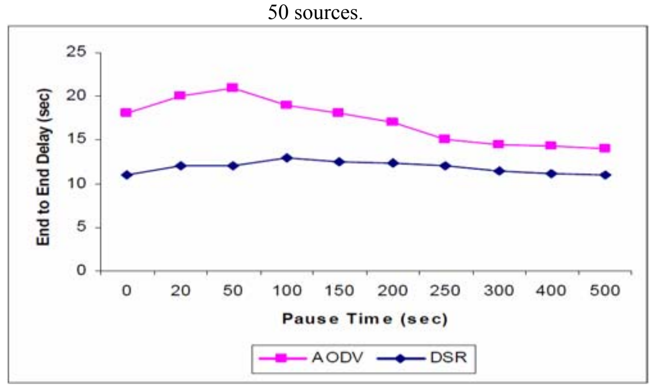

Figure 6: End to End Delay vs. Pause time for 50-node model with 10 sources

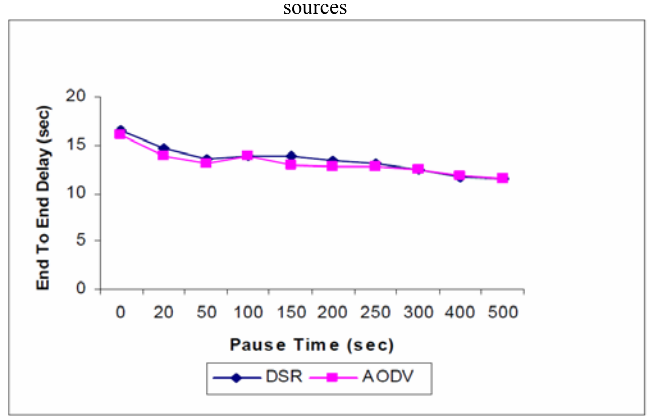

Figure 7: End to End Delay vs. Pause time for 50-node model with 20 sources

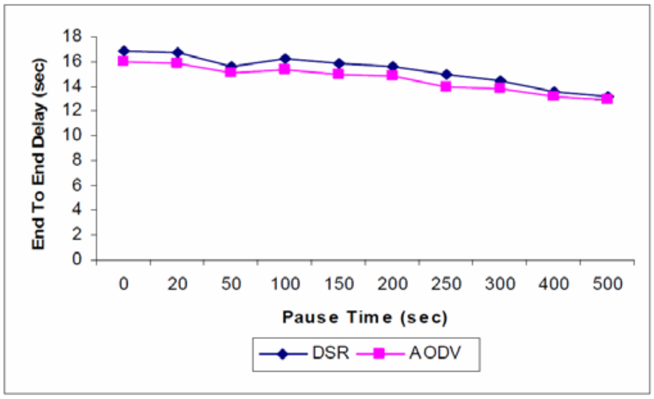

Figure 8: End to End Delay vs. Pause time for 50-node model with 50 sources.

VIII. CONCLUSION

In this paper we have evaluated the performance of AODV and DSR routing protocols for ad hoc networks using NS-2 event simulator keeping packet size of 512 Byte. AODV uses the proactive table-driven routing strategy whereas DSR uses the reactive on demand routing strategy with different routing mechanisms. Experimental results showed that DSR perform better for Packet Delivery Fraction as well as Throughput. Also, AODV apply the sequence numbers and contains one route per destination in its routing table whereas DSR uses source routing and route caches and maintains multiple routes per destination. The other observation from the experiments on AODV and DSR protocols, with an increase in number of nodes for a fixed area of 500m x 500m illustrates that even if the terrain area of the network scenario is kept constant, the behavior of these routing protocols changes.

It has been found that the overall performance of DSR routing protocol for performance matrices, Packet Delivery Fraction as well as Throughput is better than that of AODV routing protocols. In our experimental evaluation we have taken up comparison of DSR and AODV protocols with varying number of nodes. We shall consider the comparison of DSR and AODV by varying packet size and speed of nodes.

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AUTHORS PROFILE

Shivlal Mewada has received his Master of Philosophy (M.Phil.) in Computer Science and He completed his Master of Science (M.Sc.) from Institute of Computer Science, Vikram University, Ujjain. He is currently pursuing Ph.D. in Computer Science from Institute of Computer Science, Vikram University, Ujjain. He is presently working as a guest faculty in Department of Computer Science, Govt. Holkar (Autonomous) Science Collage, Indore - India. He was awarded Junior Research Fellow Award by UGC New Delhi. He has published various research papers in international journals and international conferences. He shared the responsibility of research advisor (M.Phil.) in Govt. Holkar (Autonomous) Science Collage. He has co-supervised four M.Phil. and one M.Sc. project so far. He is reviewer and editorial board member of International Journal of Engineering and Innovative Technology (IJEIT). He has been a member of IEEE since 2012, a life member of Computer Society of India (CSI) since 2012, a life member of the International Association of Computer Science and Information Technology (IACSIT) since 2012 and the International Association of Engineers (IAENG) since 2011. His research interest includes Security in-Mobile Ad-hoc Networks (MANET), Wireless Mesh Network (WMN), Cloud Computing, Data Mining and Information Technology based education.

Dr. Umesh Kumar Singh obtained his Ph.D. in Computer Science from Devi Ahilya University, Indore-INDIA. He is currently Reader (Director) in Institute of Computer Science, Vikram University, Ujjain-INDIA. He served as professor in Computer Science and Principal in Mahakal Institute of Computer Sciences (MICS-MIT), Ujjain. He is formally Director I/C of Institute of Computer Science, Vikram University Ujjain. He has served as Engineer (E&T) in education and training division of CMC Ltd., New Delhi in initial years of his career. He has authored a book on "Internet and Web technology "and his various research papers are published in national and international journals of repute. Dr. Singh is reviewer of International Journal of Network Security (IJNS), IJCSIS, ECKM Conferences and various Journals of Computer Science. His research interest includes network security, secure electronic commerce, client-server computing and IT based education.

Dr. Pradeep Sharma obtained his Ph.D. in Physics from Vikram University, Ujjain -INDIA. He is currently Professor and Head of department, (HOD) in Department of Computer Science, Govt. Holkar (Aotonomous) Science College-INDIA. He has 28 year teaching exceprience in college level. His various research papers are published in national and international journals of repute. His various paperr published in national and international conferencess His research interest includes X-ray spectroscopy, Networking.