Performance Evaluation of Ad Hoc On Demand Distance Vector in MANETs with varying Network Size using NS-2 Simulation

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***Abstract*— A mobile ad hoc network (MANET) is a collection of wireless mobile nodes dynamically forming a network topology without the use of any existing network infrastructure or centralized administration. Routing is the task of directing data packets from a source node to a given destination. The main method for evaluating the performance of MANETs is simulation. The On-demand protocol performs better than the table-driven protocol. This paper is subjected to Adhoc On Demand Distance Vector (AODV) routing protocol and evaluated its performance. We investigated the performance metrics namely Packet Delivery Fraction (PDF), Average end-to-end delay, normalized routing load and throughput by varying network size up to 50 nodes through NS-2 simulation. The performance of protocol is one of the interesting issue. Almost always the network protocols were simulated as a function of mobility, but not as a function of network density. The main interest of this paper is to test the ability of AODV routing protocol to react on network topology changes.**

***Keywords*- MANET, AODV, Performance Metrics, NS-2.34, Simulation**

I. INTRODUCTION

A Mobile Ad hoc Networks (MANETs) represents a system of wireless mobile nodes that can freely and dynamically self-organize in to arbitrary and temporary network topologies, allowing people and devices to seamlessly communicate without any pre-existing communication architecture. Each node in the network also acts as a router, forwarding data packets for other nodes. A central challenge in the design of ad hoc networks is the development of dynamic routing protocols that can efficiently find routes between two communicating nodes. Our goal is to carry out a systematic performance study of on demand routing protocol AODV [14] for ad hoc networks. Moreover our performance analysis is based on varying number of nodes in the Mobile Ad Hoc Network. Generally always the network protocols were simulated as a function of pause time, but not as a function of network size. The rest of the paper is organized as follows: The related work is provided in section II. The AODV routing protocol Description is summarized in section III. The simulation environment and performance metrics are described in Section IV. We present the simulation results and observation in section V and the conclusion is presented in section VI.

II. RELATED WORK

Several researchers have done the qualitative and quantitative analysis of Ad Hoc Routing Protocols by means of different performance metrics. They have used different simulators for this purpose.

1) J Broch et al. [1] performed experiments for performance comparison of both proactive and reactive routing protocols. In their Ns-2 simulation, a network size of 50 nodes with varying pause times and various movement patterns were chosen.

2) Jorg D.O. [3] studied the behavior of different routing protocols on network topology changes resulting from link breaks, node movement, etc. In his paper performance of routing protocols was evaluated by varying number of nodes etc. But he did not investigate the performance of protocols under heavy loads (high mobility +large number of traffic sources + larger number of nodes in the network), which may lead to congestion situations.

3)Khan et al. [4] studied and compared the performance of routing protocols by using NCTUns 4.0 network simulator. In this paper, performance of routing protocols was evaluated by varying number of nodes in multiples of 5 in the ad hoc network. The simulations were carried out for 70 seconds of the simulation time. The packet size was fixed to 1400 bytes.

4) Arunkumar B R et al. [8] in this paper they present their observations regarding the performance comparison of the routing protocols for variable bit rate (VBR) in mobile ad hoc networks (MANETs). They perform extensive simulations, using NS-2 simulator [13]. Their studies have shown that reactive protocols perform better than proactive protocols.

5) S. Gowrishanker et al [9] performed the Analysis of AODV and OLSR by using NS-2 simulator, the simulation period for each scenario was 900 seconds and the simulated mobility network area was 800 m x 500 m rectangle. In each simulation scenario, the nodes were initially located at the center of the simulation region. The nodes start moving after the first 10 seconds of simulated time. The application

used to generate is CBR traffic and IP is used as Network layer protocol.

6) N Vetrivelan & Dr. A V Reddy [10] analyzed the performance differentials using varying network size and simulation times. They performed two simulation experiments for 10 & 25 nodes for simulation time up to 100 sec.

7) S. P. Setty et.al.[6] evaluated the performance of existing wireless routing protocol AODV in various nodes placement models like Grid, Random and Uniform using QualNet 5.0.

III. AODV Routing Protocol Description

Ad hoc On Demand Distance Vector (AODV) [14] is a reactive routing protocol which initiates a route discovery process only when it has data packets to send and it does not know any route to the destination node, that is, route discovery in AODV is "on-demand". AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to avoid the routing loops that may occur during the routing calculation process. All routing packets carry these sequence numbers.

A. Route Discovery Process

During a route discovery process, the source node broadcasts a route query packet to its neighbors. If any of the neighbors has a route to the destination, it replies to the query with a route reply packet; otherwise, the neighbors rebroadcast the route query packet. Finally, some query packets reach to the destination.

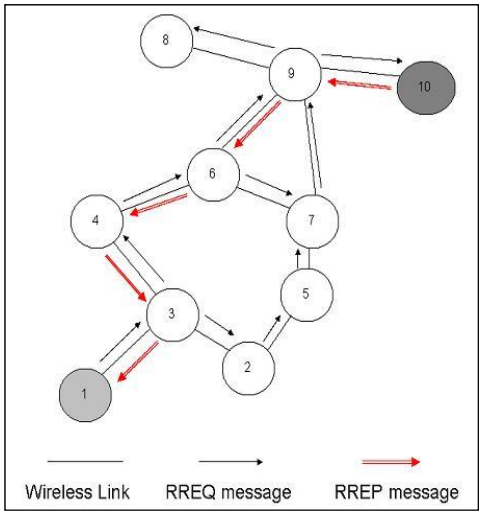

Figure 1. AODV Route Discovery Process

"Fig. 1" shows the route discovery process from source node1 to destination node 10. At that time, a reply packet is produced and transmitted tracing back the route traversed by the query packet as shown in "Fig. 1".

B. AODV Route Message Generation

The route maintenance process in AODV is very simple. When the link in the path between node 1 and node 10 breaks the upstream node that is affected by the break, in this case node 4 generates and broadcasts a RERR message. The RERR message eventually ends up in source node 1. After receiving the RERR message, node 1 will generate a new RREQ message (Fig. 2).

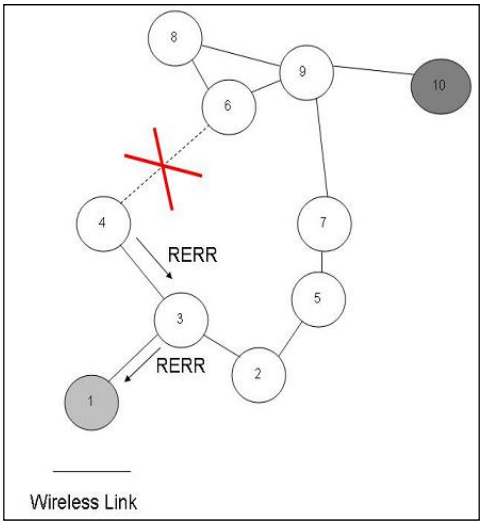

Figure 2. AODV Route Error message generation

C. AODV Route Maintenance Process

Finally, if node 2 already has a route to node 10, it will generate a RREP message, as indicated in Figure 3. Otherwise, it will re-broadcast the RREQ from source node 1 to destination node 10 as shown in "Fig. 3".

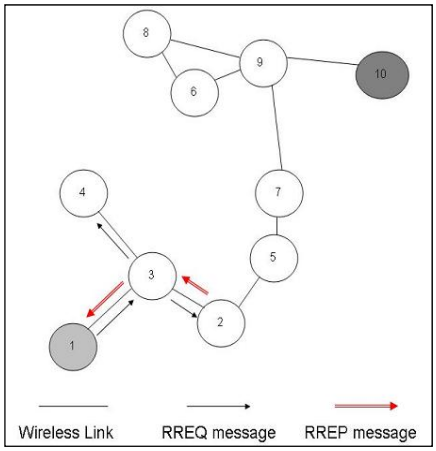

Figure 3. AODV Route Maintenance Process

IV. Simulation Environment

A. Simulation Model

Here we give the emphasis for the evaluation of performance of Ad Hoc routing protocol AODV with varying the number of mobile nodes. The simulations have been performed using network simulator NS-2 [13]. The network simulator ns-2 is discrete event simulation software for network simulations which means it simulates events

such as sending, receiving, forwarding and dropping packets. The latest version, ns-allinone-2.34, supports simulation for routing protocols for ad hoc wireless networks such as AODV, TORA, DSDV, and DSR. Ns-2 is written in C++ programming language and Object Tool Common Language (OTCL). Although ns-2.34 can be built on various platforms, we chose a Linux platform [FEDORA 7] for this paper, as Linux offers a number of programming development tools that can be used along with the simulation process. To run a simulation with ns-2.34, the user must write the simulation script in OTCL, get the simulation results in an output trace file and here, we analyzed the experimental results by using the awk command (Fig. 5).The performance metrics are graphically visualized in XGRAPH 12.1(Fig. 6,7,8,9). Ns-2 also offers a visual representation of the simulated network by tracing nodes movements and events and writing them in a network animator (NAM) file (Fig. 4).

B. Simulation Parameters

We consider a network of nodes placing within a 1000m X 1000m area. The performance of AODV is evaluated by keeping the network speed and pause time constant and varying the network size (number of mobile nodes).Table 1 shows the simulation parameters used in this evaluation.

TABLE 1: PARAMETERS VALUES FOR AODV SIMULATION

Simulation Parameters	
Simulator	ns-2.34
Protocol	AODV
Simulation duration	200 seconds
Simulation area	1000 m x 1000 m
Number of nodes	5,10,15,20,25, 30,35,40,45,50
Transmission range	250 m
Movement model	Random Waypoint
MAC Layer Protocol	IEEE 802.11
Pause Time	100 sec
Maximum speed	20 m/s
Packet rate	4 packets/sec
Traffic type	CBR (UDP)
Data payload	512 bytes/packet

C. Performance Metrics

While analyzed the AODV protocol, we focused on two performance metrics which are Packet Delivery Fraction (PDF), Average End-to-End Delay, Normalized Routing Load (NRL) and throughput.

- Packet delivery fraction: The fraction of all the received data packets successfully at the destinations over the number of data packets sent by the CBR sources is known as Packet delivery fraction.

- Average End to end delay: The average time from the beginning of a packet transmission at a source node until packet delivery to a destination. 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 of data packets. Calculate the send(S) time (t) and receive (R) time (T) and average it.

- Normalized Routing Load: The normalized routing load is defined as the fraction of all routing control packets sent by all nodes over the number of received data packets at the destination nodes.

- Throughput: Throughput is the average number of messages successfully delivered per unit time i.e. average number of bits delivered per second.

V. SIMULATION RESULTS & OBESRVATION

The simulation results are shown in the following section in the form of line graphs. The performance of AODV based on the varying the number of nodes is done on parameters like packet delivery fraction and average end-to-end delay, normalized routing load and throughput.

"Fig. 4" shows the creation of clusters with 50 mobile nodes as it is shown in the NAM console which is a built-in program in NS-2-allinone package after the end of the simulation process.

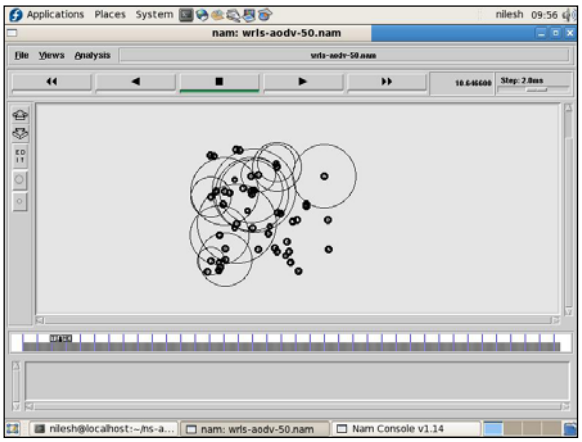

Figure 4. AODV with 50 nodes: Route Discovery

"Fig. 5" shows the calculation of send, received packets, PDF, average end-to-end delay, normalized routing load and etc. for AODV simulation with 50 nodes by running AWK script for it.

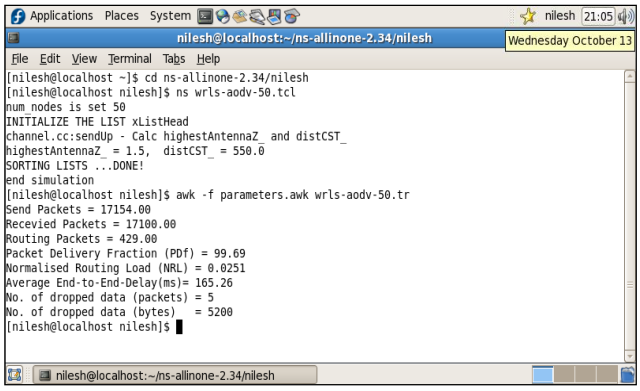

Figure 5. Snapshot of the results of performance metrics

"Fig. 6" highlights the relative performance of AODV i.e. it delivers a greater percentage of the originated data (above 99%). From figure it is observed that the performance of AODV is consistently uniform between 99.5 & 99.7 %.

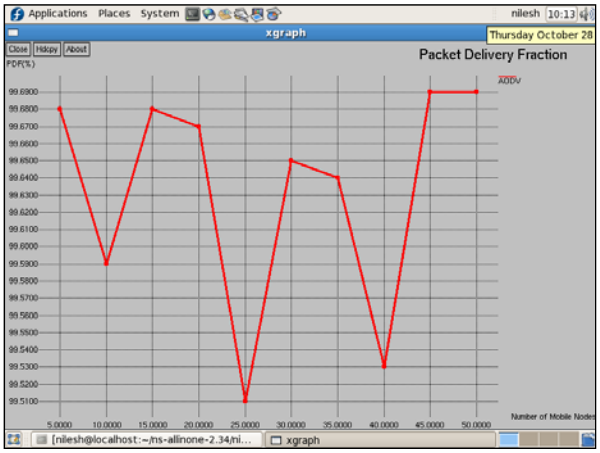

Figure 6. Packet Delivery Fraction Vs Number of Mobile Nodes

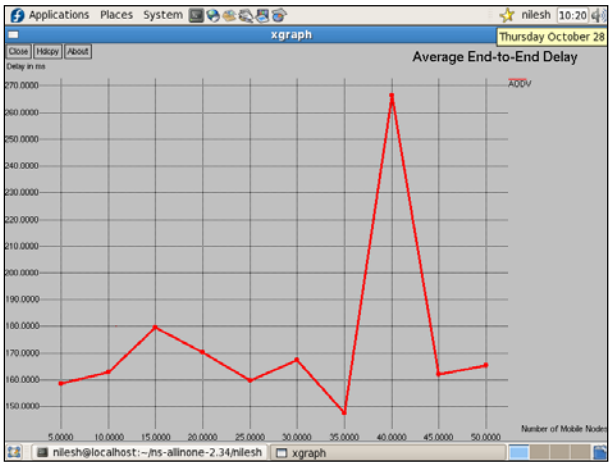

Figure 7. Average End-to-End Delay (ms) Vs Number of Mobile Nodes

For average end-to-end delay, the performance of AODV is almost uniform (below 180 ms) except for 40 nodes (Fig. 7).

From "Fig. 8" we can observed that the normalized routing load is initially low for less number of nodes but it increases with , varying the network size because in AODV routing load is dominated by route requests as a part of route discovery process.

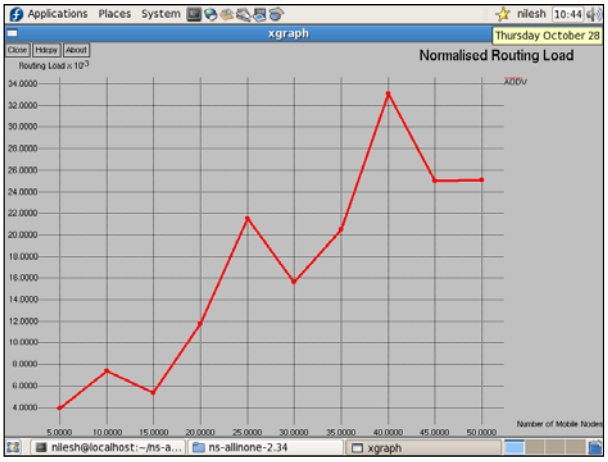

Figure 8. Normalized routing Load Vs Number of Mobile Nodes

In case of AODV protocol when number of nodes increases, initially throughput increases as large number of routes are available but after a certain limit throughput becomes stable. Figure shows that the ability of the AODV to deliver packets to their destination degrades as the network size increases (Fig. 9).

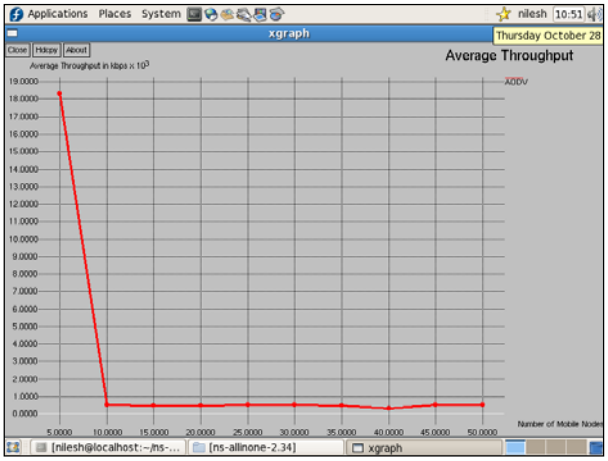

Figure 9. Throughput Vs Number of Mobile Nodes

VI. CONCLUSION

In this presented simulation work, the AODV routing protocol is evaluated for the application oriented performance metrics such as packet delivery fraction, average end-to-end delay, normalized routing load and average throughput with increasing the number of mobile nodes up to 50. As we increase the number of nodes for performing the simulation of AODV routing protocol,

number of sent, routing and delivered packets changes, hence the performance parameters changes.

As a result of our studies, we conclude that AODV exhibits a better performance in terms of packet delivery fraction and average end-to-end delay with increasing number of mobile nodes due to its on demand characteristics to determine the freshness of the routes. It suits where end-to-end delays are very critical. Also it can be said that the AODV has higher normalized routing load. Our result also indicates that as the number of nodes in the network increases AODV gives nearly constant throughput. Considering the overall performance of AODV it performs well with varying network size.

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