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Performance Evaluation of MANET Routing Protocols Using Random Waypoint Mobility Model

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***Abstract** -- A Mobile Ad-Hoc Network (MANET) is a self-configuring network of mobile nodes connected by wireless links, to form an arbitrary topology. The nodes are free to move randomly. Thus the network's wireless topology may be unpredictable and may change rapidly .Due to varying mobility characteristics; there is a significant impact on the performance of the routing protocols. There are various Mobility models to generate mobility patterns. In this paper we considered three MANET routing protocols namely DSDV, DSR and AODV.We have compared the performance of protocols by varying Speed parameter with CBR traffic source and by using Random Waypoint mobility model. The comprehensive analysis has been carried out using NS2 simulator. The metrics used for analysis are Packet Delivery Ratio, Average end-to-end Delay and Normalized Routing Load. It has been observed that, under Random Waypoint mobility model, AODV and DSR performs better than DSDV in terms of PDF. However in terms of Average end-to-end Delay, DSDV appears to be the best one.*

***Keywords**— DSDV, DSR, AODV, Performance Parameters, Network Simulator (NS-2), Mobile Ad hoc Network, Random Waypoint Mobility Model*

I. INTRODUCTION

A Mobile Ad hoc Network (MANET) is autonomous, self-configuring network of mobile nodes that can be set up randomly and formed without the need of any existing network infrastructure or centralized administration. Minimal configuration, quick deployment and absence of a central governing authority make ad hoc networks suitable for emergency situations like natural disasters, military conflicts, emergency medical situations etc. All nodes can be mobile resulting in a possibly dynamic network topology which is a real challenging issue in mobile ad hoc networks. The dynamic nature of MANET topology imposes the use of efficient routing protocols that ensure the delivery of packets safely to their destinations with acceptable delays. Simulation studies of MANET routing protocols have mostly considered Random Waypoint as a reference mobility model [1, 2].

In order to examine many different MANET applications, there is a need to provide additional mobility models. There are various mobility models such as Random Way Point, Manhattan Grid Mobility Model, Reference Point Group Mobility Model (RPGMM), Freeway Mobility Model, Gauss Markov Mobility Model etc that have been suggested for evaluation [3, 4]. Many researchers have been focused on the evaluation of routing protocols according to nodes mobility: a performance comparison of DSR and AODV protocols based on Manhattan Grid (MG) model has been published in [5]. A performance study of DSR and AODV considering probabilistic random walk and boundless simulation area has been presented in [6]. A performance evaluation of DSDV and AODV using scenario based mobility models has been presented in [7]. A comparative analysis of DSR and DSDV protocols, considering Random Waypoint, Group Mobility, Freeway and MG models can be found in [8], Performance Analysis and Comparison of MANET Routing Protocols vs. Mobility Models is presented in [9].Performance evaluation of DSR and AODV protocols using Group Mobility model is published in [10].

In our work, we have selected the Random Waypoint mobility model that models a movement of nodes with some maximum velocity. The RW model acts as the 'baseline' mobility model to evaluate the protocols in Ad Hoc Network and it is provided by the setdest tool in the standard ns-2 distribution. Thus we used the Random Waypoint model in our work to evaluate the performance of the three routing protocols namely DSDV, DSR and AODV.The purpose of this work is to understand the working mechanism of mobility models and to show which routing protocol performs better with different mobility rates and by using Random Waypoint Mobility model. The rest of this paper is organized as follows. Section 2 describes the DSDV, DSR and AODV routing protocols. Different mobility models are mentioned in section 3. The simulation environment and performance parameters are described in Section 4. In Section 5, we present simulation results and analysis. Finally, Section 6 concludes the paper.

II. MANET ROUTING PROTOCOLS(DSDV,DSR & AODV)

A. *Destination-Sequenced Distance-Vector (DSDV)*

Destination-Sequenced Distance-Vector Routing protocol is a proactive table driven algorithm based on classic Bellman-Ford routing. In proactive protocols, all nodes learn the network topology before a forward request comes in. In

DSDV protocol each node maintains routing information for all known destinations. The routing information is updated periodically. Each node maintains a table, which contains information for all available destinations, the next node to reach the destination, number of hops to reach the destination and sequence number. The nodes periodically send this table to all neighbours to maintain the topology, which adds to the network overhead. Each entry in the routing table is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops [11].

B. Dynamic Source Routing (DSR)

Dynamic Source Routing protocol is a reactive protocol i.e. it determines the proper route only when a packet needs to be forwarded. The node floods the network with a route-request and builds the required route from the responses it receives. DSR allows the network to be completely self-configuring without the need for any existing network infrastructure or administration. The DSR protocol is composed of two main mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network. All aspects of protocol operate entirely on-demand allowing routing packet overhead of DSR to scale up automatically. Route Discovery: When a source node *S* wishes to send a packet to the destination node *D*, it obtains a route to *D*. This is called Route Discovery. Route Discovery is used only when *S* attempts to send a packet to *D* and has no information on a route to *D*.

Route Maintenance: When there is a change in the network topology, the existing routes can no longer be used. In such a scenario, the source S can use an alternative route to the destination *D*, if it knows one, or invoke Route Discovery. This is called Route Maintenance.

C. Ad Hoc on-Demand Distance Vector Routing (AODV)

The Ad Hoc on-Demand Distance Vector Routing (AODV) [12] is also a reactive routing protocol in mobile ad hoc networks .Similar to DSR, AODV also has two phases for establishing and maintaining the routes. At each node, AODV maintains a routing table. Each node has a sequence number. When a node wants to initiate route discovery process, it includes its sequence number and the most fresh sequence number it has for destination. The intermediate node that receive the RREQ packet, replay to the RREQ packet only when the sequence number of its path is larger than or identical to the sequence number comprised in the RREQ packet. A reverse path from the intermediate node to the source forms with storing the node's address from which initial copy of RREQ. Thus, at the end of this request-response cycle a bidirectional route is established between the requesting node and the destination. As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically travelling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables.

III. MOBILITY MODELS

A. Random Waypoint (RW) Model

The Random Waypoint model is most commonly used mobility model in research community. In the current network simulator (ns-2) distribution, the implementation of this mobility model is as follows: at every instant, a node randomly chooses a destination and moves towards it with a velocity chosen uniformly randomly from [0,V_max], where V_max is the maximum allowable velocity for every mobile node. After reaching the destination, the node stops for a duration defined by the 'pause time' parameter. After this duration, it again chooses a random destination and repeats the whole process again until the simulation ends.

B. RPGM Model

Group mobility can be used in military battlefield communication. Here, each group has a logical centre (group leader) that determines the group's motion behaviour. Initially, each member of the group is uniformly distributed in the neighbourhood of the group leader. Subsequently, at each instant, every node has a speed and direction that is derived by randomly deviating from that of the group leader. The important characteristic of RPGM Model is every node in the group deviates its velocity (both speed and direction) randomly from that of the group leader. For that the formulas are mentioned below.

1) V_ {member} (t) = V_ {leader}(t) + random() * SDR * max_speed

2) Theta_ {member} (t) = theta_ {leader} (t) + random () * ADR * max_angle

Where 0 <= SDR, ADR <= 1. SDR is the Speed Deviation Ratio and ADR is the Angle Deviation Ratio. SDR and ADR are used to control the deviation of the velocity (magnitude and direction) of group members from that of the leader. Since the group leader mainly decides the mobility of group members, group mobility pattern is expected to have high spatial dependence for small values of SDR and ADR.

C. Freeway Mobility (FW) Model

This model emulates the motion behaviour of mobile nodes on a freeway. It can be used in exchanging traffic status or tracking a vehicle on a freeway. In this model we use maps. There are several freeways on the map and each freeway has lanes in both directions. The differences between Random Waypoint and Freeway are the following:

(1) Each mobile node is restricted to its lane on the freeway.

(2) The velocity of mobile node is temporally dependent on its previous velocity.

Formally, vec{V_{i}}(t+1) = vec{V_{i}}(t) + random() * vec{a_{i}}(t)

(3) If two mobile nodes on the same freeway lane are within the Safety Distance (SD), the velocity of the following node cannot exceed the velocity of preceding node. Formally, for all {i}, for all {j},for all{t}, if D_{i,j}(t) < Safety Distance, then vec{V_{i}}(t) < vec{V_{j}}(t), if j is ahead of i in its lane.

From the above relationships, the Freeway mobility pattern is expected to have spatial dependence and high temporal dependence. It also imposes strict geographic restrictions on the node movement by not allowing a node to change its lane.

D. Manhattan Mobility (MH) Model

We introduce the Manhattan model to emulate the movement pattern of mobile nodes on streets defined by maps. It can be useful in modelling movement in an urban area where a pervasive computing service between portable devices is provided. Maps are used in this model too. However, the map is composed of a number of horizontal and vertical streets.The mobile node is allowed to move along the grid of horizontal and vertical streets on the map. At an intersection of a horizontal and a vertical street, the mobile node can turn left, right or go straight with certain probability. Except the above difference, the inter-node and intra-node relationships involved in the Manhattan model are very similar to the Freeway model.

IV. SIMULATION ENVIRONMENT

A. *Simulation Model*

The network simulations have been carried out using Network Simulator version 2 (NS-2.35) and its associated tools for animation and analysis of results. We chose a Linux platform i.e. UBUNTU 12.10, as Linux offers a number of programming development tools that can be used with the simulation process. We analysed the experimental results contained in generated output trace files by using the AWK command. To evaluate the performance of MANET routing protocols, we used the fig. 1 flow diagram .We used traffic Scenario files(using cbrgen tool) and Mobility Scenario Files(setdest tool) for traffic generation and mobility in our simulation.

Random traffic connections of CBR and TCP can be setup between mobile nodes using a traffic-scenario generator script (cbrgen.tcl) .It can be used to create CBR and TCP traffic connections between wireless mobile nodes. In order to create a traffic-connection file, we need to define the type of traffic connection (CBR), the number of nodes and maximum number of connections to be setup between them. CBR is generally used to simulate multimedia traffic on limited capacity channels, or to fill in background traffic to affect the performance of other applications being analysed. The TCP sources are not being chosen because they adapt to the load of the network.

Mobility models were created for the simulations using 50 nodes, with pause time 0 seconds, Maximum speed of 10m/s,20m/s,30m/s and 40 m/s, topology boundary of 500x500 and simulation time of 100secs.

Fig. 1 Flow diagram for evaluating the performance in MANET Routing Protocols

B. Simulation Parameters

The simulation parameters used in our work are listed in Table 1.

TABLE I: Simulation Parameters

Parameter	Value
Simulator	NS-2 (Version 2.35)
Channel type	Channel/Wireless channel
Routing Protocols	DSDV,DSR,AODV
Simulation Duration	100ms
Max. no.of nodes	50
MAC layer protocol	802.11
Max. Speed	10,20,30,40
Traffic Type	CBR
Transmission Range	500*500m
Packet Rate	2packets/sec
Mobility Model	Random Waypoint Model
Packet Size	512bytes
Max.CBR Connections	10

C.Performance Parameters

Performance of MANET routing protocols can be evaluated using a number of quantitative metrics those are mentioned in RFC2501. We have used packet delivery ratio, end-to-end delay and normalized routing load for evaluating the performance of unicast routing protocols DSDV, DSR, AODV.

1) Packet Delivery Ratio: It is defined as the ratio of number of data packets delivered to all the receivers to the number of data packets supposed to be delivered to the receivers. This ratio represents the routing effectiveness of the protocol: PDR = Packets delivered/ Packets sent

2) Average End-to-End Delay: It is the average time taken for a data packet to move from the source to the receivers: Avg. EED = Total EED /No. of packets sent

3) Normalized Routing Load (NRL): It is defined as the ratio of total no. of data packets received to the total no. of routing packets received: NRL = No. of data packets received /No. of routing packets received .

V. Simulation Results and Analysis

A. Simulation Results

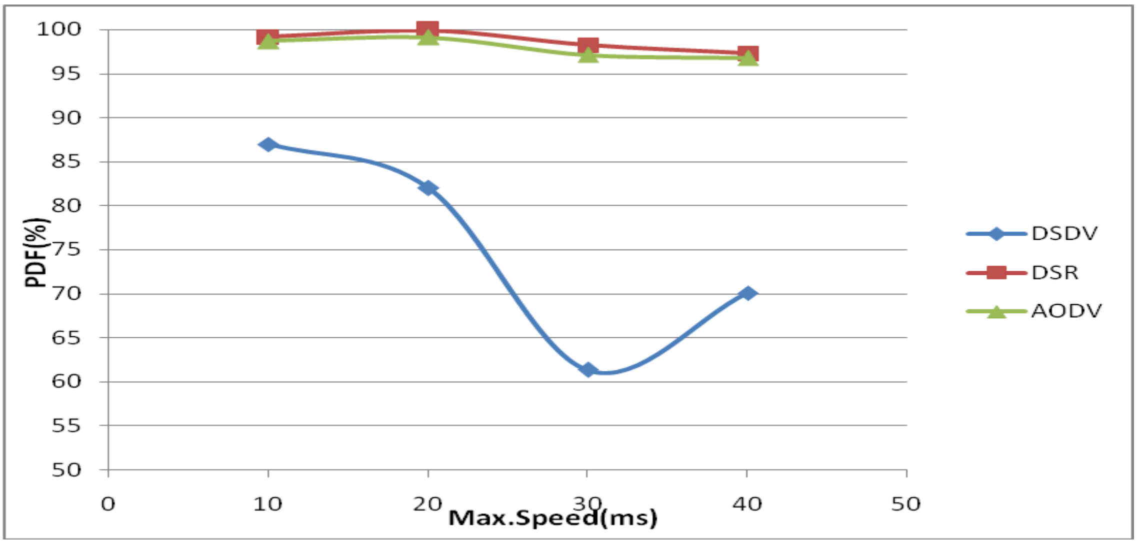

Fig. 2 PDF vs. Speed (fixed 50 nodes)

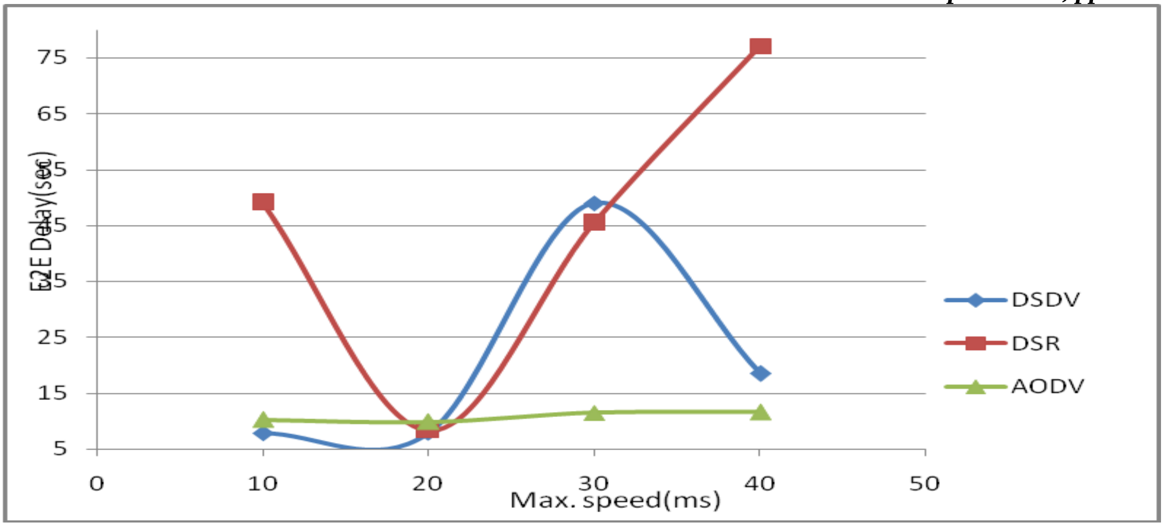

Fig .3 E2E Delay vs. Speed (fixed 50 nodes)

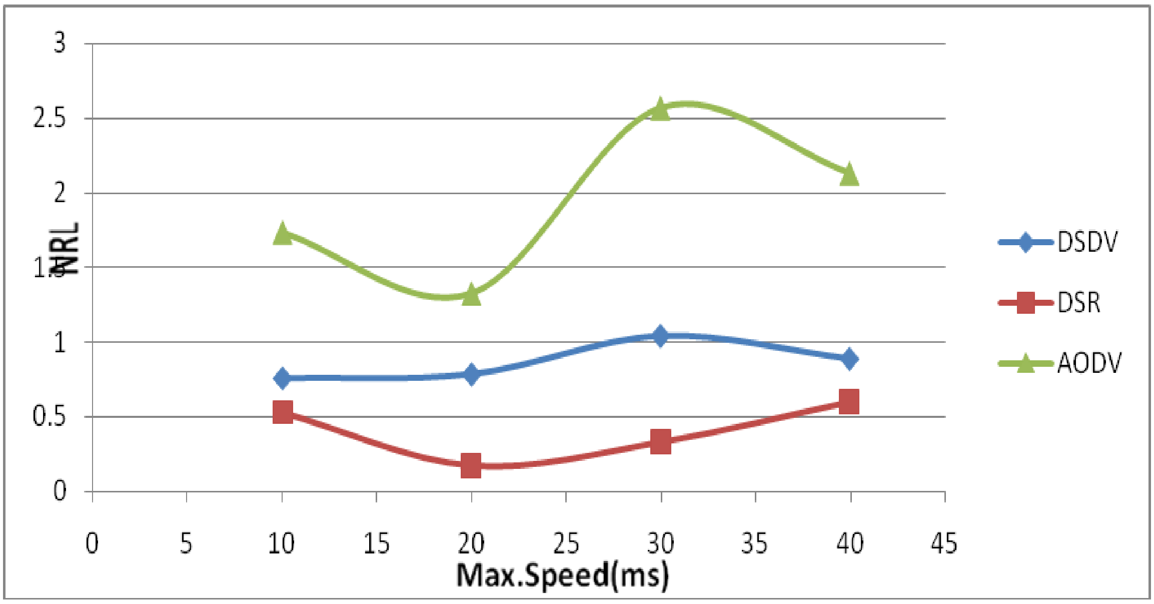

Fig .4 NRL vs. Speed (fixed 50 nodes)

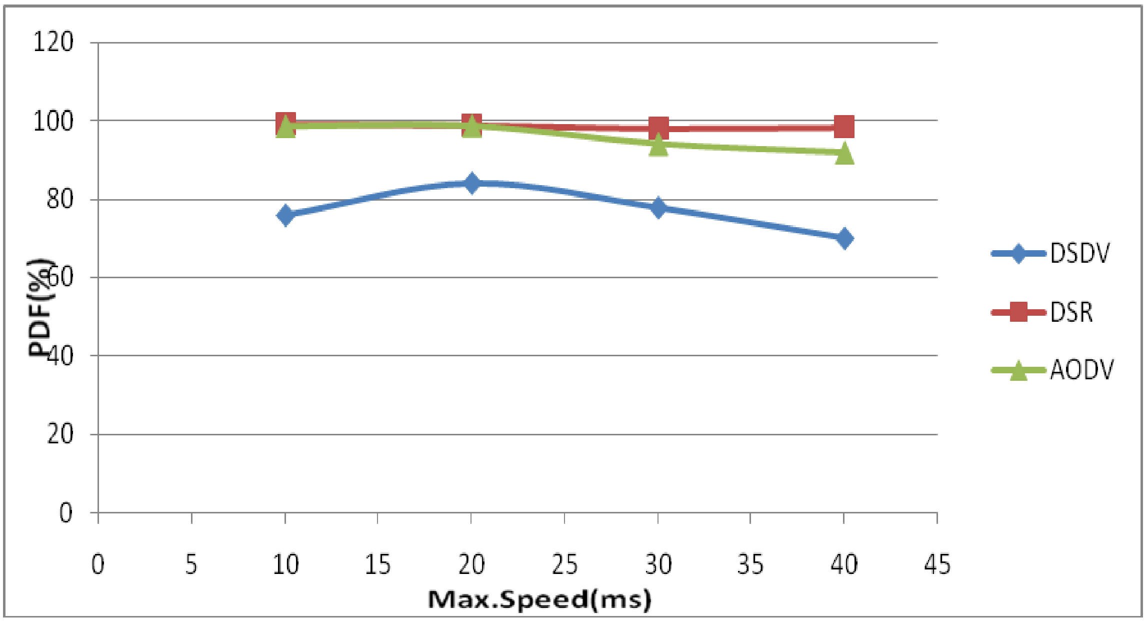

Fig. 5 PDF vs. Speed (fixed 100 nodes)

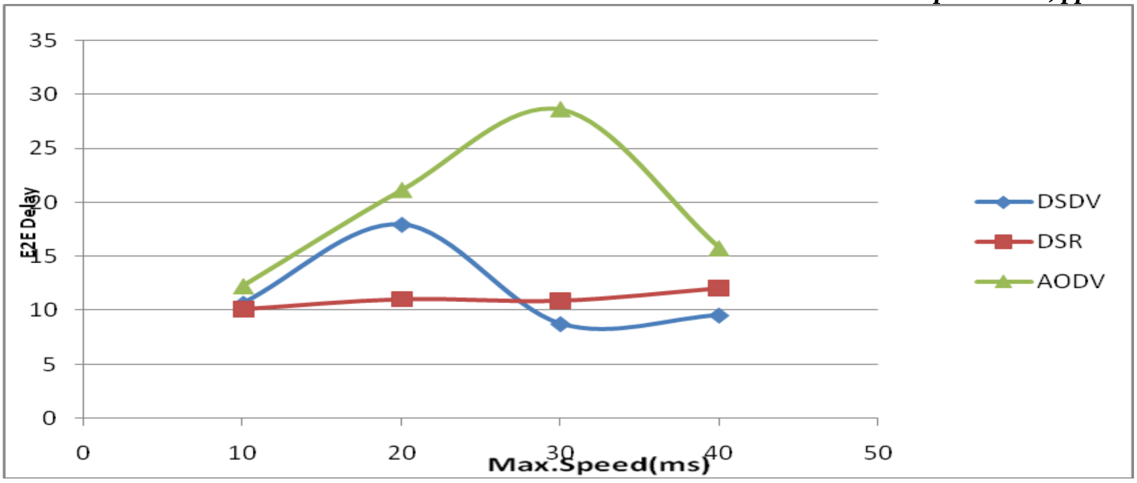

Fig.6 E2E Delay vs. Speed (fixed 100 nodes)

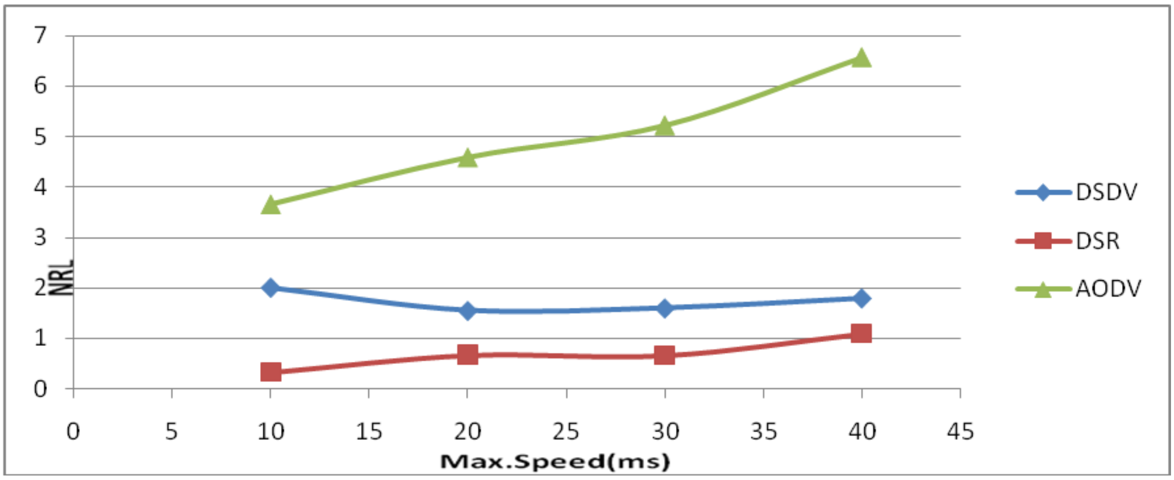

Fig.7 NRL vs. Speed (fixed 100 nodes)

B. Simulation Analysis

In this paper, we have attempted to compare all the three protocols under Random Waypoint mobility model. For all the simulations, the same movement model was used, the number of traffic sources was fixed at 50,100, the speed was varied as 10, 20, 30, 40ms, and a fixed topology boundary of 500x500. As shown in figures 2, 3, 4,5,6,7 we observe that, regardless of network size or mobility rate, AODV and DSR performed better than DSDV delivering over 90% of data packets. The Average end-to-end Delay of packet delivery was higher in DSR as demonstrated in figure 3.With increase of Network size,AODV has higher end-to-end Delay as illustrated in 6. Normalized routing load is more in AODV compared to DSR and DSDV as illustrated in fig 4 and 7 regardless of network size.

VI **CONCLUSIONS**

In this paper, DSDV, DSR, AODV routing protocols using different mobility patterns have been simulated and analyzed the parameter metrics in terms of Packet Delivery Fraction, Average end-to-end Delay and Normalized Routing Load in different environments. Simulation results show that performance parameters of the routing protocols may vary depending on network load, mobility and network size. Under Random Waypoint mobility Model, AODV and DSR experience the highest Packet Delivery Fraction with the increase of nodes, speed and CBR traffic sources. However, DSDV experiences the lowest Average end-to-end Delay. AODV and DSR performance is due to their on demand characteristics to determine the freshness of the route. And it is proved also that AODV has a higher Average end-to-end Delay than DSR with increase of number of nodes. It is observed that Normalized Routing load is also more in AODV compared to the other two protocols. This paper can be enhanced by considering MANET multicast routing protocols under different mobility models.

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