PERFORMANCE ANALYSIS OF REACTIVE ROUTING PROTOCOLS FOR CITY SCENARIO MOBILITY MODEL IN MANETS

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ABSTRACT

A MANET is a type of wireless network which does not require any predefined infrastructure to get established and is a collection of mobile nodes forming a network by their own. The performance of MANETS depends upon various factors such as- routing technique, size of network, density of network, power and bandwidth etc. Mobility model is a representation of reality of a scenario in which nodes may move in real environment. It provides an insight that how each node may move under given circumstances. The aim here is to study the impact of mobility models on the performance of routing protocols in mobile ad hoc networks. For analysis purpose we have chosen the AODV (ad-hoc on-demand distance vector routing protocol) and DSR (dynamic source routing protocol). The performance is evaluated and analyzed for two mobility models Random Waypoint and Manhattan Grid through simulation. We have designed another scenario named CSM (City Scenario Model) and analyzed it along with the aforementioned modes. The performance metrics like packet delivery ratio, average end-to-end delay, normalized routing load, and throughput are evaluated using network simulator NS2 with varying node density and varying maximum allowable velocity in the network.

KEYWORDS: *MANET, DSR, AODV, Mobility Models, City Scenario*

I. INTRODUCTION

A MANET is a collection of mobile nodes connected via wireless links and creating a network autonomously and without any predefined infrastructure. In a MANET, nodes move independently, therefore the network experiences rapid and unpredictable topology changes. It may node be possible for each node in a MANET to communicate with every other node due to restriction of transmission range. So, MANET is a multi hop network in terms of routing paths as shown in Fig.1. MANETs have several advantages such as ease of configuration and deployment, low cost, rapid access and easy scalability.

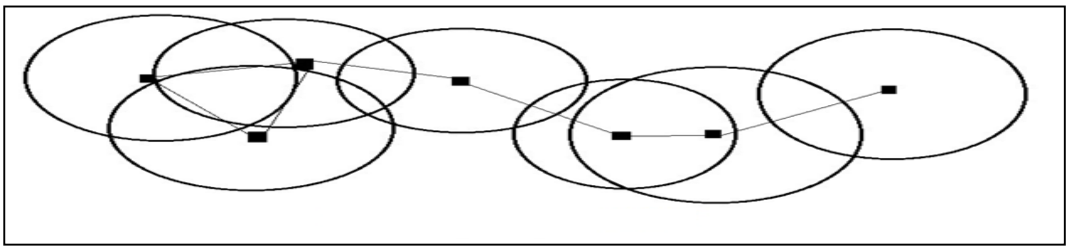

Figure 1. MANET

II. DESCRIPTION OF ROUTING PROTOCOLS

2.1 Dynamic Source Routing Protocol (DSR)

DSR is a simple on-demand protocol that is designed to meet the requirements of a multi-hop MANET. Route request packets (RREQ) and Reply route Packets (RREP) are used for route establishment. Network nodes use multiple- hops to communicate with each other.

Route Discovery in DSR: Route discovery is done by DSR to find the route and to send the data from a source to destination where the source node is not aware of the destination route. For example, in fig 2, Let us assume node 'S' wants to find a route to node 'I'.

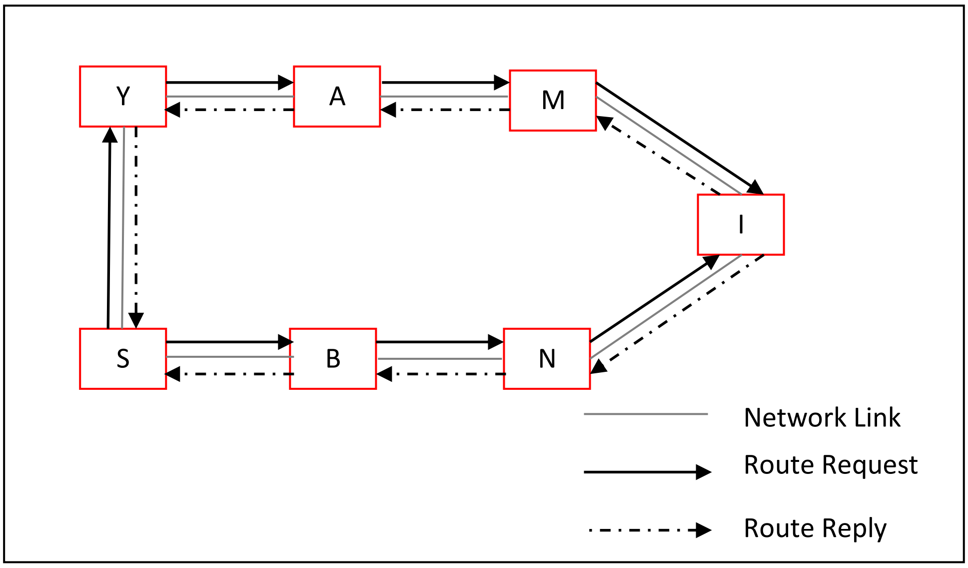

Figure 2. DSR Route Discovery

Initially node 'S' sends 'RREQ' (Route Request) which is broadcasted in the network and received by immediate neighbours. This request has information about the source and the destination along with unique request identifier. RREQ also retains the information about all the intermediate nodes visited by while reaching the destination. When the destination 'I' gets the RREQ packet, it will send the 'RREP' (Reply Route) to the source node 'S' through reverse route. 'RREP' has a copy of the route information of the RREQ then the source cache information to use in further communication process.

Route Maintenance in DSR: DSR protocol enables the route maintenance procedure while transmitting the packets from source to destination. When the route between the source and the destination is broken or else a change in topology is observed. It will result in failure of the packet transmission between source node and destination node. In this case, DSR protocol uses the route maintenance procedure, to find out other possible known route towards the destination to transmit data through cached routes during route discovery process. If the route maintenance fails in finding an alternative route it will invoke the route discovery process to find a new route to the destination.

2.2 Ad-hoc On-demand distance vector routing protocol

In AODV the source node and the intermediate nodes store the next hop for each flow for data packet transmission. The major difference between AODV and other on demand routing protocol DSR is that AODV uses a destination sequence number (DSN) for every route entry to resolve up-to-date and fresh path to destination [2].

Route Discovery: DSN is created by the destination. The DSN and the respective route information should to be included by the nodes to find out the routes to destination nodes. Routes with the higher DSN are preferred in selecting the route to destination. Fig. 3 shows AODV route discovery process. AODV uses Route Request (RREQ), Route Replies (RREP) and Route Error (RERR) in finding the route from source to destination by using UDP (user datagram protocol) packets. A source node 'S' aiming to communicate with destination 'I', generally uses the RREQ containing the source address and the broadcast ID address to its neighboring nodes to find the route to the destination. This broadcast ID is incremented by 1 for every new RREQ. When a neighbor notices a destination route it responds with RREP to the source. If the destination route cannot be found then it will re-broadcast the RREQ to its neighboring nodes by incrementing the hop count. In this process a node may receive multiple copies of the broadcast packets in transmissions from all the corresponding nodes. Now the node will check if the Broadcast ID is new, if it is so the then the node will process the request else it will ignore the re-broadcast.

Route Maintenance: When a route breaks in AODV, which is determined by monitoring the periodical signals or by link-level acknowledgements, the end nodes are informed. When a source node notices the route break, it again sets up the route to the destination. If a route break is found at an intermediate node, the node tells the end nodes by sending unsolicited RREP with the loop count set to infinity. The source node re-launches the path finding mechanism with the new a broadcast ID and the previous destination sequence number (DSN). The nodes react to the any change in network topology and path failures. In case of the path failures the respective nodes are informed with the message, and then the affected nodes will withdraw the routes using the lost path. This makes the operation of AODV "Loop free".

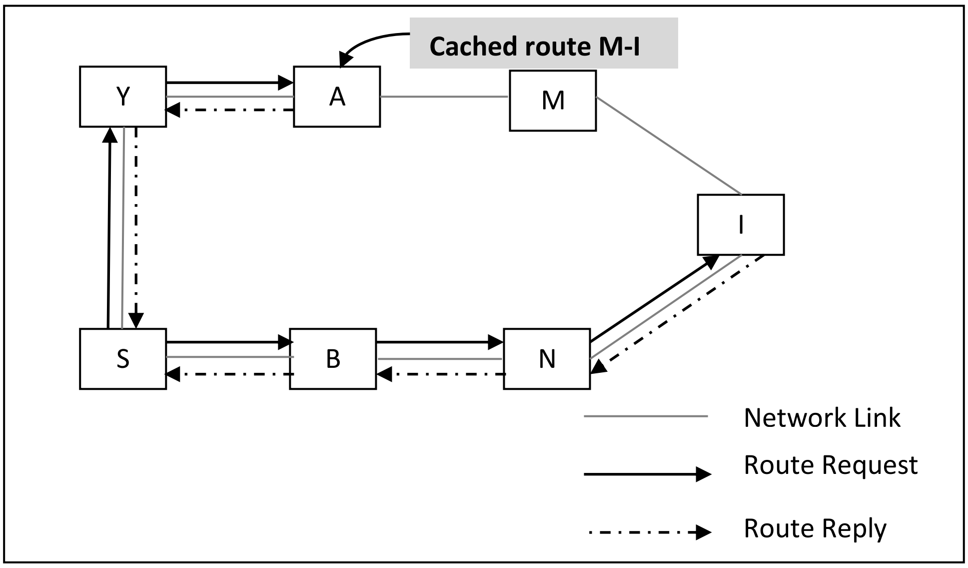

Figure 3. AODV Route Discovery

III. MOBILITY MODELS

A mobility models represent the way nodes might move in a real world environment. A mobility model is designed to represent the movement patterns, their location at a particular instance of time, direction of movement, pause pattern, and speed changes over time of the mobile nodes in a given scenario.

3.1 The Random Waypoint Model (RWP)

The idea behind Random waypoint model is continuously choosing a waypoint (destination) by the node and moving towards it. The node chooses a new waypoint after waiting for a defined pause time and it moves with a uniform speed randomly chosen between the defined speed range V[MAX,MIN] in the given simulation area. Now the node will move for the given pause time and will again choose a waypoint to visit. Fig. 4 shows the movement of a single node in the random waypoint model. We should avoid from giving a long initial period because randomly distributed nodes (at the starting of the simulation) may take some time to reach a stationary distribution.

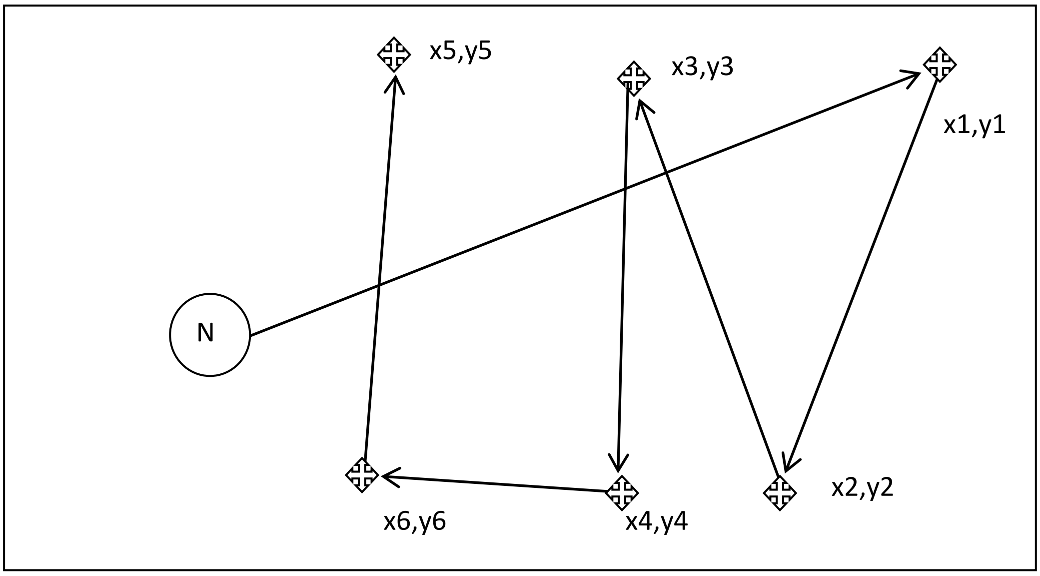

Figure 4. Sample movement of node N in RWM

3.2 Manhattan Mobility Model

Many well planned cities are divided into blocks that have uniform distribution of roads and buildings. Manhattan model was designed to emulate the scenario of movement pattern of mobile nodes on such roads/streets. It's very helpful in emulating the movement in an urban area. The scenario, as shown in Fig. 5, contains rectangular buildings and streets which run along the buildings, where mobile nodes are pedestrians moving on the streets and not visiting the buildings.

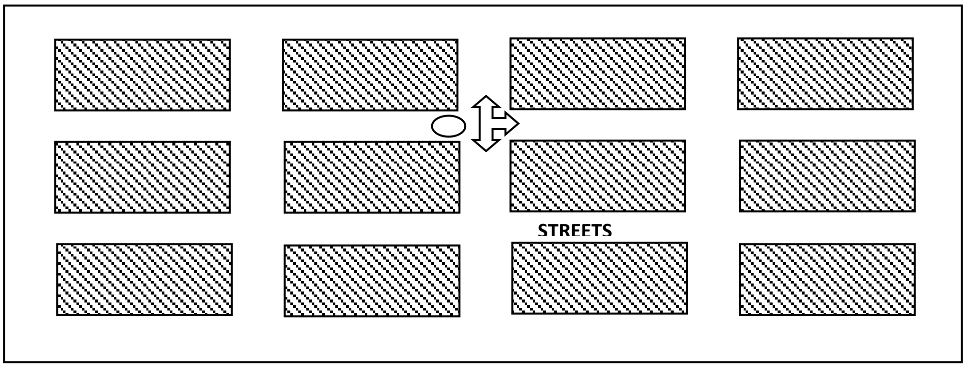

Figure 5. Movement of Node in Manhattan Mobility Model

At the starting of the simulation the nodes are distributed randomly across the streets. Each node chooses a direction to move and initial velocity. At the crossing of streets (intersection of horizontal and vertical streets) probability based decision is taken by the node independently that in which direction to move. When a node reaches the corner node changes its direction with certain probability. The velocity of the nodes keeps on changing time to time.

3.3 City Scenario Mobility Model

All the mobility models predict the nodes movement in the real world scenario. Single mobility model cannot accurately depict the same scenario as in the real world circumstances. Some real world scenarios are such that it can be depicted using two or more mobility model. In the paper, Random Waypoint model and Manhattan model are combined to depict a scenario where initially the nodes are within the premises and after some time they move out on the streets of the city. For example, employees of an organization move out of the premises after office timings to reach their destination. In the premises they are allowed to move randomly while outside the premises they can move only on streets and paths within city limits. The properties of City Scenario model are almost same as that of Random Waypoint model and Manhattan model.

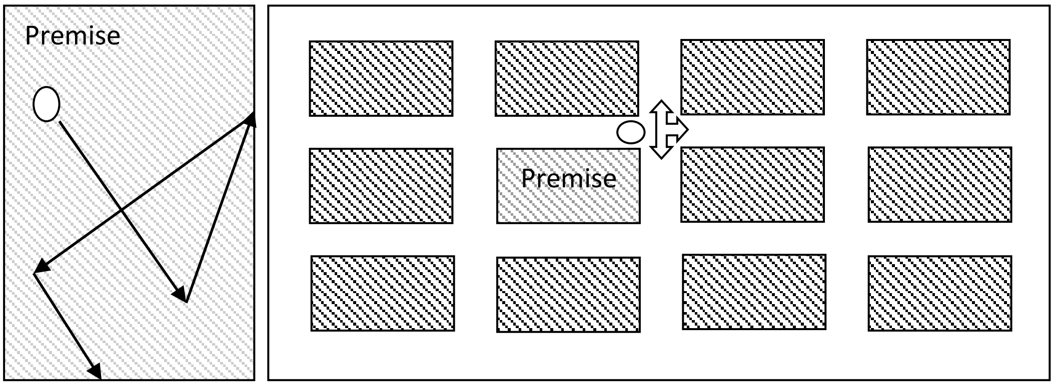

Figure 6: Node movement in City Scenario Mobility Model

IV. SIMULATION

AODV and DSR routing protocols can be implemented using Network Simulator 2.35. Network Simulator [18] is a discrete event simulator targeted at networking research. It provides substantial support for UDP and TCP routing and multicast protocols over wired and wireless networks. Using Xgraph, a plotting program, we can create graphical representation of simulation results. All the work is done under Linux platform, preferably Linux kernel higher than 2.8.

4.1 Performance metrics

Performance metrics [4] that are used for evaluation and comparison of the routing algorithms are:

Packet Delivery Ratio (PDR): represents the ratio between the numbers of packets received by the destination to the number of packets sent by the source.

$$PDR = \frac{\sum Data\ packets\ received}{\sum Data\ packets\ send}$$

Throughput: represents the average rate of successful packet delivery per unit time over a communication channel.

$$Throughput = \frac{\sum Packet\ received}{Transmission\ time}$$

Average Delay: which is the difference between the time when packet is sent by the sender node and the time when the packet arrives at the destination node. It includes all kinds of delays like queuing delay, propagation delay, etc.

$$Average\ Delay = \frac{\sum_{i=0}^{N}(H_r^i - H_t^i)}{N}$$

where H_t^i is the time instant packet is send by source, H_r^i is the time instant packet is received by destination and N is the total number of packets received.

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.

This metric discloses the efficiency of the routing protocol. The larger this fraction is, the less efficient will be the protocol.

$$Normalised\ Routing\ Load = \frac{\sum Routing\ packets\ send}{\sum Data\ packet\ Received)}$$

4.2 Simulation configuration

While analyzing the performance of ad hoc routing protocols, some parameters of the networking context should be considered carefully like Network size (number of nodes in the network), Network connectivity (average number of neighboring nodes), Rate of change in topology (change in network topology due to mobile nodes) ,Link capacity (effective speed of link) and Mobility pattern (relevant to change in performance of routing protocols).
The performance evaluation of routing protocols under the three mobility models was done in the simulation area of 1000m x 1000m for the duration of 100 seconds. The nodes use UDP traffic for communication with CBR traffic pattern. The size of each data packet is 512 bytes. The movement of node depends on the mobility scenario in which the simulation is performed.
The simulation is divided into two categories:

4.2.1 Varying nodes

The network size is change after every simulation for each routing protocol while keeping other variable constant. Scenario that is configured for the simulation is shown in the following table 1:

Table 1. Scenario of Simulation varying Network Size

Number of nodes	10, 20, 30, 40, 50
Simulation time	100s
Maximum speed	10m/s
Network area	1000m x 1000m
Traffic type	CBR
Agent	UDP
Packet size	512 bytes

4.2.2 Varying speed

The maximum allowable speed of each node is varied for every simulation for each routing protocol while keeping node density and other variable constant. Scenario configuration is shown in table 2:

Table 2. Scenario of Simulation varying Maximum Speed

Number of nodes	40
Simulation time	100s
Maximum speed (m/s)	5, 10, 15, 20, 25
Network area	1000m x 1000m
Traffic type	CBR
Agent	UDP
Packet size	512 bytes

V. RESULTS

5.1 Varying network size

5.1.1 AODV Routing Protocol Performance

On varying the network size AODV shows the following characteristics under the three mobility models while increasing the number of nodes with each simulation:

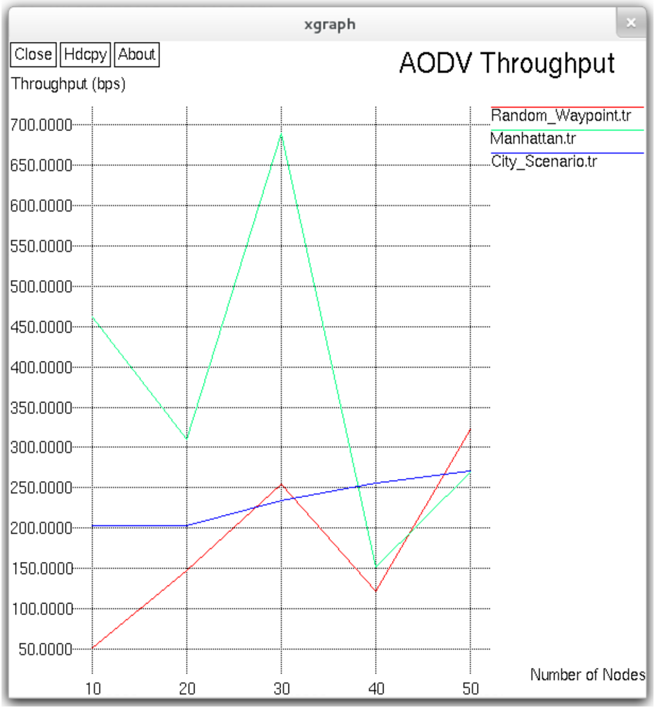

Figure 7: AODV Throughput vs Nodes

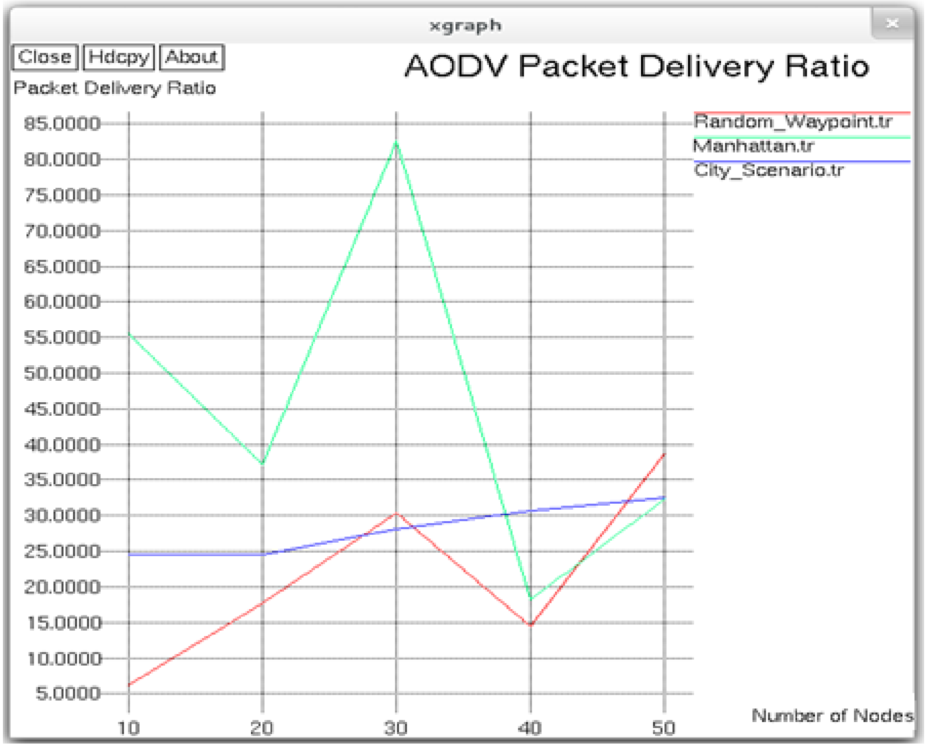

Figure 8: AODV Packet Delivery Ratio vs Nodes

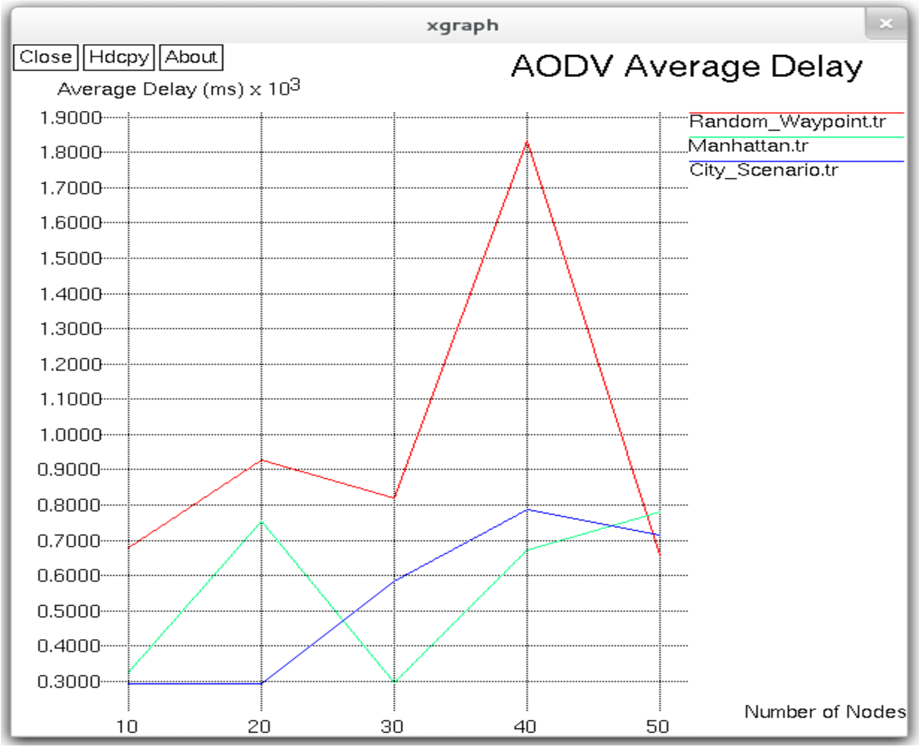

Figure 9: AODV Average Delay vs Nodes

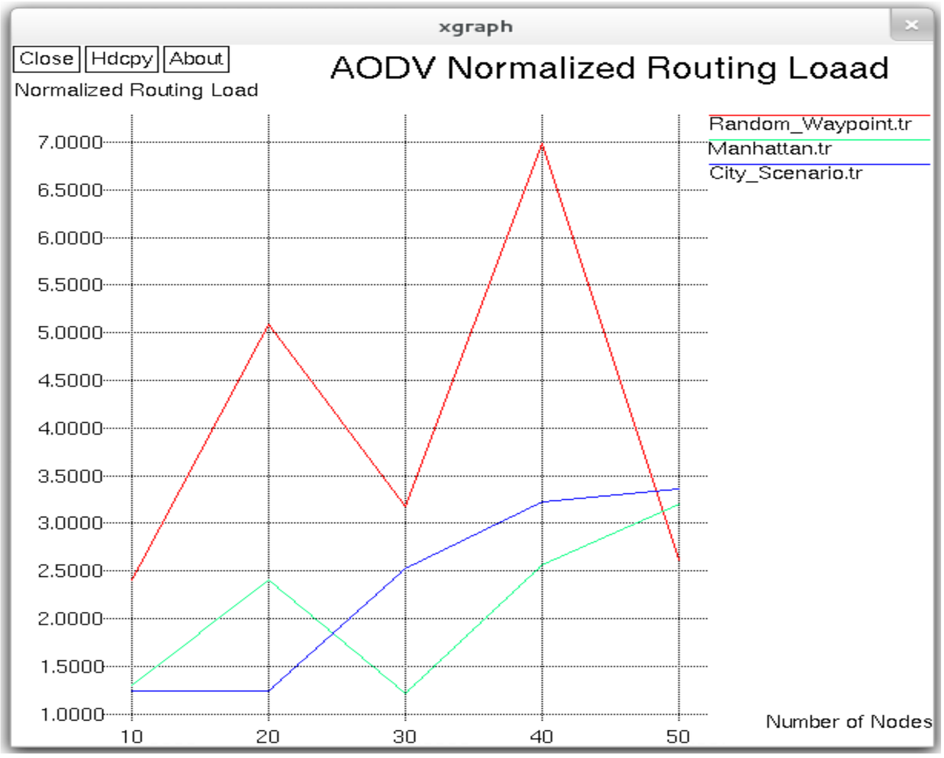

Figure 10: AODV Normalized Routing Load vs Nodes

The throughput (fig. 7) and packet delivery ratio (fig. 8) in Manhattan model shows the same characteristics as it is good for less number of nodes and as the number of nodes increases throughput in Manhattan model degrades. The throughput and packet delivery ratio in City Scenario and RWP model is low, consistent and increases with the increase of nodes. The average delay and normalized routing load in Random Waypoint model is very high while in City Scenario model average delay and normalized routing load is comparably low which makes the AODV feasible for City Scenario model.

5.1.2 DSR Routing Protocol Performance

On varying the network size DSR shows the following characteristics under the three mobility models while increasing the number of nodes with each simulation:

The throughput (fig. 11) and packet delivery ratio (fig. 12) of DSR is much better than AODV for all three models. The throughput of DSR in Manhattan model is very irregular which makes it infeasible in such mobility. The throughput and packet delivery ratio of DSR in City Scenario model is consistent and gradually increases with increase in number of nodes also the throughput and packet delivery ratio in comparison to AODV is better. In City Scenario model DSR shows better performance with respect to average delay (fig. 13) but the normalized routing load (fig. 14) is very high in comparison under other two mobility model while AODV is better in comparison with normalized routing load under City Scenario. DSR is better for routing when there is less number of nodes and there is high connectivity within the network.

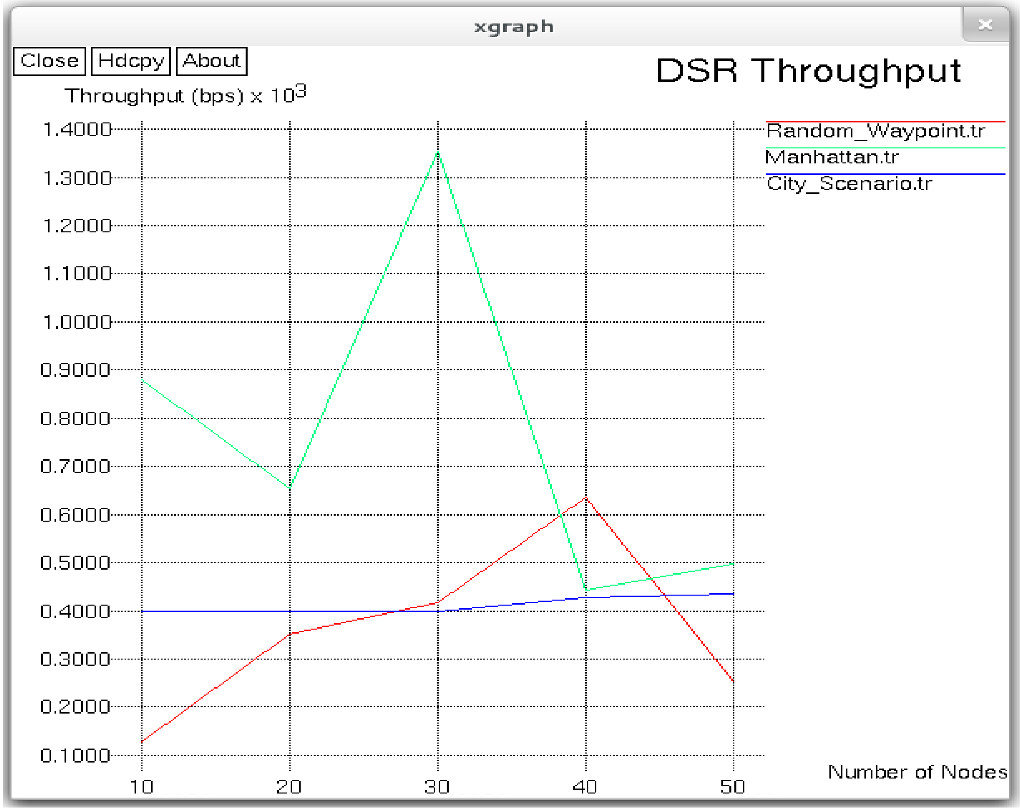

Figure 11 DSR Throughput vs Nodes

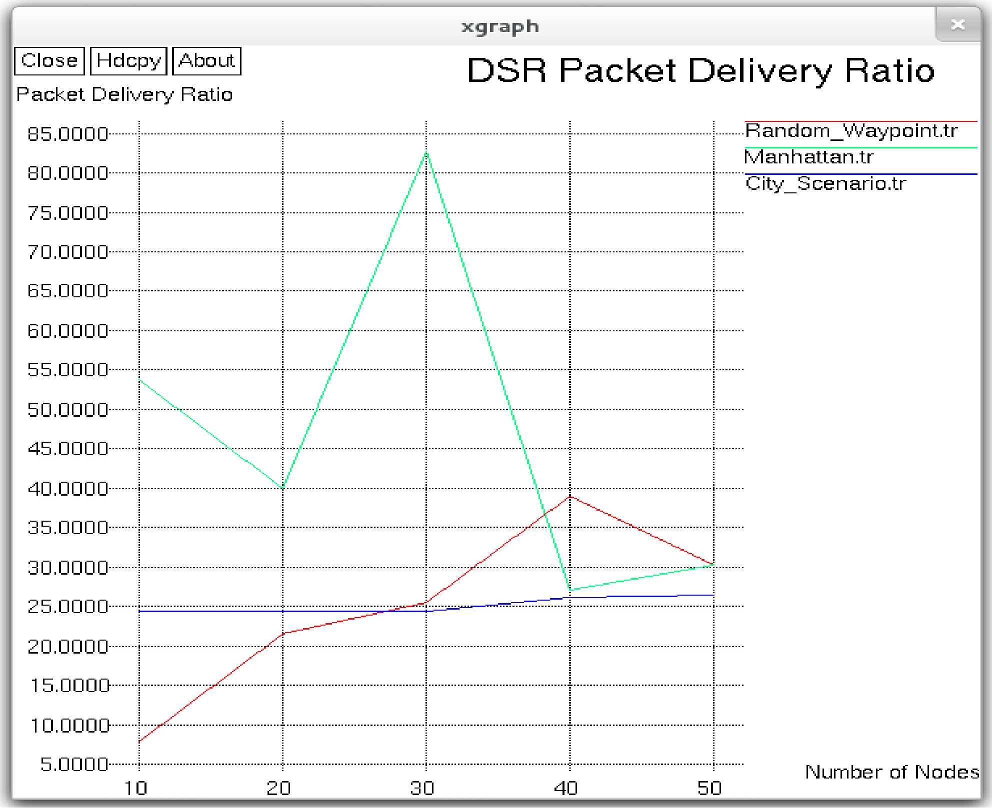

Figure 12: DSR Packet Delivery Ratio vs Nodes

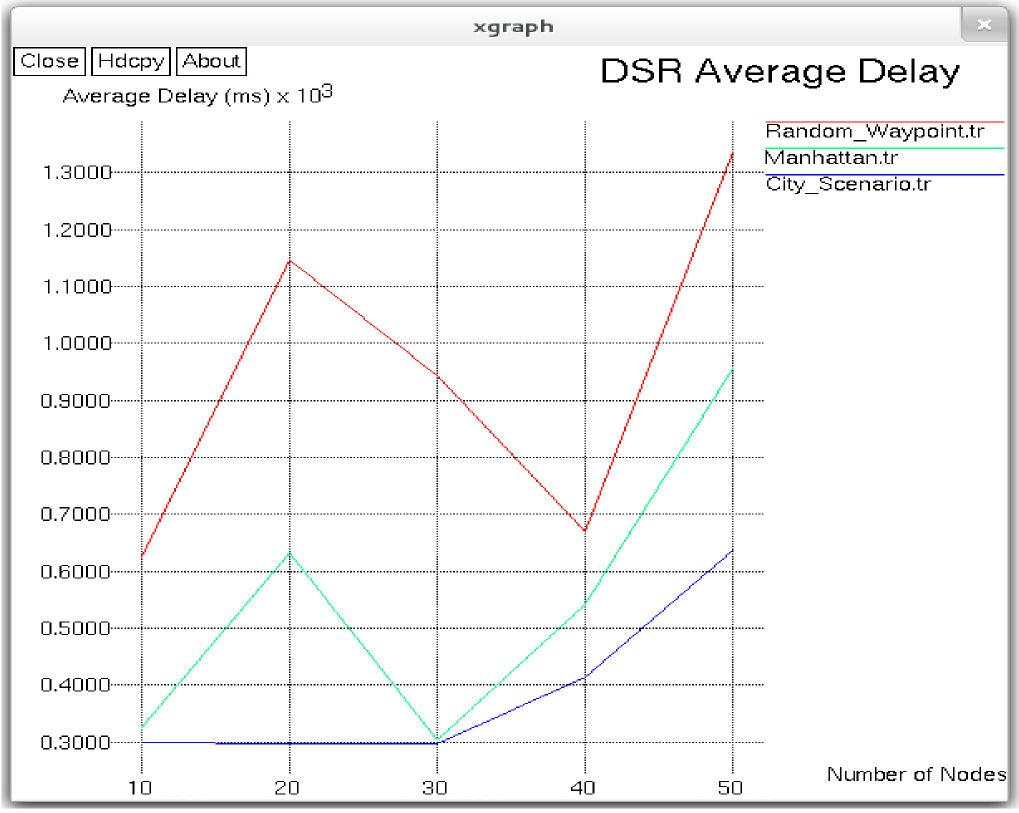

Figure 13: DSR Average Delay vs Nodes

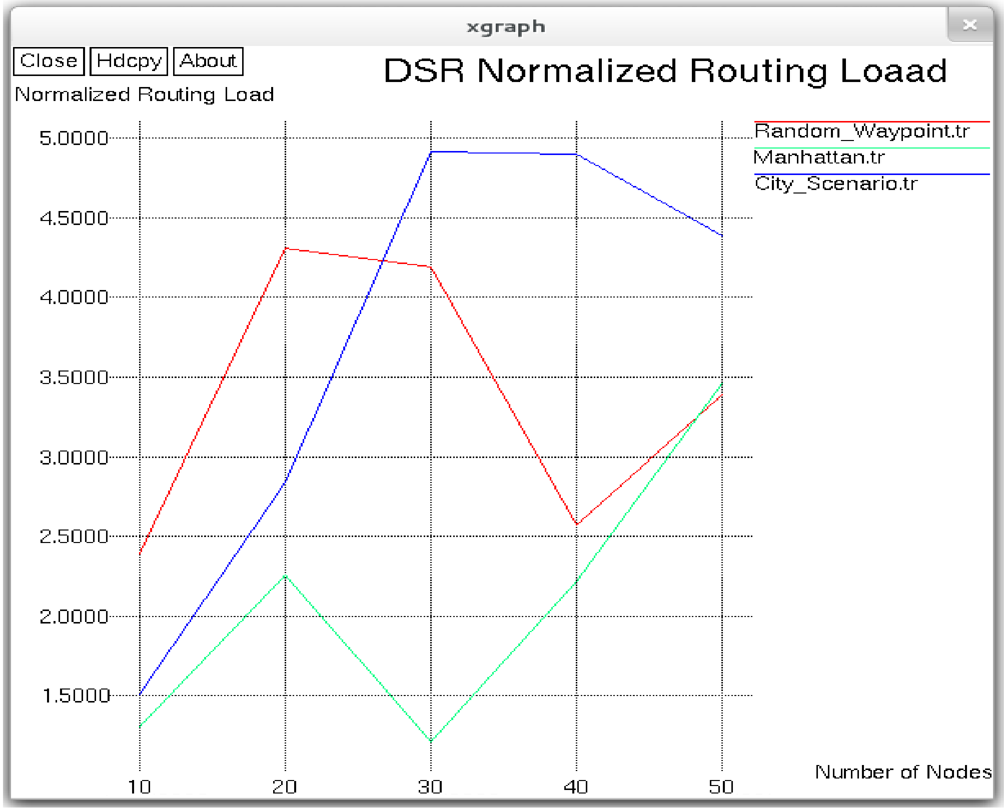

Figure 14 DSR Normalized Routing Load vs Nodes

5.2 Varying speed

5.2.1 AODV Routing Protocol Performance

On varying mobility (speed) AODV shows following characteristics under three mobility models while increasing mobility of nodes:

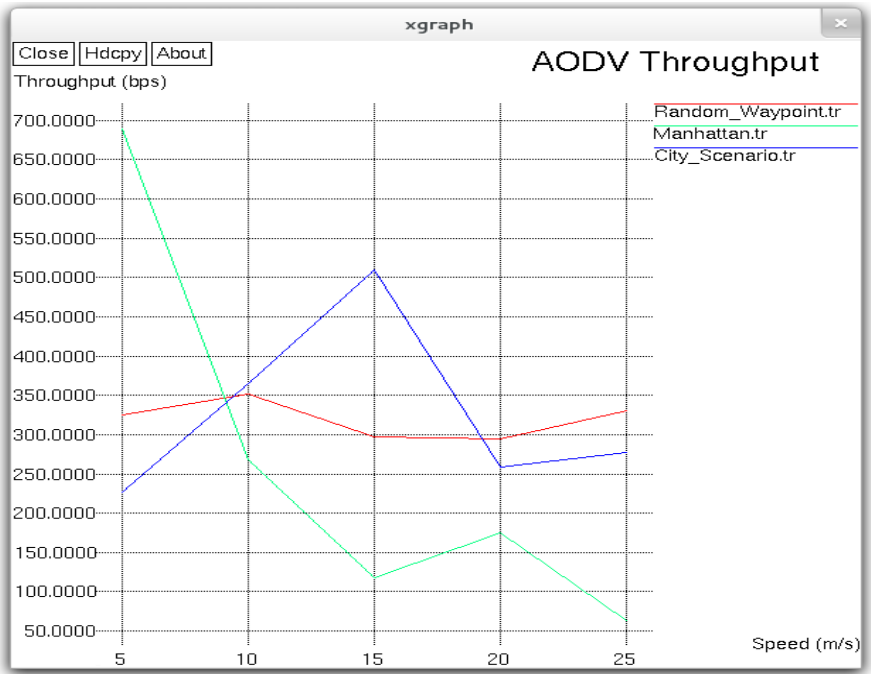

Figure 15 AODV Throughput vs Speed

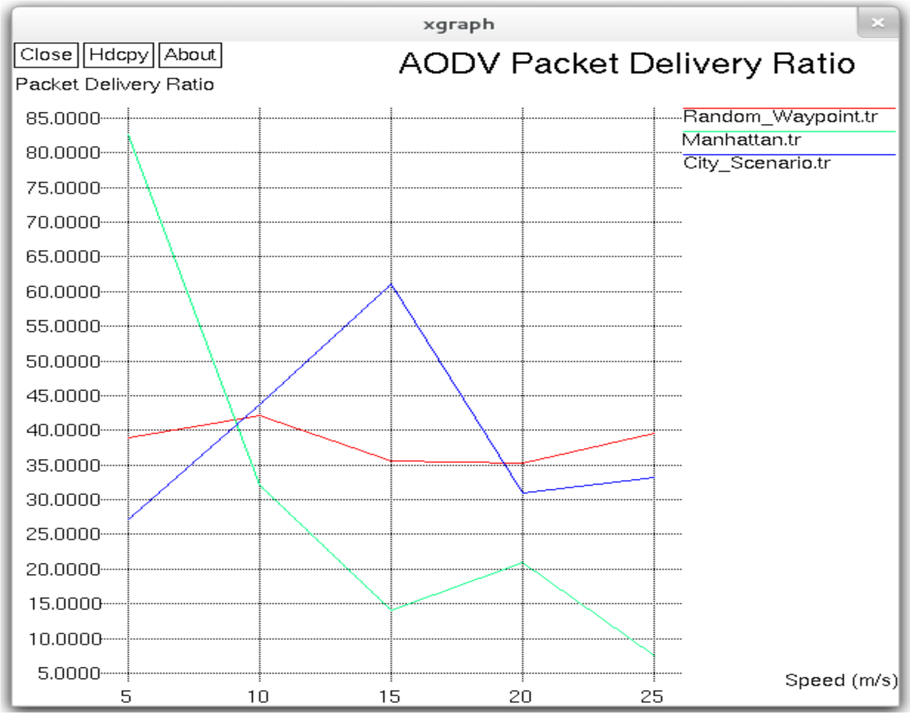

Figure 16 AODV Packet Delivery Ratio vs Speed

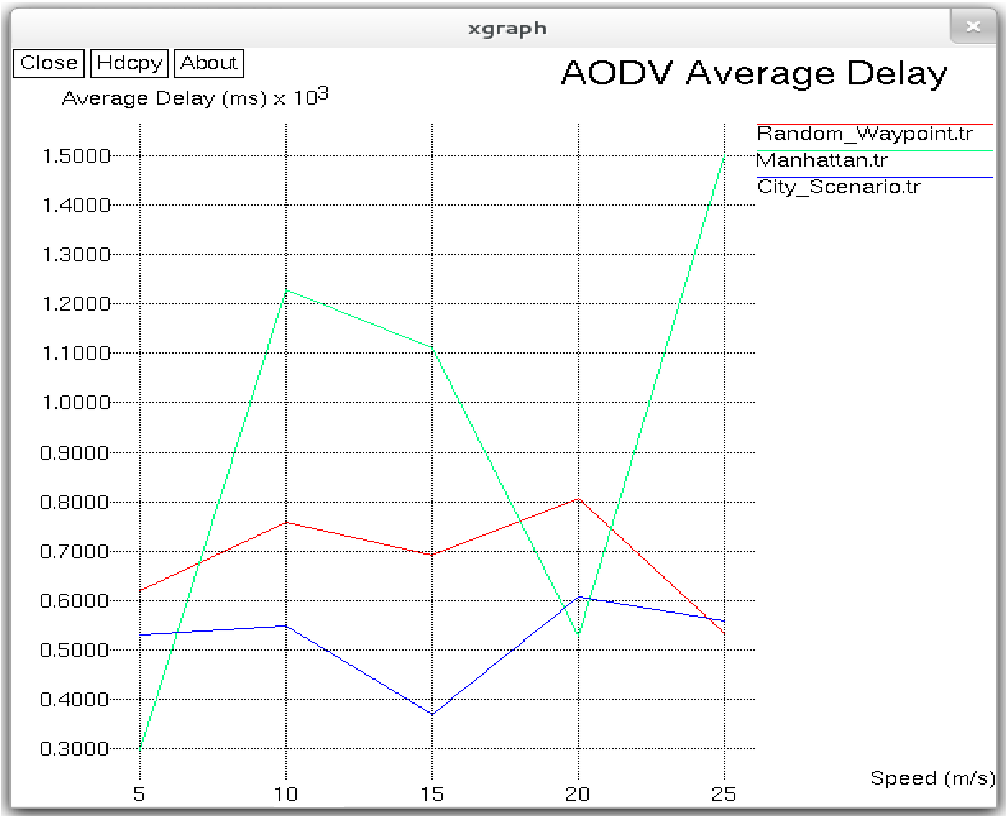

Figure 17 AODV Average Delay vs Speed

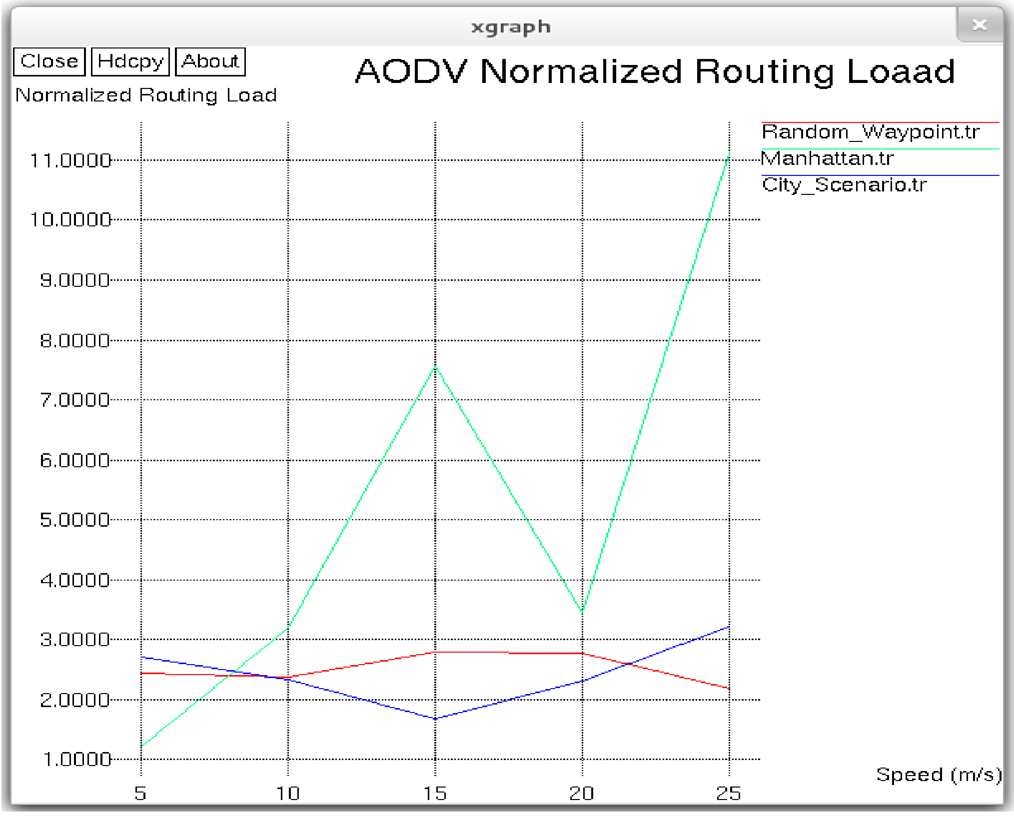

Figure 18 AODV Normalized Routing Load vs Speed

AODV under the City Scenario and RWP model shows better throughput (fig. 15) with the increase in maximum allowable node mobility speed. The throughput of AODV in Manhattan model degrades continuously with the increase in speed of nodes. In RWP model, AODV performs better with respect to packet delivery ratio (fig. 16) while the performance in Manhattan and City Scenario model the performance fluctuates very much due to highly dynamic network topology. The average delay (fig. 17) in City Scenario model is least and consistent for AODV in comparison to other two mobility model while increasing the mobility and speed in the network. The normalized routing load in Manhattan model is very high which makes AODV infeasible in this model. The performance shown by AODV in high mobility under City Scenario model with respect to normalized routing load (fig. 18) is good which makes it efficient in such mobility scenario.

4.2.2 DSR Routing Protocol Performance

On varying the speed DSR shows the following characteristics under three mobility models while increasing speed with each simulation:

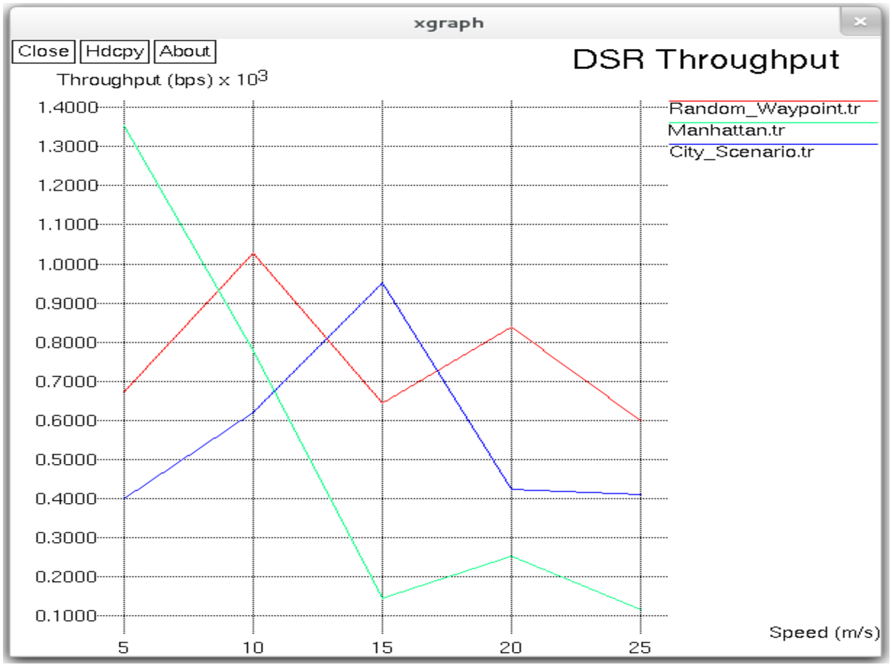

Figure 19. DSR Throughput vs Speed

The throughput (fig. 19) of DSR is better in City Scenario and RWP model while increasing the maximum allowable speed while the throughput in Manhattan model degrades continuously. The packet delivery ratio (fig. 20) of DSR is better in Random Waypoint. The packet delivery ratio degrades smoothly in City Scenario model while in Manhattan model there is a sudden degradation with increase in speed. The average delay and normalized routing load (fig. 21 and fig. 22) of DSR in City Scenario mobility model is better in comparison to with in Manhattan and Random Waypoint mobility model. But, the average delay and normalized routing load of AODV is better than that of DSR in City Scenario model.

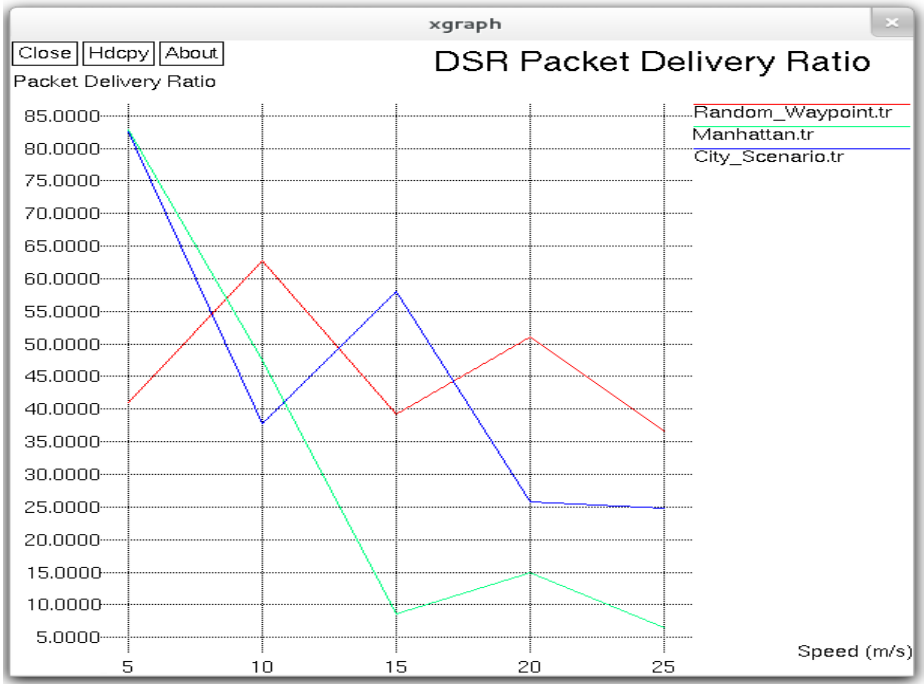

Figure 20. DSR Packet Delivery Ratio vs Speed

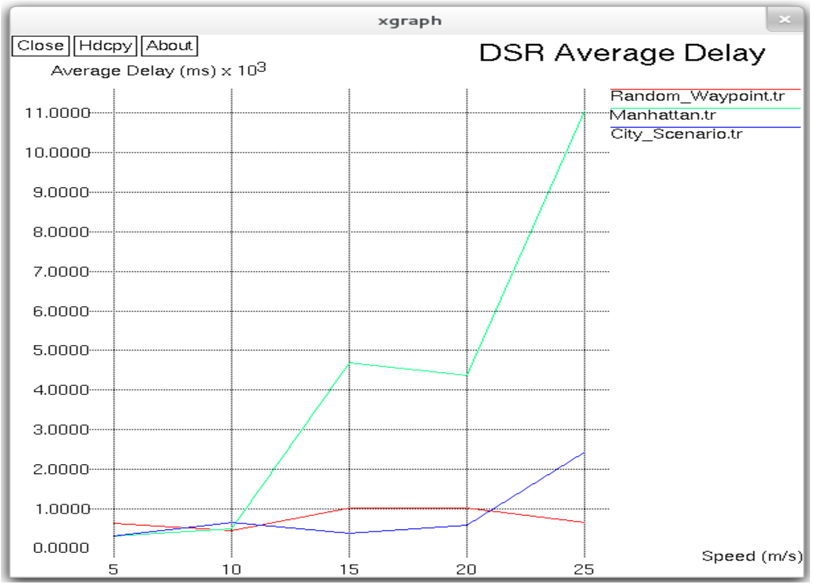

Figure 21. DSR Average Delay vs Speed

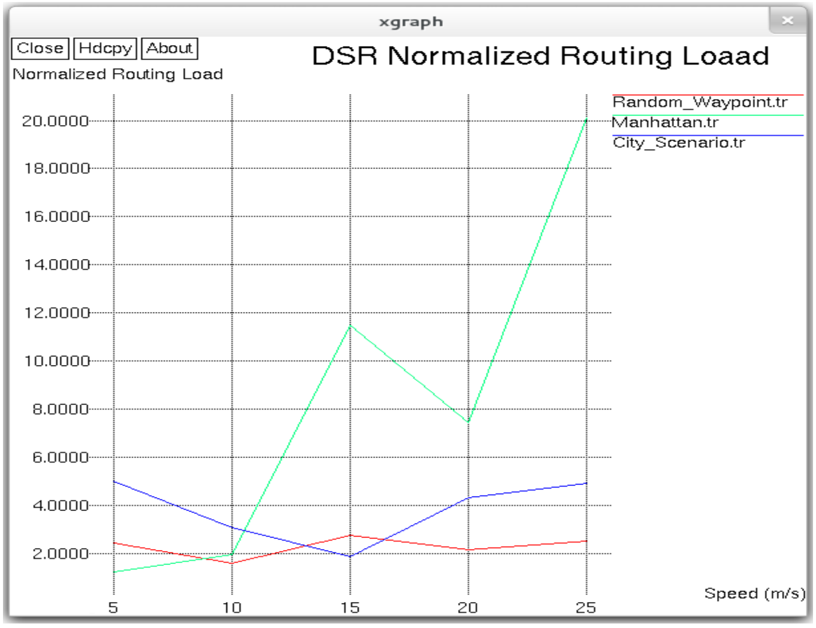

Figure 22: DSR Normalized Routing Load vs Speed

The normalized routing load of AODV is better than in DSR which makes AODV better than DSR in such scenario of high mobility.With increasing mobility or number of nodes in the network, the performance of the protocols decreases. The degree of decreased performance is enormous, mainly due to network gets congested of routing overhead as the topology of the network becomes highly dynamic in nature.

VI. CONCLUSION

In this paper the impact of the chosen mobility models on the performance of two reactive routing protocols in mobile ad hoc networks is evaluated and analyzed through simulations. The simulation experiments were conducted for the Random Waypoint, Manhattan and City Scenario model (a combination of Random Waypoint Model and Manhattan Model) with varying number of nodes and varying speed. The performance of the protocols was evaluated in terms of packet delivery ratio, average end-to-end delay, normalized routing load, and throughput. The results show that the mobility model has significant impact on the performance of the routing protocols. It is found that Random Waypoint mobility model, which is widely used in simulations of MANET cannot be applicable in each scenario. The City Scenario mobility model performed better than other mobility models for under the simulated scenarios.

AODV had a lower packet delivery ratio, higher normalized routing and a higher end-to-end delay than DSR. In networks with a small number of nodes and low mobility, AODV did not suggest a good solution as a routing protocol. However, AODV had better performance in networks with higher mobility and a greater number of nodes. Simulation results in those networks suggest that AODV presented a higher packet delivery ratio and a lower normalized routing load than DSR. DSR presented the best performance in terms of packet delivery ratio and end-to-end delay. In most cases, DSR presented the lowest normalized routing loads, showing that source routing proves to be an efficient routing mechanism in networks with a small number of nodes and high connectivity because it utilized the wireless medium for data traffic in a better way than the other protocols. DSR performance decreased in networks with higher mobility, disclosing that source routing could not efficiently adapt the network topology changes that were caused by the frequent movement of the mobility nodes. The same set of observations was obtained when comparing DSR performance in networks with an increasing number of nodes. Under that scenario, DSR presented lower performance than AODV in terms of the packet delivery ratio and end-to-end delay.

The three mobility patterns used in the paper depicts some of the real life scenarios that assists in simulating and pre-analysing routing protocols before it can be implemented in real world. The routing protocols behaviour and characteristics changes with the change in mobility pattern of the participating nodes. The network size, mobility speed and nodes movement pattern decides the overall performance of the protocols. Synthetic mobility patterns are useful where the movement pattern of the user can be traced in real world and those movement patterns is fixed but in scenarios where the node movement cannot be traced and movement is not fixed then depicting the mobility pattern according to situation and circumstances is a much better option. The objective is to depict such a scenario for movement of participating users in urban cities which is clearly depicted by City Scenario Mobility Model.

REFERENCES

[1] Radhika Ranjan Roy, "*Handbook for Mobile Ad Hoc Networks for Mobility Models*", Springer, 2011.

[2] C.Siva Ram Murthy and B. S Manoj, "*Ad Hoc Networks: Architectures and Protocols*", Pearson Education, Inc.,2007.

[3] Anil Bhasin and Dinesh Kumar, "*Performance Analysis of Reactive Routing Protocols in Chain Mobility Models",* IJCSC vol.2 no. 1 June 2012 pp. 199-201.

[4] Ashish K. Maurya, Ashish Kumar and Dinesh Singh, "*RWP Mobility Model Based Performance Evaluation of OLSR and LAR1 Routing Protocols in MANET",* IJCNC vol.3 no. 6 Nov. 2011 pp. 145-156.

[5] A Subramani and A Krishnan, "*Node Mobility Tracking in Mobile Ad Hoc Networks in their Geiographical Position (Dynamic Networks)",* IJSCE vol.1 issue 5 Sept. 2011 pp. 36-40.

[6] Mohamed Amnai, Youssef Fakhri, Jaafar Abouchabaka, "*QOS routing and performance evaluation for Mobile Ad Hoc Networks using OLSR protocol",* IJASUC vol.2 June 2011 pp. 12-23.

[7] M. Sreerama Murty and M. Venkat Das, "*Performance Evaluation of MANET Routing Protocols using Reference Point Group Mobility and Random Waypoint Models*", IJASUC vol. 2 no. 1 March 2011 pp. 33-43.

[8] Santosh Kumar,S C Sharma, Bhupendra Suman, "*Simulation Based Performance Analysis of Routing Protocols Using Random Waypoint Mobility Model in Mobile Ad Hoc Network*", GJCST vol. 11 issue 1 Feb. 2011.

[9] Fahim Maan and Nauman Mazhar, "*MANET Routing Protocols vs Mobility Models: A Performance Evaluation*", ICUFN 2011 pp. 179-184.

[10] Georgios Kioumourtzis, Christos Bouras and Apostolos Gkamas, "*Performance evaluation of ad hoc routing protocols for military communications*", IJNM 2011.

[11] Natarajan Meghanathan, "A Simulation Study on the Impact of Mobility Models on the Network Connectivity, Hop Count and Lifetime of Routes for Ad hoc Networks", Informatica 34 2010 pp. 207-221.

[12] Bhavyesh Divecha, Ajith Abraham, Crina Grosan, Sugata Sanyal, "*Impact of NodeMobility on MANET Routing Protocols Models*", JDIM vol. 5 Feb. 2007 pp. 19-24.

[13] Ibrahim khider , Wang Furong, Yin Wei Hua, Sacko, "*Study on Indoor and Outdoor environment for Mobile Ad Hoc Network: Random Waypoint Mobility Model and Manhattan Mobility Model*", UCCJ vol. 2 no. 1 2007 pp. 6-10.

[14] Christian Bettstetter, Hannes Hartenstein, Xavier P´erez–Costa, "*Stochastic Properties of the Random Waypoint Mobility Model*", ACM/Kluwer Wireless Networks, Special Issues in Modeling and Analysis of Mobile Networks vol.10 no.5 September 2004.

[15] Fan Bai, Narayanan Sadagopan and Ahmed Helmy, "*IMPORTANT: A framework to systematically analyze the Impact of Mobility on Performance of Routing protocols for Ad Hoc Networks*", INFOCOM 2003.

[16] http://nile.cise.ufl.edu/important/mobility-user-manual.pdf - Mobility Generator tool

[17] http://net.cs.uni-bonn.de/wg/cs/applications/bonnmotion - BonnMotion Mobility Generator

[18] www.isi.edu/nsnam/ns/tutorial - NS2 tutorial

[19] Rashmi Rohankar, Rinkoo Bhatia, Vineet Shrivastava and Deepak Kumar Sharma," Performance Analysis of Various Routing Protocols (Proactive and Reactive) for Random Mobility Models of Adhoc Networks", 1st Int'ernational Conf. on Recent Advances in Information Technology MAY 2012

[20] Ashish Bagwari, Raman Jee, Pankaj Joshi and Sourabh Bisht," Performance of AODV Routing Protocol with increasing the MANET Nodesand it's effects on QoS of Mobile Ad hoc Networks", International Conference on Communication Systems and Network Technologies, September 2012

[21] Zaid Ahmad, Jamalul-lail Ab Manan and Kamarularifin Abd Jalil, "Performance Evaluation on Modified AODV Protocols", IEEE Asia-Pacific Conference on Applied Electromagnetics (APACE 2012), December 11 - 13, 2012

[22] Manisha singh Chaudhary and VarshaSingh," Simulation and analysis of roiuting protocol Under CBR and TCP traffic source", International Conference on Communication Systems and Network Technologies, September 2012

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