

Performance Comparisons of Node Mobility Models on Routing Protocols on MANET

Ashish Gupta
Department of CSE
KIT, Kanpur, India

Akhilesh Kosta
Associate Professor
Department of CSE
KIT, Kanpur, India

Ajay Kumar
Assistant Professor
Department of CSE
ITM, GIDA, Gorakhpur

Abstract—A Mobile Ad-Hoc Network (MANET) is a self-configuring network of mobile nodes connected by wireless links to form an arbitrary topology without the use of existing infrastructure. Since MANETs are not currently deployed on a large scale, research in this area is mostly simulation based. Among other simulation parameters, the mobility model plays a very important role in determining the protocol performance in MANET. Thus, it is essential to study and analyze various mobility models and their effect on MANET protocols. In this paper, we study different mobility models proposed in the recent research literature and their performance of routing protocols Bellman Ford, Dynamic Source Routing (DSR), WRP and Location Aided Routing (LAR1). In this study we have considered three mobility scenarios: Random Waypoint, Group Mobility and Freeway Models. These three Mobility Models are selected to represent possibility of practical application in future.

Index terms—MANET, Bellman Ford, DSR, WRP, LAR1, Random waypoint Mobility, Random Group Mobility.

I. INTRODUCTION

In general, a Mobile Ad hoc Network (MANET) is a collection of wireless nodes communicating with each other in the absence of any infrastructure. Due to the availability of small and inexpensive wireless communicating devices, the MANET research field has attracted a lot of attention from academia and industry in the recent years. In the near future, MANETs could potentially be used in various applications such as mobile classrooms, battlefield communication and disaster relief applications.

To thoroughly and systematically study a new Mobile Ad hoc Network protocol, it is important to simulate this protocol and evaluate its protocol performance. Protocol simulation has several key parameters, including mobility model and communicating traffic pattern, among others. In this chapter and the next chapter we focus on the analysis and modeling of mobility models. We are also interested in studying the impact of mobility on the performance of MANET routing protocols. We present a survey of the status, limitations and research challenges of mobility modeling in this chapter.

The mobility model is designed to describe the movement pattern of mobile users, and how their location, velocity and acceleration change over time. Since mobility

patterns may play a significant role in determining the protocol performance, it is desirable for mobility models to emulate the movement pattern of targeted real life applications in a reasonable way. Otherwise, the observations made and the conclusions drawn from the simulation studies may be misleading. Thus, when evaluating MANET protocols, it is necessary to choose the proper underlying mobility model. For example, the nodes in Random Waypoint model behave quite differently as compared to nodes moving in groups [1]. It is not appropriate to evaluate the applications where nodes tend to move together using Random Waypoint model. Therefore, there is a real need for developing a deeper understanding of mobility models and their impact on protocol performance.

One intuitive method to create realistic mobility patterns would be to construct trace-based mobility models, in which accurate information about the mobility traces of users could be provided. However, since MANETs have not been implemented and deployed on a wide scale, obtaining real mobility traces becomes a major challenge. Therefore, various researchers proposed different kinds of mobility models, attempting to capture various characteristics of mobility and represent mobility in a somewhat 'realistic' fashion. Much of the current research has focused on the so-called synthetic mobility models [2] that are not trace-driven.

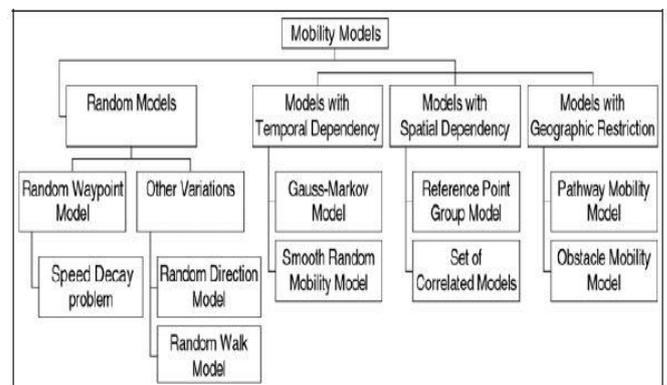


Figure 1. The categories of mobility models in Mobile Ad hoc Network

In the previous studies on mobility patterns in wireless cellular networks[3][4], researchers mainly focus on the movement of users relative to a particular area (i.e., a cell) at a macroscopic level, such as cell change rate, handover traffic and blocking probability. However, to model and

analyze the mobility models in MANET, we are more interested in the movement of individual nodes at the microscopic-level, including node location and velocity relative to other nodes, because these factors directly determine when the links are formed and broken since communication is peer-to-peer.

In Fig.1 we provide a categorization for various mobility models into several classes based on their specific mobility characteristics. For some mobility models, the movement of a mobile node is likely to be affected by its movement history. We refer to this type of mobility model as mobility model with temporal dependency. In some mobility scenarios, the mobile nodes tend to travel in a correlated manner. We refer to such models as mobility models with spatial dependency. Another class is the mobility model with geographic restriction, where the movement of nodes is bounded by streets, freeways or obstacles.

II. MOBILITY MODELS

Different mobility models can be differentiated according to their spatial and temporal dependencies.

Spatial dependency: It is a measure of how two nodes are dependent in their motion. If two nodes are moving in same direction then they have high spatial dependency.

Temporal dependency: It is a measure of how current velocity (magnitude and direction) are related to previous velocity. Nodes having same velocity have high temporal dependency.

A. Random Waypoint

The Random Waypoint model is the most commonly used mobility model in research community. At every instant, a node randomly chooses a destination and moves towards it with a velocity chosen randomly from a uniform distribution $[0, V_{max}]$, 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 until the simulation ends. Figures 2-4 illustrate examples of a topography showing the movement of nodes for Random Mobility Model.

B. Random Point Group Mobility (RPGM)

Random point group mobility can be used in military battlefield communication. Here each group has a logical centre (group leader) that determines the group's motion behavior. Initially each member of the group is uniformly distributed in the neighborhood of the group leader. Subsequently, at each instant, every node has speed and direction that is derived by randomly deviating from that of the group leader. Given below is example topography showing the movement of nodes for Random Point Group Mobility Model. The scenario contains sixteen nodes with Node 1 and Node 9 as group leaders.

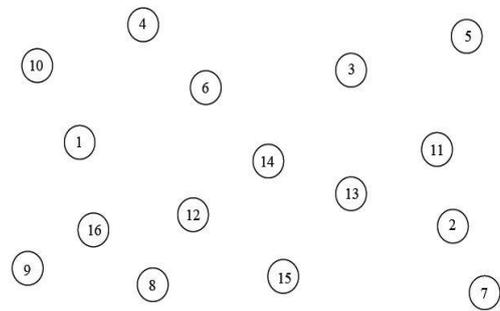


Figure 2. Topography showing Random mobility model

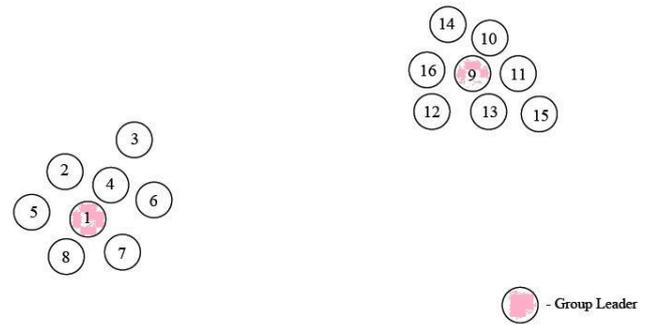


Figure 3. Topography showing Random point group mobility

C. Freeway Mobility

This model emulates the motion behavior of mobile nodes on a freeway. It can be used in exchanging traffic status or tracking a vehicle on a freeway. Each mobile node is restricted to its lane on the freeway. The velocity of mobile node is temporally dependent on its previous velocity.

Given below is example topography showing the movement of nodes for Freeway Mobility Model with twelve nodes.

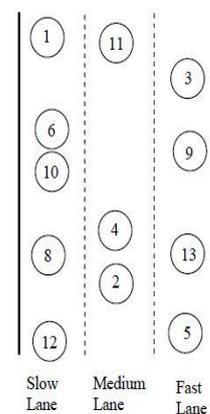


Figure 4. Topography showing Freeway mobility model

III. DESCRIPTION OF ROUTING PROTOCOLS

A. Bellman Ford Routing

Bellman-Ford Routing Algorithm, also known as Ford-Fulkerson Algorithm, is used as an algorithm by distance

vector routing protocols such as RIP, BGP, ISO IDRP, and NOVELL IPX. Routers that use this algorithm will maintain the distance tables, which tell the distances and shortest path to sending packets to each node in the network. The information in the distance table is always updated by exchanging information with the neighboring nodes. The number of data in the table equals to that of all nodes in networks (excluded itself). The columns of table represent the directly attached neighbors whereas the rows represent all destinations in the network. Each data contains the path for sending packets to each destination in the network and distance/or time to transmit on that path. The Measurements in this algorithm are the number of hops, latency, the number of outgoing packets, etc.

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 [10] [11].

C. Location Aided Routing (LARI)

Ad hoc on-demand distance vector routing (AODV) and distance vector routing (DSR) that have been previously described are both based on different variations of flooding. The goal of Location-Aided Routing (LAR) described in [6] is to reduce the routing overhead by the use of location information. Position information will be used by LAR for restricting the flooding to a certain area [7].

In the LAR routing technique, route request and route reply packets similar to DSR and AODV are being proposed. The implementation in the simulator follows the LARI algorithm similar to DSR.

Location Information When using LAR, any node needs to know its physical location. This can be achieved by using the Global Positioning System (GPS). Since the position information always includes a small error, GPS is currently

not capable of determining a node's exact position. However, differential GPS offers accuracies within only a few meters.

Expected Zone When a source node *S* wants to send a packet to some destination node *D* and needs to find a new route, it first tries to make a reasonable guess where *D* could be located. Suppose node *S* knows that at time t_0 *D*'s position was *P* and that the current time is t_1 . Using this information *S* is able to determine the *expected zone* of *D* from the viewpoint of node *S* by time t_1 . For instance if *D* traveled with an average speed v , the source node *S* expects *D* to be in a circle around the old position *P* with a radius $v(t_1-t_0)$. The expected zone is only an estimate by *S* to determine possible locations of *D*. If *D* traveled with a higher speed than *S* expected, the destination node may be outside the expected zone at time t_1 .

If the source node does not know the position of *D* at time t_0 , it will not be possible to estimate an expected zone. *D* could be anywhere. In this case, the entire ad-hoc network is selected as the expected zone and the routing algorithm reduces to a simple flooding.

Request Zone Be *S* still our source node that wants to send a packet to destination node *D*. The *request zone* is somewhat different from the expected zone, for it defines the zone where a route request should be forwarded from. An intermediate node will forward a route request packet only, if it belongs to the request zone. This is different from the flooding protocols described before. Obviously the request zone should contain the expected zone to reach destination node *D*.

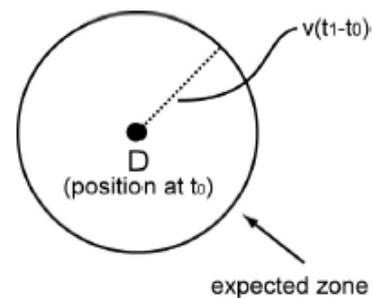


Figure 5. LAR Expected Zone

D. Wireless Routing Protocol (WRP)

WRP uses an enhanced version of the distance-vector routing protocol which uses the Bellman-Ford algorithm [9] to calculate paths. Because of the mobile nature of the nodes within the MANET, the protocol introduces mechanisms which reduce route loops and ensure reliable message exchange. WRP, similar to DSDV, inherits the properties of the distributed Bellman-Ford algorithm. To counter the count-to-infinity problem and to enable faster convergence, it employs a unique method of maintaining information regarding the shortest distance to every destination node in the network and the penultimate hop node on the path to every destination node. Since WRP, like DSDV, maintains an up-to-date view of the network, every node has a readily available route to every destination node in the network. It differs from

DSDV in table maintenance and in the update procedures. While DSDV maintains only one topology table, WRP uses a set of tables to maintain more accurate information. The tables that are maintained by a node are the following: distance table (DT), routing table (RT), link cost table (LCT), and a message retransmission list (MRL).

The DT contains the network view of the neighbors of a node. It contains a matrix where each element contains the distance and the penultimate node reported by a neighbor for a particular destination. The RT contains the up-to-date view of the network for all known destinations. It keeps the shortest distance, the predecessor node (penultimate node), the successor node (the next node to reach the destination), and a flag indicating the status of the path. The path status may be a simple path (correct), or a loop (error), or the destination node not marked (null). The LCT contains the cost (e.g., the number of hops to reach the destination) of relaying messages through each link. The cost of a broken link is infinity. It also contains the number of update periods (intervals between two successive periodic updates) passed since the last successful update was received from that link. This is done to detect links breaks. The MRL contains an entry for every update message that is to be retransmitted and maintains a counter for each entry. This counter is decremented after every retransmission of an update message. Each update message contains a list of updates. A node also marks each node in the RT that has to acknowledge the update message it transmitted. Once the counter reaches zero, the entries in the update message for which no acknowledgments have been received are to be retransmitted and the update message is deleted. Thus, a node detects a link break by the number of update periods missed since the last successful transmission. After receiving an update message, a node not only updates the distance for transmission neighbors but also checks the other neighbors' distance, hence convergence is much faster than DSDV.

IV. SIMULATION ENVIRONMENT

Simulation is based on the same environment for Bellman Ford, DSR, WRP and LAR1 Routing Protocols in Glomosim version 2.02. Because mobility is the key reason for packet losses, we design the scenarios for comparing the performance of Bellman Ford, DSR, WRP and LAR1 based on different mobility models. The mobility models can be determined by various mobility models like random waypoint, random point group mobility and freeway mobility models. Table 1 summarizes other scenario parameters for Bellman Ford, DSR, WRP and LAR1.

A. Simulation Model

The wireless network consists of varying numbers of nodes which are distributed uniform in a grid area of 1000m X 1000m. The data packet size is of 512 bytes. The simulation time is 360sec. The simulation model [8] with parameters is listed in table 1.

Traffic Pattern	CBR
Simulation Time	360 seconds
Simulation Area	1000m*1000m
Total Nodes	10, 20, 30, 40 and 50
The Data Packet Size	512 byets
Node Placement	Uniform
Speed of Node	25 m/s
Pause Time	30 Sec.

B. Traffic Model

The traffic model used is CBR (Constant Bit Rate). CBR Model generates traffic at a constant rate of 512 Byte each at the start of the simulation up to the end of the simulation. The inter departure time for each item is 1 second.

V. RESULTS

Three performance metrics are used for measuring the performance of Bellman Ford, DSR, WRP and LAR1 Routing Protocols. The simulation results are shown in the form of graph that represents (i) Packet Delivery Ratio, (ii) Average End to End Delay and (iii) Throughput.

A. Packet Delivery Ratio: Number of Data Packets Delivered over Number of Data Packets Generated. "Number of Data Packets Delivered" is the total number of received data packets by destinations; "Number of Data Packets Generated" is the total number of generated data packets by sources.

Figure 6 (a), (b) and (c) shows the graph of Bellman Ford, DSR, WRP and LAR1 routing protocol for packet delivery ratio [9] between three mobility scenarios: Random Waypoint, Group Mobility and Freeway Models respectively.

B. Average End to End Delay: average packet delivery time from a source to a destination. First for each source-destination pair, an average delay for packet delivery is computed. Then the whole average delay is computed from each pair average delay.

Figure 7 (a), (b) and (c) shows the graph of Bellman Ford, DSR, WRP and LAR1 routing protocol for average end to end delay between three mobility scenarios: Random Waypoint, Group Mobility and Freeway Models respectively.. End-to-end delay includes the delay in the send buffer, the delay in the interface queue, the bandwidth contention delay at the MAC, and the propagation delay.

Table 1. Simulation Parameters

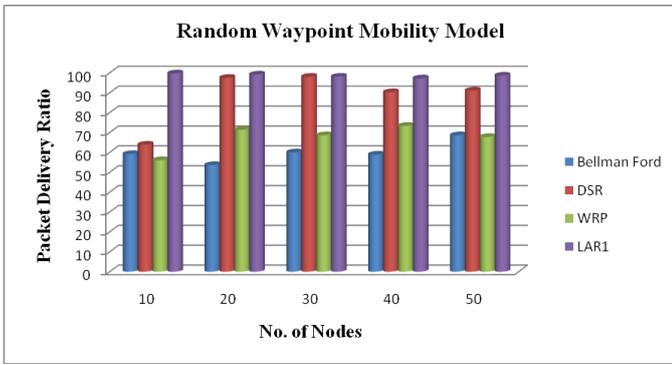


Figure 6 (a). PDR with Random Way point model

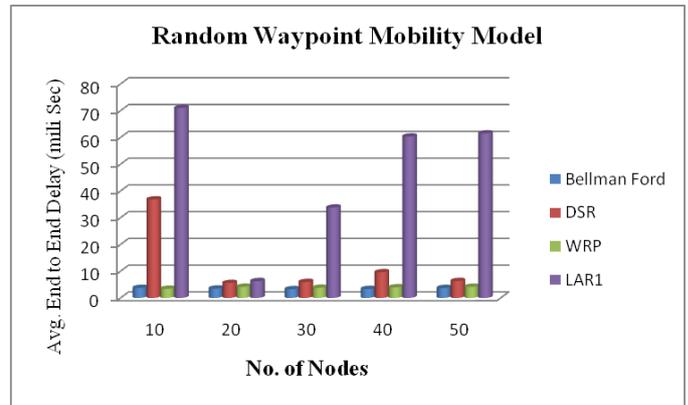


Figure 7 (a). End to End Delay with Random Way point model

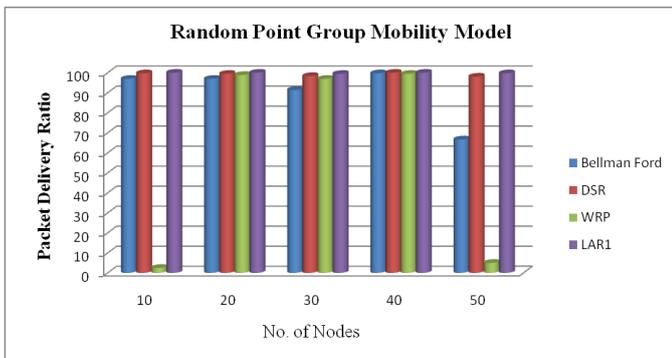


Figure. 6 (b). PDR with random point group mobility model

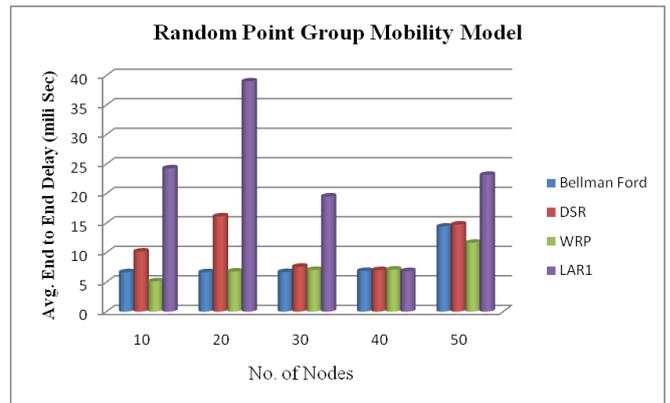


Figure 7 (b). End to End Delay with random point group mobility model

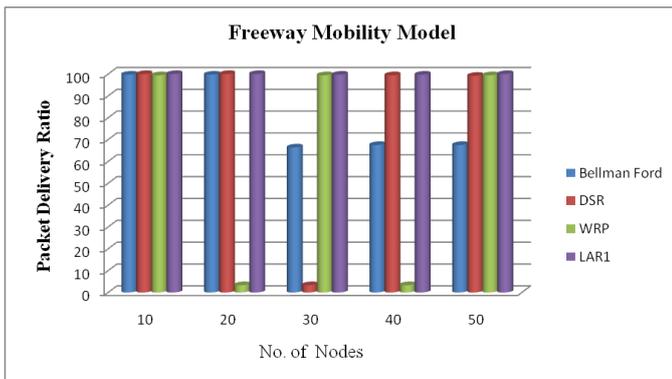


Figure. 6 (c). PDR with freeway mobility model

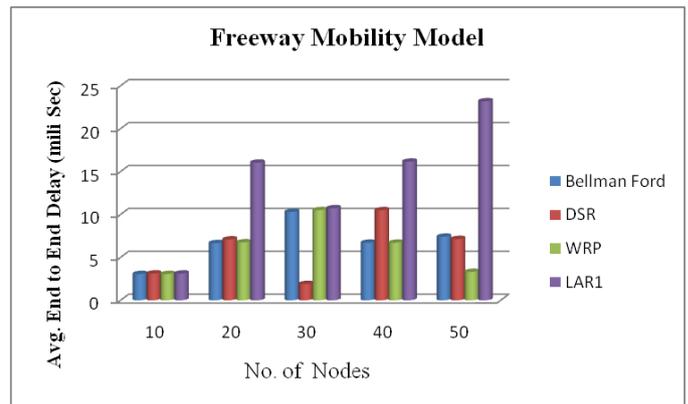


Figure 7 (c). End to End Delay with freeway mobility model

C. Throughput: Throughput is the number of packet that is passing through the channel in a particular unit of time. This performance metric show the total number of packets that have been successfully delivered from source node to destination node and it can be improved with increasing node density.

Figure 8 (a), (b) and (c) shows the graph of Bellman Ford, DSR, WRP and LAR1 routing protocol for throughput between three mobility scenarios: Random Waypoint, Group Mobility and Freeway Models respectively.

VI. CONCLUSION

In this paper we have simulated the Bellman Ford, DSR, WRP and LAR1 routing protocols on Glomosim Simulator. The performance of the protocols was measured with respect to metrics like Packet delivery ratio, end to end delay and Throughput. Simulations were carried out with identical networks and running different protocols on the mobile node. The simulation is divided in three parts basis on the mobility model (random waypoint mobility, random point

group mobility model and freeway mobility model). Here we conclude as:

1. LAR1 performs well than DSR, Bellman Ford and WRP (in reference to packet delivery ratio) if the node mobility is random waypoint and random point group mobility model.
2. Bellman Ford has performed well when the node mobility model is freeway mobility model.
3. Packet delivery ratio is increases as the number of nodes increases.
4. Freeway mobility model is better than the other two mobility models in terms of Packet Delivery Ratio.
5. Bellman Ford performs better than DSR, LAR1 and WRP in terms of average end to end delay and random waypoint mobility model is better than random point group mobility model and freeway mobility model.
5. DSR and LAR1 both have better Throughput than Bellman Ford and WRP.
6. Random point group mobility is better in compare to freeway mobility model and random way point mobility model in terms of throughput.

For the above discussion we can say that all the routing protocols and mobility models have their own significance they all have their own advantages and disadvantages its depends upon the situation where we have to use. In some situation LAR1 is better and in some situation DSR is better. In some cases Random Waypoint mobility model is better and in some cases Random Point Group mobility model is better.

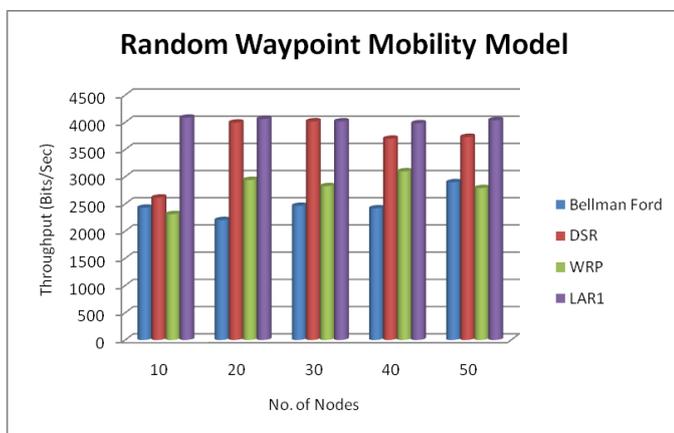


Figure 8 (a). Throughput with Random Way point model

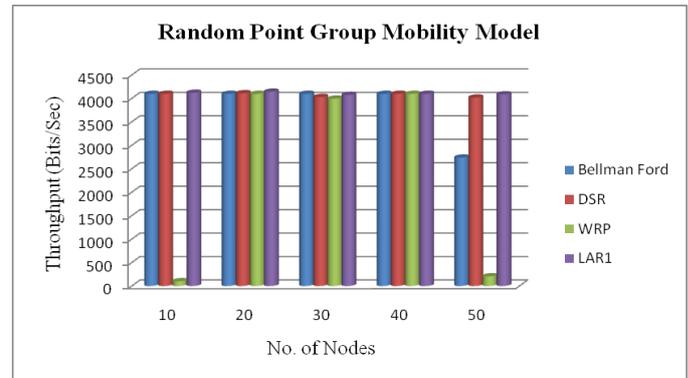


Figure 8 (b). Throughput with random point group mobility model

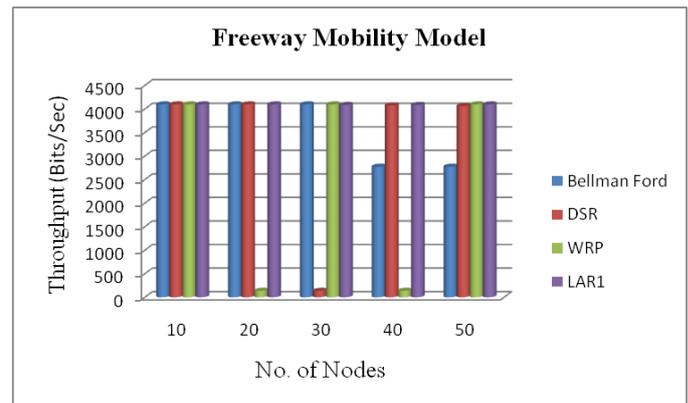


Figure 8 (c). Throughput with freeway mobility model

FUTURE SCOPE

Future work may include same experiments for DSDV and ZRP, measuring the average end to end delay, packet delivery rate and drop ratio and the same experiments for different node mobility speed of the simulation and other mobility models. Another Future work is to perform the experiments for various different node migration speeds. We used the node mobility of 45km/h in our experiments this time. However, the node migration speed of 45km/h is just one of the possible velocities. Keeping the migration speed lower may lessen or rule out the cases of packets getting dropped even before routing information is updated. This may affect the simulation results and perhaps will bring out the strengths and weaknesses of different protocols unambiguously.

REFERENCES

- [1]. S. Corson and J. Macker, Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations, RFC: 2501, January 1999.
- [2]. Carlo Kopp, "Ad Hoc Networking", Systems Journal, pp 33-40, 1999.
- [3]. Guolong Lin, Guevara Noubir and Rajmohan Rajaraman, "Mobility Models for Ad hoc Network Simulation", In Proceedings of IEEE INFOCOM 2004, Volume 1, pp. 7-11, 2004.
- [4]. Tracy Camp, Jeff Boleng and Vanessa Davies, "A Survey of Mobility Models for Ad Hoc Network" Special issue on Mobile

Ad Hoc Networking: Research, Trends and Applications, vol. 2, no. 5, pp. 483-502, 2002.

- [5]. F. Bai and A. Helmy, "The IMPORTANT Framework for Analyzing and Modeling the Impact of Mobility in Wireless Adhoc Networks", in Wireless Ad Hoc and Sensor Networks, Kluwer Academic Publishers, 2004.
- [6]. F. Bai, A. Helmy, "A Survey of Mobility Modeling and Analysis in Wireless Adhoc Networks" in Wireless Ad Hoc and Sensor Networks, Kluwer Academic Publishers, 2004.
- [7]. F. Bai, G. Bhaskara and A. Helmy, "Building the Blocks of Protocol Design and Analysis Challenges and Lessons Learned from Case Studies on Mobile Adhoc Routing and Micro-Mobility Protocols", ACM Computer Communication Review, Vol.34, No.3, pp.57-70, 2004.
- [8]. F. Bai, N. Sadagopan and A. Helmy, "IMPORTANT:A Framework to systematically analyze the Impact of Mobility on Performance of Routing protocols for Adhoc Networks, IEEE INFOCOM, pp. 825-835, 2003.
- [9]. Charles E Perkins and Pravin Bhagwat, "Highly Dynamic Destination Sequenced Distance Vector Routing (DSDV) for Mobile Computers", SIGCOMM 94, pp. 234-244, 1994.
- [10]. David B. Johnson, David A. Maltz, Yih-Chun Hu, The Dynamic Source Routing (DSR) Protocol for Mobile Ad Hoc Networks.draft-ietf-manet-dsr-10.txt, July 2004.
- [11]. David B. Johnson and David A. Maltz. "Dynamic Source Routing in Ad Hoc Wireless Networks". In *Mobile Computing*, edited by Tomasz Imielinski and Hank Korth, Chapter 5, pages 153-181, Kluwer Academic Publishers, 1996.
- [12]. Biao Zhou, Kaixin Xu and Mario Gerla, "Group and Swarm Mobility Models for Ad Hoc Network Scenarios Using Virtual Tracks, In Proceedings of MILCOM'2004, Volume 1, pp. 289-294, 1994.
- [13]. Mobility Generator (version1.0) from the site, <http://nile.usc.edu/important/software.htm>, February 2004.
- [14]. Ashish Gupta and Akhilesh Kosta, "A survey on Node Mobility Models on MANET Routing Protocols". In International Journal of Research (IJR) Vol-1, Issue-5, June 2014 ISSN 2348-6848.

with GAUTAM BUDDHA TECHNICAL UNIVERSITY LUCKNOW(India). His research interest is Mobile Computing.



Ajay Kumar received his **M.TECH** degree in computer science and engineering from Madan Mohan Malviya Engineering College, Gorakhpur. Currently he is working as a **Assistant Professor** in Computer Science and Engineering Department in I.T.M. Gida Gorakhpur. His area of interest is Algorithm and Mobile Computing.

Authors Profile



Ashish Gupta received the **B.TECH** degree in computer science and engineering from Inderprastha Engineering College Ghaziabad, affiliated with GAUTAM BUDDH TECHNICAL UNIVERSITY, LKO. India, in 2011. Currently pursuing **M.TECH** in computer science and engineering from Kanpur institute of technology, Kanpur, affiliated with GAUTAM BUDDHA TECHNICAL UNIVERSITY, LUCKNOW, India. His research interest is Mobile Computing.



Akhilesh Kosta did **B.TECH** in Computer Science and Engineering from G.B . Pant Engineering College Pauri-Garhwal affiliated with H N B Garhwal University, Srinagar-Garhwal in 2000. and did **M.TECH** in Computer Science and Engineering from MNNIT Allahabad affiliated with MNNIT Allahabad. Now he is **Associate Professor** in Kanpur Institute of Technology Kanpur, affiliated