A Survey of Random Walk Mobility Model for Congestion Control in MANET's

Abinasha Mohan Borah
Assam Don Bosco University

Bobby Sharma
Assam Don Bosco University

ABSTRACT
This paper contains a survey on the random walk mobility model for congestion control in mobile ad-hoc networks. A mobility model represents the movement of a mobile user, and how their location, velocity and acceleration change over time. The mobility model discussed in this paper is random walk mobility model where the mobile nodes move randomly and freely without restrictions. This paper gives out a brief survey of the various advancements of random walk mobility model and also draws a comparative analysis with other mobility models.

Keywords
Mobile ad-hoc Networks, Random walk model, Random Waypoint Model.

1. INTRODUCTION
A Mobile Ad-hoc network is a self configuring network of wireless mobile nodes without any centralized control to form an arbitrary topology. The nodes in MANET's are free to move randomly and rapidly from one location to the other without any control. The network's wireless topology is unpredictable and may change rapidly [1]. The fundamental characteristics which differentiate MANETs from other wireless networks is its mobility. Applications in Ad-hoc network are in military communication and operations, emergency services like disaster recovery, commercial and civilian environments [2].

The topology of ad-hoc networks is very sensitive. In order to simulate a protocol for an ad-hoc network a mobility model is very important. The mobility model describes how the nodes move within the network in wireless scenarios[3]. A variety of mobility models have been proposed for ad-hoc networks and a survey of many have been presented [4]. The mobility model discussed in this paper is random walk mobility model which is a random based mobility model. The mobile nodes in this model moves randomly and freely without any restrictions from one place to the other. The destination, speed and direction are also chosen randomly and independently of all other nodes in the network [5]. The entities in random walk model are very unpredictable as a mobile node moves from its current location to a new location by randomly choosing a direction and speed in which to travel. The new speed and new direction are both chosen from pre-defined ranges [4].

Congestion control is a major challenge for random walk mobility in mobile ad-hoc networks as when too many packets are contending for the same link, packets may get dropped due to overhead in the network. In order to control congestion in the network an effective mechanism is needed to control the traffic.

The remainder of the section is organized as follows. Section 2 gives details on the related research in the field of random walk mobility model. Section 3 gives a detailed description on the comparative analysis of the random walk mobility model with other mobility models. Section 4 presents the statistical data comparison on the mobility models in tabular form and finally in section 5 gives the conclusion.

2. RELATED WORK
There exist a wide variety of mobility models for ad-hoc networks that have been postulated from several studies and researches. A brief summarization of different mobility models can be found in [4] where random walk model has similarities with the random waypoint model because the node movement has strong randomness in both models. Also the random walk model is a memory less mobility process where the information about the previous status is not used for the future decision. Because of its simplicity of implementation and analysis they are accepted widely. However they may not accurately capture some characteristics of realistic scenarios like temporal dependency, spatial dependency and geographic restriction.

In [5], a routing protocol for MANETs is established using two mobility models. An Ad-hoc on demand multipath distance vector (AOMDV) routing protocol is described which is a multi path extension of Ad-hoc on demand distance vector (AODV) routing protocol. The mobility models are the random walk model and random waypoint model as both the models have certain similarities. The main objective is to analyze AOMDV performance with respect to varying mobility (mean node speed), network size (number of connections) and offered load (Packet Send Rate). Metrics such as throughput, Drop Packet Ratio, average delay are evaluated for random walk model and random waypoint model.

In [7], various routing protocols for MANETs have been discussed. The three random based mobility models such as the random walk model, random waypoint model and random direction model have been implemented. The mobility models are compared in terms of performance parameters like packet delivery fraction, end-to-end delay, mobility speed and network size.

In [8], a mathematical model for random walk search in a peer-to-peer network is proposed. Using this model, analytical expressions for the performance metrics such as delay, overhead and success rate can be derived.

In [9], a new framework for simulation of mobility models is discussed. This simulator named as Mobisim can generate mobility traces in various mobility models from the random families. The supported mobility models for Mobisim are random walk model, random waypoint, random direction model and freeway. The simulator introduced in this paper is a powerful java based simulator that can be used to generate mobility traces to be used in different network simulators which do not support mobility generation for mobile ad-hoc network. User friendly graphical user interface can help the users view and analyze behavior of mobile nodes in each mobility model. In this paper, a comparison of various mobility models like random walk model, random waypoint model, random direction model, levy walk model and Markov model.

In [10], a tool for generating mobility models (GEMM) is discussed. These models are capable of simulating dynamic and also complex mobility patterns representative of real-world scenarios. Simulation results are presented using AODV, OLSR and ZRP routing protocols for mobile ad-hoc networks.

In [11], performance metrics of various mobility models are evaluated using Mobisim simulator. Metrics such as degree of temporal dependency, repetitive behavior, relative speed and degree of spatial dependency are evaluated for mobility models for random families, geographic families and social models. Degree of temporal dependency measures the similarity of velocities of a mobile node during the times that are not too far apart. Relative speed measures the difference between velocities of two nodes that are not too far apart. Degree of spatial dependency measures the similarities of velocities of two nodes that are not too far apart.

The major issue in MANET is to maintain and allocate network resources effectively and fairly among a collection of users. In ad-hoc networks, since there is no fixed infrastructure, there are no separate network elements called routers, hence the mobile node themselves act as the routers.

In [12], a predictive congestion control mechanism for ad-hoc networks is discussed because in ad-hoc networks connection failure between source and destination often occurs. While sending data packets from source to destination, there is a possibility of occurring congestion at any node incurring high packet loss and long delay, which cause the performance degradation of the network. The protocol discussed in this paper is a unicast routing protocol for MANET which tries to prevent congestion occurring in the first place. Performance metrics such as packet delivery ratio, normalized routing overhead, end-to-end delay are evaluated.

In [17], the performance of multicast routing protocols like On demand Multicast routing protocol (ODMRP) and Ad hoc demand driven multicast Routing Protocol (ADMR) are evaluated under different mobility scenarios and it is found that at high mobility the throughput of ADMR is higher than ODMRP. At low mobility throughput of ODMRP increases than that of ADMR.

In [19], a new mobility model for geographic scenarios in wireless networks is proposed. This model is a behavioral model that is used in search and rescue operations, voice and video communication etc. in this paper the author have proposed a mobility model that takes into account such realistic topographical conditions. The routing protocol used is OLSR for 50 nodes and simulation is done in QOMET wireless network emulation set.

In [20], a token called as the common storage unit is used as a lightweight for opportunistic networks. This token is used to transfer the messages over time. In order to support the system they implemented a temporal random walk mobility model where sending a message is equal to copying it in the token and passing the token to the connected node.

In [21], various mobility metrics have been studied and proposed that aims to analyze and classify the different types of mobility models. Using a new methodology several mobility models and their metrics are evaluated. Using the statistical technique of correlation data are analyzed and collected statistically.

3. COMPARATIVE STUDY

In [4], it is observed that the random walk mobility model with small input parameter produces Brownian motion and therefore basically evaluates a static network. A network with large input parameter is similar to random waypoint model without pause times.

In [7], performance differentials for different routing protocols like AODV, DSDV, TORA and DSR are analyzed with different nodes in wireless sensor networks with respect to the random-based mobility models. They found that in random walk model, AODV performs better than DSR, TORA and DSDV because the average hop distance between the source-destination becomes high in AODV, and this increases packet overhead.

In [9], Mobisim simulator is used to find the mobility traces for MANET. In Mobisim, the node spatial distribution of random waypoint model is non-uniform and the node density is maximum at the center region whereas node density is almost zero at the boundary region of the simulation area. For random direction model spatial node distribution in the simulation area is uniform. Spatial node distribution in random walk model in simulation field is uniform. The simulation in the above model is performed for 20 mobile nodes in 500m x 500m simulation area, average speed of 20m/s and simulation time is 100000sec.

An extension of AODV protocol is proposed in [6] called as the Ad-hoc on demand multipath distance vector routing protocol (AOMDV) which discovers multiple paths during single route discovery process. To measure the protocol performance in mobility two mobility models are simulated using ns-2 simulator and the protocol performance is analyzed. Metrics such as throughput, drop packet ratio and average delay are estimated for random walk model and random waypoint model. AOMDV performance for both the mobility models is consistent. With random waypoint model the throughput is superior with respect to random walk model. Because of pause time the node gets a bit of steadiness which improves its throughput. In Random Walk Mobility Model the pause time also affects the average delay. With increasing mobility i.e. when mean node speed increases the average delay increases means the routing protocol performance degrades. Similar is the case for increased load. For both offered load and mobility average delay is constant for random waypoint mobility model.

In [11], mobility simulator is used to generate mobility traces. In order to analyze synthetic mobility traces, for each model needs some common minimum input parameters: No. of nodes, Max. Speed, Min Speed, border height, border width, height, width, walking time etc. Metrics which capture mobility characteristics of each node independently and in group. These metrics are degree of temporal dependency, repetitive behavior, relative speed and degree of spatial dependency. Simulation time is taken 50000 sec for all scenarios. For Random Walk and Random variant models minimum speed is taken 15 m/s and maximum speed is taken 20 m/s. Height and width of simulation area is kept 300 x 300. For Levy walk it is 800*800. Border height and border width is kept 10,10. It is evaluated that RW,RWP,RWP-WR, RD and RPGM have the lowest average degree of temporal dependency. Because in these models the movement pattern of each node is independent of its previous movement. Levy walk has the second highest value for temporal dependency. In RW, RWP, RD, Levy walk, Gauss-Markov and Slaw movement of each node is independent of its neighbors. Therefore, the degree of spatial dependency is low.

4. STATISTICAL DATA COMPARISON

In [11], the mobility models are compared using performance metrics such as Degree of temporal dependency, repetitive behavior, relative speed and degree of spatial dependency. Degree of temporal dependency measures the similarity of the mobile nodes that are not far from one another. Repetitive behavior gives the average ratio of time during which a node is in the transmission region. Relative speed measures difference of velocities of the nodes that are not too far apart. Degree of spatial dependency measures the similarity of velocity of the nodes that are not too far apart. Based on these metrics we present a tabular representation of the mobility models with respect to the above performance parameters which is given in Table 1.

. **Table 1. Comparison of mobility models w.r.t temporal dependency, relative speed and relative behavior.**

	Degree of temporal dependency	**Relative Speed**	**Relative Behaviour**
Random Walk	Lowest	Lowest	Less as compared to random waypoint model
Random Waypoint	Lowest	Lowest	Less relative behavior
Random Direction	Lowest	Lowest	Less as it is not realistic
Levy Walk	Highest	Lower than other models	High relative behaviour

In [7], mobility models such as Random walk, Random waypoint and Random direction models are compared with the parameter constraint. The two parameter constraint like packet delivery fraction and end-to-end packet delivery delay are compared with respect to mobility speed, Traffic and Network size. The routing protocols taken in this paper are AODV, DSR and TORA. The comparison is shown in Table-2.

Table 2 Comparison of mobility models w.r.t temporal dependency, relative speed and relative behavior.

	Speed vs Packet delivery fraction	**Traffic vs End-to-end delay**	**Traffic vs packet delivery**
Random Walk	Differs heavily for lower and higher mobility speed	DSDV, TORA and DSR takes very high time to deliver	Larger as compared to random waypoint model
Random Waypoint	Similar when mobility speed is low	Less time to deliver the packet	Less
Random Direction	Differs heavily for lower and higher speed	Less time to deliver the packets	Larger

5. CONCLUSION

Mobility model in MANETs represent the mobile node's behavior. By this people understand the movement pattern of different nodes and their directions along with location, velocity and acceleration. .Performance of MANETs is directly related with mobility pattern.

The advancements in mobility model have drastically increased and a number of mobility models have been introduced. In this paper we presented a survey of the random walk mobility model. We tried to draw a comparison on the mobility models like random walk mobility model, random way-point mobility model, random direction model and levy walk mobility model with respect to various performance parameters. Random walk mobility model is the simplest mobility model in which nodes move independently to a randomly chosen directions with randomly selected velocities. This model has been used by many researchers for its simplicity.

6. REFERENCES

[1] Ivan Stojmenovic. 2002. Mobile Ad-hoc Networks and Routing Protocols in Handbook of Wireless Networks and Mobile Computin. 2nd ed. John Wiley & Sons pp.371-391.

[2] Jeroen Hoebeke, Ingrid Moerman, Bart Dhoedt, Piet Demeester. An Overview of Mobile Ad-hoc Network: Applications and Challenges. IEEE.

[3] Fan Bai, Ahmed Helmy. A Survey of Mobility Models in Wireless Ad-hoc Networks. University of Southern California.

[4] Tracy Camp, Jeff Boleng, Vanessa Davies. 2002. A Survey of Mobility Models for Ad-hoc Network Research. IEEE.

[5] Xiaoyan Hong, Mario Gerla, Guangyu Peng. A group Mobility Model for Wireless Ad-hoc Networks. IEEE.

[6] V.B Kute, Dr. M.U. Kharat. 2014. Quality of Service Assessment of AOMDV for Random Waypoint Model and Random Walk Model. International Journal of Computer Science and Mobile Computing. 3(1), pp.199-203.

[7] M.K. Jeya Kumar, R.S Rajesh. 2009. Performance Analysis of MANET in different Mobility Models. International Journal in Computer Science and Network Security. 3(2).

[8] Nabhendra Bisnik, Alhussein Abouzeid. Modelling and Analysis of Random Walk Search Algorithms in P2P Networks. IEEE.

[9] S.M Mousavi, H.R Rabiee, A. Dabirmoghaddam. MobiSim: A Framework for Simulation of Mobility Models in Mobile Ad-hoc Networks. IEEE.

[10] Michael Feeley, Norman Hutchinson, Suprio Ray. Realistic Mobility for Mobile Ad-hoc Network. IEEE.

[11] Hemal Shah, Yogeshwar Kosta. 2011. Characterization and Evaluation of Mobility Metrics for Levy Walks using Mobisim. Ganpat University Journal of Engineering and Technology 1(1).

[12] S. Subburam. Predictive Congestion Control Mechanism for MANET. Indian Journal of Computer Science and Engineering.

[13] Roberto Beraldi. 2008. Random Walk with Long Jumps in Wireless Ad-hoc Networks. Elsevier.

[14] Kuo-Hsing Chiang, Nirmala Shenoy. 2004. A 2-D Random Walk Mobility Model for Location Management Studies in Wireless Networks. IEEE Transactions on Vehicular Technology.

[15] Jing Tiang, Jorg Hahner, Christian Becker. Graph Based Mobility Model for Mobile Ad-hoc Network Simulation. Google Scholar.

[16] Roberto Beraldi. 2009. Biased Random Walks in Uniform Wireless Models. IEEE Transactions in Mobile Computing.

[17] Gopal Venkatramani. 2009 Performance Evaluation of Ad-hoc Networks with different Multucast routing protocols and Mobility Models. International Conference on Advances in Recent Technologies in Communication and Computing.

[18] Agoston Petz, Justin Enderle, Christien Julien. 2009. A Framework for Evaluating DTN Mobility Models. Mobile and Pervasive Computing Group, University of Texas.

[19] Razvan Beuran, Shinsuke Miwa. 2013 Behavioural Mobility Model with Geographic Constraints. Workshops on 27th International Conference on advanced Information Networking and Applications.

[20] Victor Ramiro, Emmanuel Lochin, Patrick Senac. 2014. Temporal Random walk as a lightweight communication infrastructure for opportunistic networks. IEEE 15th International Symposium on "A World of Wireless, Mobile and Multimedia Networks".

[21] Elmano Ramalho Cavalcanti, Marco Aurelio Spohn. 2008. Estimating the impact of Mobility Models Parameter on Mobility Metrics in MANETs. Eighth IEEE Symposium on Network Computing and Applications.