EFFECT OF ENTITY MOBILITY MODELS ON REACTIVE PROTOCOL IN MOBILE AD HOC NETWORKS

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Abstract — **Mobile Ad hoc Networks (MANETs) belong to Wireless Networks where the nodes communicate with each other in a multi-hop fashion without any centralized control. In these networks, the dynamic topology of nodes, interference, path loss and multipath propagation. So, it does not require an infrastructure to resume the network connectivity. This infrastructure less, resource constrained, with limited memory and computing capacity along with the dynamic topology of MANET, demands different network strategies to be implemented to accomplish the communication. Considering all these issues, routing performs a crucial role while computing the path from source to the destination. Further, Mobility modeling and control makes the topology of MANET more challenging which requires considerable human focus. To handle this scenario, different solutions have been presented by many potential researchers. This paper attempts to focus on the performance of reactive routing protocol AODV by considering different entity mobility models by using OPNET Simulator viewing that applicability of the protocol can be enhanced. So, this paper measures some performances such as End to End delay, Throughput and Routing Overhead of MANET.**

Keywords -- MANET, AODV, OPNET

Introduction

Mobile Ad hoc Network (MANET) is an example of Infrastructure less network. Such type of network can be established anywhere, any place at any point of time without any predefined planning or resources. The self organizing nature of each node cooperates with each other to communicate without any central orbiter. So, MANET is considered as an Infrastructure less, multi hop, and rapidly changing dynamic network and can be used in many potential applications. Ad hoc networks are suitable where infrastructure is not available or not trusted.

The wide applications of MANET ranges from class room coaching to defense, military, battle field, agriculture, disaster hit areas, emergency services and many more applications where traditional Infrastructure based network is quite unfeasible. These applications have created a lot of curiosity among the researchers to analyze it more and more so that applicability of the network can be enhanced. The topology of MANET where the nodes are connected to each other without any central access point. The self-organizing capability of each node makes it to find the next hop neighbor to send the data packet. Data is transmitted through multiple hops to reach at the destination. The major task of the MANET is how to provide reliable link connectivity among the nodes for efficient transport of data. The dynamic topology, error prone wireless channel, and self-organizing capacity of MANET makes routing more challenging compared to traditional infrastructure based network. The purpose of routing protocol is to define some set of rules that each node has to obey to communicate with other node. Routing algorithm follows the specific choice of path to disseminate the data and to select a path between any two nodes available in the network. Many research papers evaluate the performance of protocols under varying degree of mobility under a bounded domain or few numbers of nodes within a limited number of hops and send the data usually with a constant data rate. But there is a lack of work with different mobility models. So in this paper, we try to evaluate the performance of reactive routing protocols with different mobility models.

ENTITY MOBILITY MODELS

Entity Mobility Models a node's movement does not control in anyway, other nodes' movements. Nodes move independently from each other, randomly. i.e. Random Waypoint Model (RWpM) , Random Walk Model (RWM), Random Direction Model (RDM), Gauss-Markov model (GMM) Smooth Random Mobility. In random-based mobility models, the mobile nodes move randomly and freely without restrictions. To be more specific, the destination, speed and direction are all chosen randomly and independently of other nodes. This kind of model has been used in many simulation studies.

A. Random way point mobility model

The Random Waypoint Model was first proposed by Johnson and Maltz[1]. Soon, it became a 'benchmark' mobility model to evaluate the MANET routing protocols, because of its simplicity and wide availability. In this model, the position of each node is randomly selected within a fixed area and after that moves to the selected position in linear form with random speed. This movement has to stop by a certain period called pause time before starting the next movement.

The pause time is determined by model initialization and its speed is uniformly distributed between [*Min Speed, Max Speed*]. The Random Waypoint Mobility Model is the most widely used mobility model. Many researchers use it to compare the performance of various mobile ad hoc network routing protocols. This model includes pause times between changes in direction and/or speed. Using the waypoint mobility model, each node starts the simulation by remaining stationary for pause-time seconds. Then, it

randomly chooses a destination in the simulation area and moves towards that destination at a speed uniformly chosen between zero and maximum speed. When the node reaches the selected destination, it halts again for pause-time, selects another destination and starts to move towards the new destination.
This process is repeated for the duration of the simulation. It has been shown that the average speed of a mobile node decays with time. This is because of the fact that low speed nodes spend more time to reach their destinations than high speed nodes. It is also shown that increasing the speed of nodes results in increased network connectivity.

Advantages

- The most common use mobility model, because of its simplicity.
- A building block for developing a variety of mobility models.

Disadvantages

- Lack of regular movement modeling.
- Exhibits speed decay.
- Exhibits density wave.
- Memory-less movement behaviors (a common problem for all random waypoint variations).

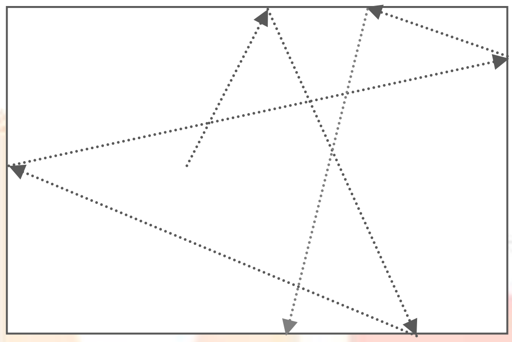

Figure 1: Node movement in the Random Waypoint Model

B. Random walk mobility model

In this mobility model mobile host moves from current location to new location by choosing randomly direction and speed from the predefined ranges between min speed and max speed. Since many entities move in unpredictable ways, the Random Walk Mobility Model was developed to mimic this erratic movement [2]. In this kind of mobility model, a mobile node randomly chooses a direction and speed to move from its current location to a new location. The speed and direction are chosen from pre-defined ranges, [minimum speed, maximum speed] and $[0, 2\pi]$ respectively. If a mobile node reaches a simulation boundary, it bounces off the simulation border with an angle determined by the incoming direction. The node then continues along this new path. The Random Walk Mobility Model is widely used [2], and it is a memory less mobility pattern because it does not have any knowledge concerning its past locations and speed values. The current direction and speed of the node are independent of its past direction and speed. This model may generate unrealistic movements such as sudden stops and sharp turns.

Advantages

- The simplest model to implement.
- Generates unpredictable movements enabling
a long-running simulation to consider all locations
and node interactions.

Disadvantages

- Unrealistic movement patterns
- Sharp and sudden turns.
- Wrapping not observed in real applications.

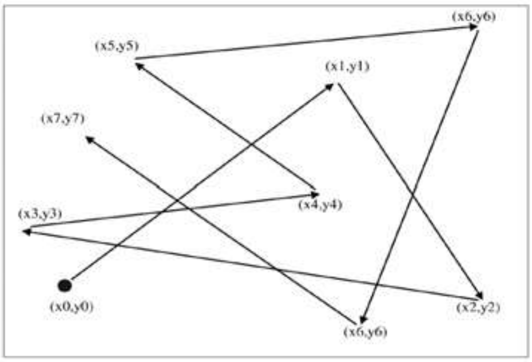

Figure 2: Node movement in the Random Walk Model

C. Random Direction Mobility Model

In the case of Random Direction Mobility Model, a node chooses a random direction uniformly within the range [0, 2π]. The velocity is also chosen uniformly from within the range [minspeed, maxspeed]. Node then moves in the chosen direction until it arrives at the boundary of the simulation area. At this point the node pauses for a specified pause time and again selects a new direction from within the range [0, π]. Since the node is on the boundary of the simulation area, the direction is limited to π.

Advantages

- A variation of the random waypoint without drawback of density wave.
- Uniform distribution of chosen routes.

Disadvantages

- Unrealistic movement pattern
- Average distances between mobile nodes are much higher than other models, leading to incorrect results for routing protocols evaluation.

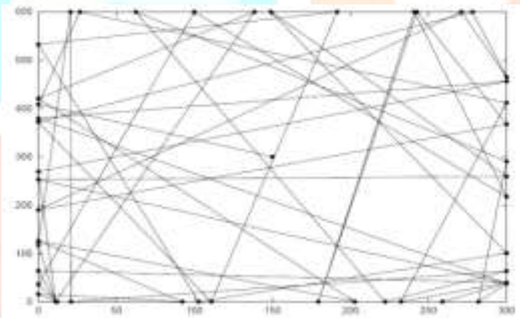

Figure 3: Traveling pattern in Random Direction Mobility Model

D. Gauss-Markov Mobility Model

The Gauss-Markov Mobility Model was first introduced by Liang and Haas [3] and widely utilized. In this model, the velocity of mobile node is assumed to be correlated over time and modeled as Gauss-Markov stochastic process. It was designed to adapt to different levels of randomness via tuning parameters. Initially each mobile node is assigned a current speed and direction. At each fixed intervals of time n a movement occurs by updating the speed and direction of each mobile node. Specifically, the value of speed and direction at the nth instance is calculated based on the basis of the value of speed and direction at the (n-1)st instance and a random variable using the following equations:

Sn= alpha * Sn-1 + (1+ alpha)*S + sqrt (1-alpha 2)*SXn-1 ………Eq. (1)

Dn= alpha * Sn-1 + (1+alpha)*D + sqrt (1-alpha 2)*DXn-1 ………Eq. (2)

Where Sn and Dn are the new speed and direction of the mobile node at the time interval n, where 0 < alpha <1, is the tuning parameter used to vary the randomness s and d are constants representing the mean value of speed and direction as n-> infinity and SXn-1 and DXn-1 are random variables from a Gaussian distribution. Speed and Direction are calculated by using Eq. (1) and Eq. (2) respectively. Random values can be obtained by setting alpha=0 and linear motion can be obtained by setting alpha=1.The value of alpha between 0 and 1, intermediate levels of randomness are obtained. The next location is calculated on the basis of the current location, speed and direction of the movement. At time interval t, position of mobile nodes is calculated by equations:

Xt=Xt-1+St-1 Cos (Dt-1) ……… Eq. (3)

Yt=Yt-1+St-1 Sin (Dt-1) ……….Eq. (4)

Xt and Yt are the nest X-dimesion and Y-dimension of node at time interval, t. These parameters are calculated by using Eq. (3) and Eq. (4) respectively and completely based upon the previous calculated parameters Sn and Dn (Speed and Direction).

Advantages

- Elimination of sudden and sharp turns.

- Provide more realistic movement patterns of nodes.

Disadvantages

- Lack of consideration of obstacles.
- User travel decisions are not considered.

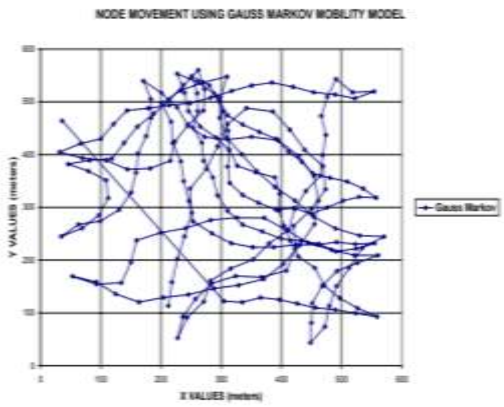

Figure: 4 Node movements in Gauss-Markov Mobility Model [4]

E. Smooth Random Mobility Model

Another mobility model considering the temporal dependency of velocity over various time slots is the Smooth Random Mobility Model. In Ref.[5], it is also found that the memory less nature of Random Waypoint model may result in unrealistic movement behaviors. Instead of the sharp turn and sudden acceleration or deceleration, Bettstetter also proposes to change the speed and direction of node movement incrementally and smoothly. The mobile nodes in real life tend to move at certain speeds $\{V^1_{pref}, V^2_{pref}, \ldots, V^n_{pref}\}$, rather than at speeds purely uniformly distributed in the range $[0, V_{max}]$. The probability distribution of node velocity is as follows: the speed within the set of preferred speed values has a high probability, while a uniform distribution is assumed on the remaining part of entire interval $[0, V_{max}]$. The frequency of speed change is assumed to be a Poisson process in Smooth random Mobility Model [3].

To avoid the unrealistic and sudden changes as well as the edge effects of RWP, RWM and RDM, Haas proposed a smooth mobility model, where the mobile nodes only change the speed gradually and the world is a torus [6].

In SM, each node is characterized by a motion vector (v, θ), where v is the speed of the node and θ is the direction. The position (x,y) of a node and its motion vector are updated periodically (every Δt seconds) as follows:

$$v(t+\Delta t) = \min[\max(v(t)+\Delta v, 0), V_{max}] \quad (1)$$

$$\theta(t+\Delta t) = \theta(t)+\Delta\theta \quad (2)$$

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$$x(t+\Delta t) = x(t)+v(t)\cos(\theta(t)) \quad (3)$$

$$y(t+\Delta t) = y(t)+v(t)\sin(\theta(t)), \quad (4)$$

where V_{max} is the maximum speed, (the minimum speed is zero), and Δv and $\Delta\theta$ are random variables denoting the change of speed and direction at each step. The uniform intervals for Δv and $\Delta\theta$ can be chose relatively small to force a smooth trajectory of the mobile nodes.

Advantages

- Eradicate of sharp turns and sudden stops.
- Acceleration and deceleration are used to provide the smooth behavior.

Disadvantages

- Lack of consideration of obstacles.
- Not focused on user's decisions.

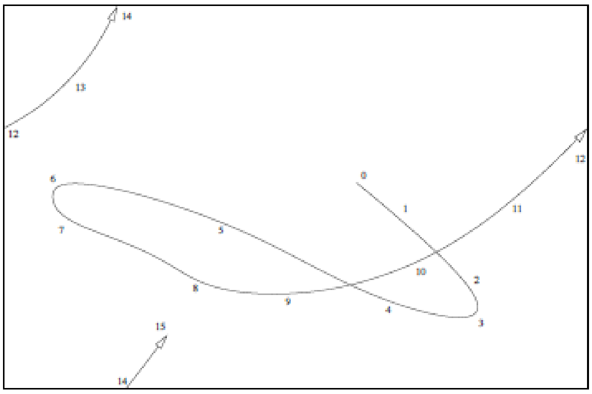

Figure: 5 The movement of a node with an SM mobility model.

From the above various mobility models, here we considered only two entity mobility viz., Random Waypoint, Random Walk Mobility Model for evaluation. To evaluate these mobility models we use MANET routing protocols AODV under varying parameters.

PERFORMANCE METRICS

There are different kinds of parameters for the performance evaluation of the Mobility Model. These have different behaviors of the overall network performance. These Mobility Models need to be checked against certain parameters for their performance. To check mobility models effectiveness in finding a route towards destination, we looked to the source that how much control messages by protocol it sends. It gives the routing protocol internal algorithm's efficiency; If the routing protocol gives much end to end delay so probably this routing protocol is not efficient as compare to the protocol which gives low end to end delay. Similarly a routing protocol offering low network load is called efficient routing protocol. The same is the case with the throughput as it represents the successful deliveries of packets in time. If a protocol shows high throughput so it is the efficient and best protocol than the routing protocol which have low throughput. These parameters have great influence in the selection of an efficient routing protocol in any communication network.

Routing overhead can be computed either as a count of the total bytes sent out as routing packets or a count of total number of routing packets sent out. Here we have used the number of routing packets as our metric because, With more routing overhead, the amount of delay experienced by data packets in reaching their destination would be more as there would be congestion, collision and queuing delay. But now as we are reducing the routing overhead, it naturally would lead to better packet delivery times.

Several entity mobility models will be studied and analyzed. Then node movement scenario will be generated and animated. The network simulator OPNET is used to illustrate the performance of the ad hoc network under these scenarios. The impact of the mobility models over the mobile ad hoc networks will be studied. Here we use following performance matrices to evaluate mobility model with AODV protocol:

Delay*:* It is the time that a packet takes to go across the network. This time is expressed in sec. Hence all the delays in the network are called packet end-to-end delay, like buffer queues and transmission time. Mathematically it can be shown as equation

$$d_{end\text{-}end} = N[d_{trans} + d_{prop} + d_{proc}]$$

Where, dend-end= End to end delay
dtrans = Transmission delay
dprop = Propagating delay
dproc = Processing delay

Throughput: It is the ratio of the total data reaches at the receiver from the sender, the time it takes by the receiver to receive the last message is called as throughput [7]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation;

$$\text{Throughput} = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{Total duration of simulation}}$$

Routing Overhead: Ad hoc networks are designed to be scalable. As the network grows, various routing protocols perform differently. The amount of routing traffic increases as the network grows. An important measure of the scalability of the protocol, and thus the network, is its routing overhead. It is defined as the total number of routing packets transmitted over the network, expressed in bits per second or packets per second. Some sources of routing overhead in a network are cited in [4] as the number of neighbors to the node and the number of hops from the source to the destination. Other causes of routing overhead are network congestion and route error packets. Mobile nodes are faced with power constraints and as such, power saving is a major factor to consider in implementation of MANET. Furthermore, radio power limitations, channel utilization and network size are considered. These factors limit the ability of nodes in a MANET to communicate directly between the source and destination. As the number of nodes increases in the network, communication between the source and destination increasingly relies on intermediate nodes. Most routing protocols rely on their neighbors to route traffic and the increase in the number of neighbors causes even more traffic in the network due to multiplication of broadcast traffic.

SIMULATION SETUP

The Simulation was setup to evaluate the effect of mobility model in performance of MANET routing protocols AODV. We use OPNET Modeler version 14.5. A college campus network was modeled within an area of 1500m*1500m. The mobile nodes were spread within the area. We take the FTP traffic to analyze the effects on routing protocols. The nodes were wireless LAN mobile nodes. Simulation time of each scenario was 300secs. We collect DES (global discrete event statistics) on each protocol with Random Waypoint mobility, Random Walk mobility model were used in this simulation. Mobile nodes move at a constant speed of 10 m/s, and when touches the destination, the pause time is 5 sec and after that it choose a new random destination. Every other parameter was fairly kept constant for all the stimulated scenarios.

We examined average statistics of the delay, throughput and Routing Overhead for the MANET. Our key goal of our simulation was to evaluate the effect of entity mobility model in performance of MANET routing protocols.

In Table 1 we describe the simulation parameters that are used in this simulation in order to evaluate and compare the performance of mobility model with selected routing protocol (AODV) over a MANET network. Each and every scenario there is different numbers of mobile nodes. In the ad hoc network, we have simulated the following scenarios:

1. Different Network density with Random Way Point Mobility, Random Walk Mobility.

Table. 1

Simulation Parameters	
Examined Protocols	AODV
Number of Nodes	40,60,80,100
Types of Nodes	Mobile
Simulation Area	1500*1500m
Simulation Time	300 seconds
Mobility	10 m/s
Pause Time	5 sec
Performance Parameters	Delay, Throughput and Routing Overhead
Traffic type	FTP
Mobility model used	Random Waypoint, Random Walk
Data Type	Constant Bit Rate (CBR)
Packet Size	512 bytes

Scenario 1 (Small Size Network) Scenario 1 is similar to what is shown in Figure 13 ; this is a network environment designed with different entities, configured for a network size of 40 nodes, the traffic is FTP , a node speed of 10 m/s with a pause time of 5 sec. Thereafter, AODV routing protocols with Random Way Point and Random Walk Mobility is evaluated for the small-sized network, based on the analysis of the performance metrics.

Scenario 2 (Medium Size Network) Scenario 2 represents a medium-sized network where the network model is designed with 60 nodes. However, the value of node speed and the file size have not been subject to changes but set at, as in Scenario 1. The intention is to observe the performance of the routing protocols through varying the node sizes from 40 to 60.

Scenario 3 (lager than Medium Size Network) Scenario 3 represents a larger than medium-sized network where the network model is designed with 80 nodes. However, the value of node speed and the file size have not been subject to changes but set at, as in Scenario 1. The intention is to observe the performance of the routing protocols through varying the node sizes from 60 to 80.

Scenario 4 (Large Size Network) this network scenario is similar to that of Scenario 1, Scenario 2 and Scenario3, except that the network size is increased to 100 nodes, so as to observe the impact of scalability in MANET.

RESULTS ANALYSIS

Simulation Environment: We analyze and discuss the results of simulations we done. We begin the analysis of AODV protocol by parameters such as delay, throughput and Routing Overhead. The results obtained in the form of graphs. Here in first scenario we used 40 mobile nodes and one fixed wlan server. The network size is of 1500*1500 meters. After that IPv4 addressing was assigned to all the nodes. All the settings must be done according to the requirement. The scenario is shown in Table 1. The protocols such as AODV was tested against parameters i.e. delay, throughput, Routing Overhead.

Performance of AODV using the Entity Mobility models over varying node density

The simulation results obtained using AODV with random waypoint, and random walk mobility models over varying node density are shown in figures 6, 7 and 8.

Delay

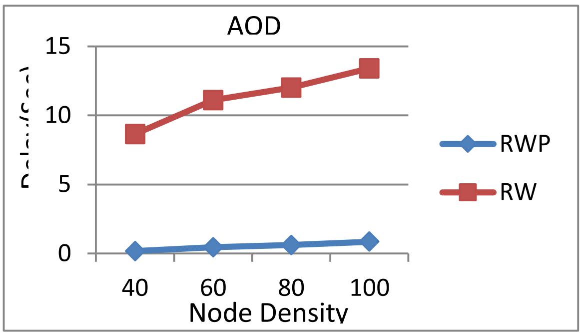

Figure: 6 Average Delay of AODV with respect to nodes density in Mobility Model

With AODV protocol delay increases with the increments in number of nodes in RWP while in RW delay has minimum variation is seen. When the number of nodes was 40 to 100, the delay of RWPM has increased in compare to that of the RW.

Throughput

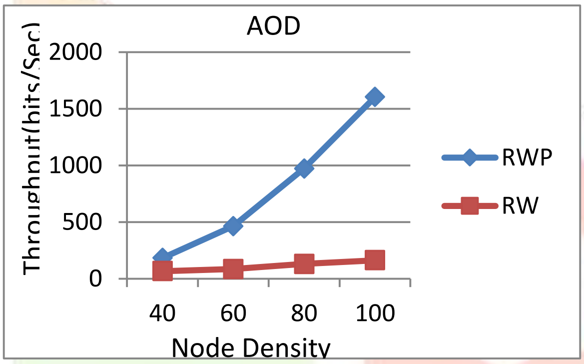

Figure: 7 Throughput of AODV with respect to nodes density in Mobility Model

From the figure, it is observed that the performance of AODV with respect to throughput using random waypoint mobility models is increased with increase in number of nodes. But as the node density increases the throughput using random walk mobility model is found slightly increased.

Overhead

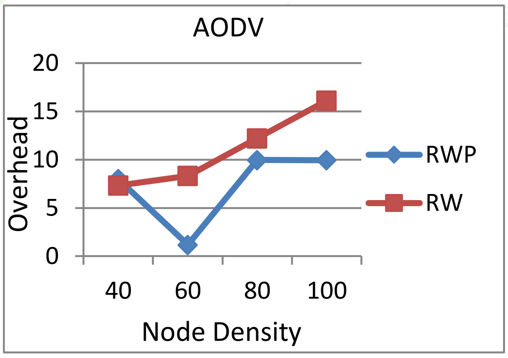

Figure: 8 Overhead of AODV with respect to nodes density in Mobility Model

Here, AODV generate the higher routing overhead with increase in node density in RW. In RWP mobility model, we observe that AODV presents decreased Routing Overhead at 60 nodes but at 80 nodes it is increased and same with regardless number of nodes.

From Above results we observed that Random Way Point Mobility Model is good for AODV working with higher number of nodes because delay is decrease with increase in number of nodes and having higher throughput with increase in node density and lower routing overhead.

CONCLUSION

Mobility Model plays an important role in MANET network protocols. By studying various mobility models, we attempt to conduct a detail study of the mobility model in a thorough and systematic manner. Beside the Random Waypoint model and its variants, many other mobility models with unique characteristics. We believe that the set of mobility models included herein reasonably reflect the state-of-art researches and technologies in this field.

The work done in this research aims to develop an understanding of the effects of mobility patterns on routing performance. We study the performance evaluation of various mobility models with respect to routing protocol Ad-hoc On-demand Distance Vector (AODV) with different performance metrics is evaluated using OPNET simulator under the fix load traffic size in FTP. In this work, a number of simulation experiments are performed by using OPNET simulator to evaluate the performance of mobility models (Random waypoint mobility and Random Walk Mobility) is used as pattern of mobility. As performance metrics Delay, throughput and routing Overhead are examined in different node density. In the first part of simulation the number of nodes is varied from 40 to 100 with file size 512 bytes and node speed 10 m/s.

In scenario 1 with 40 nodes we observe that delay in Random walk comparatively higher than the Random way point mobility model for AODV. Throughput of AODV is highest in Random Way Point Mobility model in comparison of other. Routing overhead is minimum in RWPMM in comparison of the Random Walk Mobility Model.

Scenario 2 with 60 nodes we observe that delay in Random walk comparatively higher than the Random way point mobility model for AOVD. Routing overhead of AODV is lowest in RWPM.

Scenario 3 with 80 nodes a detail comparison of parameters of different protocols in various mobility model for various amount of node within a fixed 1500*1500m area. From above table we observe that delay in Random walk comparatively higher than the Random way point mobility model for AOVD. Throughput is highest in Random Way Point Mobility model in comparison of RW. Routing overhead is highest in RWMM in comparison of the Random way point Mobility Model.

Scenario 4 with 100 nodes we observe that delay in Random walk comparatively higher than the Random way point mobility model for AOVD. Throughput is highest in Random Way Point Mobility model in comparison of RW. Routing overhead is highest in RWMM in comparison of the Random way point Mobility Model.

In above Scenarios the experimental results illustrate the comparison of parameters of among AODV protocol by varying the number of nodes for different Mobility Models. we observe that delay is gradually increase all mobility model with increase in number of nodes. Throughput is increase with increase of node but when node is 80 throughputs is decrease. Overhead is minimum in small network, it increase with increase in number of nodes.

It has been observed that the mobility pattern influences the performance of MANET routing protocols. From the results, it is analyzed that AODV has better throughput and less delay in Random Way Point Mobility model when compared to Random Walk mobility model. Random Way Point Model performs better than Random Walk Model.

The average values are taken from the graphs.

REFERENCE

[1] J. Broch, D. A. Maltz, D. B. Johnson, Y.-C. Hu, and J. Jetcheva, A performance comparison of multi-hop wireless ad hoc network routing protocols, in Proceedings of the Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking(Mobicom98), ACM, October 1998.

[2] N. Aschenbruck, E. G. Padilla, M. Gerharz, M. Frank, and P. Martini. Modelling mobility in disaster area scenarios. In Proceedings of MSWiM07, October 2007

[3] Z. Haas, "A new routing protocol for the reconfigurable wireless networks," in Proc. of the IEEE Int. Conf. on Universal Personal Communications, Oct. 1997.

[4] Performance evaluation of mobile ad hoc networks in realistic mobility and fading environments Preetha Prabhakaran University of South Florida, 2005.

[5] Emre Atsan, Oznur Ozkasap, "A Classification and Performance Comparison of Mobility Models for Ad Hoc Networks", LNCS 4104, Pages: 444-457, 2006.

[6] J. Tian, J. Hahner, C. Becker, I. Stepanov and K. Rothermel. Graph-based Mobility Model for Mobile Ad Hoc Network Simulation, in the Proceedings of 35th Annual Simulation Symposium, in cooperation with the IEEE Computer Society and ACM. San Diego, California. April 2002.

[7] Mohammad Naserian, Kemal E. Tepe and Mohammed Tarique, "Routing overhead analysis for reactive routing protocols in wireless ad hoc networks," IEEE Conference on Wireless And Mobile Computing, Networking And Communications, WiMob, 2005, pp. 87 – 92