ANALYSIS OF ENTITY AND GROUP MOBILITY MODELS WITH ROUTING PROTOCOL IN MANET

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Abstract: **A mobile ad-hoc network (MANET) is basically called as a network without any central administration or fixed infrastructure. It consists of a number of mobile nodes that use to send data packets through a wireless medium. There is always a need of a good routing protocol in order to establish the connection between mobile nodes since they possess the property of dynamic changing topology. Further, in all the existing routing protocols, mobility of a node has always been one of the important characteristics in determining the overall performance of the ad hoc network. Thus, it is essential to know about various mobility models and their effect on the routing protocols. Many academic papers have evaluated the influence of mobility models of MANET on network performance assuming similar routing and network conditions. In this paper, we do not cater the influence of mobility models in a standalone position rather we have varied mobility and analyzed the effect of several entity and group mobility patterns under proactive and reactive routing schemes based on some performance metrics. We have analyzed that proactive schemes and group mobility models outclass their counter parts. At the last we present simulation results that illustrate the importance of choosing a mobility model in the simulation of an ad hoc network protocol. Also, we illustrate how the performance results of an ad hoc network protocol drastically change as a result of changing the mobility model simulated.**

Keywords: **Mobility Model, AODV, OLSR, OPNET**

Introduction

Mobile ad hoc networks (MANETs) are widely used in wireless networks consisting of mobile devices that communicate in the absence of any centralized support. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves, i.e., routing functionality will be incorporated into mobile nodes. There are many works related to the performance evaluation of mobility models and routing protocols such as. Gowrishankar et al. [1] carried out a simulation based comparative study of various group mobility models such as community model, GFMM, RPGM, Manhattan and RWP-SS by using Adhoc On-Demand Distance Vector (AODV) as underlying routing scheme. They computed packet delivery ratio, average network delay, throughput, routing overhead and average hop count under varying mobility conditions. Simulation results concluded that community mobility model had overall performance advantage over other group mobility models. Mbarushimana et al. [2] accomplished the comparative study of reactive and proactive routing protocols under similar network conditions. Their simulation results show the superiority of proactive over reactive protocols such as traffic delivery at the cost of a higher routing load but this comparison does not take into consideration the underlying dynamic mobility and change in network state. Similarly Madhusudan et al. [3] simulated DSR, AODV and Zone Routing Protocol (ZRP) against Random Walk and Random Waypoint mobility models, and evaluated the effect of transmission range and pause time on data delivery ratio. Results depicted that there exists direct relationship between delivery ratio and both these parameters. VinodKumar et al. [4] is another classical example of such work; they evaluated AODV, Dynamic Source Routing (DSR), ZRP, Fish Eye State Routing (FSR) by varying mobility and calculated throughput, number of received packets, jitter and end-to-end delay. Results concluded that table-driven schemes performed well in high mobility scenarios than on-demand schemes. Our study is unique in the sense it provides a comparison between entity and group mobility models by varying mobility and underlying routing methodologies (proactive, reactive). This combination of routing schemes and mobility models has not been evaluated before.

Protocol used in MANET

To facilitate communication within such network, a routing protocol is used to discover and setup routes between nodes. The goal of routing protocol is to have an efficient rout establishment between a pair of nodes, so that messages can be delivered in a timely manner. In mobile ad-hoc network ad-hoc routing protocol is a standard which controls the way to route packets between computing devices decided by the nodes. Ah-hoc networks is able to use many kind of protocols according to their needs, few common protocols are as following:

Ad hoc On Demand Distance Vector Routing Protocol(AODV)

This protocol performs Route Discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. To control network wide broadcasts of RREQs, the source node uses an *expanding* ring search technique. The forward path sets up an intermediate node in its route table with a lifetime association RREP. When either destination or intermediate node using moves, a route error (RERR) is sent to the affected source node. When source node receives the (RERR), it can reinitiate route if the route is still needed. Neighborhood information is obtained from broadcast Hello packet.

As AODV protocol is a flat routing protocol it does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The AODV has great advantage in having less overhead over simple protocols which need to keep the entire route from the source host to the destination host in their messages. The RREQ and RREP messages, which are responsible for the route discovery, do not increase significantly the overhead from these control messages. AODV reacts relatively quickly to the topological changes in the network and updating only the hosts that may be affected by the change, using the RRER message. The Hello messages, which are responsible for the route maintenance, are also limited so that they do not create unnecessary overhead in the network. The AODV protocol is a loop free and avoids the counting to infinity problem, which were typical to the classical distance vector routing protocols, by the usage of the sequence numbers. [5]

Optimized Link State Routing Protocol(OLSR)

Optimized Link State Protocol (OLSR) is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes. [6] OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbors. TC messages are used for broadcasting information about own advertised neighbors which includes at least the MPR Selector list.

The proactive characteristic of the protocol provides that the protocol has all the routing information to all participated hosts in the network. However, as a drawback OLSR protocol requires each host periodically to send the updated topology information throughout the entire network. This increases the protocols bandwidth usage. But the flooding is minimized by the MPRs, which are only allowed to forward the topological messages.

Mobility Models

A mobility model which represents movement behavior of considered application scenarios should incorporate and is an important feature that may change characteristics of mobile nodes.These models are broadly categorized into two classes: (i) entity and (ii) group-based models. The former are used to mimic the movement patterns of individual MNs, while the latter are used to depict the movement patterns of a group of MNs [7], [8]. We selected Random Waypoint, Random Walk from the first category and Reference Point Column mobility and from the second, which are briefly discussed below

I. Entity- based Mobility Model

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[9]. 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).

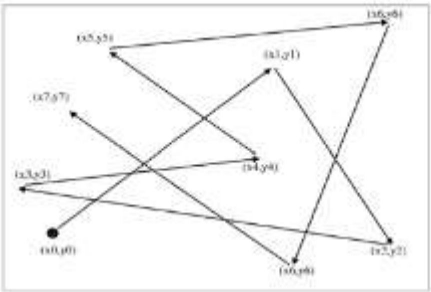

Figure 2: Node movement in the Random Waypoint Model

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 [10]. 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, 2π] 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 [10], 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.

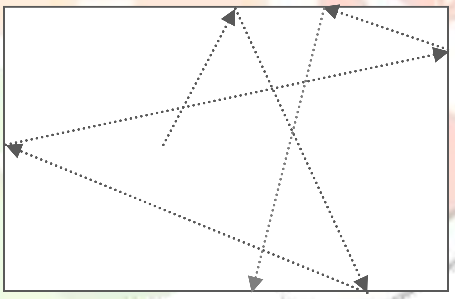

Figure 3: Node movement in the Random Walk Model

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.

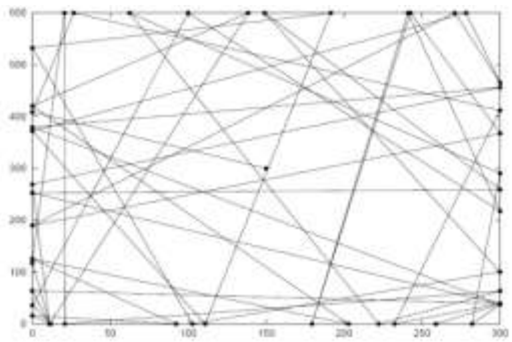

Figure 4: Traveling pattern in Random Direction Mobility Model

D. Gauss-Markov Mobility Model

The Gauss-Markov Mobility Model was first introduced by Liang and Haas [11] 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.

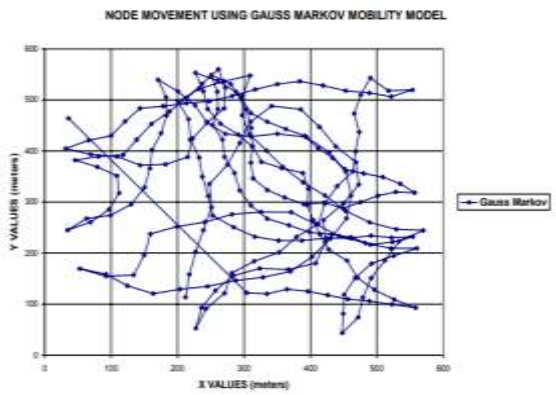

Figure: 5 Node movements in Gauss-Markov Mobility Model

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.[12], 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}, …..,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 [11].
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 [11].
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:

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

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

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

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

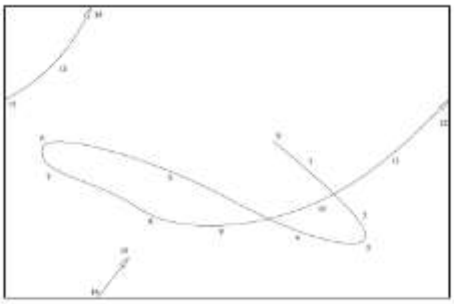

Figure: 6 The movement of a node with an SM mobility model.

II. Group Mobility Models

In Group Mobility Models Represent Mobile Nodes whose movements are dependent. Used when Mobile Nodes cooperate with each other to accomplish a common goal. Typical situations do exist in military environments (soldiers move together), i.e. Reference Point Group Model (RPGM), Column Mobility Model (CMM), Pursue Mobility Model (PMM), Nomadic Community Model (NCMM).
The location, speed and movement direction of mobile node are not affected by other nodes in the neighborhood in case of Random Waypoint model and other random models. As mentioned, these models do not capture many realistic scenarios of mobility. Moreover, in some targeted MANET applications including disaster relief and battlefield, team collaboration among users exists and the users are likely to follow the team leader. Therefore, the mobility of mobile node could be influenced by other neighboring nodes. Since the velocities of different nodes are 'correlated' in space, thus we call this characteristic as the Spatial Dependency of velocity.

***A.* Reference Point Group Mobility Model**

The whole group of mobile nodes moves randomly from one location to another. Then, the reference point of each node is determined based on the general movement of this group. Inside of this group, each node can offset some random vector to its predefined reference point. Represents the random motion of a group of mobile nodes as well as the random motion of each individual mobile node within the group.
- Group movements are based upon the path traveled by a logical center of the group.
- Individual MNs randomly move about their own pre-defined reference points.
- The RPGM model uses a group motion vector GM to calculate each MN's new reference point, RP(t +1), at time t +1.
- The length of RM is uniformly distributed within a specified radius centered at RP(t +1) and its direction is uniformly distributed between 0 and 2π.
- Both the movement of the logical center for each group, and the random motion of each individual MN within the group are implemented via the Random Waypoint Mobility Model.
- Individual MNs do not use pause times while the group is moving. Pause times are only used when the group reference point reaches a destination and all group nodes pause for the same period of time.

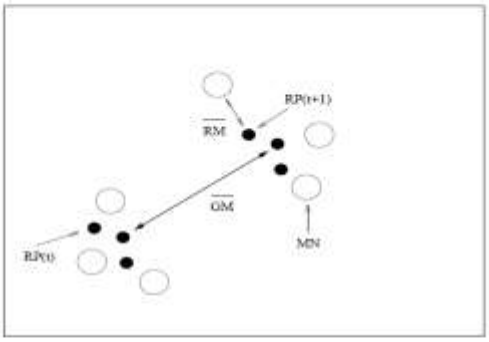

Figure: 7 Movement of three nodes using RPGM model

B. **Column Mobility Model**

The Column Mobility Model represents a set of mobile nodes (e.g., robots) that move in a certain fixed direction. This mobility model can be used in searching and scanning activity, such as destroying mines by military robots.

At time slot t, the mobile node i is to update its reference point RP_i^t by adding an advance vector α to its previous reference point RP_i^{t-1},

Formally,

$$RP_i^t = RP_i^{t-1} + \alpha_i^t$$

where the advance vector α_i^t is the predefined offset used to move the reference grid of node i at time t. After the reference point is updated, the new position of mobile node i is to randomly deviate from the updated reference point by a random vector w_i^t. Formally,

$$P_i^t = RP_i^t + w_i^t$$

When the mobile node is about to travel beyond the boundary of a simulation field, the movement direction is then flipped 180 degree. Thus, the mobile node is able to move towards the center of simulation field in the new direction.

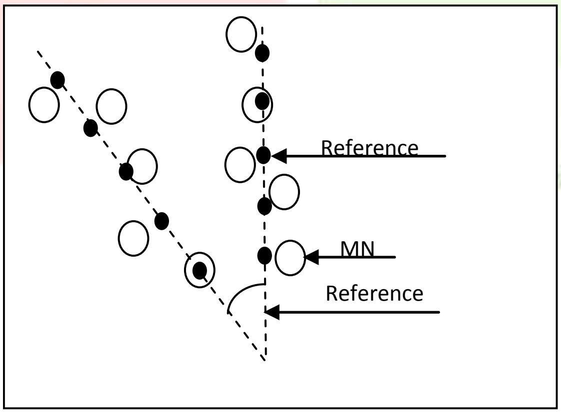

Figure: 8 Node Movement in Column Mobility Model

C. Pathway Mobility Model

Pathway Mobility Model (PMM) is used to restrict the behavior of MNs according to obstacles in pathway. The map is predefined or can be generated randomly based on certain map of real life situation. A

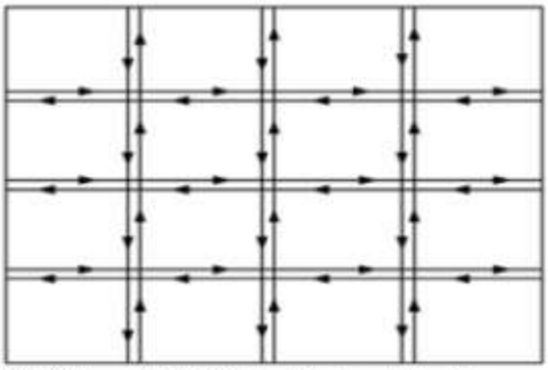

Fig. 9 Pathway Mobility Model with node mobility pattern

figure 9 show the PMM in which node describes the buildings and edge describes the path between those buildings. MNs are placed on edge and simulation starts and with randomly chosen destination node move towards destination and after reaching it take pause for certain amount of time . When all MNs reach at boundary, simulation stops.

D. Obstacle Mobility Model

Obstacle Mobility Model (OMM) describes the behavior of MNs in different obstacles placed between simulation areas. As shown in figure 10 obstacles in the form of rectangular area placed within the simulation area. Voronoi path computation used to extract the pathway between buildings. Voronoi diagram provides the movement behavior to MNs when travelling between obstacles. In this graph all route are at same distance in adjacent obstacle. So every time the shortest path is calculate between two locations by using dijikstra's algorithm. The MNs are allowed to move on the pathway defined between buildings or obstacles. MNs choose the random location within the simulation area and also select the random destination and after reaching at destination it pauses for certain amount of time and then again start moving until simulation stops.

Advantages

- Innovative approach that close to reality.
- Allowed the MNs to enter inside the obstacle and capture the movement behavior MNs under different obstacles.

Disadvantages

- Without consideration of correlated sequence of user trips.
- Independent movement behavior of MNs with respect to each others.

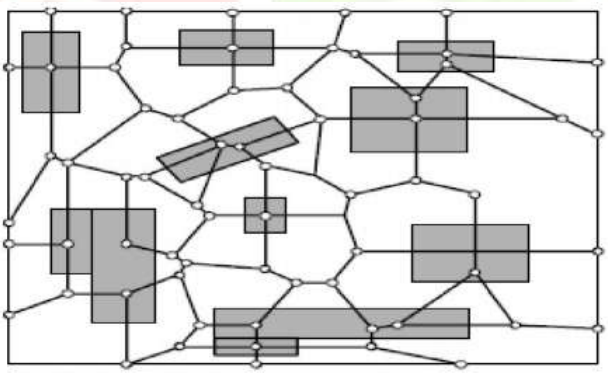

Figure:10 Node Movement in Obstacles Mobility Model

SIMULATIONS

Several simulation scenarios have been furnished to compare the mobility models. Software supports adjustable number of nodes, node speed and pause time. Table I represents adjustable parameters of the system. Simulations were conducted for each unique combination of routing protocol and mobility model. All the adjustable parameters were kept fix except number of nodes, which were varied from a minimum of 40 to a maximum of 100.

TABLE I. SIMULATION PARAMETERS

Simulation	Parameter Value (Range of Values)
Number of nodes	40-100
Node Speed	10-25 m/s
Number of entity	MMs 2 (RWP, RW)
Number of group	MMs 2 (RPGM, Column)
Length of Column(Column MM)	5 nodes

Reactive protocols	AODV
Proactive protocols	OLSR
Data packet size	512 bytes
Software	OPNET
Simulation area	1500m x 1500m
Simulation time	300 sec
Pause time	10 sec

PERFORMANCE EVALUATION

In this section, we analyze how different combinations of mobility models and routing protocols react when subjected to number of nodes changes. The performance of two routing protocols and four mobility models is measured based on average end-to-end delay, throughput and routing overhead. Table-2 and Table-3 provide a comprehensive overview of the performance. Red entries represent average value of performance measures for individual mobility models, blue entries represent average values of performance parameters for individual routing protocols in different nodes, whereas black entries illustrate performance measures for their different combinations.

Table 2 Average End to End Delay, Throughput and Overhead for different routing protocols and Mobility Models in varied node density.

Mobility Models	Protocols / No. of Nodes	AODV 40	60	80	100	Average Delay for MM	OLSR 40	60	80	100	Average Delay for MM
Delay											
Entity Mobility Model	Random Way Point	0.17	0.45	0.61	0.85	0.52	0.27	0.33	0.39	0.45	0.36
	Random Walk	8.64	11.1	12	13.4	11.29	4.15	3.71	3.88	3.12	3.72
Average Delay for Entity MM's						5.90					2.04
Group Mobility Model	Reference Point Group	0.73	0.91	1.21	0.98	0.96	0.72	0.98	1.18	1.2	1.02
	Column Mobility	10.5	29	64	118	55.38	41.11	22.76	63	144	67.72
Average Delay for Group MM's						28.17					34.37
Average Delay for individual RP's		60.04	101.5	157.82	233.2		86.25	87.78	148.45	248.77	
Throughput											
Entity Mobility Model	Random Way Point	183.3	463.4	971.74	1603	805.365	1290	4040	9136.4	17024	7872.515
	Random Walk	67.25	85.42	130.31	163.2	111.555	110.1	160	187.65	207.05	166.21
Average Throughput for Entity MM's						458.46					4019.36
Group Mobility Model	Reference Point Group	1070	980	800	845	923.75	1070	985	870	1120	1011.25
	Column Mobility	430	450	500	300	420	389	500	488	376	438.25
Average Throughput for Group MM's						671.88					724.75
Average Delay for individual RP's		1751	1979	2402.1	2911		2859	5685	10682	18727	
Overhead											
Entity Mobility Model	Random Way Point	8	1.18	9.96	9.95	7.27	6.52	7.98	7.97	7.95	7.61
	Random Walk	7.33	8.32	12.22	16.11	11.00	8.45	9.89	11.67	14.21	11.06
Average Overhead for Entity MM's						9.13					9.33

Group Mobility Model	Reference Point Group	5	5.21	6.42	6.38	5.75	6.11	5.95	7.88	10.01	7.49
	Column Mobility	6	16	20	34	19	18	24	36	40	29.50
Average Overhead for Group MM's						12.38					18.49
Average Delay for individual RP's		26.33	30.71	48.6	66.44		39.08	47.82	63.52	72.17	

Table 3 Average End to End Delay, Throughput and Overhead for different routing protocols and Mobility Models in varied node Speed.

Mobility Models	Protocols → / Speed. of Nodes →	**AODV** 10 m/s	15 m/s	20 m/s	25 m/s	**Average Delay for MM**	**OLSR** 10 m/s	15 m/s	20 m/s	25 m/s	**Average Delay for MM**
Delay											
Entity Mobility Model	Random Way Point	0.019	0.026	0.0243	0.021	0.02	0.017	0.022	0.0212	0.02	0.02
	Random Walk	0.885	0.897	0.921	0.956	0.91	1.22	2.032	2.88	2.923	2.26
Average Delay for Entity MM's						**0.47**					**1.14**
Group Mobility Model	Reference Point Group	1.092	1.099	1.058	1.073	1.08	1.05	1.05	1.016	1.008	1.03
	Column Mobility	0.38	0.234	0.387	0.325	0.33	0.54	0.87	1.05	1.11	0.89
Average Delay for Group MM's						**0.71**					**0.96**
Average Delay for individual RP's		**2.376**	**2.256**	**2.3903**	**2.375**		**2.827**	**3.974**	**4.9672**	**5.061**	
Throughput											
Entity Mobility Model	Random Way Point	12531	12524	12520	12522	12524.25	12721	12730	12716	12705	12718
	Random Walk	44035	44327	44678	44874	44478.52	44481	44222	43452	42002	43539.3
Average Throughput for Entity MM's						**28501.38**					**28128.65**
Group Mobility Model	Reference Point Group	23110	44300	63301	78444	52288.75	48222	56376	65222	77134	61738.5
	Column Mobility	36110	41209	43388	58444	44787.75	39873	46762	53222	67444	51825.25
Average Throughput for Group MM's						**48538.25**					**56781.88**
Average Delay for individual RP's		**115786**	**142360**	**163887**	**194284**		**145297**	**160090**	**174612**	**199285**	
Overhead											
Entity Mobility Model	Random Way Point	710	850	640	504	676	3100	3260	3750	4080	3547.5
	Random Walk	389	398	374	368	382.25	440	446	453	459	449.5
Average Overhead for Entity MM's						**529.13**					**1998.50**
Group Mobility Model	Reference Point Group	580	548	318	322	442	658	703	756	745	715.5
	Column Mobility	453	422	308	279	365.5	232	211	198	176	204.25
Average Overhead for Group MM's						**403.75**					**459.88**
Average Delay for individual RP's		**2132**	**2218**	**1640**	**1473**		**4430**	**4620**	**5157**	**5460**	

Performance Comparison of Mobility Models While analyzing performance of mobility models in Table 2 with varied number of nodes, we see that entity mobility models performs best in all parameters i.e. higher average values of throughput, and lower average values of delay and Overhead and when varied speed of nodes, group mobility models outclass entity mobility models in all respects.

Group mobility models exhibit higher average values of throughput, and lower average values of delay and Overhead. There are solid reasons behind this phenomenon. Firstly, nodes in group mobility models move in a group and links are always maintained amongst them when they chase target so control information is transferred more reliably that results in higher control packet throughput. Secondly, group nodes share similar aim and links rarely break in a group, so data is sent more reliably on connected and active links that results in higher data packet throughput. Finally, communication takes place amongst group nodes which are very close to each other so packets suffer minimum end-to-end delay.

A. Performance Comparison of Entity Mobility Models

Performance of different entity mobility models varies drastically as can be viewed in above Tables. It has been observed that the mobility pattern influences the performance of MANET routing protocols. It has been observed that OLSR achieve the highest throughput and least overhead with Random Way Point Mobility when compared to Random Walk mobility models with different node density. This is because with similar relative speed, between random Walk and Random Way Point Mobility, high degree of spatial dependence for Random Way Point Mobility means higher link duration and correspondingly higher path duration, which in turn will result in higher throughput and lower routing overhead.

From the results, when node speed had been varied, 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 and

B. Performance Comparison of Group Mobility Models

It is also interesting to analyze the performance variance amongst group mobility models. On the basis of simulation results, it is observed that AODV has better throughput in all mobility models with increase in the speed of node, but Reference point group mobility performs better in case of throughput in comparison of column mobility models, i.e. OLSR is more scalable. Delay to send the packet at the destination is less in group mobility model, protocols AODV and OLSR have lesser delay in column mobility in comparison of RPGM model. At last, for throughput has most satisfactory performance among two mobility models. When speed of nodes is fixed but number of node was varied, it is conclude that, OLSR have a better throughput than AODV protocol and performance is good when column mobility model is used with different pause time. Routing overhead is high for OLSR in both column and group mobility model when number of node are varied and lower overhead is with AODV when speed of nodes are different.

In summary, if a group mobility model is desired, it is recommended to use the Reference Point Group Mobility Model with appropriate parameters. If an entity mobility model is desired, the Random Waypoint Mobility Model should be used. However, a preferred entity mobility model combines the strengths of the current entity mobility model.

Conclusion

In this paper we have accomplished a comprehensive analysis of the performance of mobility models of MANeTs with reactive and proactive routing protocols by varying mobility. The simulation experiments were carried out for a minimum of 40 nodes to a maximum of 100 nodes. The results gained during the simulation experiments were quite informative. From results, we can conclude that proactive protocols outclass reactive protocols in several ways. Similarly, group mobility models outshine entity mobility models in almost all aspects. Individually speaking, restricted random walk and pursue mobility models had overall performance advantage over other entity and group mobility models respectively. Since different combinations of routing protocols and mobility models vary in performance level, so their combination should be very carefully selected depending upon the application scenario.

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