Impact of Mobility models on Mobile Sensor Networks

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***Abstract*----Wireless sensor networks (WSN) is an emerging technology, finds variety of applications in military, movement tracking, industries and medical fields. WSN are self configurable, self healing networks. In mobile sensor network, (MSN) nodes are free to move with wireless links without infrastructure. In this paper, we have studied the impact of various mobility models with AODV and DSDV routing protocols and have compared the throughput of the models. Parameters such as loss ratio, hop counts, velocity of the nodes are analyzed by varying the node density using various mobility models and routing protocols.**

Keywords- Mobile Sensor Networks, Mobile Node, Mobility model.

I. INTRODUCTION

WSN are self configuring, self healing networks consisting of mobile or static sensor nodes connected wirelessly to form an arbitrary topology. WSN are not currently deployed on a large scale, research in this area is mostly simulation based [1]. Mobile wireless sensor networks owe its name the presence of mobile sink. Advantage of mobile WSN over static WSN are better energy efficiency, improved coverage and enhance target tracking and superior channel capacity [2]. Mobility of the nodes affects the throughput of the protocol because the bandwidth reservation made or the control information exchanged may end with no use, if the node mobility is very high [3]. Figure 1 shows the mobile sensor network scenario in which the position of a mobile node at time t, (t +1), and (t+2) are shown as A, B and C respectively. Performance of routing protocols is studied with the MANETS using different mobility models. Among other simulation parameters, the mobility model plays a very important role in determining the protocol performance in MSN. Hence it is essential to study and analyze various mobility models and their effect on MSN. This paper compares the two different protocols with four mobility models and their performance with parameters like velocity, scalability, loss ratio and throughput in MSN. Figure 2 shows the design flow of how the mobility metrics are added to the mobility model and the protocol performance with the connected paths is analysed.

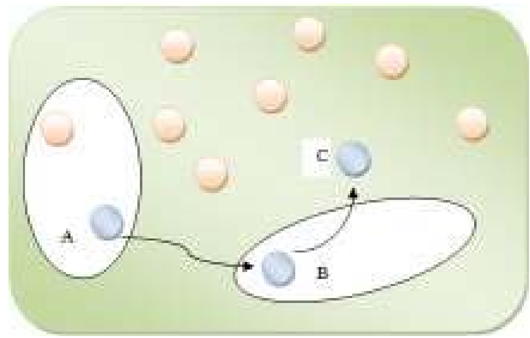

Figure 1. Mobile Sensor Network Scenario

II. RELATED WORKS

The effects of various mobility models and the performance of two routing protocols Dynamic Source Routing (DSR-Reactive Protocol) and Destination-Sequenced Distance-Vector (DSDV-Proactive Protocol) is studied in [4]. Performance comparison has also been conducted across varying node densities and number of hops. Experiment results illustrate that performance of the routing protocol varies across different mobility models, node densities and length of data paths.

Mobile wireless ad hoc networks are infrastructureless and often used to operate under unattended mode. So, it is significant in bringing out a comparison of the various routing protocols for better understanding and implementation of them. In this paper, comparison of the performance of various routing protocols like Ad hoc On-Demand Vector routing (AODV), Fisheye, Dynamic MANET On-demand (DYMO), Source Tree Adaptive Routing (STAR) protocol, Routing Information Protocol (RIP), Bellman Ford, LANd Mark Ad hoc Routing protocol (LANMAR) and Location Aided Routing protocol (LAR)are discussed. The comparison results were graphically depicted and explained [5].

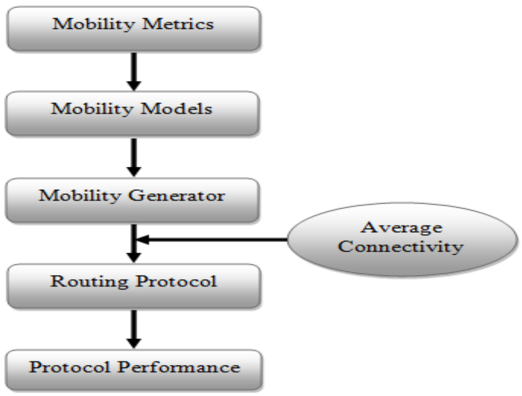

Figure 2. Design flow

The mobility model is the most important factors in the performance evaluation of a mobile ad hoc network (MANET). Traditionally, the random waypoint mobility model has been used to model the node mobility, where the movement of one node is modeled as independent from all others. However, in large scale military scenarios, mobility coherence among nodes is quite common. One typical mobility behavior is group mobility. Thus, to investigate military MANET scenarios, an underlying realistic mobility model is highly desired. In this paper a "virtual track" based group mobility model (VT model) which closely approximates the mobility patterns in military MANET scenarios is proposed. It models various types of node mobility such as group moving nodes, individually moving nodes as well as static nodes. Moreover, the VT model not only models the group mobility, it also models the dynamics of group mobility such as group merge and split. Simulation experiments show that the choice of mobility model has significant impact on network performance [6].

III. MOBILITY MODELS

Mobility models consist of two different type of dependencies such as spatial and temporal dependency. Mobility of a node may be constrained and limited by the physical laws of acceleration, velocity and rate of change of direction. Spatial dependence is a measure of node mobility direction. Two nodes moving in same direction have high spatial dependency. The current velocity of a mobile node may depend on its previous velocity. The velocities of single node at different time slots are correlated. This mobility characteristic is called as the temporal dependency of velocity [1].

Frequently used mobility models includes Random waypoint, Manhattan, Gauss Markov, Reference point group mobility model (RPGM). We compare the performance of these models with parameters like velocity, throughput, and hop count using two different routing protocols.

A. Random way point mobility model:

The Random Waypoint Mobility Model is a variation of Random Walk model with spatial dependence. It includes pause times between changes in direction and/or speed. A Mobile Node (MN) stays in one location for a certain period of time (a pause time), then MN chooses a random destination(x, y) in the simulation area with parameters such as speed between $[0,V_{max}]$,pause time between $[P_{min}, P_{max}]$ that are uniformly distributed. The MN then travels toward the newly chosen destination at the selected speed. Upon arrival, the MN pauses for a specified time period before starting the process again. The value of pauses and speeds is relevant. Fast nodes and long pauses produce a more stable network than slow nodes and short pauses. The most argued issue is that nodes are more likely to be in the central part of the topology rather than close to the bounds [1] [4].

B. Manhattan Mobility Model:

In this mobility model, the mobile nodes move in horizontal or vertical direction in the terrain. This employs a probabilistic approach in the selection of nodes movements as at each intersection, node can move in left, right or straight in same direction. The probability of taking a left turn is 1/2 and that of right turn is 1/4 in each case. The mobile node is allowed to move along the grid of horizontal and vertical path in the terrain [1].

C. Gauss Markov Mobility Model:

This model have temporal dependency with the memory level parameter α. α is a parameter to reflect the randomness of Gauss-Markov process. The velocity of mobile node is assumed to be correlated over time and modeled as a Gauss-Markov stochastic process. When the node is going to travel beyond the boundaries of the simulation field, the direction of movement is forced to flip 180 degree to remain within the simulation field [9].

D. Random point group mobility model (RPGM):

This model exhibits spatial dependency. This model consists groups of nodes that work cooperatively. Each group has a group leader, and number of members. The movement of the group leader determines the mobility behaviour of the entire group. Motion of the group leader at time t represented by the vector $\vec{v}^{t}$. Each member of this group deviates from this general motion vector $\vec{v}^{t}$ by some degree. For each node, mobility is assigned with a reference point that follows the group movement. The random motion is independent identically distributed random process whose length is uniformly distributed in the interval $[0,r_{max}]$ where r_{max} is maximum allowed distance deviation and the direction is uniformly distributed in the interval$[0,2\pi)$. Since the group leader mainly decides the mobility of group members, group mobility pattern is expected to have high spatial dependence for small values of speed and angle deviation ratio [1].

IV. ROUTING PROTOCOLS

A. Destination Sequenced Distance Vector Routing protocol (DSDV):

DSDV is a proactive, table driven algorithm based on Bellman-Ford routing. Each node has a routing table having the destination, next hop and number of hops to the destination. The nodes periodically broadcast the updates. A sequence number is tagged with time also the shortest path to a destination is used. If a node detects route to a destination is broken then the hop number is set to infinity and its sequence number is updated to a odd number. Even numbers represent the sequence numbers of connected paths. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops [4][7][8].

B. Ad-Hoc on Demand Distance Vector Routing Protocol (AODV):

AODV is a distance vector type routing protocol. This protocol does not maintain the routes to destination that are not actively used. Till the nodes have valid routes to each other AODV does not play a role. It uses Route request (REREQ), Route replies (RREPs), Route error (RERR) messages to discover and maintain the routes. When a node wants a route to a destination it broadcasts RREQ to the entire network till the destination is reached or a fresh route is found. Then a RREP is sent back to the source with the discovered path. When the node detects the route is not valid it broadcasts a RERR message [4][7].

IV. EXPERIMENT AND RESULTS

Each model is implemented with the AODV and DSDV protocols and their performance is analyzed with various node densities such as 10, 25 and 50 with standard 802.11 MAC layer. The packet type generated in the trace file is UDP. In the simulation scenario we used Omni directional antennas with transmission range 250m.Our simulation results has shown that packet loss ratio is higher with the DSDV protocol leading to higher throughput with AODV. Packet loss ratio is given by the ratio of number of packets lost to the number of packets sent. Also throughput is given by the ratio of number of packets received by number of packets sent.

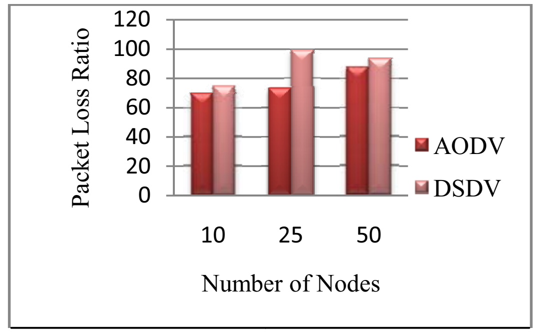

Figure 3. Random Waypoint Model

The Figure 3 shows the protocol DSDV with greater packet loss ratio and lower throughput with increasing node density in the random waypoint mobility model. The node chooses the random velocity between [0 ,V_{max}].

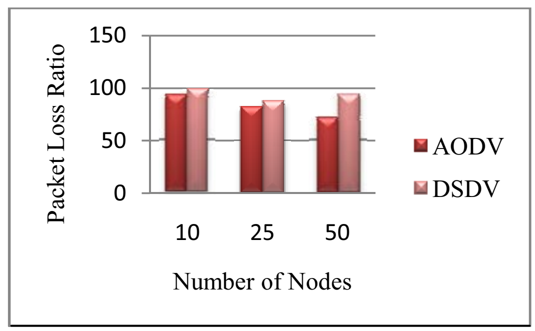

Figure 4. Manhattan Mobility Model

In Manhattan mobility model, the node chooses the velocity and moves with the same all the time till the simulation ends up. The Figure 4 also shows AODV with lower loss ratio with increasing node densities. In Gauss Markov Model, when the memory level parameter α=0, the model is memory less, and when α =1 it is memory dependent and when 0< α <1 the model has some memory dependence. So, the new velocity chosen is dependent on the previous velocity and this model has AODV protocol with less loss ratio increasing the throughput than DSDV protocol shown in Figure 5.

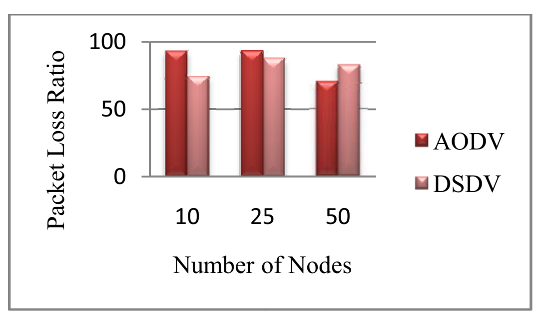

Figure 5. Gauss Markov Model

In *RPGM* mobility model, mobility is defined by V_{max} of group leader, because the leader is the highly mobile node. Other nodes in the group are spatially and temporally correlated to the motion of the leader. The above Figure 6 shows DSDV protocol having little difference in the packet loss ratio with AODV. As throughput decreases with increasing loss ratio AODV gives better performance with RPGM mobility model.

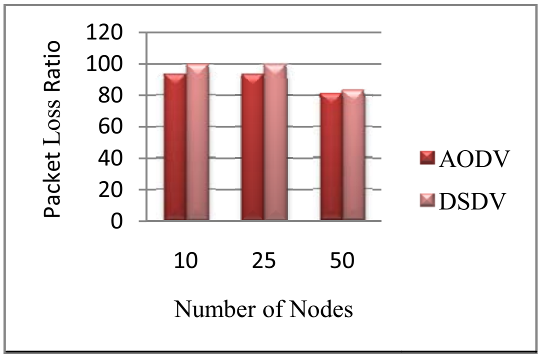

Figure 6. Random Point Group Mobility Model

Figure 7 shows the mobility models with the velocity comparison graph. The random way point mobility model chooses the random velocity between minimum and maximum velocity. Other three models are compared with the user defined velocity and the results show that the loss ratio of AODV is lesser than that of DSDV.

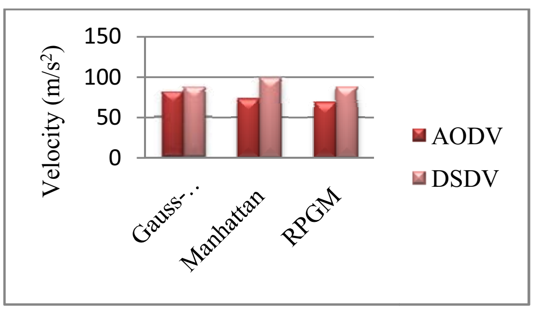

Figure 7. Mobility models vs Velocity

A. Hop count:

The number of nodes traversed by a packet between its source and destination is given by the hop count. In our simulation predicting the exact number of hops taken by the route is not easy to find, we have compared the performances of DSDV and AODV in terms of data rate (bytes per second) and averaged it for less than and more than 25 hops. We have used Random Waypoint Mobility model with 50 mobile nodes for this comparison in which the hop count increases with the increase in delay of the network. Our simulation results have shown that AODV protocol has greater throughput than the DSDV protocol. With hop count less than 25 and greater than 25 in a network the packet loss ratio is shown in the table 4.1.

TABLE I. LOSS RATIO WITH HOP COUNT

Protocol	**AODV**	**DSDV**
Less than 25 hops	71.76	87.05
More than 25 hops	80.71	96.56

B. Loss ratio vs Mobility models

Routing protocol performance varies with the mobility metrics and it affects the efficiency of the network. Impact of node mobility in mobile sensor networks affects the connectivity of the network. With high node mobility the loss ratio is higher which is compared using various mobility models. Figure 8. shows that the RPGM model has high loss ratio and low throughput where as the Random waypoint mobility model has higher throughput.

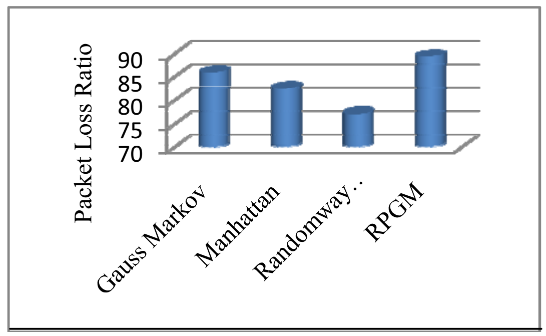

Figure 8. Loss Ratio Vs Mobility models

TABLE II. SIMULATION PARAMETERS

Parameter	**Unit**	**Value**
Terrain size	meter	1000 * 1000
Simulation Time	Seconds	10
Velocity	m/s^2	100
Hop count	-	< 25 and > 25
Throughput	Bits/second	-

IV. CONCLUSION

WSN are still not widely deployed, even though a lot of research has been done. But it is a fundamental factor that influences network protocol performance when mobile sensor nodes are used. The usage of mobility models allows the performance comparison with various traces and the results have shown that the AODV protocol higher throughput and less loss ratio than DSDV protocol with variable density. The Random waypoint mobility model gives better throughput than other mobility models with less packet loss ratio in the mobile sensor network scenario.

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