The Design and Implementation of a Novel Skew Scenario Model in Mobile Ad Hoc Networks

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Abstract: Problem statement: In this research, it had been presented a novel Skew Scenario Model that has been developed and implemented for mobile ad hoc networks. There exist several mobility patterns that try to capture the behavior of the mobile devices under different circumstances, whereas in our work, the direction movement of the nodes is significantly specified horizontally, vertically and diagonally in the simulation area. **Approach:** Our novel Skew Scenario Model and the impact of mobility on MANET protocols had been compared and analyzed. The performance of DSDV and DSR under SSM in terms of packet delivery fraction, routing load and latency for varying source and destination traffic from 10, 20, 30, 40 and 50 under 100 nodes environment had been analyzed. Apart from this, our SSM with the existing waypoint model in 100 nodes environment had been compared. A suitable algorithm for SSM has also been developed. **Results:** Our simulation result showed that the functioning of our SSM had greatly influenced the performance of routing protocols in MANET environment. Simulation experiments confirm that for DSR under SSM, the PDF is highest between 93.56-99.43%, routing load is lowest between 1.005-1.068 and Latency is very less between 0.0163-0.049 sec, in the case of DSDV under SSM, the PDF is 63.22-79.104%, routing load is 1.20-1.58 and latency is 0.018-0.050 sec. The result revealed the fact that the reactive routing protocol DSR outperforms much more than the Proactive routing protocol DSDV. Our Novel Model has performed well when we compared it with existing waypoint mobility model while setting many source-destination connections. In DSR under SSM and waypoint model, PDF is between 93.56-99.43% in SSM and in waypoint 94.20-98.88%. Routing load in SSM is 1.0056-1.068, waypoint 1.01-1.06 seconds. Latency is between 0.026-0.063 in SSM and in waypoint 0.026-0.1235 sec. **Conclusion:** This study revealed the fact that the DSR discovers new routes faster and more effectively to the destination when the old route is broken as it invokes route repair mechanism locally also high route cache hit ratio in DSR, whereas in DSDV there is no route repair mechanism. In DSDV, if no route is found to the destination, the packets are dropped. While our novel SSM is compared with the existing waypoint model, the performance of SSM is better as far as PDF, Normalized Routing Load and latency are concerned. The reasons are velocity of mobile nodes are memory less random process and they move independently over other nodes also mobile node can move with a restriction in accordance with the given direction.

Key words: Mobility, DSR, MANET, Skew Scenario and simulation

INTRODUCTION

In Mobile Ad hoc Networks (MANET), a group of mobile nodes communicates with one another without a central control infrastructure. The network is vigorously changing and even they do not have any central administration system. The routes are multi hop due to available radio propagation range of wireless device. The network topology changes frequently due to random movement of nodes and thus prediction of network topology is very difficult. The trajectories of mobile nodes strongly influence MANET (Corson and Macker, 1999) performance. An Ad hoc routing protocols is a convention or standard that controls how nodes come to agree with a way to route packets between computing devices in a mobile ad hoc network, nodes do not have a prior knowledge of topology of network around them, they have to discover it. The basic idea is that a new node announces its presence and listens to broadcast announcements from its

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neighbors. The node learns about new near nodes and ways to reach them and announces that it can also reach those nodes. The most common way to study mobile ad hoc networks is through simulations. Simulations are fast and repeatable (Network Simulator 2, 1995; Azad *et al.*, 2007; Bai *et al.*, 2004; Lin *et al.*, 2004).

A mobility model should attempt to mimic the movements of real MNs. Changes in speed and direction must occur and they must occur in reasonable time slots. We would not want MNs to travel in straight lines at constant speeds throughout the course of the entire simulation because real MNs would not travel in such a restricted manner. The Random Waypoint Mobility Model (Camp *et al.*, 2002) is the 'bench mark' mobility model that is widely used in the current simulation environment. Nevertheless, RWMM (Camp *et al.*, 2002) cannot accurately imitate all authentic mobility patterns in MANET. Therefore a variety of mobility models and communication pattern have been developed in the simulators for performance evaluation of a design. It is important to use realistic mobility models so that the evaluation results will have a close correlation to the performance when deployed. We show from our simulations results that Skew Scenario Model has a considerable effect on the performance of these routing protocols (Johnson *et al.*, 2004; Royer and Toh, 1999; Gerharz and de Wael, 2002; Perkins and Royer, 2003; Bettsltter *et al.*, 2003).

Related work: Mobility model for simulations has been one of the important topics of research in this field. One of the early contributions was made by where they evaluated DSR, AODV, DSDV (Johnson and Maltz, 1996) and TORA using the Random Waypoint model (Camp *et al.*, 2002). They concluded that mobility has its impact on the performance of routing protocols. To evaluate these protocols over a wider range of scenarios, (Johansson *et al.*, 1999) proposed the scenario-based performance analysis. In this study, they proposed mobility models for disaster relief, event coverage and conferences. Hong *et al.* (2001) proposed the RPGM model. One of the main applications of this model is in battlefield communications. The authors give several other applications of RPGM. While defining their framework they proposed to evaluate the protocols under a richer set of mobility models. Apart from using the RW and RPGM, they used two other mobility models, i.e., the FW and MH model. (Camp *et al.*, 2002) surveyed the mobility models that are used in the simulations of Ad hoc networks. Authors described several mobility models that represent mobile nodes whose movements are independent of each other (i.e., entity mobility models) and several mobility models that represent mobile nodes whose movements are dependent on each other (i.e., group mobility models).

MATERIALS AND METHODS

A Skew Scenario Model: There exist several mobility patterns that try to capture the behavior of the mobile devices under different circumstances. In this sense, SSM has been proposed. At the start of the simulation first creates the initial random position for the given number of nodes within the coverage area. In the SSM, The direction movement of the nodes is specified by Vertical, Horizontal, Forward Diagonal and Backward Diagonal (Skew Scenario). Here in this case the velocity of the nodes is independent. At the beginning of the each time interval, each node randomly chooses a speed between S_min and S_max.

The node chooses the destination only horizontally, vertically and diagonally and moves to it with a randomly chosen speed and interval. If the node touches the boundary of the simulation grid, then it moves to the opposite direction. The preceding process is repeated until the simulation termination condition is reached. The Fig. 1 illustrates orthogonal move. A move that has one coordinate zero, i.e., of pattern {0,s}. The Fig. 2 illustrates diagonal move. A move with both coordinates of equal magnitude, i.e., of pattern {r,r}, lines of cells at 45° to the horizontal and vertical.
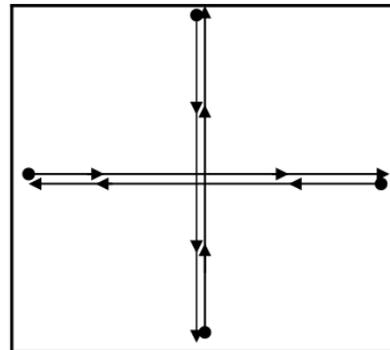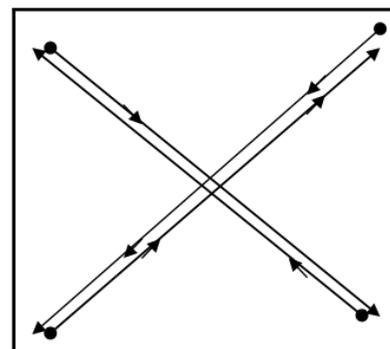

Fig. 1: Orthogonal or rookwise movement

Fig. 2: Diagonal or bishopwise movement
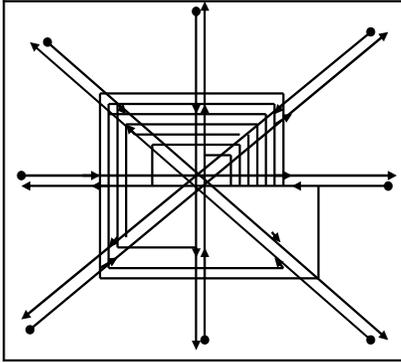
Fig. 3: Skew scenario movement

Table 1: A node mobility under skew scenario model

Angle	X = cos (angle*3.14/180)	Y = sin (angle*3.14/180)
0	1.000000	0.000000
45	0.707388	0.706825
90	0.000796	1.000000
135	-0.706260	0.707951
180	-1.000000	0.001593
225	-0.708510	-0.705700
270	-0.705700	-1.000000
315	0.705133	-0.709070
360	0.999995	-0.003190

Table 2: Notations and definitions

Symbol	Description
V_A	Speed of MN_A
V_B	Speed of MN_B with the minimum speed S_{min} and maximum speed S_{max}
V_r	Relative velocity
θ	Angle θ is a discrete random variable defining a point of entry
d	Distance between two adjacent nodes
m	Minimum speed>0
M	Maximum speed
p	pause time
n	Number of nodes
x	x dimension of space
y	y dimension of space

The Fig. 3 illustrates Skew move. A move with both coordinates different and non-zero. If r<s then the four moves vertical (±r, ±s) and horizontal (±s, ±r).

Table 1 illustrates according to various angles listed in the Table 1, the direction movement of the nodes are changing in the simulation area.

The destination x^1 and y^1 is calculated by:

$$\text{Destination\_x} = \text{Old\_x} + \text{Random speed}* \cos(\text{angle}*3.14/180)* \text{interval} \qquad (1)$$

$$\text{Destination\_y} = \text{Old\_y} + \text{Random speed}* \sin(\text{angle}*3.14/180)*\text{interval} \qquad (2)$$

General notations and definitions: Table 2 lists out the notations and parameters used in the proposed SSM.

Algorithm-SSM Model:

Step 1: Load start time, stop time, Time interval, speed range and angle. (Initial angle should be 0, 45, 90, 135, 180, 225, 270, 315 degrees only)

Step 2: Set initial node x and y position as a Random Location

Step 3: Pick a random speed between Speed min (S_{min}) and Speed max (S_{max}) value

Step 4: Calculate next x^1 and y^1 from speed, time interval and angle of the node:

$$x^1 = x + \text{speed}* \cos(\text{angle})* \text{interval}$$
$$y^1 = y + \text{speed}* \sin(\text{angle})* \text{interval}$$

Step 5: If the new x^1 or y^1 position touches the boundary, then it changes the movement to opposite direction.

Step 6: Repeat from Step 3 until stop time reached

Protocol description:
Dynamic Source Routing (DSR): The key distinguishing feature of DSR (Johnson *et al*., 2004) is the use of source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route. Route discovery works by flooding the network with Route Request (RREQ) packets. Each node receiving a RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a Route Reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed across the network. The RREP routes itself back to the source by traversing this path backward. The route carried back by the RREP packet is cached at the source for future use. If any link on a source route is broken, the source node is notified using a Route Error (RERR) packet.

Destination Sequenced Distance Vector (DSDV): DSDV (Perkins and Bhagwat, 1994) is a hop-by-hop distance vector routing protocol. It is proactive; each network node maintains a routing table that contains the next-hop for and number of hops to, all reachable destinations. Periodical broadcasts of routing updates attempt to keep the routing table completely updated at all times. To guarantee loop-freedom DSDV uses a concept of sequence numbers to indicate the freshness of a route.

Table 3: Simulation parameter values

Parameter	Values
Simulator	Ns22.34
Number of nodes	100
MAC layer	IEEE 802.11
Mobility model	SSM model
Topology x dimension	1000 m
Topology y dimension	1000 m
Transmission range	250 m
Antenna type	Omni directional
Minimum speed	0 m sec^{-1}
Maximum speed	10 m sec^{-1}
Pause time	5 m sec^{-1}
Traffic type	Constant bit rate
Packet size	512
Traffic rate (pkts sec^{-1})	10
Simulation duration	100 sec
Source-destination traffic	udp

A route R is considered more favorable than R' if R has a greater sequence number or, if the routes have the same sequence number, R has lower hop-count. The sequence number for a route is set by the destination node and increased by one for every new originating route advertisement. When a node along a path detects a broken route to a destination D, it advertises its route to D with an infinite hop-count and a sequence number is increased by one. Route loops can occur when incorrect routing information is present in the network after a change in the network topology, e.g., a broken link. In this context the use of sequence numbers adapts DSDV to a dynamic network topology such as in an ad-hoc network.

Simulation parameters:
Evaluation methodology: To evaluate the SSM in MANET, three performance metrics to compare and analyze the realistic movements were used. Table 3 indicates the typical values for some of the parameters related to the mobility patterns of the SSM.

Packet delivery fraction: The ratio of number of data packets successfully delivered to the destination, generated by CBR sources:

$$PDF = (\text{Received Packets/Sent Packets})*100$$

Routing load: It is an important metric for measuring scalability of a protocol. The number of routing packet transmitted per data packet delivered at destination. Each hop wise transmission of a routing packet is counted as one transmission:

$$\text{Routing load} = \text{Packets sent/Received packet}$$

Latency: The time, it takes for a packet to cross a network connection from sender to receiver.

RESULTS AND DISCUSSION

We have analyzed the performance of DSDV and DSR under SSM in terms of Packet Delivery Fraction, Routing Load and Latency for varying source and destination traffic from 10, 20, 30, 40 and 50 under 100 nodes environment.

As shown in the Fig. 4-6, we investigated the impact and effect of mobility on relative performance of protocols. As far as PDF, routing load and latency are concerned DSR outperforms. Simulation experiments shown in Fig. 4-6 confirm that for DSR under SSM, the PDF is highest between 93.56-99.43%, Routing Load is lowest between 1.005-1.068 and Latency is very less between 0.0163-0.049 sec, in the case of DSDV under SSM, the PDF is 63.22-79.104%, Routing Load is 1.20-1.58 and Latency is 0.018-0.050 sec. We observed that DSR under SSM producing the highest performance. This is due to the networks with a dynamic topology, proactive protocols such as DSDV have considerable difficulties in maintaining valid routes and loses many packets. It strives to continuously maintain routes to every node that increases network load as updations become larger. Route maintenance is much better in DSR as compared to DSDV. The reduction in performance can be attributed to link breakage, which is more probable as the length of the route increases.
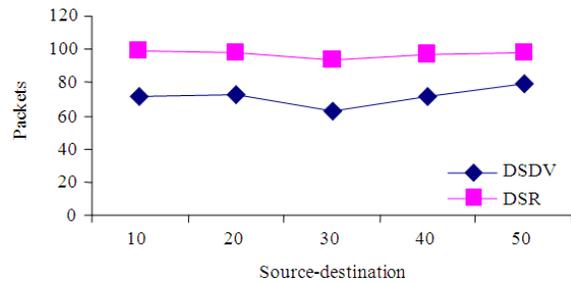

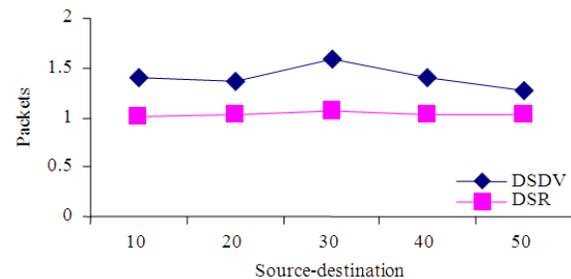Fig. 4: PDF-varying source-destination for routing protocols

Fig. 5: Normalized routing load-varying source-destination for routing protocols
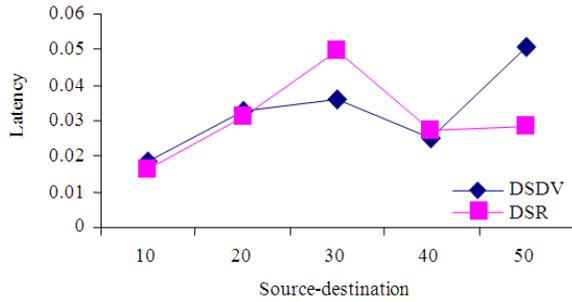
Fig. 6: Latency-varying source-destination for routing protocols
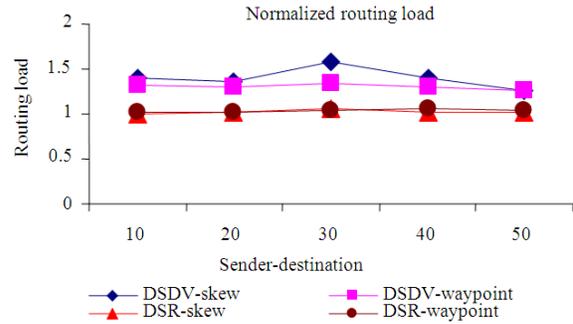

Fig. 8: Normalized routing load-comparison of skew model with waypoint model
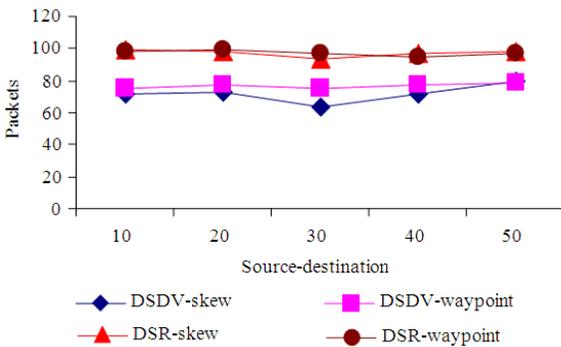

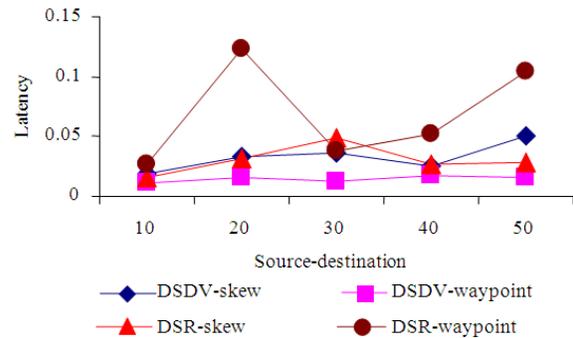Fig. 7: PDF-comparison of skew model with waypoint model

Fig. 9: Latency-comparison of skew model with waypoint model

In case of DSDV re-establishment of new routes does not take place till there is a route table information packet coming from its neighbor nodes. But in case of DSR, when route breakage takes place, packets are cached and route repair takes place. This improves the overall performance of the system.

As shown in the Fig. 7-9, we run the simulator for 100 sec with 10, 20, 30, 40 and 50 udp connections (flows). The result reveals that our novel Skew Scenario Model performs better than the existing Way Point model for DSR protocol. From the results we can see that if compared the performance of Skew Scenario Model with Waypoint for higher number of Source-Destination. Simulation experiments shown in Fig. 7-9 confirm that for DSR under SSM and Waypoint Model, PDF is between 93.56-99.43% in SSM and in Waypoint 94.20-98.88%. Routing Load in SSM is 1.0056-1.068, Waypoint 1.01-1.06 sec. Latency is between 0.026-0.063 in SSM and in Waypoint 0.026-0.1235 sec. SSM is comparatively performing better for DSR protocol. The velocity of mobile nodes, which have memory less random process i.e., Temporal Dependency.

The mobile nodes are considered as an entity that moves independently of other nodes i.e., Spatial Dependency. The mobile node can move within simulation field with a restriction in accordance with the given angle. i.e., Geographic Restrictions of movement.

CONCLUSION

We designed, implemented and analyzed the performance of the Skew Scenario model with 100 nodes environment. The performance metrics PDF, Routing Load and Latency have been taken to evaluate routing protocols DSR and DSDV. In our SSM, we have varied the Source-Destination flow vide 10, 20, 30, 40 and 50 and movement direction of nodes are specified Horizontally, Vertically and Diagonally. It has been found that DSR outperforms. The DSR discovers new route faster and more effectively to the destination when the old route is broken as it invokes route repair mechanism locally also high route cache hit ratio in DSR, whereas in DSDV there is no route repair mechanism. In DSDV, if no route is found to the

destination, the packets are dropped. While our novel SSM is compared with the existing Waypoint model, the performance of Skew Scenario Model is better as far as PDF, Normalized Routing Load and Latency are concerned. The reasons are velocity of mobile nodes are memory less random process and they move independently over other nodes also mobile node can move with a restriction in accordance with the given direction.

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