

# Design and Development of Boundless Simulation Mobility and Routing Algorithm on Mobile Ad Hoc Networks

Dr. Meenakshi Chaturvedi\*

## Abstract

Mobile ad hoc networks (MANETs) do not rely on any fixed infrastructure but communicate in a self-organized way. Boundless simulation area mobility model removes limitation by allowing nodes to wrap around to the other side of the simulation area when they encounter a border. In this paper, the study is based on description of the Boundless simulation area mobility model for an ad hoc network. A Boundless simulation area mobility model is a model that converts a 2D rectangular simulation area into a torus - shaped simulation area and introduced a new tool for facilitating the generation of realistic mobility models that include obstacles for ad hoc mobile networks.

Keywords: Boundless simulation, torus - shaped simulation, mobility model, ad hoc networks, MANETs

## Introduction

An ad hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure or centralized administration. In such an environment, it may be necessary for one mobile host to enlist the aid of other hosts in forwarding a packet to its destination, due to the limited range of each mobile host's wireless transmissions. Mobile ad hoc networks (MANETs) do not rely on any fixed infrastructure but communicate in a self-organized way. Boundless simulation area mobility model removes limitation by allowing nodes to wrap around to the other side of the simulation area when they encounter a border. The effect of this change is to create a simulation area modeled as a torus, rather than a rectangular surface. I believe that computer usage is moving towards a model of mobility. Users are migrating from their traditional desktop personal computers to laptops and portable computers with wireless communication capabilities. For efficiency and convenience, these users would naturally like to be able to share information with minimal mobility constraints and administration costs. To this end, much work has been done

---

\*Department of Computer Science, Vishveshwarya Engineering College, Dadri, Greater Noida, INDIA

in the construction of wireless ad hoc networks – self-organizing wireless networks that require no infrastructure and no administrative intervention. Many protocols have been developed to solve the numerous problems encountered in ad hoc networks. Simulating these networks during the evaluation of a protocol requires careful consideration and design of mobility and communication patterns, which may drastically affect the performance results of a given algorithm.

### Simulation Environment

Simulation environments are an important tool for the evaluation of new concepts in networking. The study of mobile ad hoc networks depends on understanding protocols from simulations, before these protocols are implemented in a real-world setting. In the performance evaluation of a protocol for an ad hoc network, the protocol should be tested under realistic conditions including, but not limited to a sensible transmission range, limited buffer space for the storage of messages, representative data traffic models and realistic movements of the mobile users (i.e. a mobility model). Network simulators emerged as the most common method of evaluating the performance of large and complex networking systems.

### Boundless Simulation Area Mobility

The Boundless Simulation Area Mobility Model is also different in how the boundary of a simulation area is handled. In this mobility Model, MNs (Mobile Networks) that reach one side of the simulation area continue traveling and reappear on the opposite side of the simulation area. When the node encounters the simulation boundary, it appears on the opposite side of the simulation area and continues traveling at the same angle and velocity. When  $\Delta t$  time steps finish, the MN chooses a new direction and velocity evaluated based on the previous direction and velocity and begins traveling again. In effect, this technique creates a torus-shaped simulation area that allows MNs to travel unobstructed. The node reaching the boundary reappears on the opposite side of the simulation area. When it reappears, the MNs parameters like the speed, direction are not changed and also the MNs do not stop there. This generates mobility without any sharp turns or sudden increase/decrease of velocity of the MN. Also the distribution will be uniform which ensures constant number of neighbors for all the MNs.

There are a variety of environments where the deployment of ad hoc networks is expected. Samples of these include cities, campuses, highways, conferences and battlefields. What most of these environments have in common is the presence of obstacles that block node movement and that hinder propagation of wireless signals. Examples of obstacles include buildings, foliage, mountains, hillsides, cars and people.

The Boundless Simulation Area Mobility Model is also different in how the boundary of a simulation area is handled. MNs reflect off or stop moving once they reach a simulation boundary. In the Boundless Simulation Area Mobility Model, MNs that reach one side of the simulation area continue traveling and reappear on the opposite side of the simulation area.

### Mathematical Formulation of Boundless simulation Area in Mobility Model

In the Boundless Simulation Area Mobility Model, a relationship between the previous direction of travel and velocity of an MN with its current direction of travel and velocity exists.

A velocity vector  $v = (v; \theta)$  is used to describe an MN's velocity  $v$  as well as its direction  $\theta$ ; the MN's position is represented as  $(x; y)$ . Both the velocity vector and the position are updated at every  $\Delta t$  time steps according to the following formulas:

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

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

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

$$y(t+\Delta t) = y(t) + v(t) * \sin\theta(t);$$

where,  $V_{\max}$  is the maximum velocity defined in the simulation,  $\Delta v$  is the change in velocity which is uniformly distributed between  $[-A_{\max} * \Delta t, A_{\max} * \Delta t]$ .  $A_{\max}$  is the maximum acceleration of a given MN,  $\Delta\theta$  is the change in direction which is uniformly distributed between  $[-\alpha * \Delta t, \alpha * \Delta t]$ , and  $\alpha$  is the maximum angular change in the direction in which an MN is traveling.

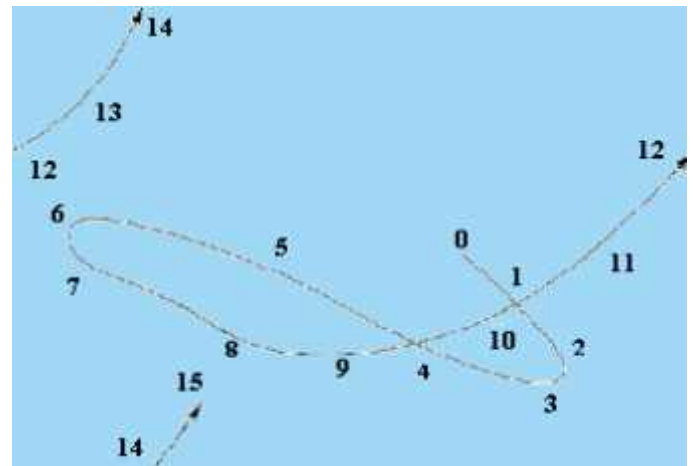


Figure 1: The movement of a node with Boundless mobility model

This technique creates a torus-shaped simulation area allowing MNs to travel unobstructed. The rectangular area on the left side of Figure 1 is transformed into the torus shape depicted on the right side in the Figure 2 in two steps:

1. I fold the simulation area so that the top border ( $y = Y_{\max}$ ) lies against the bottom border ( $y = 0$ ), forming a cylinder, and then
2. Fold the resulting cylinder so that both open circular ends connect.

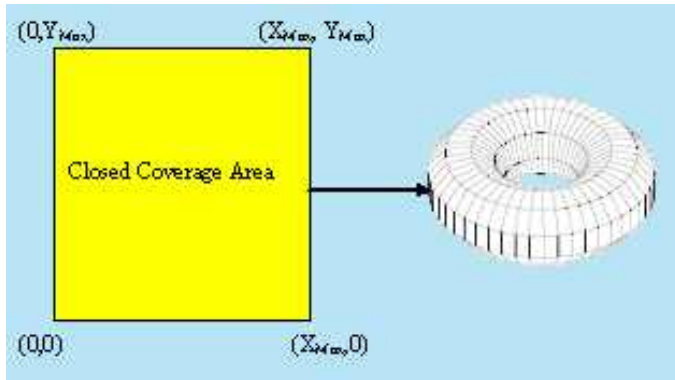


Figure 2: Rectangular Simulation area mapped to a torus in the Boundless Simulation Area Mobility Model

The Simulation points are as follows:

1. Sometimes it can be interesting to discard the border of the simulation area. In fact, the perimeter of it does affect nodes when they reach it.
2. Nodes move on the torus internal surface.
3. It is not any longer needed to describe the node's behavior on the border.
4. Radio signal propagation must be modeled accordingly.

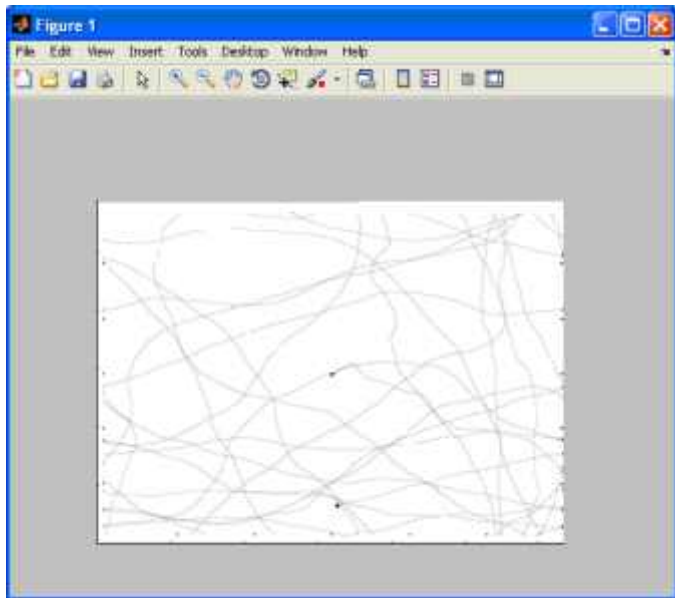


Figure 3: Traveling Pattern of a mobile node using Boundless Simulation Area Mobility Model

**Simulation Parameters for Performance**

The effect of simulation parameters on the accuracy of performance results is evaluated based on the following parameters:

1. Transmission Range
2. Simulation Time
3. Number of Nodes
4. Traffic Load

**Transmission Range**

Nodes are stationary for most of the time in this scenario; I expect the number of one-hop neighbors to increase with transmission

range, resulting in markedly higher ratio of packets being successfully delivered.

**Simulation Time**

I now vary the simulation time from 5000 seconds to 50000 seconds and observe the variation in the indicated performance.

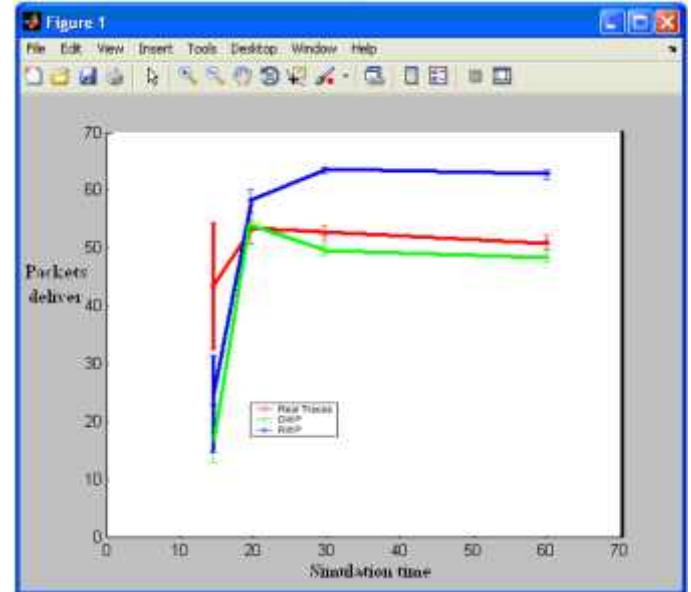


Figure 4: Graph between Simulation Time and Packet delivery rates

DWP- Direct Way Point

RWP- Random Way Point

I observe high variability in the results for the first few experiments. There are two reasons for this phenomenon:

1. The CBR traffic sources begin sending traffic at arbitrary times within the first 3000 seconds. Hence, the number of connections as well as the duration for which they have been active varies widely across connection patterns.
2. Secondly, in case of the reference traces and DWP, all nodes have not yet arrived in the simulation area within the first few thousand seconds. As a result, the number of recipients of the traffic sources varies across connection patterns.

**Number of Nodes**

In this experiment, I vary the number of nodes participating in the simulation from 20 to 100 in steps of 20. The results are shown below.

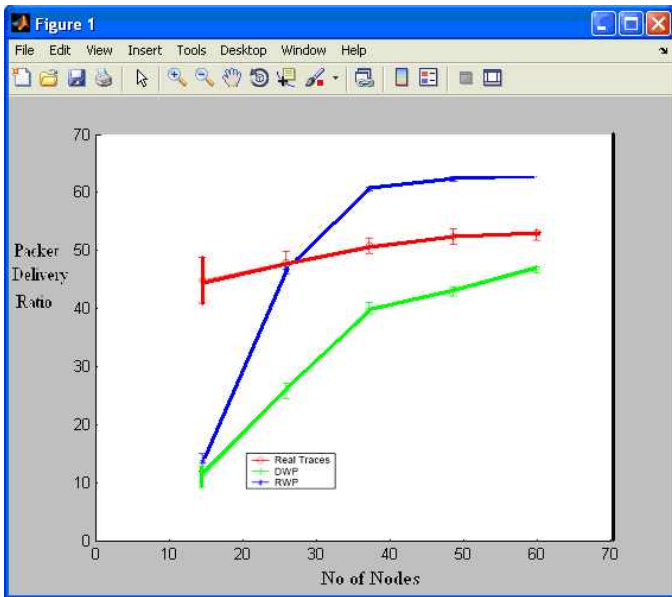


Figure 5: Graph between No of Nodes and Packet delivery rate

Traffic Load

Evaluate the effects of traffic load on the accuracy of DWP.

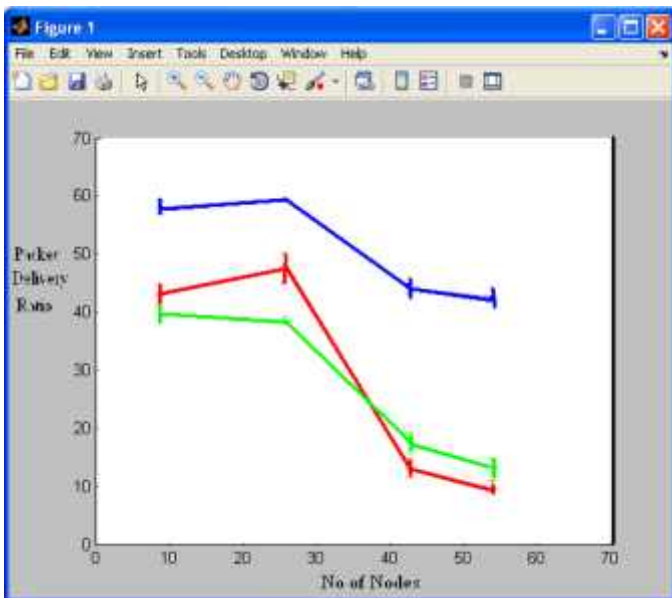


Figure 6: Graph between No of Nodes and Packet delivery rates

Findings and Result

The Boundless Simulation Area Mobility Model provides movement patterns that one might expect in the real world. In addition, this model is the only one that allows MNs to travel unobstructed in the simulation area, thus removing any simulation edge effects from the performance evaluation. One concern, however, is the undesired side effects that would occur from allowing the MNs to move around a torus. For example, one static MN and one MN that continues to move in the same direction become neighbors again and again. In addition, a

simulation area without edges would force modification of the radio propagation model to wrap transmissions from one edge of the area to the other.

Proposed New Mobility Model

The Obstacle Mobility Model is based on the following real-life observations. First, people move towards specific destinations rather than randomly choosing some destinations. Second, there are obstacles in the real world. These obstacles, most commonly the buildings block people’s movements as well hinder signal-propagation. Third, people do not walk along random trajectories; they usually move along pathways and select shortest paths.

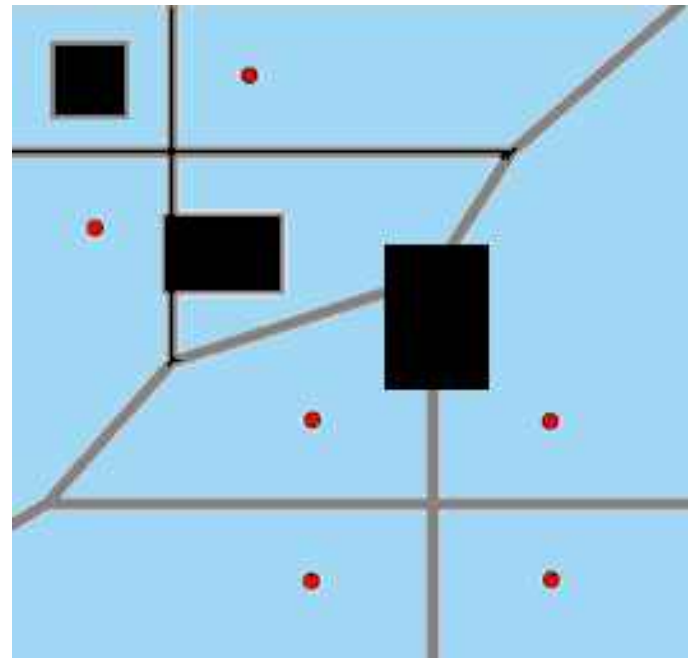


Figure 7: Example for Obstacle Mobility Model

The developed new obstacle mobility model does not rely on a graph. To move from a source location to a destination one, each node has to find its appropriate pathway through the environment. In order to allow nodes not to pass through obstacles, I implemented a path finding algorithm. This algorithm uses a ray launching technique coupled with an optimized sweep line algorithm for the fast ray intersection search computation.

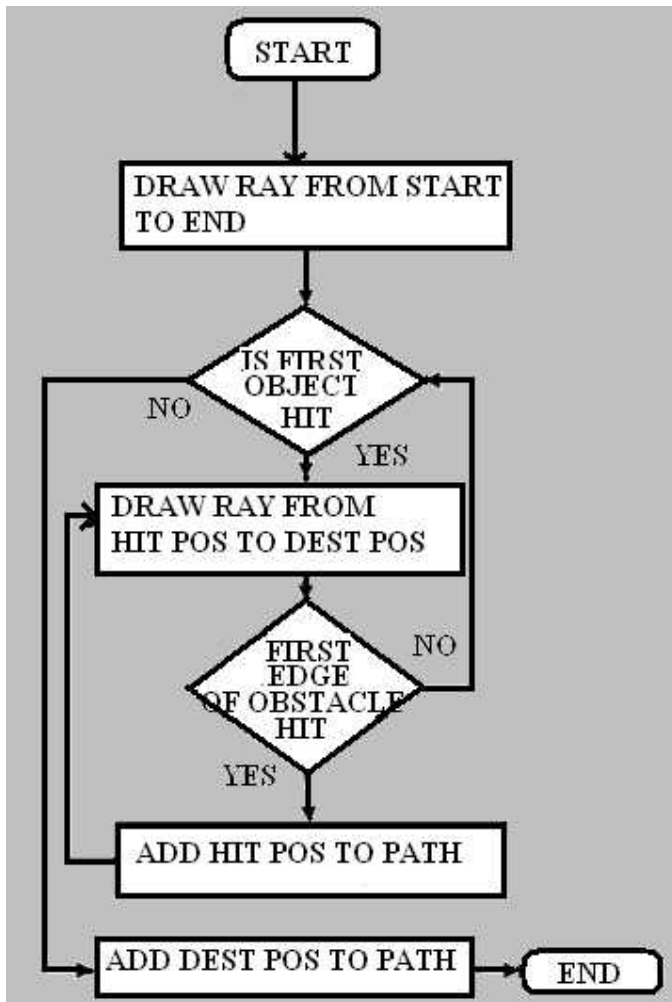


Figure 8: Path finding process flow

### The Path Finding Algorithm

A path is a set of location points which form adjacent segments and no segment intersects with an obstacle in the environment. The algorithm is as follows:

- Step 1 : Initialize the starting and ending point.
- Step 2 : Draw ray between these two points.
- Step 3 : Is first object hit? If yes go to step 4, otherwise go to step 7.
- Step 4 : Draw ray from hit position to destination position.
- Step 5 : Now check first edge of obstacle hit. If it is then go to step 6 otherwise go to step 3.
- Step 6 : Add hit position to path. Go to step 4.
- Step 7 : Add destination position to path. Go to step 8.
- Step 8 : Stop

At the beginning, the start position and the actual position are the same. I launch a ray from source to destination and search for the first obstacle hit by this ray. Now I add the first hit point to the path and try to border this first obstacle. To do this, I search for the first edge hit in this obstacle. If an edge is hit, the actual position moves to the intersection point on this edge. I choose the nearest side of the hit edge in order to minimize the final path length. I repeat it until an obstacle is encountered. This means

that the ray from the node position to destination does not hit any edge of this obstacle.

### Optimization of the Model

For computing the fast intersection search of a ray with obstacles, I used a step line algorithm. This algorithm has a complexity of  $n \log(n + k)$  with  $k$  being the number of intersections and  $n$  the number of vertices of all obstacles. The procedure is as follows:

- i) First, a status structure stores the list of events like add/remove a line segment from the list.
- ii) A priority queue, which stores the sequence of line segments in the environment, is maintained. The line segments are stored in an order.
- iii) To compare two points I first examine the X coordinate, then the Y coordinate.

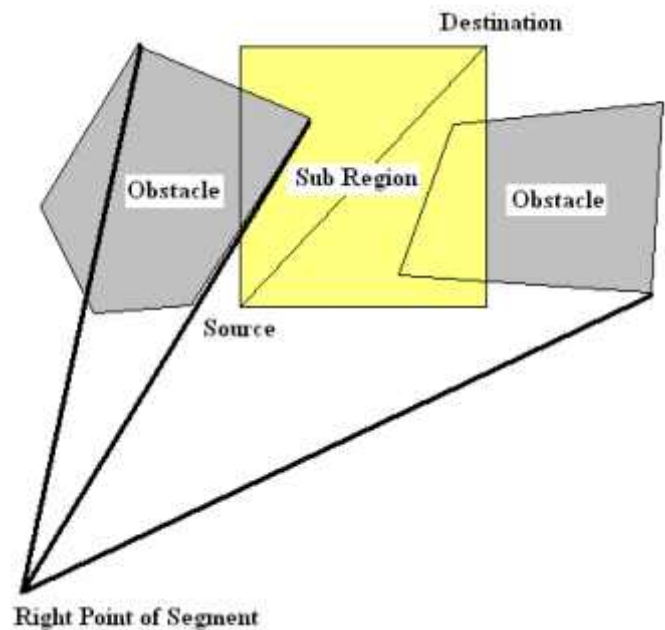


Figure 9: Step Line Intersection

- iv) To speed up this algorithm, the real time environment is clipped to a small rectangular zone each time I search a pathway for a node movement.
- v) I choose the sub region between the node position and the destination. The path finding algorithm is then implemented only in this sub region because the obstacles out of this selected region are far away and will never be hit by a ray.
- vi) A second performed optimization is stored in a list, the index of the first line segment situated on the left of each point coordinate.
- vii) Without this information, the algorithm has to restart the step process at the first index in the priority queue each time its searches for an intersection.

### Conclusion

In this paper, I have studied and described the Boundless simulation area mobility model for an ad hoc network. A

Boundless simulation area mobility model is a model that converts a 2D rectangular simulation area into a torus-shaped simulation area and thus this technique creates a torus-shaped simulation area allowing Mobile Nodes to travel unobstructed.

The study shows that the Mobility models play an important role in the evaluation of wireless network protocols. Wireless ad hoc simulation models need to approximate accurately common real world environments in order for the simulations to assess conveniently any studied ad hoc communication protocol. The work presented in this paper introduced a new tool for facilitating the generation of realistic mobility models that include obstacles for ad hoc mobile networks. I implemented a path finding algorithm. This algorithm uses a ray launching technique coupled with an optimized step line algorithm for the fast ray intersection search computation. In this algorithm, when a node needs to move from its location to a chosen destination location, a ray is launched from its actual position towards the destination position. The operation is repeated each time until I want to find the next position to be added to a mobile node pathway towards its destination location.

## Reference

1. Lin, Y. D. and Hsu, Y.C. (2000), *Multi-Hop Cellular: A new architecture for wireless Communication*, *Proceedings of IEEE INFOCOM*, March 2000:1273-1282.
2. Zahed, A. N., Jabbari, B., Pickholtz, R. and Vojcic, B. (2002), *Self Organizing Packet Radio Ad Hoc networks with overlay*, *IEEE Communication Magazine*, June 2002, 40(6):140-157.
3. Ruay-Shiung and Shing-Jiuan (2004), *Handoff Ordering Using Signal Strength for Multimedia Communications in Wireless Networks*, *IEEE Transactions on wireless Communications*, September.
4. Gregory, P.P. (1996), *Trends in Handover design*, *IEEE Communication Magazine*, March.
5. Camp, T., Jeff, B. and Vanessa, D. (2002), *A Survey of Mobility Models for Mobile ad hoc network Research*, *Wireless Communication & Mobile Computing (WCMC), Special issue on mobile Ad Hoc Networking: Research Trends and Applications: 483-502*.
6. Tracy Camp, Jeff Boleng and Vanessa Davies (2002), *A survey of mobility models for ad hoc network research*, *Wireless Communications and Mobile Computing*, 2002, Page no: 483-502, *Techterms*, "Ad Hoc Networks".
7. Sanchez, M. and Manzoni, P. (2001), *Anejos: A java based simulator for ad-hoc networks*, *Future Generation Computer Systems*, pages 573-583.
8. Davies, V., Camp, T. and Boleng, J. (2002), "A Survey of Mobility Models for Ad Hoc Network", *Special issue on Mobile Ad Hoc Networking*, April.
9. Stepanov, I., "A framework for user mobility modeling", <http://canu.informatik.uni-stuttgart.de>.
10. Bettstetter, C. (2001), "Smooth is Better than Sharp: A random Mobility Model for Simulation of Wireless Networks", *Proceedings of the 4th ACM International Workshop on Modeling, Analysis, and Simulation of Wireless and Mobile Systems (MSWIM)*, Rome, Italy, July.
11. <http://www.techterms.com/definition/adhocnetwork> wisegreek, "What is an ad hoc network".
12. <http://www.wisegeek.com/what-is-an-ad-hoc-network.htm> Searchmobilecomputing, Adhoc networks definition.
13. <http://searchmobilecomputing.techtarget.com/definition/ad-hocnetwork>.
14. <http://www.jr.iitjournals.org/article.asp?issn=0377-2063;year=2007;volume=53;issue=1;spage=3;epage=12;aulast=Radha;type=0> <http://www.gel.usherb.ca/interlab/downloads/amadeos.html>.