A Visible Obstacle Mobility Model based on Activity Area

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Abstract

In this paper we present a visible obstacle mobility model based on activity area (VOMBAA) for ad hoc network. Typical examples where the nodes of mobile ad hoc network are human-operated are natural or man-made disasters, military activities and so on. In these scenarios, people don't move random and their sights are obstructed by obstacles. In the proposed mobility model, nodes are divided into several clusters. Each cluster has properties of activity area, speed, pause time and capacity. According to different clusters, the corresponding nodes' activity areas are also different. There are no existed roads in this model, the nodes move around the obstacles in a natural and realistic way. When there are obstacles in the line that connected the node's current position and the final destination point, the node will move to a current visible obstacle's vertex to bypass the obstacle. The path that the node selected is the current shortest path from the source point to the destination point. Simulation results show that the proposed model has different impacts on network topology and routing performance.

Keywords: *Mobile ad hoc network, Obstacle mobility model, Activity area, Simulation*

1. Introduction

A Mobile Ad hoc Network (MANET) is a collection of wireless nodes communicating with each other in the absence of any infrastructure. An important component of the network simulator is the mobility model which determines the mobility patterns of the nodes in the network [1, 2]. Nodes have the different movement in the different mobile models. It is clear that the mobility patterns have a significant impact on the network performance and have a decisive impact on the reliability of simulations [3].

Many mobility models have been proposed, a survey of these models can be found in [1, 2, 4]. Researchers classify mobility models into four categories: random based models, models with temporal dependency, models with spatial dependency and models with geographic restrictions.Then, random based models include the Random Waypoint (RWP) mobility model [1] and the Random Walk (RW) mobility model [1]; Models with temporal dependency include Time-Based Random Waypoint (TBRWP) model [12] and Semi-Markov Smooth (SMS) model [13]; Models with spatial dependency include Dynamic Conditional Random Field (DCRF) model [14] and Time- variant Community Mobility Model [15]; Models with geographic restrictions include Freeway Mobility Model [3] and Manhattan Mobility Model [3].

However, we find that most of the exiting mobility models are not taking obstacles into account. However, obstacles are almost everywhere in real world, especially in the emergency situations like battlefields and disaster area where the ad hoc network is usually deployed. The obstacles hinder the movements of nodes and influence the propagation of the signals between them. Hence, it is important to consider the impact of obstacles when designing mobility models.

Recently the researchers have proposed some obstacle mobility models [5-8], and these models have mentioned obstacle avoidance in the mobile ad hoc network. A classic obstacles mobility model (OM) has been proposed in [10]. The OM model supports movement in campus-like environment with nodes following predefined paths which are computed by the Voronoi path computation. Extend this work, reference [6] presents a model in which nodes select destinations based on their activity type. However, all the proposed obstacle mobility models are based on the assumption that all the information about the obstacles like position, shape and size is already known by nodes before moving.

There is a scene in the actual environment and other models have not yet analyzed it. In this scene: 1) nodes can classify according to the node's characteristics, the type of its task or other criteria. The node's type is different, its scope of activities or other mobile features is also different; 2) nodes are not limited move on the pre-roads; 3) nodes move individual; 4) nodes do not understand the all obstacles in the panorama, only position the obstacles in the line of sight, use prediction method to select the movement path, the path is the current shortest path. A real-life scenario showed, such as in the relief work, nodes are divided into the two types which are relief workers and health care workers. The relief workers move in the area of the incident, the health care workers move in the secure area; there are not pre-roads or roads are destroyed in scene, they move to the destination followed the current shortest path, which is selected from the visible obstacles; during the move, similar mobile nodes have the almost same speed and pause time.

In order to analyze this scene, this paper presents a visible obstacle mobility model based on activity area (VOMBAA). We obtained the impact on the network of the VOMBAA model is real through the simulation of the model and compared with other models. The model is suitable for the simulation of the actual scene of the ad hoc network.

The remainder of the paper is organized as follows. Section 2 details related research in the area of mobility molding. Section 3 presents in detail the visible obstacle mobility model based on activity area (VOMBAA). Section 4 provides our simulation results and analysis. Finally, the conclusion is given in Section 5.

2. The Visible Obstacle Mobility Model Based On Activity Area

The proposed visible obstacle mobility model based on activity area targets to realistically simulate mobile ad hoc networks that consisted of human-operated nodes, nodes are deployed in areas where obstacles are present and move based on activity area.

2.1. Model Design

2.1.1. Obstacle Specification

In this model, the nodes' movement and signal propagation are influenced by obstacles which are represented by polygons. Each polygonal shape is specified as an ordered sequence of its vertices, where each vertex is defined by its coordinates.

2.1.2. Cluster

The VOMBAA model put forward the concept of "cluster" based on the type of node or other criteria. Cluster has properties included node capacity (the size of nodes can accommodate), node activity area, node speed and node pause time.

Definition 1 (Activity Area): Corresponds to the actual scene, the activity area, said the scope of activities of the node, the possibility of the existence of the node in this region than elsewhere. The shape of the activity area is a square in paper, expressed [x1, y1, x2, y2], where (x1, y1) is the upper-left corner coordinate of the activity area, (x2, y2) is the lower-right corner coordinate of the activity area.

2.1.3. The Criteria of Assign the Initial Source Location and the Initial Destination Location for Node

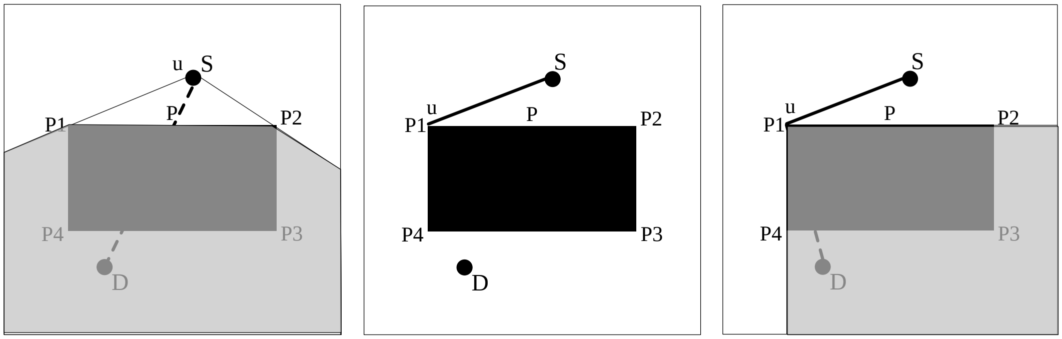
Set any location other than inside the obstacles in the simulation area as the node’s initial source location.

Set a random location in an activity area that its distance to the node’s initial source location is the shortest. The distance of the node to the activity area refers to the distance of the node to the center position of activity area.

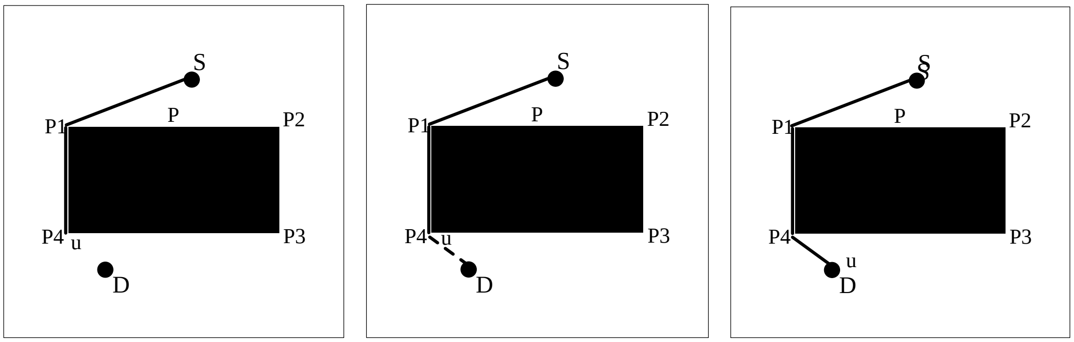
2.1.4. Movement

There are obstacles often in the network environment, nodes affected by the obstruction of obstacles, can not move directly to the destination, they need to bypass the obstacles. In the VOMBAA model, nodes can only position the visible obstacles and be unable to perceive those obstacles out of their sights. The node finds the blocking obstacle that it has to bypass at first, and then using the A * [9] evaluation function to calculate the assessed value of the visible vertices on the obstacle, select a vertex as an intermediate point. Node moves to the point to get around the obstacle, and make the possibility distance that moving to the destination point is the current shortest.

An example depicting this movement process is shown in Figure 1.



(a) (b) (c)



(d) (e) (f)

Figure 1. An Example of How a Node Moves Towards its Destination Point Around the Obstacles According to the VOMBAA Model

2.2. Model Realization

We initialize the cluster at first, set the attribute value of the cluster; then initialize the node, assign it to a cluster randomly if the capacity of the current cluster is full, and then continue randomly assigning to another cluster [10, 11, 12]. The model uses the unified criterion to assign the initial source location and the initial destination of node. The node moves from the source location to the destination point by using the pathway selection that discussed in movement section. The speed of nodes that are belong to the same cluster are equal, the value is the average speed of the cluster. Node pauses for some time when it reached the destination point. The length of the pause time is the average pause time of the cluster. After pause some time when it reached the destination point, then continue to move until the end of the simulation.

3. Simulations

In order to analyze the impact on the network of the VOMBAA model, we achieve this model on Microsoft Visual C++ 6.0 platform and compare with the VOM model (the simplified VOMBAA model that don’t consider the activity area) and the OMBAA model. Through analyzing network topology, then we use the simulation tool NS-2 do network simulation, to compare each model’s routing protocol performance [13-18].

3.1. Simulation Environment

The simulation area is 1000m×1000m, and the maximum node transmission range is 250m. There are 70 nodes moving in the simulation area. The obstacles are set to rectangles for the sake of simplicity. The obstacles influence the nodes’ movements and the propagation of signals. Unless otherwise stated, the velocity of which is randomly selected between 0 and 5 m/s, and the pause time is also randomly selected between 0 and 5 seconds. The simulation of each experiment is 1800 seconds, while each value depicted in the figures below is taken as an average of 10 executions with different seeds.

To measure the characteristics of network pathway selection, we use the following evaluation parameter:

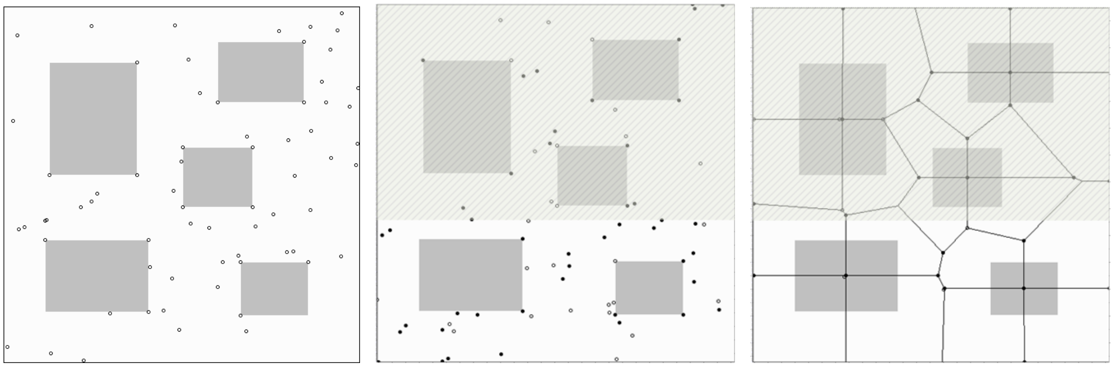
- Average path length: Average distance from a source to a destination.

Specifically, to understand the network topology characteristics created by our model, we evaluate the following metrics which are important for evaluating the network topology [3]:

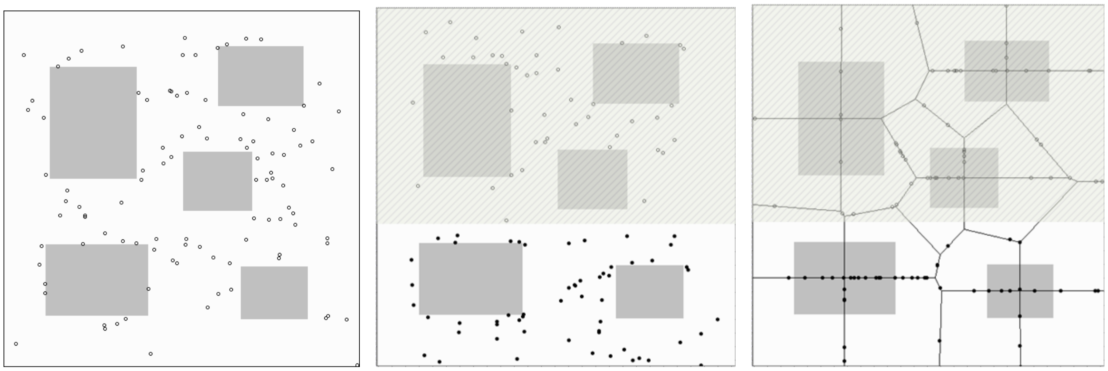
- Average node density: Average number of neighbors per node.
- Average number of link changes: Average number of link changes for a pair of nodes the number of times the link between them transitions from “down” to “up”.
- To determine the impact of our model on the performance of routing protocol, the important metrics we evaluate in these simulations are as followed [3]:
- Packet delivery ratio: The ratio of the number of received packets at their destinations over the number of the packets originally sent.
- End-to-end delay: End-to-end transmission time for packets. This value includes delays due to route discovery.
- Control overhead: Number of network-layer control packet transmissions.

3.2. Results

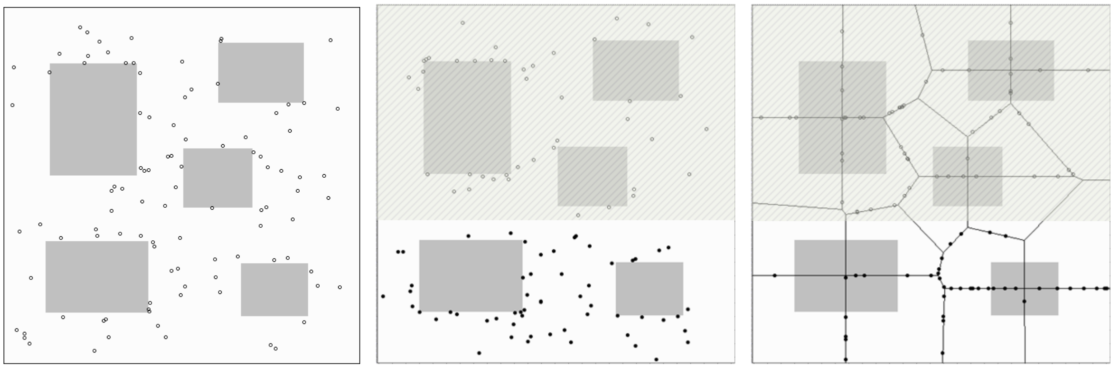
3.2.1. Network Topology



(a) VOM 0*s* (b) VOMBAA 0*s* (c) OMBAA 0*s*



(d) VOM 500*s* (e) VOMBAA 500*s* (f) OMBAA 500*s*



(g) VOM 1000*s* (h) VOMBAA 1000*s* (i) OMBAA 1000*s*

Figure 2. Nodes Distributions of VOM, VOMBAA and OMBAA

Figure 2 shows the nodes distribution of each model. According to Figure 2(a)(d)(f), The VOM model does not distinguish node's type, and there was no activity area, the nodes' activity range is the whole simulation region. Nodes distribution is rather dispersed in the VOM model. In Figure 2(b)(e)(h), the VOMBAA model's nodes are divided into two types, with a hollow circle and solid circle marked; the VOMBAA model has two activity areas, the nodes whose types are same are in the same activity area. In Figure 2(c)(f)(i), the same type nodes are also in the same activity area in the OMBAA model [6], but the nodes are moving under the scheduled roads, they gather on these roads at the moment, so the nodes distribution is the most densely.

According to the nodes distribution, calculate the average node density every 100 seconds, the results are as follows:

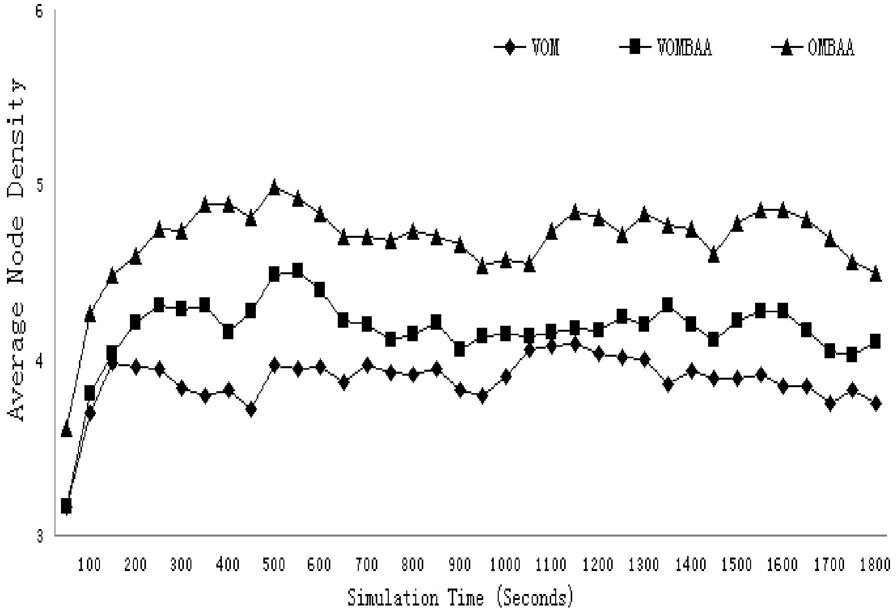


Figure 3. Average Node Density

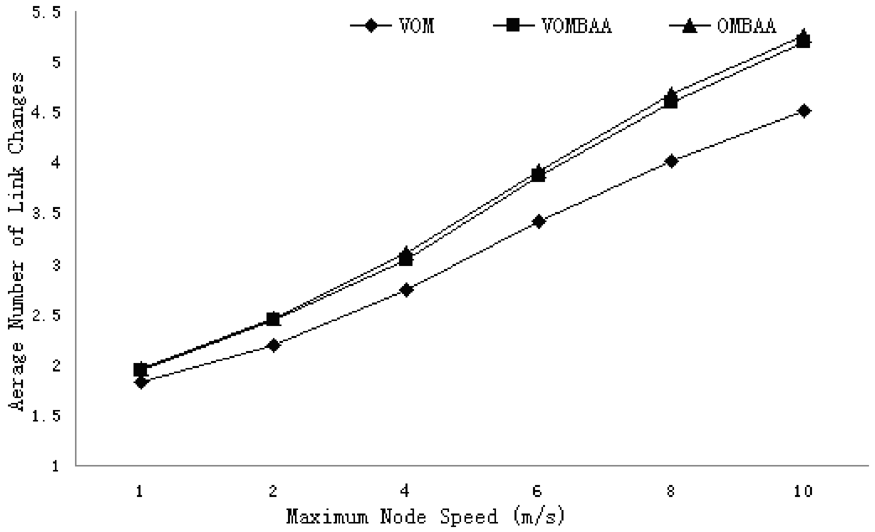


Figure 4. Number of Link Changes

3.2.2. Routing Performance

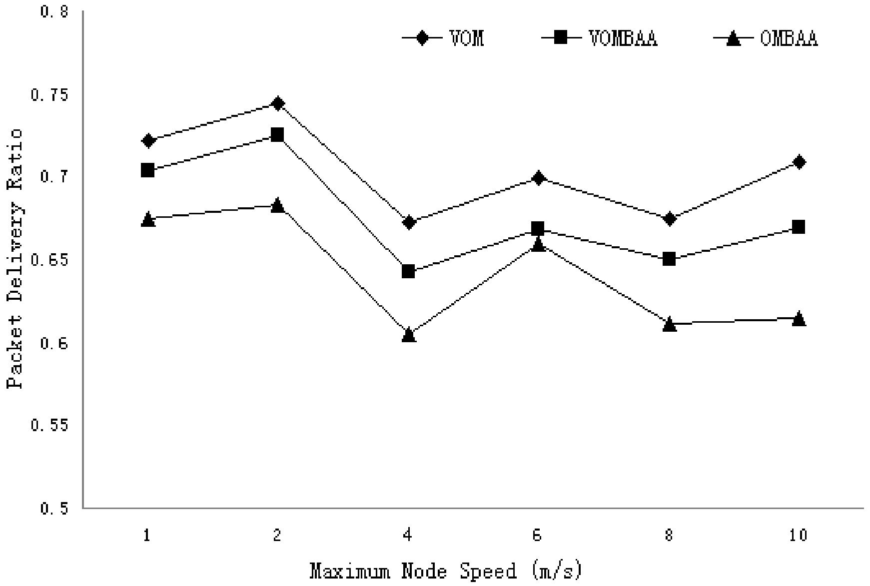


Figure 5. Packet Delivery Ratio

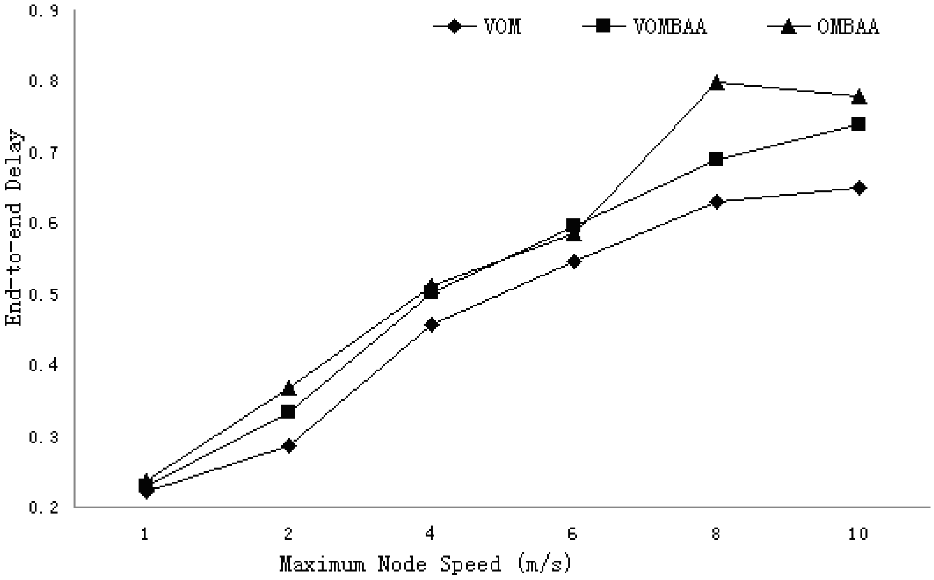


Figure 6. End to End Delay

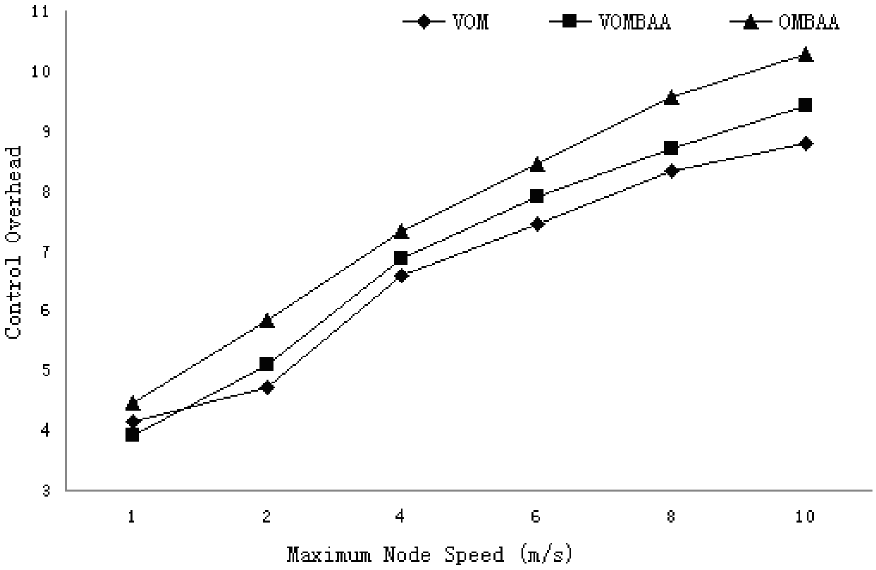


Figure 7. Control Overhead

From the Figure 5, Figure 6 and Figure 7, we can see, the OMBAA model's network routing protocol performance is the worst, the VOM model is best, while the VOMBAA model is between in the OMBAA model and the VOM model.

The simulated experimental results show that if the model's average node density is larger, the model's packet delivery ratio will be lower and end to end delay will be larger and the control overhead will also be increased, so that the network routing protocol performance will be worse. It can be seen from Figure 3, the average node density of the OMBAA model is most, the nodes distribution is most concentrated, and the routing protocol performance is the worst. Also, the average node density of the VOM model is the minimum, the nodes distribution is the most diffuse, and the routing protocol performance of the VOM model is the best.

4. Conclusion

In this paper, we proposed a visible obstacle mobility model based on activity area (VOMBAA). In this model, the nodes that clustered move in the fixed area range in the same way and the path selected is the current shortest path. Obstructions not only affect the node's mobility, but will also prevent the propagation of the signal between the nodes.

Through a series of simulation experiments, we did a series of comparison in the VOMBAA model and the other obstacle mobility models. The simulation results show those different mobile models, the network topology are different, the routing protocol performance are also significant different, you should choose the right mobility model for the real scene.

The VOMBAA model can be further extended. We can change the 2D scene to 3D scene, making the model more realistic.

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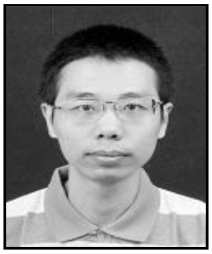

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