Simulation and Analysis of a Combined Mobility Model with Obstacles

(Poster Abstract)

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ABSTRACT

The use of simulations has become increasingly frequent in the study and the performance evaluation of network systems. The simulation environment deeply influences the behaviour of results, so a model that simulates a realistic movement of the nodes is necessary for the study of wireless networks. Simple mobility models do not provide realistic scenarios. Often movements are completely random, uncorrelated and in open space, without the chance of considering the effects of obstacles or rules that limit and guide the movement.

In this paper, we propose a more realistic mobility model, studied for indoor environments (but applicable to outdoor models as well). Given the map of the obstacles in the simulation area (e.g. a floor plan), the nodes have the possibility to move in random walk just avoiding to cross the obstacles (e.g. walls), or following a specified virtual path that connects all the simulation area, or a hybrid of the two. Our tool creates a file containing the movement of the nodes during the whole simulation time. Simulation results show that nodes are highly dependent on the different obstacles maps and pathways. Furthermore, a mathematical demonstration is given to validate the results obtained by simulation in a simple case.

Categories and Subject Descriptors: C.2.1 [Wireless communication]

General Terms: Algorithms, Performance

Keywords

Simulation, Mobility Model, Wireless Network, NS-2

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1. INTRODUCTION

In this paper we propose an improvement of a mobility model [2] that offers the chance to incorporate obstacles and pathways in the simulation area in order to create more realistic movements. Our model loads the map of the obstacles from an image file and a virtual pathway graph file. Then it is possible for the user to decide if the nodes: a) have to move according to a random walk, b) along the pathway, or c) in a hybrid movement. In the first case, the movement is the same as the Random Waypoint Model (RWP)[4], but nodes have to avoid crossing the obstacles. In the second case, the nodes choose a destination vertex in the pathway graph, and they move to that location using the shortest path. In the third case, the nodes use the RWP, but sometimes move to different areas using the pathway graph. Then they start moving according to RWP again.

The presence of obstacles affects not only the movement of the nodes, but also the signal propagation. In our model the attenuation of a signal between source and destination depends not only on the distance of the two nodes, but also on the material properties of the obstacles placed in between.

2. ORIGINAL MODEL

The model proposed in [2] allows emulating the movement of nodes in the simulation area in presence of obstacles. The original project of this model is divided in two different sub-models. In the first, called Constrained Mobility (CM), the obstacles affect only the propagation, not the movement. In the second sub-model, called the Shell Model, the nodes move following the rules of the RWP model, just avoiding crossing the external perimeter of the area and, then, ignoring the internal obstacles of the map, which affect just the propagation.

The structure of this original model allows creating a very complex and detailed map of the obstacles, but it can barely represent a realistic movement in an indoor environment. The nodes can or just move in a prefixed path, or move in a completely random way. It is not realistic that a node enters into a room and remains steady at one point. On the other side, moving randomly, the internal obstacles are completely ignored and, at every step, the movement is not correlated with the previous ones.

3. OUR MODEL

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The problems presented in the previous section have been fixed in our model. First, we improved the Shell Model enabling internal obstacles for the nodes movement and not only for the signal propagation. To do this, we define crossable obstacles, i.e., areas of the map (like doors) that don't stop the movement of the nodes, but attenuate the propagation. Despite this enhancement, the new model is not realistic either. In fact, moving randomly in an indoor scenario, the chance of leaving a room is low, so the probability of reaching rooms far from the initial one is very low. The idea is then to use both the CM and the new Shell models together, creating a new hybrid model. The nodes can switch from one sub-model to another, creating a more realistic behaviour. At every step they can move according to the RWP model with a probability *rw*, or they can jump into the graph and move to a destination vertex following the shortest path with a probability 1-*rw*. Note that for *rw*=1 and *rw*=0 our model returns to the original model. In practice, *rw* is the parameter that measures the distance of our model from the two sub-models. For a generic *rw*, the nodes usually move randomly in a room and use the graph to go into another room. Leaving the room is also possible during the RWP movement. In fact the node chooses a random destination in line of sight, and it can be a point belonging to another room. Furthermore, it is also possible to assign different values to the parameter *rw* for different sub-areas of the simulation. It allows, for example, distinguishing the behaviour of the nodes in rooms (where the RWP model fits better) and in corridors (where the use of the graph is more suitable). A random speed uniformly distributed between [Vmin, Vmax] is chosen for every RWP movement and at every vertex of the path reached. It is possible to choose the use or not of the pause. With the pause, the node stops for a random time uniformly distributed between [0,T] at the end of every RWP movement and every time it reaches the destination vertex when it uses the graph.

In order to fix the problems of the original version of the model, and to provide these new features, our model has been designed as follows. The image that contains the map of the obstacles becomes more elaborated, since every sub-area has to be painted with a different colour.

4. SIMULATIONS

4.1 Metrics

The metrics used are some of those suggested in [5] for the study of ad-hoc networks:

- Link Changes: Number of transitions between "off" and "on" status for a pair of nodes. It counts the number of times the link between two nodes is established.
- Link Duration: Duration of link in status "on".
- Node Degree: Number of neighbours per node.
- Relative Speed: SHORT DESCRIPTION
- Spatial Correlation: SHORT DESCRIPTION
- Temporal Correlation: SHORT DESCRIPTION

The metrics has been extracted during the simulation and then calculated as the average over node pairs and time instants.

The evaluation of protocol performance metrics is not considered in this paper, due to space considerations.

4.2 Simulation Environment

Our tool creates files compatible with the input mobility files used by NS-2 [1]. We have run the tool using 3 different maps. The first one is a floor plan of a building with a big number of pretty small rooms and long corridors. The second map is a simpler floor plan with few, but very wide rooms. The third map shows that this model can be also easily used to study outdoor environment or huge indoor areas like stations, airports. An additional scenario has been simulated to study the simplest case possible: a squared area without any obstacles inside and a single destination vertex positioned in the centre.

The simulations run for a period of 1800 (simulated) seconds, in which 30 nodes move in an area of 70m x 70m (total) with a random speed uniformly distributed in [1,5] m/s. The pause time (when used) has a uniform distribution in [0,180] seconds. The value of parameter *rw* has been chosen for the values between 0 and 1, with step 0.1. At the beginning of the simulations the nodes are randomly distributed on the destination vertices of the graph. The maximum node transmission range is 25m. Every simulation has been run 30 times.

5. CONCLUSIONS

The paper describes a new mobility model based on one previously suggested in [2]. Our model enables the simulation of scenarios with obstacles, designed in particular for indoor environments (but easily applicable for outdoor environments too). The model is a hybrid of two sub-models: the Random Waypoint model, avoiding crossing obstacles, and the Constrained Mobility model, where the nodes move on a virtual graph defined by the user, choosing the shortest path to reach the destination vertex. During every step of the simulation the node chooses to use the first sub-model with a probability *rw* or the second one with a probability 1-*rw*. The parameter *rw* can depend on the sub-area in which the node is. The mix of the models offers a more flexible and realistic mobility model.

There are many ways to extend this model. One is the use of a non-uniform distribution for destination selection. A second extension of the model can be the introduction of pauses at the entrances of the rooms.

7. REFERENCES

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