Advances in Mobile Medium Ad Hoc Network Research

John DeDourek, Przemyslaw Pochec
Faculty of Computer Science
University of New Brunswick
Fredericton, Canada
e-mail: {dedourek, pochec}@unb.ca

***Abstract*—Mobile Medium Ad Hoc Network (M2ANET) is the network model that can replace the Mobile Ad Hoc Network (MANET) model. New features of the simulation environment for experimenting with Mobile Medium are presented: random motion generation with no border effect, a technique for transforming motion paths and extensions of 2D simulation to 3D. Factors impacting Mobile Medium performance are reviewed, including node density and node mobility patterns.**

Keywords-MANET; Mobile Medium; simulation; movement generators

I. INTRODUCTION

Ten years have passed since the introduction of Mobile Medium: a new model of a mobile ad hoc network [1]. Since then, in collaboration with 10 graduate students, we developed simulation tools for evaluating new models and investigated numerous scenarios and configurations demonstrating the power of the new model. The purpose of this paper is to provide a summary of our findings and give a single go-to resource for referencing the body of our research.

In Section II, we compare the new Mobile Medium model to a standard MANET. In Section III, we present selected contributions to wireless network simulation that were developed when investigating M2ANETs. In Section IV, the highlights of the developed network configurations and their performance are summarized. Finally, Section V presents the ideas about the future of Mobile Medium.

II. MANET VS M2ANET

A Mobile Ad hoc Network is created from a group of mobile wireless nodes exchanging messages with one another [2]. Mobile devices are linked together through wireless connections without infrastructure and can change locations and reconfigure network connections. During the lifetime of the network, nodes are free to move around within the network and node mobility plays an important role in determining mobile ad hoc network performance [2]. A Mobile Medium Ad Hoc Network, proposed in [1], is a particular configuration of a typical MANET where mobile nodes are divided into two categories: (i) the forwarding only nodes forming the so called Mobile Medium, and (ii) the communicating nodes, mobile or otherwise, that send data and use this Mobile Medium for communication. The advantage of this M2ANET model is that the performance of such a network is based on *how well the Mobile Medium can carry the messages between the communicating nodes and not based on whether all mobile nodes form a fully connected network (Figure 1, note that the path between two communicating nodes marked in red exists, while some of the forwarding nodes in blue remain out of range).*

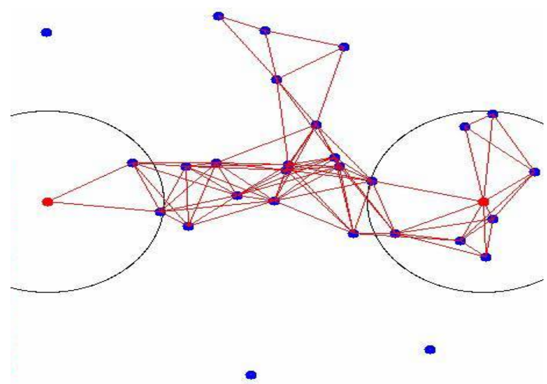

Figure 1. Sample M2ANET with two communicating nodes [1].

Multi-hop transmissions are possible when routing is used to forward packets to more distant nodes. An example of an implementation of a M2ANET is a cloud of drones equipped with routers released over an area of interest to facilitate communication in this area. A deployment of a MANET is characterized by the physical parameters of transceivers at each node, the number of nodes used, their movement pattern and the routing and transmission protocols used. They all impact the performance of the network. Given a MANET with its many complicated deployment characteristics, simulation can be applied to evaluate its performance.

III. ADVANCES IN MOBILE NETWORK SIMULATION

Mobile Medium can be viewed as a cloud of nodes buzzing in space and ready to carry a message between any nodes trying to communicate through it. Standard simulation tools used for MANET research can be used for experimenting with such a network. In our work, we addressed two particular features of the modelling environment: modelling motion and modelling in 3D.

A. Avoiding the border effect

Random mobility model is commonly used as a reference scenario in mobile network investigations. The model available in a popular open source simulator ns2 is the Random Way Point (RWP) model [3]. In RWP, nodes are

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moved in a piecewise linear fashion, with each linear segment pointing to a randomly selected destination and the node moving at a constant, but randomly selected speed. RWP models suffer from what is called the border effect, which is a non uniformity in node density along the edges of the region where the mobile nodes are confined to stay. To create models of Mobile Medium with uniform density of nodes, we modified the RWP movement generator and created a new movement generator for the ns2 simulator that does not suffer form the border effect [4].

B. *Transforming movement paths*

A typical RWP movement generator directs the node to move along a straight path. Aiming at a new modelling environment with movements along curves, we created a new tool, which uses the RWP generated paths as input and then generates new movements with each straight line replaced by a fractal curve [5].

C. *Modelling mobile networks in 3D*

A typical mobile network simulation environment, like ns2, models mobile nodes moving on a 2D plane. We modified the open source ns2 simulator [3] to allow for modelling Mobile Medium with nodes moving in 3D [6]. This work included developing an RWP movement generator for the 3D environment.

IV. Focus on Density and Node Movement in M2ANETS

Mobile Medium is a structure (medium) through which data is transmitted. The quality of communication depends on the properties of individual nodes (range, data rate, protocol) and the placement of the nodes in the network. The topology of the network and the movement of the nodes was the main focus of our research on Mobile Medium.

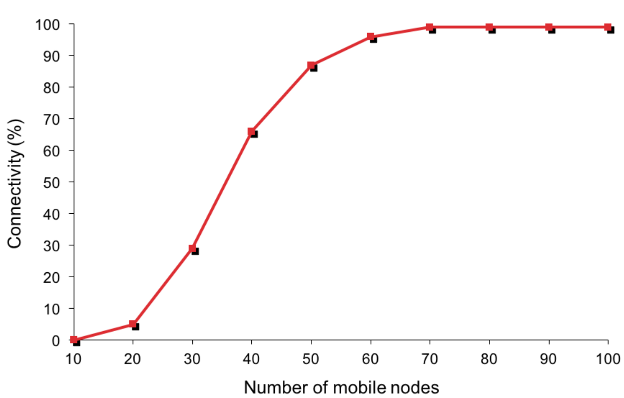

Figure 2. A typical relation between node density and user connectivity in a M2ANET [1].

The early work demonstrated a strong relation between the node density and the quality of the channel (measured as user connectivity, Figure 2) [1]. Using the RWP movement as the base scenario, we researched the Mobile Medium behavior with the node movement constrained. Either the allowed paths were constrained, like in a simulated city grid where the nodes travel in the predetermined corridors only [7], or the individual node movement was controlled by an algorithm. Two controlled movement scenarios were used: nodes moving in formations with the leader node moving at random and a number of follower nodes tracing behind at a distance [8], and all nodes still moving along random paths but exercising autonomous control ever their speed [9]. In the latter scenario the nodes would slow down when placed in a location with lots of network traffic.

V. Conclusion and Future Work

Mobile Medium proved itself as an interesting way to model ad hoc networks. In the course of investigating Mobile Medium, a number of generic simulation tools were created. These include novel traffic generators, a novel tool for transforming movement directions used in simulation and a 3D version of a popular open source simulator. The experiments showed Mobile Medium works best when there are enough nodes in the medium (high density) to form reliable paths for communication and when nodes are able to stay in the areas where most traffic occurs.

The model may form the basis of future infrastructureless autonomous and adaptable ad hoc networks.

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