Movement Generators in Mobile Medium Ad Hoc Network Simulation

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***Abstract*—Mobile Medium Ad Hoc Network (M2ANET) is the network model introduced in 2011 that could replace the Mobile Ad Hoc Network (MANET) model. Rather than focusing on user node mobility, the M2ANET models a cloud of mobile nodes forming a forwarding network accessible to any users (stationary or otherwise). The performance of such a network depends on the pattern of node movements. Thus, any performance evaluation requires modelling of the movement of the forwarding nodes. We review different node movement paradigms used in our research and suggest use cases for their applications.**

Keywords-MANET; Mobile Medium; simulation; movement generators.

I. Introduction

The Mobile Medium Ad Hoc Network (M2ANET) concept [1] introduced in 2011 precedes the discussion of the drone networks [2] and Flying Ad Hoc Networks (FANETs) [3]. As a new concept, it introduces a cloud of mobile forwarding nodes at a service of communicating clients. The Mobile Medium is not necessarily tied to any physical implementation of mobility so, as a model, it can be applied in multiple scenarios, including the likes of drone and FANET networks. Simulation of M2ANETs requires modelling of the movement of mobile nodes [4]. In this short paper, we survey the node movement generation techniques used in our research on M2ANETs over the past decade.

In Section II, we review the new Mobile Medium model and compare it to a standard MANET. In Section III, we present different methods for modelling movement of mobile nodes in simulation. In Section IV, we discuss a novel methodology for node movement modelling which is based on processing the movement files themselves. Finally, Section V presents some ideas about the future of Mobile Medium research.

II. MANET vs M2ANET

Typically, a network is called a Mobile Ad Hoc Network if it consists of a group of mobile wireless nodes exchanging messages with one another [5]. During the lifetime of the network, nodes move freely and form opportunistic connections that allow for establishing routes and forwarding data within the network. Thus, the node mobility plays an important role in formation of the links, establishing the routes and then forwarding data between the nodes [5]. In a Mobile Medium Ad Hoc Network [1], the 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 key performance measure of the M2ANET is its capability of forming a route between the specific user client nodes sending data. In other words, whether all the mobile nodes forming the Mobile Medium are fully connected is irrelevant as long as they can form a route between the specific users trying to connect through this network. The network is the medium and it only matters for forming a route between the user client nodes.

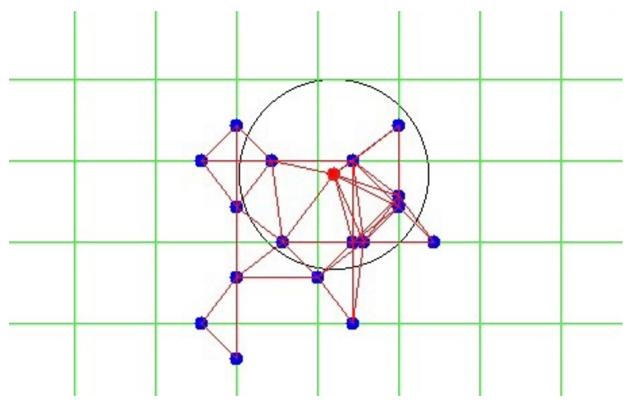

Figure 1. Mobile nodes moving randomly on a lattice.

In a M2ANET, standard MANET routing protocols can be used for establishing the routes for transferring data between the user client nodes through the Mobile Medium created with forwarding nodes [5].

III. Modelling node movement in Mobile Medium simulation

In any Ad Hoc Network, opportunistic connections form between stations positioned within the transmission range. In the Mobile Medium, the wireless links proliferate when a sufficient node density is achieved in a region long enough for the routing algorithms to successfully detect the available connections and establish the available routes [1]. The location of the nodes in a network is determined by their movement pattern. Therefore, in order to model the

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operation of the Mobile Medium, we have to model the movement of the nodes. The following is the discussion of the mobile movement models we used in our research.

A. *Random Models*

Random mobility is commonly used as a reference scenario in investigating the behavior of mobile networks. It is available in the popular open source simulator ns2 where it is referred to as the Random Way Point (RWP) model [6]. In RWP, nodes are moved in a piecewise linear fashion, with each linear segment pointing to a randomly selected destination (way point) and the node moving at a constant, but randomly selected speed. While the RWP model available in the standard ns2 simulation suite operates in two dimensions, it can also be extended to 3D [7]. RWP models suffer from what is called the border effect [8], which is a non-uniformity in node density occurring along the edges of the region where the mobile nodes are confined to stay. In our research, we experimented with modifications to the RWP movement generator in order to minimize the border effect [9].

B. *Constrained Random Models*

In a more realistic scenario, nodes may not have complete freedom to move in any direction. The existing restrictions on the node movement may be due to the physical environment constraints (e.g., obstacles) or due to the limitations on the node propulsion system (e.g., a balloon can change altitude, but cannot move in a chosen direction). An example of a constrained movement modelling would be having nodes placed randomly, but allowed to move only by changing one coordinate, i.e., move either in a horizontal or vertical direction [10]. In our research, we also used another example of the constrained random model with all the node movements constrained to a square lattice, Figure 1, representing a city grid [11]. In this scenario, the nodes can choose to move up and down the lattice grid and can also turn at the grid intersections. We note here that, in similar studies, the network nodes were modelled to move like vehicles in a simulated urban environment, for example in Simulation of Urban Mobility (SUMO) [12].

C. *Deterministic Models*

Here, we consider the scenarios where a node is moving in a specific direction predetermined by other factors. This would include the use of the prerecorded movement traces in setting the motion of mobile nodes. One *quasi* deterministic model considered in our research (with possible applications for modelling drone swarms) is based on modelling the movement of nodes in formations [13]. A formation is a group of nodes moving together with one specific node playing the role of a leader; all other nodes in the group follow the leader. In this case, only the leader retains the flexibility of choosing the direction of the movement (e.g., moving randomly) while the other nodes in the group simply retrace the path of the leader node following it at a predetermined distance. Possible parametrizations of this scenario include varying the number of members of the group, the path each member takes and the distance at which one node follows another.

IV. Processing the Movement Files

In general, network simulations systems use a node mobility model to create network scenarios for testing. First, the movement model is chosen, then the scenario is defined in terms of the number of nodes, the area of movement, initial positions of the nodes, the velocity of their movement etc. Parameters are entered into the movement generator, like an RWP, and the movement file is generated. This movement file is then used as the input to a network simulator, like ns2, to define the networking scenario. The movement file can also be analyzed for characteristics of the movement patterns like, for example, the presence of the border effect already mentioned in the previous section.

In our research on M2ANETs, we proposed a novel approach to generating new movement files by *processing* the existing movement files. (A good analogy to this idea is image processing, where the objective is not to create a new image, but rather to “improve” on an existing one.) This processing can be used to achieve the desired characteristics of the node movements not available directly in the existing movement generators. For example, new way points can be added to the ones already included in the movement file generated based on the RWP model, or the speed of movements can be modified. Specifically, we processed standard RWP generated files replacing each move along a straight line with the movement along a curve [14] (for efficiency, each straight line movement was replaced by the movement along a fractal curve by inserting additional way points into the movement file; the computational complexity of this process was managed by limiting the number of iterations in constructing the fractal curve). A possible application of this technique could be in replacing the straight line trajectories generated using a standard RWP model with a more realistic movement, for example, along ballistic curves in a 3D simulation.

V. Conclusion and Future Work

Mobile Medium is an interesting way to model the operation of wireless Ad Hoc Networks. The model favors path forming over the full connectivity when assessing the performance of a network. Like in any Ad Hoc Network, the performance is dependent on proximity between nodes which facilitates connectivity and formation of routes across the network. Experimenting with M2ANETs is facilitated by the use of simulators coupled with movement generators.

The standard random movement models allow for establishing general characteristics of the networks built on the principle of the Mobile Medium, like establishing a relation between the node density and the path forming capacity of the Medium. For more particular scenarios, more tailored movement generators may be required.

In this paper, the novel concept of transforming the movement files is introduced. In general, this procedure is applicable to both randomly generated and deterministic (recorded) movement files. Processing the movement files directly would allow to test the new "what if" scenarios without modifying the original process of generating the movement file.

REFERENCES

[1] J. DeDourek and P. Pochec, "M2ANET: a Mobile Medium Ad Hoc Network", Wireless Sensor Networks: Theory and Practice, WSN 2011, Paris, France, Feb. 2011, pp. 1-4.

[2] E. Yanmaz, S. Yahyanejad, B. Rinner, H. Hellwagner, and C. Bettstetter, "Drone networks: Communications, coordination, and sensing", Ad Hoc Networks, Elsevier, vol. 68, 2018, pp. 1-15.

[3] I. Bekmezci, O. K. Sahingoz, and S. Temel, "Flying Ad-Hoc Networks (FANETs): A survey", Ad Hoc Networks, Elsevier, vol. 11, 2013, pp. 1254-1270.

[4] T. Camp, J. Boleng, and V. Davies, "A survey of mobility models for Ad Hoc Network research", Wireless Communications and Mobile Computing, Wiley, vol. 2, 2002, pp. 483-502.

[5] S. K. Sarkar, T. G. Basavaraju, and C. Puttamadappa, Ad Hoc Mobile Wireless Networks, Principles, Protocols, and Applications, Auerbach Publications Taylor & Francis Group, 2007.

[6] H. Ekram and T. Issariyakul, Introduction to Network Simulator ns2, Springer, 2009.

[7] N. Mahmood, J. DeDourek, and P. Pochec, "M2ANET simulation in 3D in ns2", The Sixth International Conference on Advances in System Simulation SIMUL 2014, Nice, France, Oct. 12-16, 2014, pp. 24-28.

[8] C. Bettstetter, H. Hartenstein, and X. Perez-Costa, "Stochastic Properties of the Random Waypoint Mobility Model", Wireless Networks, vol. 10, 2004, pp. 555-567.

[9] R. Alghamdi, J. DeDourek, and P. Pochec, "Avoiding Border Effect in Mobile Network Simulation", The Twelfth International Conference on Networks ICN 2013, Seville, Spain, Jan. 27- Feb. 1, 2013, pp. 184-189.

[10] M. Alzaylaee, J. DeDourek, and P. Pochec, "Linear Node Movement Patterns in MANETS", The Ninth International Conference on Wireless and Mobile Communications ICWMC 2013, Nice, France, July 21-26, 2013, pp. 162-166.

[11] X. Zhang, Simulation of Manet in Urban Environment, University of New Brunswick MCS Thesis, 2010.

[12] D. Krajzewicz, J. Erdmann, M. Behrisch, and L. Bieker, "Recent Development and Applications of SUMO – Simulation of Urban Mobility", International Journal of Advances in Systems and Measurements, vol. 6, no. 3&4, 2012, pp. 128-138.

[13] A. Alshehri, J. DeDourek, and P. Pochec, "The Advantage of Moving Nodes in Formations in MANETs and M2ANETs", The Ninth International Conference on Wireless and Mobile Communications ICWMC 2013, Nice, France, July 21-26, 2013, pp. 228-232.

[14] H. Alseef, J. DeDourek, and P. Pochec, "A Method for Transforming Movement Paths in Wireless Mobile Network Simulation", the International Journal on Advances in Networks and Services, vol. 9, no. 1&2, 2016, pp. 11-19.