

Automated Generation of Movement Trace for Aircraft Ad Hoc Networks

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Abstract — Following our previous our work [1] to get realistic movement trace for aircraft ad hoc networks, in this paper, we propose how to generate the automated scenarios that are supposed to be used in simulation. Even though an approach for realistic mobility model was proposed as well as implemented in our previous work, it lacks of repeatability and takes long time to get the trace file due to manual configuration for parameters of all aircrafts. Thus, automated scenario generation is strongly required for diverse different scenarios in a way of convenient and easy configuration. To achieve this research goal, some additional functions are proposed and implemented under the same software architecture as the previous work.

Keywords-movement trace; aircraft ad hoc networks.

I. INTRODUCTION

As many researches for AANET (Aircraft Ad Hoc Networks) [2] have been recently conducted, performance evaluation through network simulator is regarded as one of essential tasks while developing new enhanced protocols or network architecture. Nevertheless, since current popular network simulators are not sufficiently equipped for adequately simulating the mobility of moving aircraft, corresponding components for each simulator is strongly required. Among required components, movement trace is one of big research challenges because there are little available sources. Thus, a new source of realistic mobility traces for simulation should be concerned significantly. This requirement was also observed in research experience from pure mobile ad hoc networks to vehicular ad hoc networks.

Related to movement trace, it can be obtained by either mathematical model or actual observation. For former example, a new model was introduced in [3]. In this work, we propose how to create a position and velocity function for an aircraft, given its starting location and speed, altitude, and heading on each leg of its height. In addition, an optimization procedure is used to fit the position and velocity functions to the supplied data. Even though the proposed scheme in [3] enables the researcher to facilitate the movement information; however, the proposed method is not suitable to generate realistic mobility model. The major reason for this drawback is caused by the following fact that there is a large number of aircrafts with different properties and great changes in flying surrounding situations such as wind. Therefore, despite of complex dynamics of each aircraft and external environments, it should be considered together with a mathematical model; for the realistic movement model,

mathematical model presented in [3] cannot accommodate all possible situations. This fact leads to unrealistic movement trace in many scenarios. In the latter case, as a current observation, real-world aircraft will be tracked using on-board or subsidiary devices and vehicle positions recorded at regular intervals. However, while such a mobility model will arguably result in the most realistic aircraft movement, its use is limited by this approaches' inherent limitation to a small set of mobility parameters. Changing only one parameter, e.g., the density of vehicles, and keeping all other parameters unchanged is simply infeasible in reasonably large scenarios. The restriction of trace data on what could be recorded from real-world vehicle movements can be easily overcome by generating such movement traces artificially.

To solve problem mentioned above, we proposed how to use commercial flight simulator for movement trace. As far as we know, this is the first approach to use commercial flight simulator for the research in AANET.

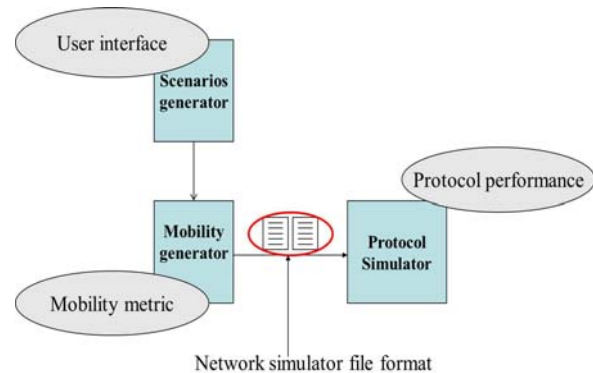


Figure 1. Software architecture

By using flight simulator, actual movement of each aircraft is controlled by each user's manual aviation or automatic flight in the commercial flight simulator depending on dynamic of each aircraft. The software architecture for the movement trace is shown in Figure 1. Through user interface, a user can create several scenarios. And then, mobility generator that is implemented by help of flight simulator is executed to generate raw movement data. Finally, raw data is converted to the adequate format in each network simulator. In Figure 2, we can see the real implementation and experiment results. A user can create each node in developed software and this action brings about

the creation of aircraft in flight simulator. Similar to this procedure, positional information of waypoints are transferred to corresponding object in flight simulator. After executing simulation, an aircraft starts its aviation and generates the trace for movement. This information is displayed in developed software to prove its operation.

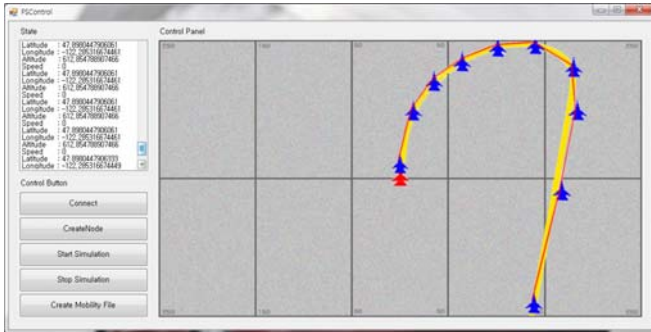


Figure 2. Movement toward waypoint and display of position information at the left side

II. AUTOMATED TRACE FOR MOVEMENT

By using the works described in the previous section, it is possible for researchers to gather realistic movement trace. But, it is recommended to employ automated scenarios configuration rather than manual one for the diverse scenarios since multiple runs are naturally required in the procedure for performance evaluation. With the same demand, "setdest" [4] external command for mobility generation for random waypoint model is provided in NS-2. In addition, a mobility scenario generation and analysis tool was already released as shown in [5]. In this section, we explain how to extend the current software to generate automated movement trace.

A. Analysis of Automated Movement Trace

The procedure toward automated scenarios requires following information to gather movement trace, number of aircrafts, type of aircrafts, mobility pattern, and simulation time. Figure 3 illustrates the example of user interface for generating scenarios. In this interface, if a user wants to create eight aircrafts totally, four aircrafts are made after creating four ones, respectively. The type of aircrafts can be determined in a group.

B. Implementation Issues

- Initial position of aircraft: When many aircrafts are created, the initial position of them can affect the movement traces. To prevent dense deployment, the position of aircraft is determined in a uniform way where the aircraft were arranged in any position within the square in uniform topology.
- Mobility type: For the mobility pattern, we design two different types. One is random walk model [6] and the other is mission based model. The latter is assumed that a special mission is performed by the corresponding aircraft. Thus, an aircraft starts

aviation toward the destination in this mode. After an aircraft arrives the destination and then it change the direction to the original point. On the other hand, an aircraft moves with arbitrary speed and direction during the predetermined time in the random walk model. After the duration is over, new direction is selected and an aircraft change its moving direction according to new one. The major different feature with typical random walk is that moving speed is not changed but fixed in this model. The model is very suitable dynamic situation where there is fighting.

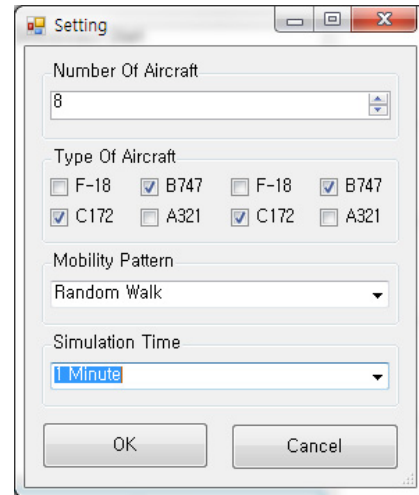


Figure 3. User interface for scenario generator

C. Algorithm for Movement Trace

The algorithm for automated movement is shown below. The main part of algorithm is defined in line 4 as FUNC. This function is provided by commercial flight simulator to model realistic movement of each aircraft.

A_i : i^{th} aircraft ($0 \leq i \leq \text{number of aircrafts}$)
 $A_i(m)$: mobility model of i^{th} aircraft
 $A_i(k)$: kind of i^{th} aircraft
 $P_i(t)$: Position of A_i at time t
 $V(i)$: Velocity of aircraft i
 $Distance_i(j-1,j)$: Moving distance from time $j-1$ to j
 T : simulation time

1. for all aircrafts {
2. $P_i(0)$ = initial position of A_i
3. while (current_time < T) {
4. $Distance_i(j-1,j)$ = $\text{FUNC}_i(V(i), A_i(k), A_i(m))$
 where FUNC_i is defined by dynamic of each aircraft in Flight Simulator
5. $P_i(j)$ = $P_i(j-1)$ + $Distance_i(j-1,j)$
6. converts $P_i(j)$ to ns-2 format
7. j++
8. }
9. }

- STEP 1: for all aircrafts, set initial position.
- STEP 2: Compute the next position with realistic dynamics of aircrafts until whole simulation time is over.
- STEP 3: Generated position information is converted to NS-2 format.

III. EXPERIMENTS

We implemented the core technologies for mobility and scenario generator. In Figure 4, the initial position of 10 aircraft is shown when each aircraft locates in uniform way. In addition, Figure 5 shows the movement of aircrafts when movement pattern is modeled as random walk. The colored link represented the consecutive positions that aircraft sequentially visited. Moreover, experiment for mission based model is illustrated in Figure 6. Different from case in Figure 5, we can see the respective destination that an aircraft is supposed to visit the place. Each aircraft move toward the destination based on its dynamic model.

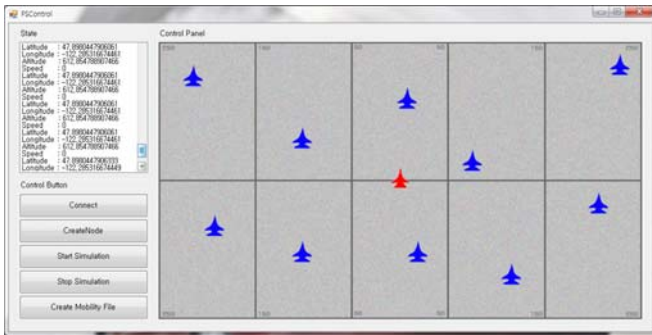


Figure 4. Locates aircraft at the initial point

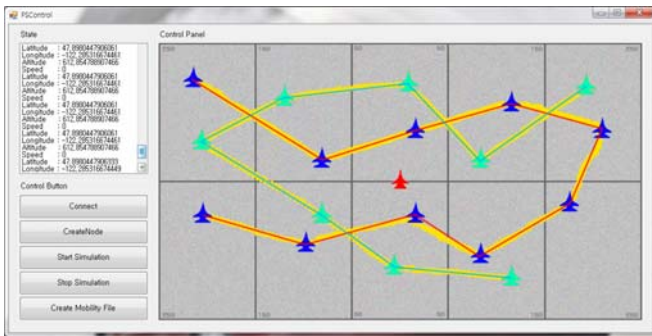


Figure 5. Movement display in random walk model

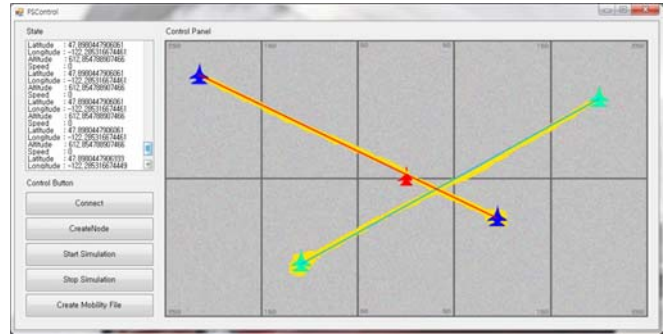


Figure 6. Movement display in mission based model

IV. COMPARISON WITH PREVIOUS WORK

In this section, the proposed scheme is compared with previous work [3], based on mathematical equation. The position is marked in the realistic map as you can see in Figure 7 and Figure 8. First, aircraft in Figure 7 shows the mathematical movement. Since the mobility model is not affected by external environment as well as dynamic of aircraft, movement is illustrated as straight line. Also, direction is changed rapidly at the waypoint. On the other hand, movement for Boeing 747 aircraft shows different pattern with the former one. When corresponding aircraft requires wide range of turning direction where external environment is not always the same, different movement trace around the waypoints are observed. Another point worthwhile mentioning is that the actual movement cannot guarantee to pass waypoints exactly even though the aircraft approaches them nearly. Meanwhile, movement that is managed by the equation, all points are shown to covered exactly by the trace.



Figure 7. Movement trace by the proposed scheme

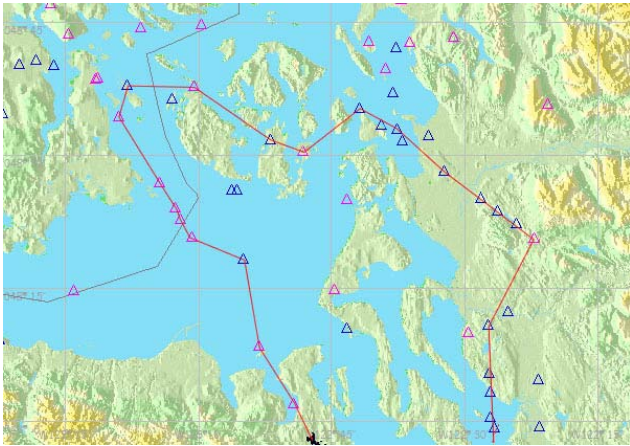


Figure 8. Movement trace by [3]

V. CONCLUSION

In this paper, we proposed how to implement automated scenarios and mobility generator for aircraft ad hoc networks. Based on software architecture in our previous works, some functions are additionally implemented while considering implementation issues such as mobility pattern. Finally, results for experiment of implementation are shown to prove the correctness of the implementation.

For the further works, we will provide more functions for initial positioning such as random distribution. Also, other mobility patterns such as group mobility will be concerned for implementation. Furthermore, performance evaluation of

the routing protocol with generated mobility trace file will be accomplished and analyzed.

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REFERENCES

- [1] K. I. Kim and K. C. Park, "Design of Movement Scenarios for Aircraft Ad Hoc Networks," Proc. of ASEA, Korea, Dec. 2012.
- [2] Airborne Ad Hoc Networks, <http://www.csse.monash.edu.au/~carlo/adhoc.html>, [retrieved: Oct., 2012]
- [3] J. Nutaro, S. Jarboe, B. Zeigler, and D. Fulton, "A Method for Generating Synthetic Air Tracks," in Proc. of 12th IEEE/ACM International Symposium on Distributed Simulation and Real-Time Applications, pp. 245-251, 2008.
- [4] The Network Simulator ns-2: Documentation, <http://www.isi.edu/nsnam/ns/ns-documentation.html> [retrieved: Nov., 2011]
- [5] BonnMotion, <http://net.cs.uni-onn.de/wg/cs/applications/bonnmotion/>, [retrieved: May, 2012]
- [6] T. Camp, J. Boleng, and V. Davies, "A Survey of Mobility Models for Ad Hoc Network Research," Wireless Communication and Mobile Computing (WCMC): Special issue on Mobile Ad Hoc Networking: Research, Trends and Applications, vol. 2, no. 5, pp. 483-502, 2002.