Evaluation Framework for Simulating MANET-based Systems

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Abstract: For emergency situations, the network system based on wireless multihop networks such as a mobile ad hoc network (MANET) has been developing to exchange messages among users without the aid of the infrastructure networks. However, many MANET-based systems have been evaluated through the simulation experiments. In this paper, we propose an evaluation framework combining simulator and game engine to simulate MANET-based systems in more realistic environment and present the case study of the evaluation framework.

Keywords: Mobile ad hoc networks, Network simulation, Game engine, Mobile application development

Classification: Network system

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1 Introduction

In recent years, for the goal of the realistic simulation, the simulation framework of the coupling of the simulator and the game engine has been proposed
[1, 2]. The MANET-based system is useful for users to exchanges messages among them without the aid of the base stations in emergency situations. Mobile users in the real world select the evacuation route based on the up-to-date information and then move to the place of refuge. Therefore, the behavior of mobile users should be considered to evaluate the mobile application in the MANET-based systems through the simulation. However, in most of simulation experiments, the behavior of users in the simulator cannot be controlled. This paper proposes an evaluation framework in which we can operate the users’ behavior in the simulator. The evaluation framework is composed of simulator, mobile application, visualizing software, and controller. The simulator represents all the users moving in the MANET-based system. Furthermore, the simulator serves as a mock-up of the mobile application software running on the mobile device. The visualizing software shows the view of the user in the simulation field and it is implemented by the Unity game engine [3, 4]. During the simulation, the mobile user operates the movement of the user in the simulator based on the information obtained by the visualizing software and the mobile application, which receive a variety of messages from the simulator. In particular, our evaluation framework allows to examine the interactions between the mobile devices in more detail. In this paper, we adopt our MANET-based building evacuation system [5, 6] as a MANET-based system for our evaluation framework.

2 MANET-based Building Evacuation Systems [5, 6]

The MANET-based building evacuation system provides users residing in the building with the appropriate evacuation route in case of emergency situations. Each user has a mobile terminal on which the mobile application for the system is installed. In the system, we assume the building is divided into multiple sections including an exit area which is the outside of the building. To provide a user with her/his current position, each section is equipped with at least one beacon. A user looks for the beacon with the strongest RSSI signal to derive her/his current position. Each user exchanges the section state and the number of users in the current section with each other through the MANET communication to obtain the field information in the building. The section state in each section is distinguished by four different states: unknown, safe, crowded and blocked. It is set to unknown if a user has no further information about a section. If at least one user is in a section, this section is considered as safe. When the number of users in a section exceeds 50 % of its maximum capacity, this section is considered as crowded. The section which users cannot pass through due to the fire is set to blocked. The mobile application derives the evacuation route including as many safe sections as possible for the users according to the field information. Since the users are always moving toward the exit and the field information is changing with time, it recalculates the evacuation route whenever a user enters into the next section.
Fig. 1. Overview of the evaluation framework. Four components in the framework can work on different devices and they are connected by UDP communication. In the simulator, users (including a linked user) are communicated with each other through the MANET communication.

3 Development of Evaluation Framework

Figure 1 shows the overview of the evaluation framework. It is composed of simulator, mobile application, visualizing software, and controller as shown in Figure 2. In the framework, there are three types of users, which are a mobile user, a linked user, and a user. The mobile user is a user in the real world and uses a mobile application. The linked user is a user who is moving in the simulator and the behavior of the linked user is operated by the mobile user through the controller. The user is a user who is moving in the simulator.

3.1 Simulator

We adopt our simulator for the MANET-based building evacuation system described in Section 2 as a simulator for the evaluation framework. The simulator creates users who use the building evacuation system in the simulator, and they share their section information through the MANET. The users in the simulator move toward the exit according to the selected evacuation route based on the collected field information.

A mobile user in the real world has the mobile application for the building evacuation system. It provides the appropriate evacuation route to the mobile user. One user in the simulator behaves as the mobile user by the evaluation framework. The user is set as the linked user in the simulator. The linked user shares the information among the other users by flooding in the simulator. The linked user which received the messages in the simulator forwards all of them to the mobile application.
3.2 Mobile application
The mobile application is a software including the building topology and provides an appropriate evacuation route to a user. In the framework, it receives a variety of information regarding the simulation from the simulator through the linked user, and then calculates and shows the evacuation route with the situation of the simulation field. At the beginning of the simulation, it receives the field information and the current position and the ID of the linked user. During the simulation, it receives the messages from the simulator whenever the linked user receives the messages, and then creates and updates the field information. Then, it recalculates the evacuation route when the linked user migrates to the next section in the simulator. The recalculated evacuation route is shown to the mobile user. The linked user requests the next position to the mobile user to move in the simulator. The mobile user must reply the next position to the linked user in order to proceed the simulation. However, since the mobile user is not easy to move in the actual building, we develop the controller to operate the user’s position in the simulator. The mobile user replies the next position to the linked user through the controller.

3.3 Visualizing software
The visualizing software periodically receives the simulation information regarding the simulation field and simulation run which are generated by the simulator in JSON format. During the simulation, the visualizing software visualizes the users’ behavior and the field information by Unity [3]. The building topology including the field size, section size and the number of sections is given in advance. The visualizing software receives the simulation information and show the three-dimensional objects whenever the users move in the simulator.

3.4 Implementation of Evaluation Framework
The simulator and the visualizing software are developed by Java and by C# in Unity on Windows OS. The mobile application is implemented on the Android OS smartphone. Instead of the mobile user in the real world, the linked user moves in the simulation field. We develop the controller as Java application to operate the movement of the linked user. The controller is connected with the simulator through the wired or wireless LAN. The mobile user uses the controller to operate the behavior of the linked user in the simulator. The mobile application receives the messages from the simulator. Figure 2 shows the controller application. Whenever the mobile application receives the request of the next position of the linked user, the mobile user decides the direction indicated by the mobile application and pushes the button. The direction is sent to the simulator by UDP socket. The simulation run is temporally suspended until it receives the message from the mobile application.
4 Case Study of Evaluation Framework

We evaluate our MANET-based building evacuation system as a case study and confirm the behavior of the evaluation framework. Figure 2 shows the screenshot of the evaluation framework. The simulator shows the field topology and the location of the users (represented by small circles) while conducting the MANET simulation. In the simulation of the MANET-based system, the field size of the building is 100 meters × 100 meters. The field is divided into 25 sections. Each of them is 20 meters × 20 meters. An emergency case occurs at the center of the field (red colored area), and then 100 users move to the exit sections (green colored area) in the simulator. We operate the behavior of the linked user in the simulator by the controller as the mobile user. The linked user sends the received messages from the simulator to the mobile application, and then the evacuation route is selected and provided by the mobile application. The visualizing software provides the field information and the linked user’s view. Each circle denotes a user and the area which is drawn by a smoke-like object represents the emergency case. The yellow triangle is the linked user’s view and the right side of the visualizing software shows the situation of the field which it can see.

We can test the MANET-based system in the environment considering the actual-case scenario by operating the linked user using the controller while checking the visualizing software and the mobile application. During the experiments, whenever the mobile application receives the messages from the linked user, the evacuation route is appropriately updated. The blue line displayed on the mobile application denotes the selected evacuation route at that time. As a result, it is confirmed that we could evaluate the MANET-based system by our evaluation framework in which the simulator, the visualizing software, the mobile application, and the controller cooperate with each other.
5 Conclusion

This paper has presented the evaluation framework for the development of the MANET-based systems. In the future work, we are planning to cooperate the evaluation framework with the network simulator for efficiently simulating and evaluating the MANET-based systems.