Design of a Realtime Network Topology and Packet Flow Visualizing System for MANET Field Experiments

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***Abstract*—In order to evaluate the performance of the network system in MANET field experiments, we have to understand the network topology among mobile terminals in real time and conduct the field experiments efficiently. In this paper, we design a system to visualize a network topology and packet flow in real time, and implement it in Android terminals for MANET field experiments. In case that Android terminals communicate with each other over MANETs, each terminal can grasp the information on the neighboring terminals and visualize the topology between the neighboring terminals and its own terminal in the proposed system. In addition, since each terminal sends the information on the neighboring terminals and the transmission and reception of data packets to the log management server, it grasps these information from the server and can visualize the network topology and packet flow in real time. As a result, thanks to these mechanisms in the visualizing system, we can understand the network situation such as the network topology and the packet flow in real time, and then conduct the MANET field experiments more efficiently. Finally, we can analyze the log data in the server to evaluate the MANET-based application software after we conducted the MANET field experiments.**

***Keywords*—Bluetooth MANET; Visualizing system; Field experiments;**

I. Introduction

We conducted the MANET field experiments of the assessment information acquisition and dissemination system based on Bluetooth MANETs (shortly, KASHI-HAKU[1] system) [1] at the Hiroshima national confectionery exposition in April 2013. Bluetooth MANET is one of mobile ad hoc networks that consists of Android terminals which are equipped with Bluetooth device. The KASHI-HAKU system is a system to provide the assessment information on confectionery to the participants in the exposition because each participant inputs the assessment information on confectionery which he/she tasted into his/her Android terminal and the assessment information is delivered to nearby terminals. In the KASHI-HAKU system, a user inputs the assessment information on confectionery into the KASHI-HAKU application which is installed in the Android terminal, and then sends it to the neighboring Android terminals which are connected with each other over Bluetooth MANET. For the efficient dissemination of the assessment information in the exposition, the KASHI-HAKU system uses Epidemic routing to forward data packets.

[1]"KASHI" means confectionery in Japanese, and "HAKU" is abbreviated from "HAKUrankai" that means exposition in Japanese.

In the MANET field experiment, we evaluated the network performance of Bluetooth MANET and the hop counts of the assessment information disseminated by multi-hop communication of the KASHI-HAKU system. However, if we could grasp the network topology and the packet flow in real time, we can conduct efficient MANET field experiment to evaluate the MANET-based system. Therefore, in this paper, we propose the design of a visualizing system to visualize the network topology and the packet flow in real time for MANET field experiments.

II. Design of Visualizing System

A. Requirements

Each Android terminal is capable of establishing concurrent cellular and Bluetooth/WiFi connections. MANET-based application and Visualizing-system application are installed in each Android terminal. MANET-based application can configure a MANET by using Bluetooth or WiFi connections, and Visualizing-system application can access to the Internet by using cellular connections.

B. System Overview

Figure 1 shows the overview of our visualizing system. The visualizing system consists of one log management server and multiple Android terminals like Android terminals A, B and C. The log management server manages the log data which are sent from Android terminals. Each Android terminal

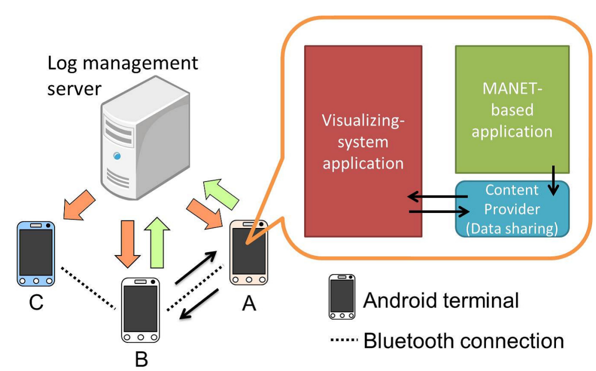

Fig. 1. System overview.

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can communicate with the log management server by cellular connections, whereas Android terminals can communicate with each other by Bluetooth connections. When we conduct the MANET field experiment, our visualizing system can visualize (1) the connection information between an Android terminal and the neighboring Android terminals, (2) the network topology information, and (3) the packet flow information in the network. The visualizing-system application grasps many types of the information from a MANET-based application in each terminal, and sends them to the log management server. Then, the visualizing-system application obtains all the information on the other Android terminals from the log management server and visualizes the network topology and the packet flow in the network in each Android terminal. In addition, since all log data are stored in the log management server, we can analyze the data on MANET field experiments after we conducted the field experiments.

C. *System functions*

In Android terminals, we use the mechanism of a content provider to share the information between the visualizing-system application and the MANET-based application. The mechanism of a content provider is provided by the Android SDK and is the standard interface that connects data in one application with another application. By adding the framework of the content provider for the visualizing-system application into the MANET-based application, each Android terminal is capable of the information sharing between the visualizing-system application and the MANET-based application. The MANET-based application stores the records on the packet transmission and reception as the data through the content provide framework, whereas the visualizing-system application accesses to the data to obtain the information and sends it to the log management server as well as obtain the information on the other Android terminals from the log management server by using HTTP protocol over the cellular connection.

We present the three main functions of the visualizing system as follows.

1) The connection information between an Android terminal and the neighboring Android terminals: In each Android terminal, the visualizing-system application obtains the node ID (ex. MAC address) of the neighboring Android terminals based on the packets which are exchanged with the neighboring Android terminals. Based on the destination information and the time when the Android terminal sends or receives the packets, the visualizing-system visualizes the connection information between its own terminal and the neighboring Android terminals.

2) The network topology information: In each Android terminal, the visualizing-system application periodically sends its own ID and the current positioning information so that it can obtain the location information of all Android terminals from the log management server and visualize the network topology.

3) The packet flow information in the network: In each Android terminal, the visualizing-system application periodically sends the information on the transmission and reception of the packets which are exchanged with the neighboring Android terminals by MANET-based application to the log management server so that it can obtain the packet flow information on all Android terminals from the log management server and visualize the packet flow information in the network.

III. Implementation of Visualizing System

As shown in Figure 2, the log management server stores the log data which are sent from Android terminals. We have proposed the layer structure which consists of device, routing, and application layers for developing the MANET-based application on the Android OS in [3]. In the log data, the different log format is introduced for each layer.

(1) Log Data for Device layer (layer=1)

The log data for Device layer represents the status of the Bluetooth connection and the positioning information. This log data format consists of $time$, $local\_addr$, $type$, and $addr\_or\_size$. $time$ is the time when a event occurs and $local\_addr$ is the MAC address of the Android terminal. $type$ is 1 when the connection occurs, 2 when the disconnection occurs, and 3 when the current positioning is sent. $addr\_or\_size$ is the MAC address of the neighboring Android terminal when $type$ is 1 or 2, and changes the location provider, the latitude, and the longitude when $type$ is 3.

(2) Log Data for Routing layer (layer=2)

The log data for Routing layer represents the information on routing and packet forwarding. This log data format consists of $time$, $local\_address$, $gen\_address$, $sequence\_num$, hop_count, and ep_flg. $time$ is the time when the packet is transmitted or received, $local\_addr$ is the MAC address of the Android terminal. $gen\_address$ is the source address of the packet, $sequence\_num$ is the sequence number of the packet generated by the source terminal, hop_count is the number of hops forwarded from the source terminal, and ep_flg shows whether this packet is forwarded based on the epidemic routing.

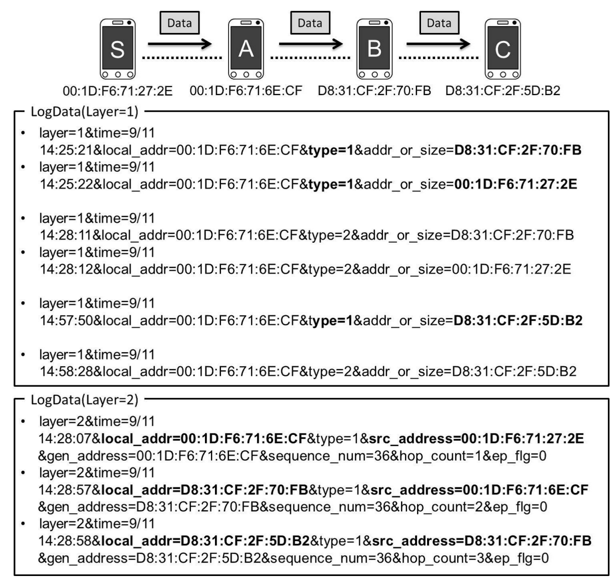

Fig. 2. Log Data which represents multi-hop forwarding of the packets.

As the log data for Device layer, the connection status is sent whenever the link to the neighboring terminal is connected or disconnected, and the positioning information is sent every 30 seconds to the log management server by Visualizing-system application. In addition, as the log data for Routing layer, the routing information is sent to the log management server whenever each Android terminal sends or receives a packet. Visualizing-system application obtains these information from the log management server to visualize the network topology and the packet flow in the network. In our Visualizing system, MANET-based application provides the above log data to Visualizing-system application via Content Provider, and then Visualizing-system application sends the log data to the log management server.

In case of the multi-hop forwarding as shown in Figure 2, we describe the log data used in each function as follows.

1) The connection information between an Android terminal and the neighboring Android terminals: Based on the connection status of all the neighboring Android terminals obtained from $addr\_or\_size$ in the log data for Device layer, Visualizing-system application visualizes the connection information to the neighboring Android terminals.

2) The network topology information: Based on the connection status and positioning information of all android terminals obtained from $addr\_or\_size$ in the log data for Device layer in the log management server, Visualizing-system application visualizes the network topology.

3) The packet flow information in the network: Based on the packet information obtained from $gen\_address$, $local\_addr$, and $src\_address$ in the log data for Routing layer in the log management server, Visualizing-system application visualizes the packet flow in the network.

IV. Verification of Visualizing System

We have tested the visualizing system in the field experiments by installing both MANET-based application and Visualizing-system application in Android terminals.

A. Experimental Environment

Table I shows the specification of Android terminals that we use in the field experiments. In order to conduct the field experiments, we implemented Kuchi-Komi[2] application as a MANET-based application, and Kuchi-Komi application and Visualizing-system application are installed in each android terminal. In Kuchi-Komi application, the assessment information which a user inputs is disseminated based on the epidemic routing to the other Android terminals over the Bluetooth MANET, like KASHI-HAKU application.

B. Experimental Results

Figures 3 and 4 show the visualization of the connection information of Android terminal S, and the network topology and the packet flow information in the visualizing system when we performed Kuchi-Komi system in the field experiments.

[2]"Kuchi-Komi" means word-of-mouse communication in Japanese. "Kuchi" means mouse in Japanese, and "Komi" is abbreviated from "Kominikeisyon" that means communication in Japanese.

TABLE I. Specification of Android terminals.

	Galaxy S III	Galaxy Note II
CPU	Exynos Quad 1.4GHz	Exynos Quad 1.6GHz
Memory	1GB RAM	2GB RAM
OS	Android 4.1.1	Android 4.1.1
Wireless device	Bluetooth 4.0	Bluetooth 4.0

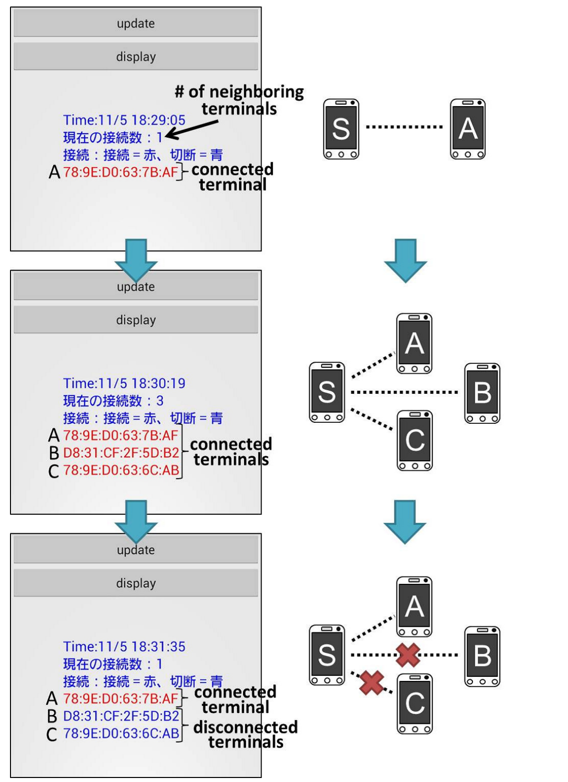

Fig. 3. Connection information of Android terminal S to the neighboring terminals.

Figure 3 shows the status of the connection between Android terminal S and the neighboring terminals. The left and right figures denote the screen shop of visualizing-system application in Android terminal S and the network topology, respectively. First, when Android terminals S and A are connected, MAC address of Android terminal A is shown at the connection status. Then, when Android terminals B and C are newly connected with Android terminal S, their MAC addresses are also shown at the connection status. Finally, when Android terminals B and C are disconnected due to the node movement, their MAC address are shown at the disconnection status without deleting the MAC addresses because the changes of the network topology are visually indicated.

Figure 4 shows the network topology based on the GPS information of each Android terminal because all Android terminals periodically send the current positioning information and the connection information to the neighboring Android terminals to the log management server. In addition, the right figure of Figure 4 shows the flow of the packet which is forwarded Android terminals A to C via B. As a result, the

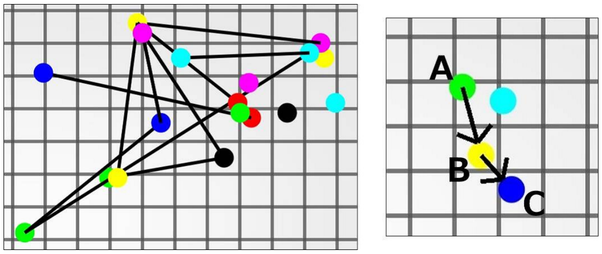

Fig. 4. Network topology (left) and packet flow (right) information.

both information can be seen in each Android terminal in real time because the visualizing-system application obtains the information from the log management server.

V. Conclusion

We have presented the design of a realtime network topology and packet flow visualizing system for MANET field experiments, and the experimental results. The visualizing system provides the network topology and packet flow to the developers of the MANET-based application so that they can conduct the MANET field experiment and verify the behaviors of the MANET-based application software efficiently.

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