Information Providing System for Commuters Unable to Get Home at the Time of Disaster by Constructing Local Network using Single-board Computers

Hiroto Funakoshi[1], Keisuke Utsu [2], and Osamu Uchida[3]
[1]Graduate School of Engineering, Tokai University, Hiratsuka, Kanagawa, Japan
[2] Department of Communication and Network Engineering, Tokai University, Minato, Tokyo, Japan
[3]Department of Human and Information Science, Tokai University, Hiratsuka, Kanagawa, Japan

Abstract - *Please consider these Instructions as guidelines for preparation of Final Camera-ready Papers. The Camera-Ready Papers would be acceptable as long as it is formatted reasonably close to the format being suggested here. Note that these instructions are reasonably comparable to the standard IEEE typesetting format. Type the abstract (100 words minimum and 150 words maximum) using Italic font with point size 10. The abstract is an essential part of the paper. Use short, direct, and complete sentences. It should be brief and as concise as possible*.

Keywords: A Maximum of 6 Keywords

1 Introduction

When the Great East Japan Great Earthquake occurred on March 11, 2011, many railroads stopped operating, and a large-scale road congestion also occurred in Japan. Due to this influence, about 5.15 million people in the metropolitan area have fallen into difficulty going home [1]. And when the operation of public transportation was resumed, the confusion increased as they started coming home all at once [2]. Such a situation is considered to have arisen because the information necessary for taking calm action, such as the damage situation and the prospect of restoration of public transportation, did not reach the victims. There is concern that such confusion may trigger a crowd accident. In order to dispel these, it is important to promptly and reliably communicate appropriate information and instructions to people. It is reported that a situation occurred in which a part of the communication network could not be used due to power failure, congestion, damage to communication equipment, etc., when the Great East Japan Earthquake occurred [3]. Therefore, it is assumed that Internet and telephone cannot be used as usual at the time of disaster of the same scale. Therefore, it is important to consider the disaster information provision method that is independent of the Internet. In general, those who are difficult to return home try to obtain information from digital signage or voice announcement at the nearest station, but the information they want is not always provided. There is also concern about misunderstanding of audio information and obtaining erroneous information due to misreading visual information. Then, there remains a problem of how to accurately convey information to people who are unable to get home.

Currently, there are many services that provide information when a disaster occurs. However, these are services based on the premise of using communication infrastructure, then these cannot be used when the communication infrastructure becomes in a state of malfunction for a long time as in the case of the Great East Japan Earthquake. Also, it is difficult to obtain personalized information using these services.

Based on the background stated above, in this study we propose a real-time information providing system for commuters unable to get home at the time of disaster by constructing local network using single-board computers. Since the proposed system can switch the information to be provided for each microcomputer board, it is possible, for example, to provide different information for each floor.

2 Related Works

Utsu et al. proposed a safety confirmation system using Twitter [4]. The purpose of their study is to realize personal safety confirmation at the time of a large-scale disaster, and as a countermeasure against infrastructure failure, a method using multi-hop wireless LAN was considered. A local network is constructed by connecting a plurality of wireless LAN devices to each other, and only the gateway serving as a base point is connected to the Internet. A safety confirmation system is operating in each wireless LAN device. The data generated through the system is transferred to the external service by multi-hoping to the equipment in the gateway direction. However, considering practical aspects, it is necessary to make the gateway redundant. Moreover, countermeasures to be taken when the gateway is disabled remain as issues.

3 Disaster information providing system

We consider to implement a real-time information providing system for commuters unable to get home at the time of disaster by constructing local network using single-board computers. By using this system, disaster-related information can be provided in real time. Our system can provide independent information for each floor.

3.1 System overview

As the user terminal, it is assumed that a device capable of Wi-Fi connection, such as, for example, a smartphone, a tablet terminal, and a PC. As described in detail in the next section, this system is deployed on the local server. There are information provision pages and information browsing pages created by PHP and JavaScript on the local server. Information providers can provide disaster-related information through this system. The provided information is transmitted to the user in real time. In this system, real time provision is realized in a pseudo manner by using Server Sent Event [5]. Server Sent Event is a type of html5 related API proposed by W3C to perform push notification from the server, and it is possible to send a notification at the timing when the state in the server has changed. In the proposed system, data is transmitted to the viewer in real time with the update of the provided data triggered. The information provider can select distribution for whole or distribution for a specific group.

3.2 User interface and behavior of the system

Screenshots of this system are shown in Figs. 1 to 9. Fig. 1 to 3 are the screen of the information viewer side, and Figs. 4 to 9 are the screen of the information provider side.

3.2.1 Screen of the information viewer side

A. Common information (screen #1)

When the information viewer accesses the local server with the Web browser, this screen is displayed (Fig. 1). A list of posted titles is displayed as a link, and in case of pressing “next page” or “previous page”, the link of another page is dynamically displayed. When each link is pressed, details of posted contents (screen #3) are displayed. When “group information” is pressed, it transits to the group information list screen (screen #2).

B. Group information (screen #2)

On this screen, the link of the posting list of the group to which the viewer belongs is displayed (Fig. 3). When each link is pressed, details of posted contents (screen #3) are displayed. For paging, it operates in the same way as the common information screen (screen #1).

Fig.1 screen #1
Common information

Fig.2 screen #2
Group information

Fig.3 screen #3
Content display screen

C. Content display screen (screen #3)

On this screen, posting time, posted title, posted image, posted contents are displayed (Fig. 3). If there is no posted image, only text is displayed.

3.2.2 Screen of the information provider side

A. Login page (screen #4)

On this screen (Fig. 4), entering the login ID, Pass and pressing “Sign In” transits to the common information management screen (screen #5).

B. Management of common information (screen #5)

Common information to be distributed to information viewers is managed (Fig. 5). A list of previously posted titles is displayed as a link, and when a link is pressed, a

Fig.4 screen #4
Login page

Fig.5 screen #5
Management of common information

Fig.6 screen #6
Content editing

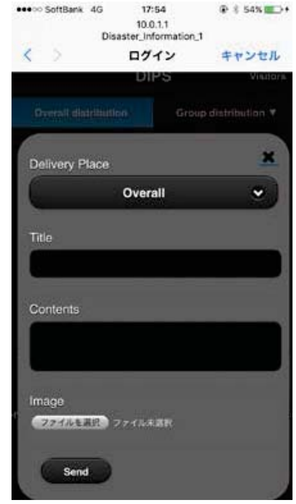


Fig.7 screen #7
Content posting

contribution content editing screen (screen #6) is displayed. When "Add" is pressed, a post screen (screen #7) is displayed. When "group information" is pressed, a list of management groups (screen #8) is displayed.

C. Content editing (screen #6)

On this screen, it is possible to delete posted contents (Fig. 6). When "Delete" is pressed, a confirmation alert is displayed and the operation is executed after "ok" is selected. After deletion of the content, the system transitions to the common information management screen (screen # 5).

D. Content posting (screen #7)

On this screen, information to be posted to the viewer is managed (Fig. 7). At the selection part of the type of information, the information provider selects the common information or group information. In the title space, the information provider enters the title of the content. This title is displayed as a link on the common information screen or the group information screen. In the space of contents, the information provider enters the text to post. (There is no limit on the number of characters.) The information provider can post images by pushing file selection bouton under the text input space. (When there is no image to be posted, it is put in an unselected state.) Finally, by pressing the "send" button, the entered contents are transmitted to the information viewers in real time.

E. Group selection (screen #8)

On this screen, the group of the information delivery destination is selected (Fig. 8). By selecting a group from the group list, the screen transitions to the information management screen of the selected group (screen #9).

Fig.8 screen #8
Group selection

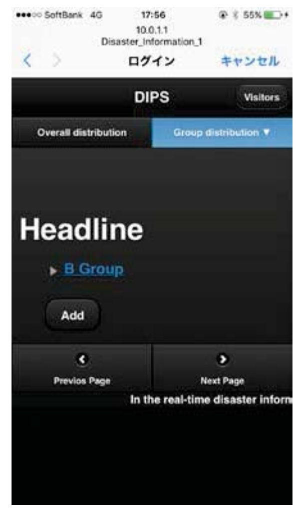


Fig.9 screen #9
Management of group information

F. Management of group information (screen #9)

Group information to be distributed to information viewers is managed (Fig. 9). Items and operations are the same as screen #6.

4 Development of disaster information providing system

A local network is constructed by using multiple single-board computers. Hereinafter, the access point apparatus as a base point is referred to as gateway, and the other access point apparatuses as repeater. In this study, Raspberry Pi 3 Model B [6] was used as a single-board computer. The reasons for adopting Raspberry Pi are as follows; the price is low, it can operate with low power consumption, and the Linux can be installed. In this study, Rasbian [7] was adopted.

In this research, two USB wireless LAN adapters are installed to construct Raspberry Pi with Wi-Fi relay function. One adapter is operated as client mode (slave) and the Mac layer is IEEE 802.11.g. The other adapter operates as infrastructure mode (master) by hostapd [8] and the Mac layer is IEEE 802.11.g. Dnsmasq [9] is used for assigning IP addresses to clients. The slave unit of the repeater is connected to the master unit of another repeater, and the master unit is connected to the slave unit of another repeater. By connecting repeaters as described above, a local network is constructed (Fig. 10). Since the slave unit and the master unit in the repeater belong to different network segments, packets are transferred between segments by using NAPT. To build the Web system in the gateway Apache 2.4.23, MariaDB 10.2.0, and PHP 5.5.36. were installed. On the other hand, Nginx 1.11.4 [10] was installed on the repeater. The gateway's web server is used for web system and redirection after Wi-Fi connection. The web server of the repeater is used only with redirection after Wi-Fi connection. The gateway has an information providing page, and immediately after connecting to the gateway or repeaters by the information viewers, the information providing page will be displayed without inputting the URL. There is a mechanism called Captive Portal as a method for guiding to a specific page when connecting to Wi-Fi. This is a technology for forcibly referring to a specific Web page before using the Internet, and is generally used for displaying an authentication screen when connecting to Wi-Fi. In this study, by forcibly displaying the information provision page instead of the authentication screen, the operation of the user is simplified.

A unique IP address is allocated to the gateway and repeater to which the information viewer is connected in the local network. Then, when the information viewer uses the information providing page, it is possible to acquire information corresponding to the belonging group (Fig. 11).

5 Experiments

In order to verify the usefulness of the proposed method, two evaluation experiments were conducted. The first one is an experiment to verify the range of information transmission, and the second is the experiment to verify the real-time nature of information transmission. The experimental environment was set assuming three situations A, B, and C as shown in Fig. 12. As experimental equipment, one gateway, two repeaters, and five iOS terminals were prepared. Then, by using these pieces of information, providing information to the information viewer is switched.

5.1 Validation of transmittable range

5.1.1 Experimental method

In this experiment, the range that the information posted by the information provider can be transmitted to the slave unit connected on the local network is verified. In A and B, one information viewer is connected to the repeater, and in C, one information viewer connects to the repeater on the first floor. The information provider connects to the gateway.

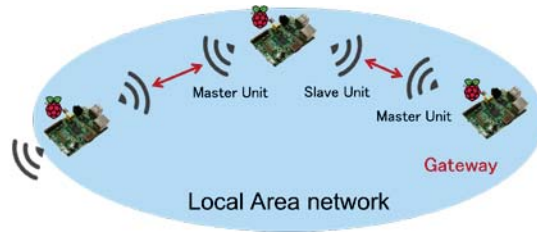


Fig.10 Network configuration of the proposed system

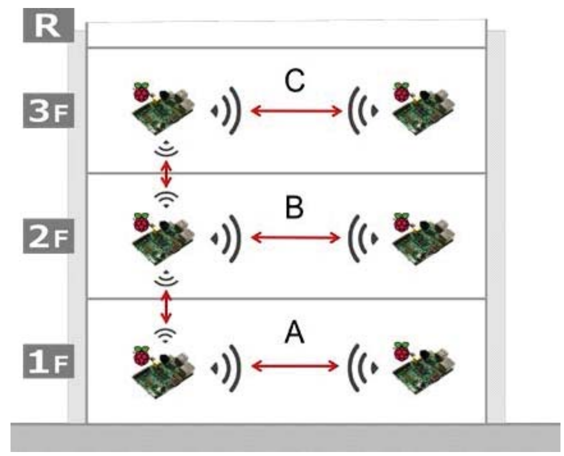
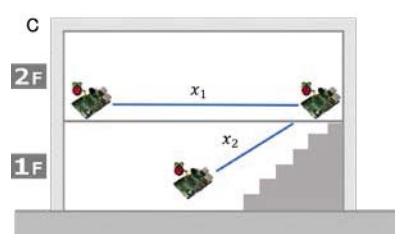


Fig.11 Information distribution by group

(a) No shielding (situation A)

(b) With shielding (situation B)



(c) Crossing the floor (situation C)

Fig.12 Experimental environment

5.1.2 Experimental result

The experimental results are shown in Table 1. It was possible to connect up to about 50 m with a straight line without shielding (the case A), and up to about 32 m with a straight line with shielding (the case B). Also, it was possible to connect up to 85 m in total distance across floors (the case C). From that, it can be said that by using the staircase part, it is possible to transmit to other floors.

5.2 Validation of real time property

5.2.1 Experimental method

In this experiment, we verify the time until the information posted by the information provider is reflected on the slave unit connected on the local network. In A and B, four viewers are connected to the repeater, and four viewers are connected to the repeater of the first floor in C, and the administrator connects to the gateway. (The arrangement of repeaters was the same as in 5.1.1.)

5.2.2 Experimental result

The experimental results are shown in Table 2. The overall average response time is about 2 seconds.

6 Discussion

As shown in Table 1, when there was a shielding object, the transmittable distance was reduced by 18 m compared with the case without shielding. Therefore, when a shielding object is present, it is necessary to increase the number of repeaters in order not to decrease the transmission distance. From the result of C, it is thought that it is useful to use a place with few obstacles such as a stairwell when communicating across a floor.

As shown in Table 2, the overall average response time was about 2 seconds. Although the number of repeaters and connected terminals was small this time, in the future, to verify the operation in the real environment, experiments are conducted in a state where the load on the network is increased by greatly increasing the number of repeaters and connecting terminals.

7 Conclusion and future works

In this study, we proposed a real-time information providing system for commuters unable to get home at the time of disaster by constructing local network using single-board computers. In the future, we will conduct various investigations as follows. As for the application aspect, when the gateway network connection is possible, we will consider constructing a mechanism to acquire disaster-related information from information sources like Twitter. We are also considering improving UI making consideration for ease of use by conducting usability evaluation experiment.

Table 1 Maximum transmittable range

Situation	A	B	C
x_1	50m	32m	50m
x_2			35m
total	50m	32m	85m

Table 2 Response time

Situation	A	B	C
Average [sec]	2.18	2.61	2.19

Acknowledgement

This study was supported by Tokai University General Research Organization.

References

[1] Cabinet Office, Government of Japan, http://www.bousai.go.jp/jishin/kitakukonnan/pdf/kitakukonnan_guideline.pdf

[2] Tokyo Fire Department, http://www.tfd.metro.tokyo.jp/hp-sidouka/201204/201204.pdf

[3] Ministry of Internal Affairs and Communication, Japan, White Paper 2011, Information and Communication in Japan.

[4] K. Utsu, A. Ogata, K. Sakurai, M. Tsutsumi, A. Suzaki, R. Abe, A. Manaka, H. Ishii, O. Uchida, "Prototype Development of Twitter-Based Safety Confirmation System for Disaster", Proc. 22nd International Conf. on Parallel and Distributed Processing Techniques and Applications, 2016.

[5] Server Sent Event, https://www.w3schools.com/html/html5_serversentevents.asp

[6] Raspberry Pi 3, https://www.raspberrypi.org/products/raspberry-pi-3-model-b/

[7] Rasbian, https://www.raspberrypi.org/downloads/raspbian/

[8] hostapd, http://linuxwireless.org/en/users/Documentation/hostapd/#About_hostapd

[9] dnsmasq, http://www.thekelleys.org.uk/dnsmasq/doc.html

[10] Nginx, https://nginx.org/