Evaluation of an Information Delivery System for Hearing Impairments at a School for Deaf

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Abstract. We have been developing IDDD (Information Delivery System for Deaf People in a Major Disaster) system [7, 8] from 2007. In 2012, we have a chance to develop new IDDD system and test it at the school for the deaf in Miyagi. In this paper, we report the results the system performance test and the users evaluation of the new IDDD based on an experiment at the school for the deaf in Miyagi. As the result, the network performance was increased and application development cost might be half of that of the old IDDD. Also, Fast-Scroll is most legible for hearing impairments people.

1 Introduction

Based on research of the status of people with handicaps during the earthquake in Kobe and Tottori [1,2], we designed the Information Delivery System for Deaf People in a Major Disaster (IDDD), using mobile phone and ad hoc networking technology with an evaluation test conducted in many different locations since 2007. We found many of the deaf left without support during the disaster. Some of them were left in a house and could not go to shelter. In case of disaster, usually electric power supply is stopped, so that they could not receive information from TV. Half of the dead people of the earthquake in Kobe [1] were people who required support for evacuation, such as elderly people or disables people. So that, an information delivery method for hearing impairment people is strongly required. We developed information delivery system based on mobile phone network and without AC power and performed several trials [3, 4, 5, 6], and obtained good results for commercial release. This system was designed based on the following requirements [3,4].

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R1. Accurate information rapidly for deaf people
R2. Appropriate information according to individual situation
R3. Robust equipment to display information definitely
R4. Applicable for the use in daily life
R5. No complicated operation
R6. Work when blackout

To achieve these requirements, we designed IDDD as follows.

1. IDDD was designed to send disaster information at black out. The main components are mobile phone and LED display. Both can work with battery. Disaster information is sent through network or directly from a mobile phone.
2. IDDD displays disaster information on both mobile phones and displays.
3. A disaster message received by a mobile phone is directly transferred to a display via near field communication.
4. Display has function of ad hoc networking to transfer disaster information to rooms automatically. A large wall-mounted or rack-mounted LED display is used in an office or public space, and small box-type display is used in a residential living room.

We performed 19 trials of IDDD from 2007 to 2011, asked attendants to answer questioners, and received answers from 312 people. Fig. 1 is an example of a LED display of IDDD used for a trial in a hospital. In this case, the LED display shows the number of the person next in line, and we tested the display to show disaster information as part of the trial. The overall impression of 46 people was very good as described in Fig. 2. Details are described in [6]. Also, IDDD is used in three offices in Tokyo that employ people with hearing impairments. We confirmed that the size and color (Red for emergency messages and Green for normal messages) of characters are legible and recognizable.

During these trials, we received many different requirements at the different demo locations and from the different attendants. However, IDDD was expensive and not sufficiently flexible to meet every request. Also we received the cost down

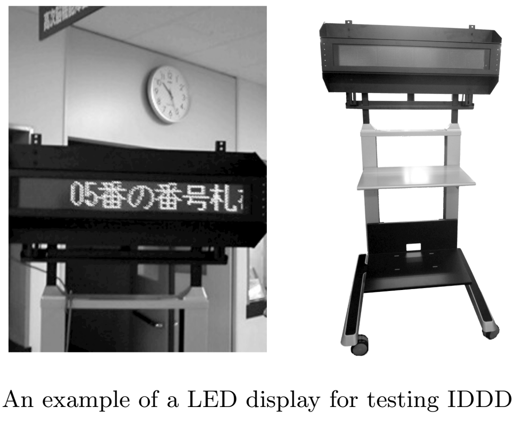


Fig. 1. An example of a LED display for testing IDDD in a hospital

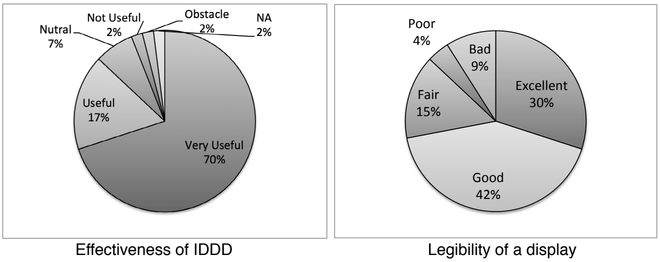


Fig. 2. Effectiveness of the system and legibility of the display of IDDD

of the LED display. So that, we re-designed new IDDD [7] and started a new project for the long-term evaluation of IDDD to check the usability at the school of deaf in Miyagi.

In this paper, we report the results the system performance test and the users evaluation of the new IDDD system [7] based on an experiment at the school for the deaf in Miyagi. In the section 2, we explain the outline of the new IDDD system, then the result of evaluation at the school of deaf in Miyagi is mentioned in section 3. At lat we conclude this paper in section 4.

2 Outline of the New IDDD System

Fig. 3 is an outline of the new IDDD system. A disaster message will be sent from Webserver to Android phone. Then the message is transferred to Display-1 and also transferred to Display-1 to Display-2 etc. using ad hoc networking function.

The difference between IDDD described in [3,4,5,6,7] and [8] is described in Table 1. To achieve flexibility, we changed the application platform for the LED

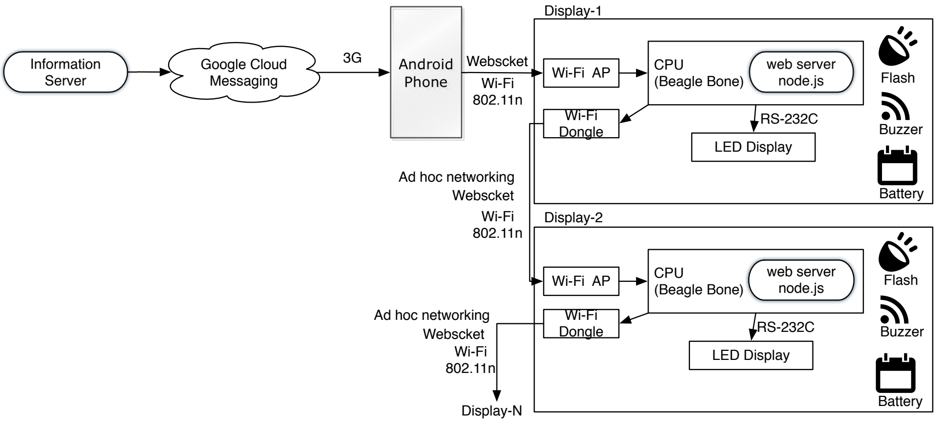


Fig. 3. Architecture of the new IDDD system

Table 1. Difference Between Previous System and New System

Items	Previous System	New System
OS	Linux	Linux
App	Native	Java Script
Display	LED 2 color	LED 3 color
WAN	SMS	IP (Google Cloud Messaging)
Local Communication	Bluetooth	WiFi

display to allow easy customization of APIs as described in [7,8], altered the communication method to increase flexibility, and reduced the development costs. We used Web technology to achieve these requirements. For communication between Android phone and LED display, also between LED displays, we used Websocket [9]. To execute application on LED display and communications among devices, node.js [10] is used as application engine.

This architecture is very effective. For example, we implemented ad hoc network, AODV [11] in one week on node.js using Java Script. As our experience, it may take two weeks to implement AODV by using C on Linux. So that this approach is useful to reduce development cost of application to meet various requirement from users to make IDDD better.

3 Evaluation and Result

We performed evaluation of the new IDDD from two aspects, one is network performance and another is legibility of the LED display of IDDD. In this section, we will explain the result of evaluation from these points.

3.1 Evaluation of Network Performance

First, we evaluated the performance of the system from the delay in sending messages from the information provider to the LED display. We measured the transmission delay in each section of the network described. The measured delay is described in Fig. 4.

We measured several aspects of this system by using the test configuration described in Fig. 4. We measured three delays to check the performance. One is

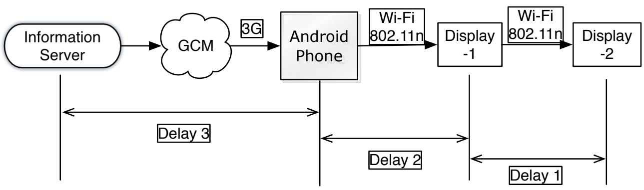


Fig. 4. Test setting to measure performance

delay between two LED displays, Display-1 and 2, (Delay 1 in Fig. 4) , the second is delay between Android phone and LED display (Delay 2 in Fig. 4) and the third is delay between information server and Android phone (Display 3 in Figure 5). Delay 1 is important to deliver information using ad hoc network function and Delay 2+3 is important to deliver urgent information as quickly as possible. We think that the following criterias are important to evaluate delay of information delivery. (C1) As fast as possible: Disaster information sometimes include urgent information such as tsunami alert and earthquake alert. So that, information should be delivered as soon as possible. (C2) Delay should be constant: Sometime the delay is short and sometime the delay is large, the system looks unstable and may give anxiety to people who use IDDD. So that the delay should be constant.

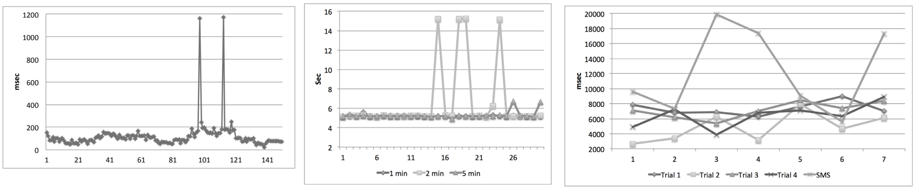
Delay between Two LED Displays (Delay1). As described in Fig. 3, we are using ad-hoc networking between two displays using Wi-Fi (802.11n). Fig. 5 (1) shows the delay between the two LED displays. There are two major delays, however almost under 200 msec. We are planning to set five LED displays in the school for the deaf in Miyagi, so that the maximum delay to display information on all LED display is one second. We think that this result satisfies criteria C2 and there is no problem for the delay in message transmission between two LED displays. In our previous system, we used Bluetooth for the message transfer between LED displays, and it usually took less than one second. We can conclude that Wi-Fi has the same performance as Bluetooth. Also, the range of Bluetooth is 10 m, but Wi-Fi is usually farther. Wi-Fi is useful for larger spaces or buildings like a school.

Delay between Android Phone and LED Display (Delay2). Our greatest concern was the delay in the GCM and mode change of 3G to Wi-Fi in Android phones. Firstly, we measured delay between Android phone and LED display. This delay means the delay of mode change of 3G to Wi-Fi in Android phones. For this test, we used IS17SH (Android 4.0) with DHCP to get IP address. As described in Fig. 5 (2), the delay was 5.69 sec and there was no significant difference among variation of sending message interval. We think that if we use fixed IP address, the delay might be reduced.

Delay between Information Server and Android Phone (Delay 3). Finally, we measured delay between information server and Android phone through GCM. We used the Galaxy Nexus with Android 4.0 for testing of the delay of GCM. If we would like to maintain a short, stable response time using GCM, we need to send messages frequently (within 1 minute) from the information server. In addition, we compared delay of GCM and SMS as displayed in Fig. 5 (3). Average delay of GCM (5sec) was 6.4 sec and that of SMS was 12.4 sec. So that performance of GCM is better than SMS.

3.2 Evaluation of Legibility

The second is the evaluation by the user. We plan to evaluate the system at the Miyagi School for the Deaf from October to December 2012. We plan to execute



(1) Delay between two LED displays (Delay1)

(2) Delay of message between Android Phone and LED display (Delay 2)

(3) Comparison between GCM (5min) and SMS (Delay 3)

Fig. 5. Evaluation of Network Performance

two types of subjective evaluations: one is a test of awareness of the display and the other is a test of the legibility of the display. There evaluation items are decided based on the discussion with medical doctors and teachers of a school of deaf.

- The number of examinees was 66.
- The size of the tested LED display was as follows: 128 dots x 16 dots (eight characters), 768 mm x 96 mm.
- Scroll speed: "Fast" is 3.45 sec to display eight characters, "Medium" is 6.9 sec to display eight characters and "Slow" is 10.35 sec to display eight characters.
- Display mode: "Scroll" or "Not-Scroll"

Awareness of the Display: Firstly, we set up a LED display at the entrance of the school and displayed messages relating to the festival such as "Welcome to the festival" or "The next performance is "MOMOTARO" by 4th grade". We asked them whether they aware the display or not, and usefulness of them by using the following three questions.

Q1 Did you find and see the LED display?
Q2 Did you understand what was displayed on the LED display?
Q3 Do you think that this LED display is useful in showing various kinds of information?

77% of the examinees answered that they aware the Display as described in Fig. 6. 73% (Well Understand + Understand) of the examinees answered that they could understand the messages. 85% (Very Useful + Useful) of the examinees answered that this kind of display is useful. Awareness and understandability were lower than usefulness, so that we analyzed the effect of distance, speed of scrolling and color in the next subsection.

Legibility of the Display: To investigate the legibility, we tested the following parameters.

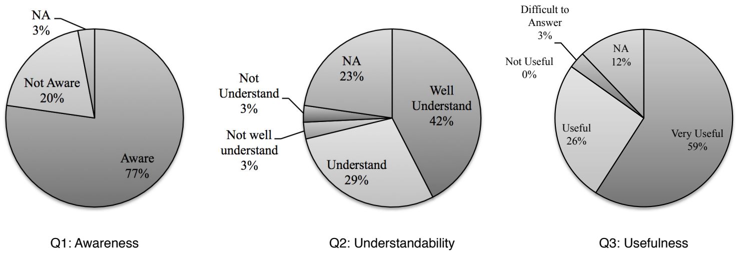


Fig. 6. Awareness and understandability of the Display

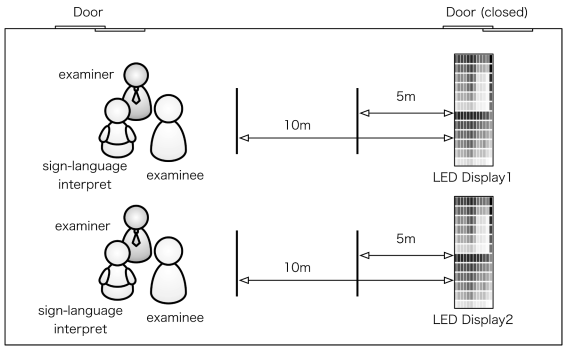


Fig. 7. Test setting to measure legibility

- Effect of color: Red, Green
- Effect of speed of scrolling: Slow and Fast
- Effect of scroll: Still or Scroll

For that purpose, we set up two LED displays in a class room as described in Fig. 7. We asked visitors of the festival to join the evaluation and brought them to the class room where the displays were set.
First, we explain the result from examinees who were hearing impairments.

- There was no effect by difference of color (Green or Red) for legibility of display (Table 2).
- Also, faster scrolling was better (Table 3) and they preferred scrolling rather than still (Table 4).
- Some examinees answered in the comments; if the sentence is correctly segmented, still display mode might be better.

For this experiment, we prepared message that contains ten characters. So that, if we use Not-Scroll mode, after changing displayed message, only two characters were displayed. This might be one reason that they preferred Scroll mode.

Table 2. Color of characters (Hearing Impairments): P-value 0.290

Condition	Easy to read	Difficult to read	Total
Green	37	7	44
Red	33	11	44
Total	79	18	176

Table 3. Speed of scroll (Hearing Impairments): P-value 3.761E-05

Condition	Easy to read	Difficult to read	Total
Slow	64	24	88
Fast	84	4	88
Total	148	28	176

Table 4. Usefulness of scroll (Hearing Impairments): P-value 4.082E-05

Condition	Easy to read	Difficult to read	Total
Scrolling	70	18	88
Not Scrolling	44	44	88
Total	114	62	176

Table 5. Color of characters (Normal): P-value 0.017

Condition	Easy to read	Difficult to read	Total
Green	38	24	82
Red	50	12	62
Total	88	36	124

Table 6. Speed of scroll (Normal): P-value 3.497E-07

Condition	Easy to read	Difficult to read	Total
Slow	73	51	124
Fast	111	13	124
Total	184	64	176

Table 7. Usefulness of scroll (Normal): P-value 2.696E-05

Condition	Easy to read	Difficult to read	Total
Scrolling	75	49	124
Not Scrolling	42	82	124
Total	117	131	248

Next, we explain the result form examinees who were not have hearing impairments. They preferred Red rather than Green (Table 5). For scrolling speed and display mode (Scroll or Not-Scroll), the answer was as same as examinees who are hearing impairments (Table 6,7).

We also checked the effect of combination of color, speed and distance. For the group of hearing impairments, the most legible combination was as follows.

- 5m, Green, Fast: 100%
- 5m, Red, Fast: 95%
- 10m, Green, Fast: 95%
- 10m, Red, Fast: 91%

We could conclude that Fast-Scroll is better. However, there is no clear result on the difference of color.

4 Conclusion

In this paper, we report the results the system performance test and the users evaluation of the new IDDD based on an experiment at the school for the deaf in Miyagi. As the result, the network performance was increased and application development cost might be half of that of the old IDDD, and Fast-Scroll is most legible for hearing impairments people. However, we could not get the clear data of effect by color (Red and Green), so that this is one of the issue in 2013. Also, to add more LED displays in the school and test the IDDD system under the more realistic situation.

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