A Development of Information System for Disaster Victims with Autonomous Wireless Network

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Abstract. In times of huge disaster such as earthquake, information needs increase among victims and rescuers. Social ferment rises within afflicted area and the damage is spread, if the needs of information are not satisfied. In this research we developed an information system for disaster victims as a distributed autonomous system using a wireless network. This system consists of many sub systems. These sub systems are robust for collecting disaster information because they are small and simple. An authorized user can register information using one of the sub systems that is working correctly. Asynchronously, they search another sub system via wireless network, and then they communicate to each other in order to exchange information they have. As a result, the information will be shared within a wide area by those processes like a bucket brigade.

Keywords: earthquake, disaster victims, distributed autonomous system, wireless network.

1 Introduction

An epicentral earthquake with magnitude of seven on the Tokyo metropolitan area is predicted to occur within the next three decades.[1] Rough estimate of the damage are shown as Table 1 and Table 2.

In a time of huge disaster such as earthquake, information needs increase among victims and rescuers. The information of disaster includes itself (cause, aftershock activity), the safety of near relatives or acquaintances, situation of evacuation area and so on. Social ferment arises within afflicted area, and the damage is spread, if the needs of information are not satisfied. [4][5] In order to prevent the damage from spreading, information of the damage as well as the situation of victim should be collected as early as possible. Fig. 1 shows the relation between the disaster information system and the social organizations infrastructure and the inhabitants. The right side of figure represents hierarchy of the social organizations infrastructure, and left side represents system that corresponds to these social organizations

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infrastructure. This means that these disaster information systems form a similar hierarchy. Currently, the disaster information system gradually is put in government as well as local municipalities. The initial information can be directly collected only at evacuation center; and there are many people who need the information; however, disaster information systems are not deployed to there yet. Therefore, disaster system for evacuation center is required. The system should be constructed in the community-based approach, because the inhabitants involve in the system directly.

In this research, we developed information system for disaster victims as the distributed autonomous system using a wireless network, on the basis of the above consideration.

Table 1. Rough estimate of the damage (premises and persons)[2]

Time	Wind velocity	Premises destroyed	Casualty count	Persons injured	Persons seriously-injured
Winter, 5AM	3m/s	230,000	5,300	160,000	17,000
Winter,	3m/s	480,000	7,300	180,000	28,000
6PM	15m/s	850,000	11,000	210,000	37,000

Table 2. rough estimate of the damage (essential utilities)[3]

Type	Damage	Recovery period
Electric power	9.2-16.9%	6 days
Communication	6.0-10.1%	14 days
Gas	6.4-17.9%	22 days
Water supply	24.5-34.8%	21 days
Sewage line	19.9-23.3%	21 days

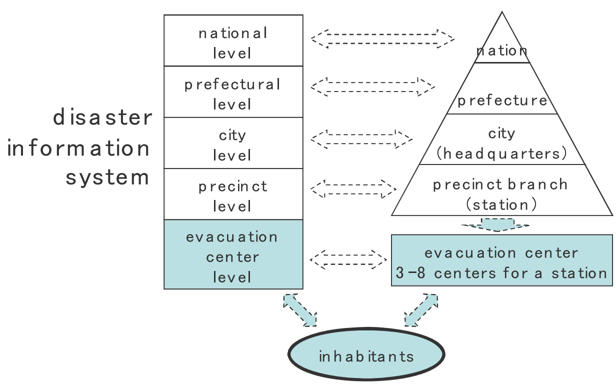

Fig. 1. The relation between the disaster information system and the social organizations infrastructure and the inhabitants [6]

2 Method

This research discussed the following issue when the disaster information system is developed.

- Just after when the earthquake broke out, it is able to collect and provide disaster information.
- Depending on the recovery of system area, service area can extend.
- Provides the disaster information system that can be operated actually.
- Takes into account the safety such as information's credibility as well as personal information.

2.1 Structure of the System

The system consists of many sub systems that are called nodes. The nodes are laid out the evacuation centers, sconces, and another place. The nodes are robust for collecting disaster information because they are small and simple. Elements of the node are shown in Fig. 2. The node has a power circuit and batteries in order to keep running without AC power line.

An authorized user can register information using one of the nodes that is working correctly. A user with IC card can be authenticated by the node, because physical accessing is required for security reasons. Unauthorized users can refer the information via wireless network, but they have no way to register any information.

Asynchronously, the nodes search another sub system, and then the pairs of nodes communicate to each other in order to exchange information they have. Hence, the information is gradually gathered by those processes like a bucket brigade, if there is an accessible working node. The information can be sent to another node, even if the nearest node is damaged. As a result, the information will be shared within a wide area. Whole image of the system is shown in Fig. 3.

Software such as operating system, autonomous control system, HTTP server, and web applications are installed on the nodes. The interfaces to register information are provided as web application software. Fig. 4 shows the user interface of some of them.

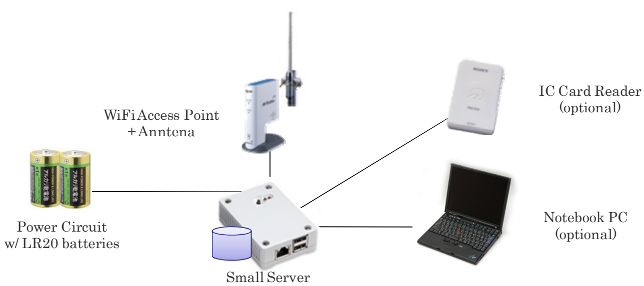

Fig. 2. Elements of the node

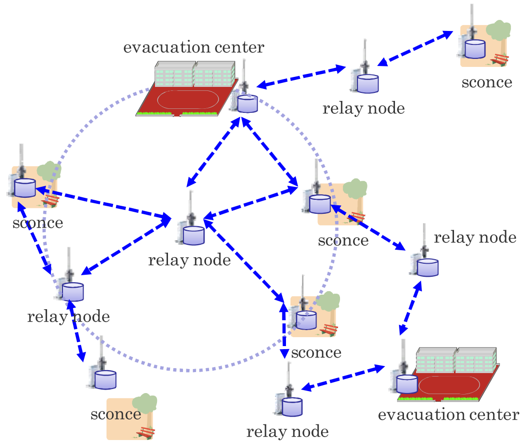

Fig. 3. Whole image of the system: all nodes search another sub system, and then they communicate to each other in order to exchange information they had

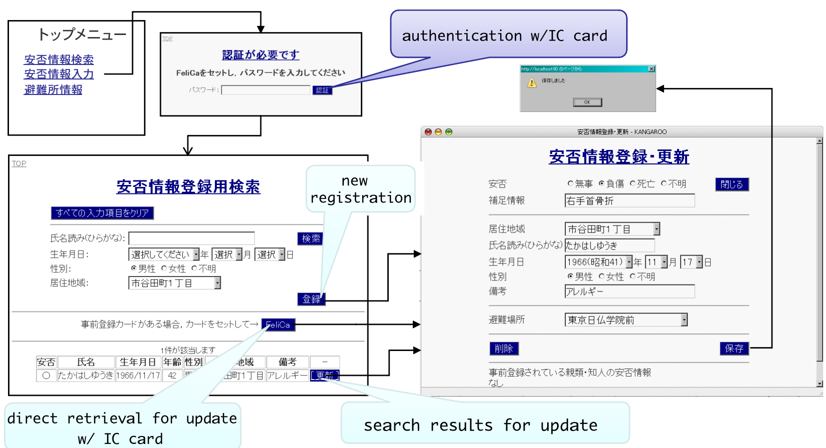

Fig. 4. User interface of the web application: to register someone's safety

2.2 Evaluation

2.2.1 Usability

In this research, ISO9241-11's definition of usability is used. The system is used under particular circumstances compared to normal system. One, the user is disaster victim; the other, the user must operate the system without any training. In the 'context of use' as above, each evaluated indexes of the usability are set up as followings,

- Effectiveness: a user can register the information (someone's safety) correctly without any help,

- Efficiency: a user can register sixty set of the information (someone's safety) within an hour,
- Satisfaction: a user is not alarmed, and has no guesswork to operate the system.

2.2.2 Performance of the System

Each evaluated indexes of the performance are set up as followings,

- Rate of information throughout: hundred registered data should be transferred to nearby nodes within five minutes,
- Thrifty power consumption: measurement of the operating time with dry batteries, this result is used to determine number of dry batteries saved against emergency,
- Distance of wireless communication: measurement of the distance of wireless communication, this result is used to consider the arrangement of the nodes.

3 Verification Experiment

Verification experiments consist of two parts that are corresponding to evaluation.

- User testing: Verification of usability for a user who has never operated the system.
- Software Simulation: Verification of the number of the nodes and the relation to the rate of information throughout, using the result of actual measurement.
- Field testing: Verification of behavior of the system in the actual installation location.
- (Measurement of the operating time with dry battery)
- (Measurement of the distance of wireless communication)

3.1 User Testing

3.1.1 Participants

Participants were 10 persons ranging in age from 22 to 35 years (mean = 26.7, standard deviation =4.6). All of the participants had experience in operating personal computers, but they had never operated the system. They were free volunteers. All had normal or corrected-to-normal vision, and were right-handed.

3.1.2 Apparatus and Materials

The experiment was conducted at a notebook computer (IBM ThinkPad ™ X61, Windows Vista ™ Ultimate (32bit), Japanese Edition, display size: 12.1", display resolution: 1024 x 768), and a small server (AtmarkTechno Armadillo-9 + Sony PaSoRi (RS-320) + Compact Flash (16GB)). The web browser was Mozilla Firefox version 3. The utterances and movements of the participants were recorded with a digital video camera (Panasonic NVMX3000). A manual that instructed on how to set up the notebook computer and how to register information about someone's safety, was placed near the subject. A list of information that contained thirty victim's information as name, gender, birthday, habitation area, and additional information was held by the experimenter. The list contained three groups, ten preregistered

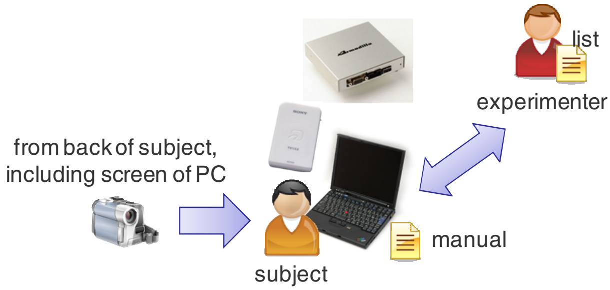

Fig. 5. Layout of apparatus

inhabitants with IC card, ten preregistered without IC card, and the other ten was not registered. The half of each groups had additional information such as injury. As shown in Fig. 5, these apparatus were arranged.

3.1.3 Procedure

Prior to experiment, participants sign the letter of consent, and heard the accounts of the tasks. They could speak freely while the experiment, and progress the task without a time limit. Assistances were provided on demand. At first, recording by the video camera was started, and then every participant executed the task as followings:

1. The subject read a manual, booted up the notebook computer, and executed login procedures,
2. The subject launched the web browser, and was authenticated with an IC card,
3. The experimenter told each data of someone's safety on the list one by one, and the subject registered them.

After the task ended, they filled in the questionnaire that asked difficulty of the task, and interviewed about that by the experimenter.

3.2 Software Simulation

3.2.1 Apparatus and Materials

The experiment was conducted at a notebook computer (IBM ThinkPad™ X61s, Windows Vista™ Ultimate (64bit), Japanese Edition, Intel® Core™2 Duo CPU L7500, 4GBRAM), and the simulator was written in Java language (jdk1.6.0-11). The simulator generated defined node objects, put defined data, and made them communicate each other. Each node objects recorded the time when they received all of the data. The parameters (required time to search, connect, and transfer data) were taken from actual measurements.

3.2.2 Procedure

At first, the node objects and data were defined in text files that contained comma separated values, and then the parameters were defined in properties file of Java language. Next, the simulator was executed ten times.

3.3 Field Testing

3.3.1 Apparatus and Materials

The experiment was conducted at small servers (AtmarkTechno Armadillo-220 (as node A) / 240 (as node B) + IO-DATA GW-US54GXS + USB memory (16GB)) and a notebook computer (as node C, IBM ThinkPad ™ X61, Windows Vista ™ Ultimate (32bit), Japanese Edition). As shown in Fig. 6, these apparatus were located.

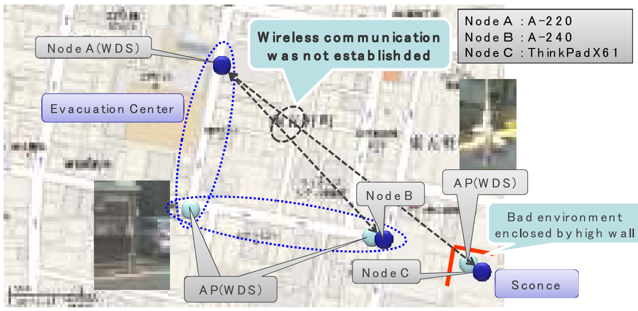

Fig. 6. The layout of the nodes

3.3.2 Procedure

At first, hundred data were put into node A. Next, the other nodes (B, C) communicated to node A in order to exchange information they had. They recorded the times of beginning and ending the communication. These trials were repeated three times.

4 Result and Discussion

4.1 User Testing

Every participants could register all (thirty) data correctly. Therefore, the index about effectiveness was satisfied. Fig. 7 shows the periods required to register information

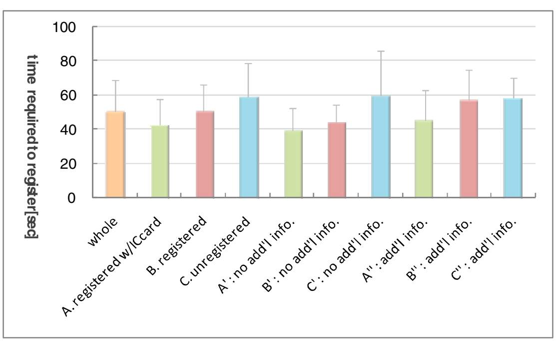

Fig. 7. Required time to register information about someone's safety

Table 3. Analysis of variance table of two way layout

Source	SS	DF	MS	F	P
additional information	745.34	1	2.56	3.955	
way to search (w/ICcard, registerd,	4069.96	2	6.99	3.105	<.01
Interaction	806.76	2	1.38	3.105	

Table 4. The results of the questionarrie

Subject										
Gender	m	m	m	f	f	m	f	m	m	m
Age	35	31	26	25	24	30	30	22	22	22
Manual										
Understandable	no	yes	yes	yes	yes	yes	easy	yes	easy	yes
Sufficient information	yes	no	yes	yes	yes	no	yes	yes	yes	yes
Setup										
Guessed	yes	no	no	no	no	no	yes	no	no	no
Alarmed	yes	no	yes	no	no	no	yes	no	no	no
Registration										
Guessed	no	no	no	no	no	no	no	no	no	no
Alarmed	yes	yes	no	yes	no	no	no	no	no	yes

for one. The average of them was 50.5sec (SD: 18.4sec), thus, the index about efficiency was also satisfied. Table 3 shows analysis of variance table of two way layout. It indicated the efficiency is affected to registration status of inhabitants, and is not related to with or without additional information.

Table 4 shows the results of the questionnaire. Almost of the participants had no alarmed and no guessing about the tasks. Thus, the index about satisfaction was also satisfied. However, there were some requirements against the manual or the user interface of the system. The requirements have to be improved.

The system is used under particular circumstances compared to normal system. One, the user is disaster victim; the other, the user must operate the system without any training. However, the former was not evaluated well in this research. The 'context of use' of usability of the system, was limited as operating the system without any training.

4.2 Software Simulation

Table 4 shows the period required to distribute hundred data from the center node. It indicates the performance is well to far nodes; however, to the nearby nodes of the center node is not satisfied. This caused the communication was serialized; the center node could not communicate to the others, when the number of the nearby nodes was three or more. This point of the system should be improved. Anyway, our target city requires two hundred nodes in order to cover the city, thus, the result indicates the information will be shared in the city within thirty minutes.

4.3 Field Testing

There were some high-rise apartment house that blocked communication between evacuation center and sconces. However, node B and node C could communicate to node A using wireless access points that were set up as relay node (WDS with node A).

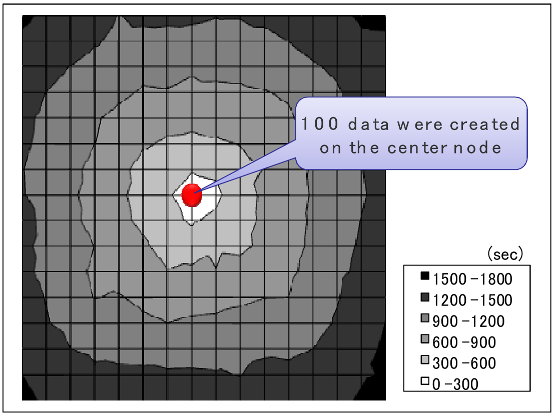

Fig. 8. The period required to distribute hundred data

The required period to transferred hundred data, was 310.7sec (SD: 17.2sec). It indicated that a node could communicate to another node, even if they could not communicate directly, when a relay node was laid out suitable place.

4.4 Measurement of the Operating Time with Dry Battery

A node that consists of a small server and wireless access point, could run through 276 minutes (SD: 14minutes) using eight alkaline batteries (LR20). A wireless access point could run 729 minutes (SD: 12minutes) using three alkaline batteries. Therefore, 128 alkaline batteries will be required by a node for three days running, and 18 will be required by a wireless access point. This result can be accepted to create a stockpile.

4.5 Measurement of the Distance of Wireless Communication

Two nodes could communicate to each other within 300 m on straight road with a good view. They could connect each other; but they could not complete to transfer hundred data over 300 m. Therefore, maximum distance between two nodes should be less than 300 m.

5 Conclusion

We developed information system for disaster victims as the distributed autonomous system using wireless network, and evaluated it. Results of this study will be of service to construct disaster information systems for inhabitants.

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