Information Infrastructure for Rescue Systems

Hajime Asama[1], Yasushi Hada[2, 3], Kuniaki Kawabata[3],
Itsuki Noda[4], Osamu Takizawa[2], Junichi Meguro[5],
Kiichiro Ishikawa[5], Takumi Hashizume[5], Tomowo Ohga[6],
Kensuke, Takita[7], Michinori Hatayama[8],
Fumitoshi Matsuno[9], and Satoshi Todokoro[10]

[1] RACE, The University of Tokyo, Kashiwanoha 5-1-5, Kashiwa 277-8568, Japan
asama@race.u-tokyo.ac.jp
[2] National Institute of Information and Communications Technology (NICT), Tokyo, Japan
{had, taki}@nict.go.jp
[3] Institute of Physical and Chemical Research (RIKEN), Saitama, Japan
kuniakik@riken.jp
[4] National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
I.Noda@aist.go.jp
[5] Advanced Research Institute for Science and Engineering, Waseda University, Tokyo, Japan
{meguro, ishikawa}@power.mech.waseda.ac.jp, hasizume@waseda.jp
[6] Asia Air Survey Co., Ltd., Kawasaki, Japan
tom.ohga@ajiko.co.jp
[7] HiBot Corporation, Japan
takita@hibot.co.jp
[8] Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan
hatayama@imdr.dpri.kyoto-u.ac.jp
[9] Dept. of Mech. Eng., & Intelligent Systems, Univ. of Electro-Communications, Tokyo, Japan
matsuno@hi.mce.uec.ac.jp
[10] Graduate School of Information Sciences, Tohoku University, Sendai, Japan
tadokoro@rm.is.tohoku.ac.jp

Abstract. In the disaster situation, it is important to collect quickly global information on the disaster area and victims buried in the debris and waiting for rescue. In the DDT project (Special Project for Earthquake Disaster Mitigation in Urban Areas), the research and development on rescue infrastructure for global information collection have been carried out. In the activity of the mission unit for infrastructure, ubiquitous handy terminal devices and technology for forming an ad-hoc wireless communication network have been developed as well as technology to integrate the collected information on the GIS system including communication protocol design. In this paper, the current R & D activities of the mission unit for infrastructure in the DDT project are overviewed, and some technologies developed so far are introduced.

Keywords: Ubiquitous device, disaster information collection, ad hoc network, communication protocol, GIS

1 Introduction

In the disaster situation represented by earthquake, it is important to collect various types of information on the disaster as soon as possible and provide the people with it. Quick information acquisition on where is the damaged area, how the damage is, in which rubbles the victims are possibly trapped, is required for the rescue strategy planning. On the other hand, the people suffered from the disaster seek for information on the location of refuge and the family. For such information collection and provision, the information infrastructure plays quite an important role. In the disaster situation, since the conventional information infrastructure, such as the internet and the cellular phone, is possibly damaged and useless, it is indispensable to form the information infrastructure ad hoc. In this paper, the recent R & D activities of the mission unit for infrastructure in the DDT project [1] are overviewed, and some technologies developed so far are introduced.

2 Rescue infrastructure

2.1 Information Collection and Sharing in DDT Project

In the Japanese project for Development of Advanced Robots and Information Systems for Disaster Response in DDT (Special Project for Earthquake Disaster Mitigation in Urban Areas)[1], the infrastructure mission unit has been developing ubiquitous devices for means to collect information on the disaster area with constructing ad-hoc network, and a system to integrate the collected information into GIS (Geographic Information Systems). In the DDT project, various types of robots (on-rubble robots, in-Rubble robots, aerial robots) have been developed for searching for victims, collect information on the disaster area, etc. The information infrastructure is also assumed to collaborate with these robots. The information collected by robots is transmitted by the ubiquitous devices for the information infrastructure, and integrated with GIS. The robots can also utilize the information (e.g. map information, victim information, etc.) stored in GIS to operate intelligently and effectively.

2.2 R & D Activity Overview in Infra-MU

This mission unit[2][3] has conducted research and development in technology for integrating the information of a large number of intelligent sensors distributed in a disaster-stricken area. Operating effectively as a system in real time, network household electric appliances, PDA’s, and robots provide information and an action plan can be derived for a stricken area’s situation. We have implemented trial production based on research and development work so far, with emphasis on the following two developments:

(1) Developing a ubiquitous handy terminal device and technology for forming an ad-hoc wireless communication network
(2) Design of communication protocols and development of a technology to integrate the collected information on the GIS system

Figure 1 shows the final image of the R & D activities in the mission unit for rescue information infrastructure.

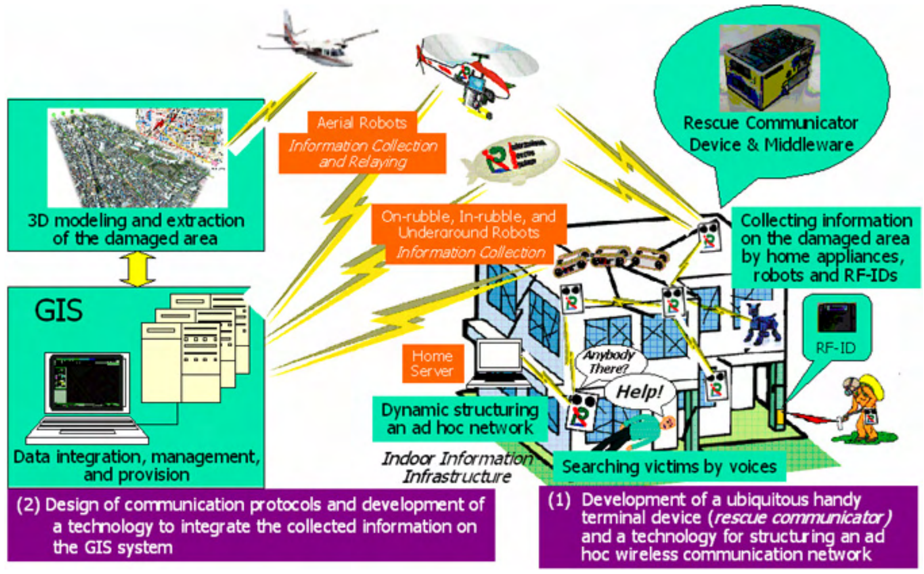


Fig. 1. Image of task force of rescue infrastructure

3 Development of Ubiquitous Devices for Collecting and Providing Information

3.1 Development of Rescue Communicator

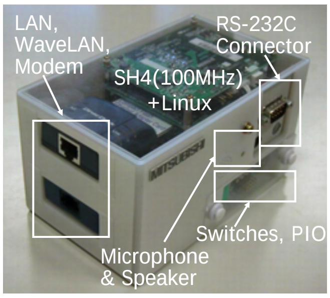
A new intelligent sensor node called rescue communicator (*R-Comm*) as a ubiquitous device for a rescue information infrastructure platform has been developed for collecting and providing information. The main specification of the *R-Comm* is shown in Table 1, which was composed of a micro processor, a memory, three compact flash slots, a voice playback module including a speaker, a voice recording module including a microphone, a battery including power control module, and two serial interfaces. A wireless or wired LAN model is equipped on a compact flash slot for wireless/wired communication. Linux is installed and used as the OS of the *R-Comm*. An RF-ID Reader/Writer and other peripheral devices can be connected to the serial interface. If the power plug is connected, the power control system charges the battery, and if the power supply was cut, it switches the power source automatically to the battery. For the intermittent use, it can operate 72 hours, which is the critical time for human to survive.

Two types *R-Comm* were developed, which are a Long-type and a Short-type depending on inclusion or exclusion of the compact flash cards. Figure 2 shows the photos of the two types of *R-Comm*.

A function to form ad-hoc network among the multiple *R-Comms* was developed. Any data collected by the *R-Comms* can be sent not only by one-to-one wired/wireless communication link, but also by hopping among multiple devices using the common protocol called MISP via the ad-hoc network, which was also developed in this project. The detail of the protocol is presented later.

Table 1. Specification of *R-Comm*

CPU:	Renesas SH4 (100MHz)
Memory:	32MB
Extension slot :	Compact Flash * 3, RS-232C * 2
Communication:	Wireless LAN, InfraRed, RS-232C)
Other interfaces:	AD/DA/voice
Size:	985/635cc, 500g
acting time:	4hrs(continuous) 72hrs(intermittent)



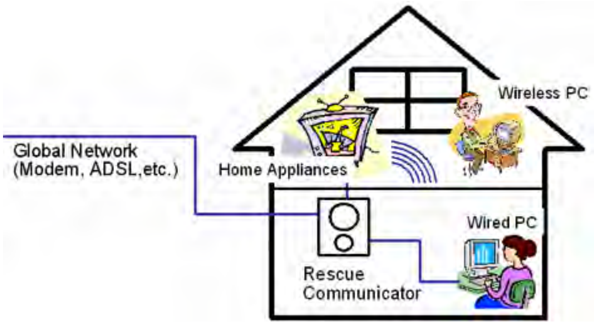
Short type

Long Type

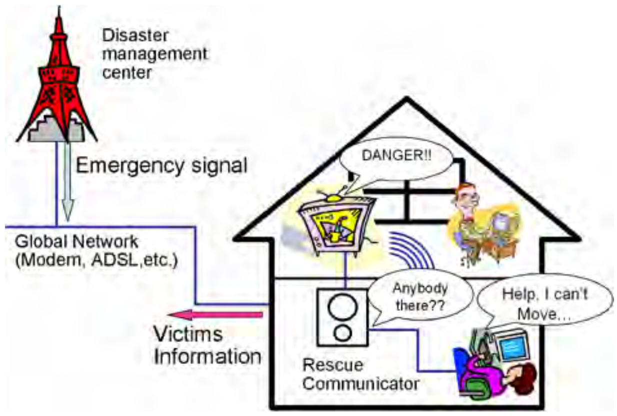
Fig. 2. Photos of *R-Comm*

3.2 Verbal Victim Search by *R-Comms*

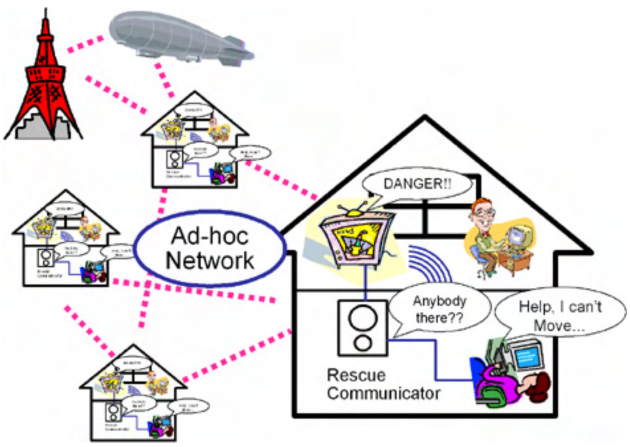
A verbal victim search system was developed in RIKEN (The Institute of Physical and Chemical Research) and the University of Tokyo by utilizing the voice playback and recording function of the device[4][5]. In the emergency situation, the device set in our living environment can be activated by any signals sent from external systems or any earthquakes detected by the internal sensors (occurrence of vibration or voltage drop), and we can make the device operate automatically to call for victims by playing voice message and record any sounds for several seconds after the message, in which any voice reply of the victims must be included.



(a) Normal Situation



(b) Emergency Situation (Global network is alive)



(c) Emergency Situation (Global network is down)

Fig. 3. Procedure of Victim Search Depending on Situation

The device is supposed to set in the fire alarm in the houses/buildings, or as a wireless LAN router/access point in home in advance. The figure 3 (a), (b), (c) shows a procedure of the victim search in the latter case.

In the normal situation, the *R-Comm* functions as a network router, an access point, or an bridge, and can serve for home network service with information home appliances, nursing elderly people, or security and guard as shown in Figure 3-a. But, if the *R-Comm* detects any earthquakes, the *R-Comm* changes its mode, broadcasts an emergency information, calls for victims, collects information on victims, and sends the information to the disaster management center as shown in Figure 3-b. If the global network is down, the *R-Comm* forms the ad-hoc network automatically with neighboring devices to send the information as shown in Figure 3-c.

A new version of the *R-Comm* is under development by IRS (International Rescue System Institute), which has a TITech Wire I/F giving high expandability to add function to control the robots; A/D converter, D/A converter, counter, motor driver, etc. PCMCIA card I/F, IEEE 1394 I/F modules are also under development for the new version of the *R-Comm*.

To realize a distributed search environment, a miniature type *R-Comm* with reduced function is also under development. By using the miniature *R-Comm*, we can construct a hierarchical local network by one parent *R-Comm* and several miniature *R-Comms*, which can deployed to each room. The Figure 4 shows an experimental setup to construct such a local network using one parent *R-Comm* and three IDR-Rs (Intelligent Data Carriers for Rescue) representing the miniature *R-Comm* terminals.

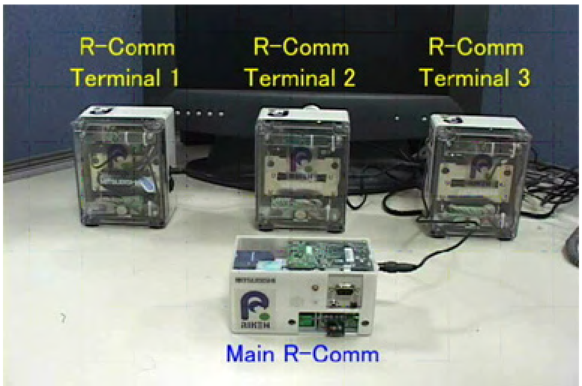


Fig. 4. Local network setup

UAV (Unmanned Aerial Vehicle) is an effective means to collect the sensory data stored in R-Comms using ad-hoc network and to link them to recorded videos from air. Field tests using an unmanned blimp developed by RIKEN[6][7], a cable driven balloon developed by IRS[8] and an autonomous helicopter developed by Kyoto Univ.[9] were carried out as shown in Figure 5, 6, and 7 respectively. As a result, it was turned out that the communication between *R-Comm* and UAVs is reliable within 5[m], 40[m], and 20[m] in the case of blimp, balloon, and helicopter respectively, while stable communication range on the ground without occlusion is 300[m].

Figure 5. Communication test between blimp and *R-Comm* in indoor environment

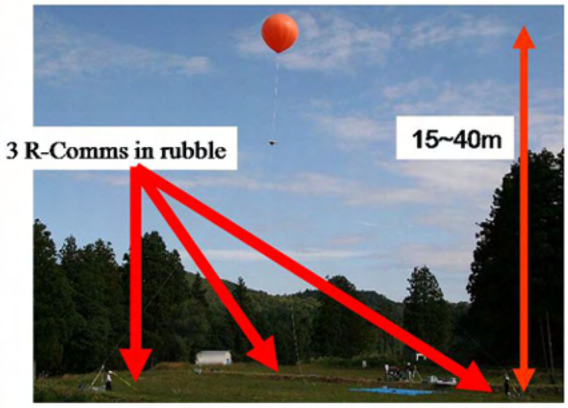


Figure 6. Communication test between balloon and *R-Comm*

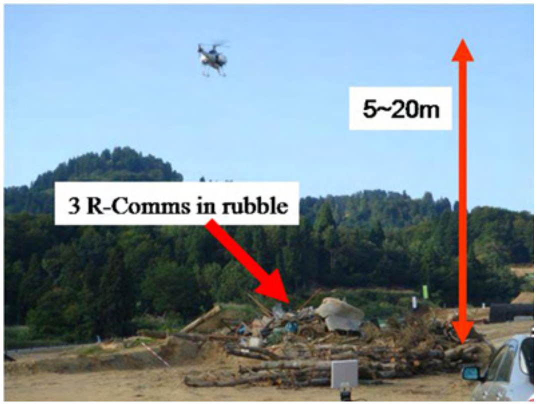


Figure 7. Communication test between helicopter and *R-Comm*

3.3 RF-ID Based Emergency Information Collecting and Delivery System

A disaster information collecting system using RF-ID transceiver and ad-hoc network was developed in NICT (National Institute of Information and Communications Technology)[10][11]. RF-ID is useful as means to collect information on damage and states of people using intelligent devices and networks to determine strategies for rescue in disasters. As an electrical signboard, a victim who evacuates from the damaged house to a refuge can put the RF-ID tag at the entrance gate of the house and write into the tag the message on his/her safety and on his/her evacuation refuge to the family who visits the house.

Another usage of the RF-ID tag is the information storage on the logs for victim search by the rescue surveyors and corps. Any fire fighters, rescue surveyors or corps who searched the house can store the results of the search in the tag set at the entrance gate. This information can be shared by any other rescue surveyors or corps who visit the location with carrying the reader device. The information can also be transmitted to the disaster information management center where all the information is collected, integrated and utilized.

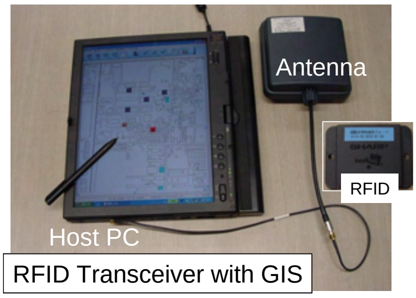


Fig. 8. Handy terminal and RF-ID tag

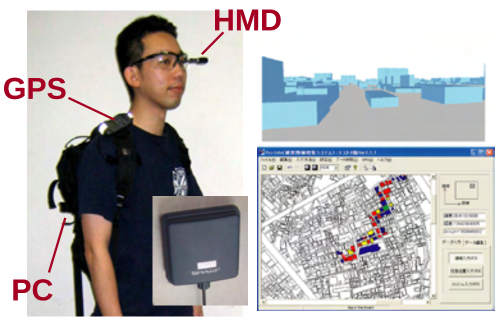


Fig.9. Wearable system for rescue surveyor

Figure 8 shows the developed handy terminal and the RF-ID tag. A GPS antenna is equipped with the handy terminal. The rescue corps who carries the terminal can see the map of the damaged area with marks where any rescue information is stored, which can be displayed with the GIS (Geographic Information System).

The rescue corps who visit a location where a tag was put can read the message in the tag by the reader device, and can store the information together with the location information obtained by the GPS antenna to the GIS system, or can send the information to the center by wireless communication. Figure 9 shows a wearable terminal prototype, with which the rescue corps can see the 2D or 3D map with rescue information through HMD (Head Mount Display).

Field test experiments on the system were done, and it was verified that the information obtained by the multiple rescue corps with carrying the terminal device can be transmitted to the center by ad-hoc and multi-hop wireless networks, and that all the collected information can be integrated on the GIS database at the center.

4 Disaster Information Collection and Data Integration Using Dynamic Communication Networks

4.1 Protocols for Rescue Information Collection and Common-use Database for Data Integration

In order to utilize effectively all the information collected by various agents, such as rescue surveyors, rescue corps, rescue robots, sensor nodes (rescue communicators), a common protocol for rescue information exchange and sharing was designed by AIST (National Institute of Advanced Industrial Science and Technology)[12], which is called MISP (Mitigation Information Sharing Protocol). All the collected data should be should be integrated on a database, referred efficiently, and served for quick decision making on rescue team deployment to the right locations. A new common-use rescue information integrated database for unifying information using the MISP protocol and the API was developed by AIST[12], which is called RaRuMa (DAtabase for RescUe MAnagement). This integrated database accumulates the information that the rescue infrastructure, the rescue robot, etc. collect in real time, and offers it in a reusable form. This rescue-integrated database is planned to be combined with integrated earthquake disaster simulation GIS systems called DiMMSIS/DyLUPAs, currently being developed by the National Research Institute for Earth Science and Disaster Prevention (NIED)[13].

The DaRuMa and MISP have such convenient function for the rescue information integration as extendable, fast and scalable, network-based, and compatible with various standards, namely platform free. Some standard templates are provided for sensor data and coverage.

The details of the MISP and DaRuMa are described in another chapter of this volume[14].

4.2 Experiments of Rescue Information Collection and Integration

Information sharing based on spatial temporal GIS between the rescue robot systems and the disaster management system has been discussed in Kyoto University, University of Electro-Communications, and Waseda University[15][16].

An autonomous mobile vehicle and a system to extract objects differentiated from the ordinary scene were also developed. The system employs an omni-directional vision system. The system can be utilized for detection of the objects which appear by the disaster, or the damaged objects and buildings in the disaster area, by extracting the difference of the captured scene from the ordinary scene. The detected objects can be registered in the GIS in KIWI+ format.

The information exchange software was developed based on MISP, and applied to information sharing experiments at Yomakoshi area, which a big earthquake attacked and was destroyed in 2004. Figure 10 shows the system configuration of the experimental system of ground and aerial information collection for spatial temporal GIS. The system allows various ways of data collection such as manual camera work by rescue surveyor using a PDA equipped with a GPS, image capturing from the air by an unmanned aerial vehicle (UAV), and image capturing by a ground vehicle equipped with a GPS gyro consisting of an RTK-GPS, a D-GPS and an inertia sensor, a high-resolution camera, and a laser range finder. All the data obtained by these means are sent to the DaRuMa database based on MISP, and also sent to the spatial temporal GIS (DiMSIS/DyLUPAs).

Figure 11 shows the result of the experiment. Each picture is saved on DiMSIS/DyLUPAs synchronized with position and time, and the data is displayed on a map as a mark by a viewer system, and the contents of the data such as images can be displayed by clicking the mark. The integration of the data collected by various types of information sources on a GIS database was successfully executed, and the easy lookup of all the collected data on the map was verified.

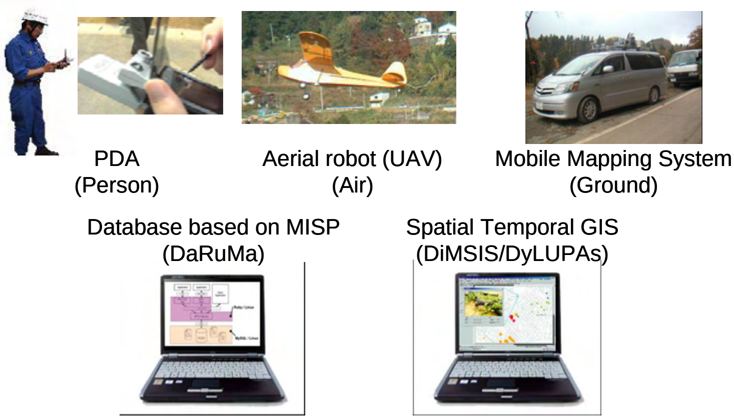


Fig. 10. Ground and Aerial Information Collection System

Fig. 11. Experiment Result in the vast disaster field

4 Conclusions

In this paper, the R&D activities of the information infrastructure mission unit of DDT project were overviewed. The ubiquitous devices developed called Rescue Communicator (*R-Comm*) so far for rescue infrastructure to collect, transmit, provide information on the disaster situation was introduced as well as its applications to victim search together with utilization of RF-ID tags. The designed communication protocol, MISP, between various types of data collection devices including rescue robots was introduced as well as the GIS database called DaRuMa for the disaster and rescue data integration. Some results of the experiment done at the real disaster area was also shown, in which an UAV, an ground vehicle and rescue surveyors were used for data collection, and the collected information was sent to and integrated on a GIS database.

The information infrastructure mission unit is carrying out some more tests together with other mission units on transmission and integration of data collected by on-rubble robots, in-rubble robots, and aerial robots in test fields and in a real disaster area.

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