Proceedings of the 2006 IEEE/RSJ
International Conference on Intelligent Robots and Systems
October 9 - 15, 2006, Beijing, China

Rescue Communicators for Global Victim Search and Local Rescue Planning

Yasushi Hada, Kuniaki Kawabata, Harutoshi Koguchi, Hayato Kaetsu
Distributed Adaptive RoboticS(DARS) Research Unit
RIKEN
Saitama, Japan
{ had, kuniakik, koguchi, kaetsu } @riken.jp

Hajime Asama
Research into Artifacts, Center for Engineering (RACE)
The University of Tokyo
Tokyo, Japan
asama@race.u-tokyo.ac.jp

***Abstract* - We are conducting research and development in technology for unifying 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, a personal digital assistant (PDA), a robot, etc. provided information and an action plan for a stricken area's situation. In this paper we introduce ubiquitous device "Intelligent Data Carriers for Rescue (IDC-R) " and formation of a dynamic network, and development of a means of disaster information communication (a group of people, a robot, an ad-hoc network, a home network, etc.). Target experiment for actual proof is also introduced.**

Index Terms* - *Sensor Network, ubiquitous device, Ad-Hoc network

I. INTRODUCTION

It is one of the most important challenges to be solved to make public announcement of the safety and whereabouts of missing persons and persons to be saved as soon as possible in case of any of disasters such as a big earthquake in the urban city. Although, at present, rescue corps and dogs strive to find the victims everywhere in the disaster area, it takes too long to discover them in some cases. To address this problem, a small sized wireless communication device called " Intelligent Data Carrier for Rescue (IDC-R) is developed. IDC-R can call to the missing victims possibly trapped under rubble and record their voices if any so as to efficiently find them immediately after the disaster. Installed indoors prior to the attack of a disaster or placed in the disaster-affected site after the attack, the devices under development are capable of forming an intelligent network throughout the environment around the site. This works in parallel at the disaster site (ubiquitously searching) and supports that rescue corps search for the victim, effectively.

In this paper, we describe two uses of victim search methods using IDC-R. One usage is to determine which rubbles the victim persons to be saved are in wide area , and the other usage is to determine how to rescue him or her in the local specified rubble. Our IDC-R system satisfies these two different objectives using a same hardware.

II. GLOBAL VICTIM SEARCH SERVICE

The objective of this study is to build a victim search system with a small wireless communication device capable of calling to missing victims possibly trapped under rubble and recording their voices. It enables the rescue corps search for persons to be saved at all once over the whole disaster site (ubiquitous environment) and immediately collect on-site information using flight vehicles like a blimp (Fig. 1). Being developed devices can also support efficient rescue-activity such as to building up wireless information network at the disaster site.

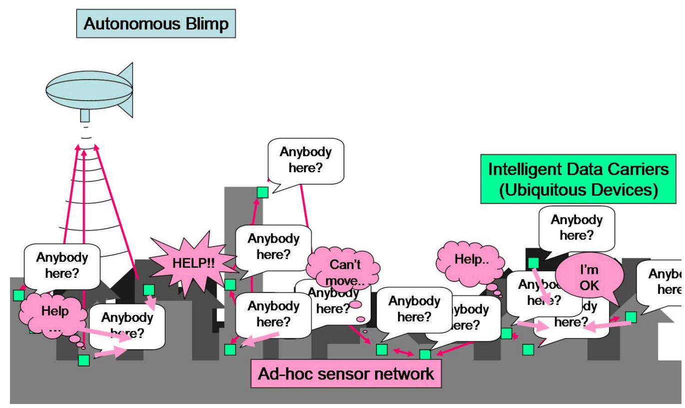

Figure 1: Global Victim Search System

To achieve this system, fundamental specification requirements of IDC-R have been defined. The IDC-R is intended to record the voices of victims in the disaster area and upload the stored voice information onto the blimp travelling in the upper air to provide information useful for the Disaster Management Center to take its backup activities. The IDC-Rs must have been installed at arbitrary positions such as in a ceiling beforehand. The IDC-R also has implemented the functions for initiating recording of the voice or sound in the rubble at arbitrary times in response to a start-up signal sent by the blimp travelling about 50 [m] above the ground. and for uploading the stored voice or sound information onto the blimp within one second. Moreover, in the experience of Hanshin-Awaji Earthquake it must be equipped with a battery for continuing to operate as long as possible even under the environment in which no electric power is supplied.(ideally spearking, over 72 hours)

The IDC-R is designed to cycle mainly through the four states described below to search for the victims possibly for the victims possibly trapped under rubble for a long period.

1) Idle ... In the normal condition, the IDC-R is idle. In case of an earthquake, it is activated when receiving an external start-up instruction.
2) Active ... The IDC-R asks the victims whether they are quite right through a loud speaker when receiving the start-up instruction and records the responses (voices or sounds in the surroundings), if any.
3) Standby ... After going through one cycle, the IDC-R stays in the Standby state until the successive cycle is initiated. Since then, the voice is successively recorded and latest voice files are stored depending on the storage capacity. (old files are overwritten by new one when it is over the storage capacity.)
4) Communicating ... The IDC-R uploads the voice or sound information stored so far onto the blimp when in the Active or Standby state, receiving the upload instruction from it. Once having finished data transmission, the IDC-R enters the Standby state to resume recording of voice information.

For approximate localization of IDC-R, it has its own ID such as specifying where the device was installed. It is utilized to specify the building, house and room in which the victims are.

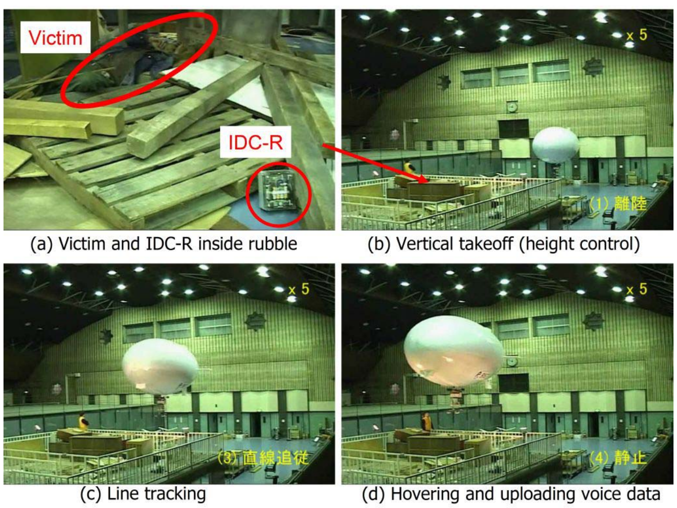

Figure 2: Intelligent blimp for information collection from IDC-R.

III. LOCAL VICTIM SEARCH SERVICE

In the process of development of global victim search service, we consider them to apply it to search inside the local specified rubble. Through the interviews to rescue workers, we found they are looking forward to the following.

1) Specify where the victim inside the rubble is.
2) Know the health condition of the victim inside the rubble.
3) Make communication with the victim inside rubble and encourage him.

Based on the requirements, we added some functions as follows.
1) One master IDC-R and some slave IDC-Rs is put to each room in a house beforehand, to gather the sounds around them simultaneously. The collected sound data is transmitted and stored to the master IDC-R. Master IDC-R transmits them to outside of the rubble in accordance with the rescuers request.

For 2) and 3), VoIP (Voice over IP) function is added onto IDC-R. Using mobile terminal, Rescuer outside rubble can talk with the victim even if he or she is missing inside rubble.

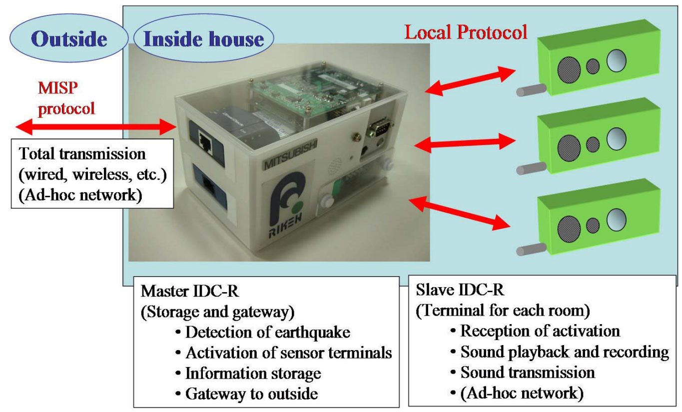

Figure 3: Local Rescue network inside house.

Using these functions , one rescue scenario will be realized as follows.

1) One master IDC-R and some slave IDC-Rs is put to each room in a house beforehand. Residents can store some types of their own information into the master IDC-R. The information would be room layout, family structure, blood type, and so on.

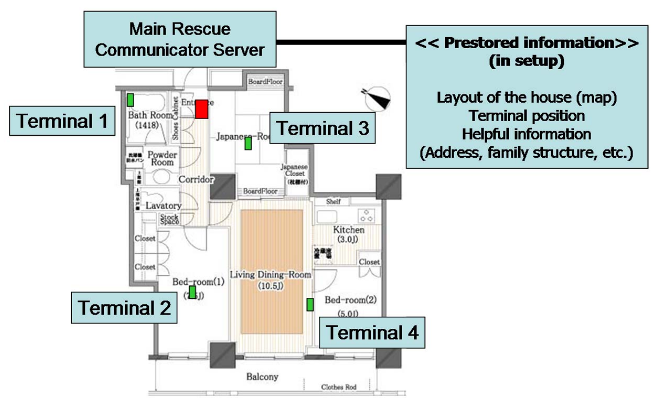

Figure 4: Preset IDC-Rs and informations.

2) When the earthquake occurs, inside rubble, master IDC-R detects the vibration using tilt sensor, and give the command to slave IDC-Rs automatically. Slave IDC-Rs speak automatic message to the victims and collect voice response.

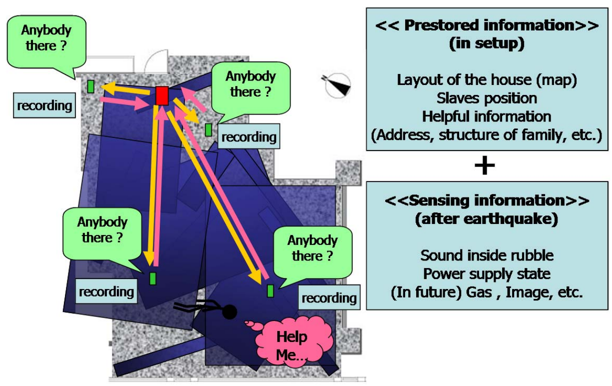

Figure 5: Local victim searching inside collapsed house.

3) After rescue team arrived at the scene of the collapse, they can get the audio response of the victim and some important information such as room layout, family structure and blood type from master IDC-R using wireless mobile terminal. The information of the victim allows people outside rubble to make some strategy for rescue.

4) Using VoIP function, rescuers can also try to talk with the invisible victim to estimate his or her condition. Victim perhaps survive longer thanks to the encouragement by rescuers.

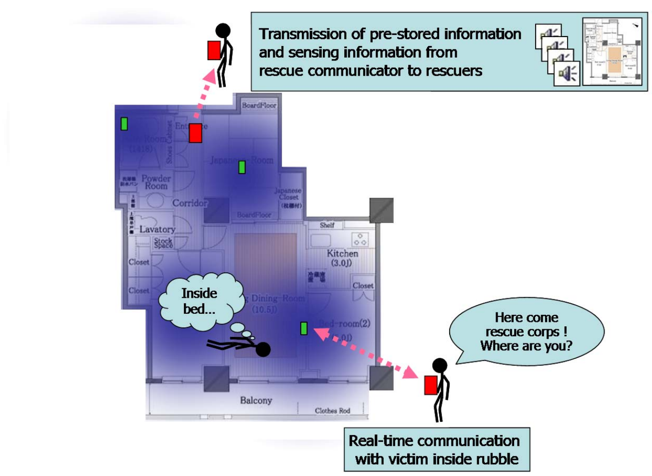

Figure 6: Victim Searching using mobile IDC-R.

IV. DEVELOPED PROTOTYPE OF IDC-R

Developed prototype of IDC-R is shown in Fig.3. It implemented speaker/microphone devices for sound playing/recording, wireless communications system, and power controller based on a micro-server. The IDC-R is designed so that it may record voice for up to 90[sec] at a time and upload compressed voice or sound data within one second onto the blimp traveling at an altitude of 50[m] in the air. Capable of operating by means of an internal battery, as well as of a domestic power supply, the IDC-R may be rather easily put to practical use assuming that the means for collecting information is provided. Furthermore, the IDC-R may collect voice information in any other method than the blimp, for example, a person or car carrying a reader/writer and an antenna with him/her. In this case, even if the blimp can not travel in the air above the disaster-affected site, voice information may be collected.

In addition, not only such a victim search function but also the functions for supporting the rescue activities on the site will be implemented. Especifically, taking advantage of voice information playback function, an additional function for talking to a member will be implemented for talking the member of a rescue corps with a victim trapped under the rubble by wireless. This may facilitate the communication between the rescue member and the victim trapped under the rubble, which has been difficult so far.

Here, a basic experiment is attempted using the just developed IDC-R. Such an application was developed that; 1) the previously recorded voice of calling to any victim " Is anyone present? If so, please answer!" is played back; 2) voice and surrounding sound are recorded for four seconds; 3) the recorded voice and sound are uploaded onto a server by wireless; and 4) the voice or sound data is confirmed at the management site. As a result of it, it could be verified that this enabled us to record voice heard from the place about 10[m] apart from the IDC-R with no obstacle. A problem was identified that it can operate only for four to eight hours by means of a battery.

On the other hand, in order to meet the specification that 1M[bit] of voice data shall be transmitted within one second to the blimp travelling in the upper sky, a radio frequency communication study is used. The result of a pilot study of speed advantage over the other two focusing on the tolerance to the distance from it and to any obstruction is shown in Fig 5 (ftp file transfer rates were compared among three communication types, IEEE802.11b, g, and a.) To reflect the actual status of the disaster-affected site, the study was conducted by surrounding one of two wireless terminals in simulated rubble field with concrete obstructions, wood materials, iron materials, etc. Based on the result, it could be verified that the 802.11g type has an advantage over other two types from the aspects of communications rate, safety, and others.

IV. FROM IDC-R TO RESCUE COMMUNICATOR

In this stage, a Rescue communicator(R-comm.) is developing based on the IDC-R technologies and implementation of additional functions. R-comm. is shown in Fig. 6 not only has achieved further power saving and reduced size, but also has incorporated a various types of additional functions to use as a common laboratory platform, where an information infrastructure is to be expanded in case of a disaster, including the function of IDC-R. In future, it is expected that it will act as an intelligent device to gather on-site information for the rescue database based on GIS. It is also distributed in the disaster area and works as not only information collection but also relayed the information to the blimp based on dynamically forming an ad-hoc network.

The main specifications of the R-comm. being developed are shown in Table II. R-comm. has incorporated a wired LAN, modem, and wireless LAN for connecting to networks including Internet, a telephone network, and so on. It is a small-sized, light-weight, and long-life Linux micro server which contains the voice I/O function and so on, R-comm. may be automatically charged when an AC power supply is connected. The device intermittently operates for 72 hours by means of the battery when the power source is shut off.

At normal times, the R-comm. serves as a domestic broadband router using its internal wired LAN, wireless LAN, modem, and others. Besides, it may be used in watching elders or pet animals, monitoring any water leakage or short circuit, and performing overall control of domestic apparatuses on a daily basis. In our assumed scenario, it may start to collect information by receiving an alarm packet sent by the Disaster Management Center or using the internal sensor (ex: vibration sensor) to toggle between the modes (daily life and emergency). UBKit (Ubiquity Building tool Kit) being developed by AIST, is a part system used in building a ubiquitous computing environment. It will be incorporated so that even if any of networks such as a WAN is shut off or down, the internal wired LAN may be used to form an ad-hoc network connecting neighbouring R-comms.. It can be useful for facilitating the implementation of a sort of robust sensor network for victim search in case of an earthquake.

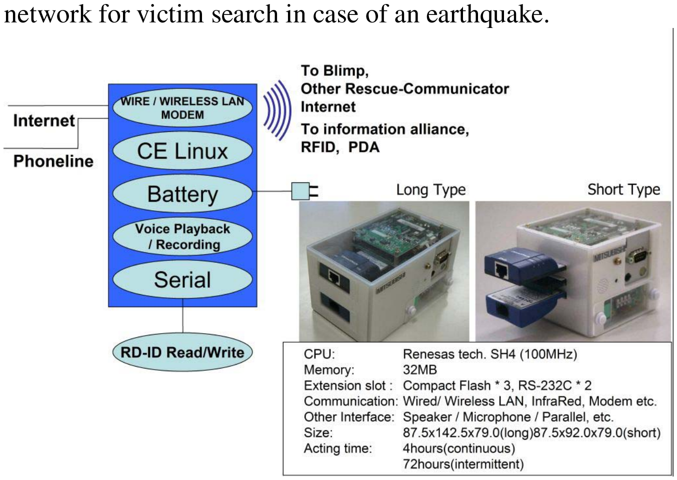

Figure 7: Specifications of new IDC-R (based on Rescue Communicator)

V. SUMMARY

In this paper, the prototype of IDC-R is introduced and it is discussed the result of a fundamental verification test. Also, the R-comm, in which its functions have been sorted out and enhanced, power consumption has been further saved, and durability has been made higher was discussed. In the future, the function for expanding the information infrastructure will be developed and implemented. Furthermore, it will be proceeded to integrate the function of IDC-R on R-comm and autonomous flight function of the blimp for realizing victim search system.

ACKNOWLEDGMENT

This research was performed as a part of Special Project for Earthquake Disaster Mitigation in Urban Areas in cooperation with International Rescue System Institute (IRS) and National Research Institute for Earth Science and Disaster Prevention (NIED).

The authors would like to thank the members of Infrastructure Mission Unit in DDT project for their rechnical contributions to be developing R-comm.

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