Autonomous Disaster Information System for Local Residents

A Preparation to the Earthquake Disaster of the Metropolitan Area

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Abstract— **It has been pointed out that when people lack the information needed in the event of a disaster, such as a disastrous earthquake, this could lead to social chaos, including unwanted rumors and outrages, or could disrupt rescue and relief activities. In Japan, by law in principle, self-help or mutual assistance is required immediately after a disaster, and local residents are required to make judgments for action on their own. In our prior study, we established and evaluated a service infrastructure with an autonomous wireless network, aiming at providing services to collect and deliver disaster information, which will be required by local residents. The system consists of many small 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. In this study, we improved and extended the system so that it may meet more nearly actually.**

Keywords-earthquake; disaster victims; distributed autonomous system; wireless network

I. INTRODUCTION

In the event of a disaster, such as a disastrous earthquake, information provision is effective in preventing chaos at the scene. Therefore, timely and accurate information collection and delivery services are essential [3][4].

In Japan, by law in principle, self-help or mutual assistance is required immediately after a disaster, and local residents are required to make judgments for action on their own. Although disaster information systems are gradually being organized at the municipal level, actual emergency evacuation areas and essential information for local citizens are still not sufficiently ready for provision at this stage [5]. These services allow prompt rescue and relief activities and appropriate information delivery to local residents. Thus, it is urgent to establish a system to enable these services. The systems proposed so far are ones with Internet or mobile phone connections or with ad-hoc wireless LAN networks [6][7]. We call such systems communication channel dependent systems, which require communication channels or establish communication channels between clients and servers via an ad-hoc network. From the perspective of an information service, such systems that accumulate information in PDAs and send it via an ad-hoc network when a communication channel is established are also regarded as communication channel dependent systems.

There are two issues of concern regarding this system: 1) the system is not available until a communication channel is established, and 2) as users access the server to gain information, the intense access may lower server performance or cause communication channel congestion. In prior study, we would like to propose an approach to resolve these issues. As it is difficult to generalize the situations of earthquake disasters, we set the following assumptions: (a) assuming a strong earthquake of approximate magnitude 7 in a residential area, (b) all the lifelines including electricity and communication channels stopped functioning, (c) lines for land phones and mobiles are congested and not working, and (d) the proposed system (hereafter called “the system”) can be preliminarily placed.

II. METHOD

In order to resolve the above issues, we placed servers, which store information, closed to users in prior study [1][2]. By doing this, the system can run without a communication channel established, and the service can be continuously provided even with a narrow bandwidth. Since disaster information system users, such as local residents, shelter authorities, rescue and relief crews, and municipal employees are diverse and geographically dispersed, multiple servers are required to meet the condition in which servers must be placed close to users. Each server must hold information and be synchronized with each other. Also, they must independently run, communicate with each other, and dynamically detect others in case some are damaged in a disaster.

The service infrastructure consists of many small sub-systems. Each of these systems independently provides information collection and delivery services. Also, these sub-systems can autonomously work together with other sub-systems to exchange information. By appropriately allocating sub-systems within a region, regional information is continuously shared, which can solve the issue of information shortages in a disaster. We adopted general

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consumer hardware products that are supposed to work approximately 72 hours with batteries. Though each hardware product itself is not robust, they are all independent so even if some of them are damaged, they do not affect others. Also, as it is allowed to dynamically add sub-systems, damaged ones can be easily replaced to immediately recover the entire service.

The network configuration of this system is illustrated in Figure 1. The system is formed by a group of small servers (hereafter called nodes) with server abilities and dynamic communication functions. Each node can function as a web server and allows clients (e.g. PCs and PDA) to connect to register or browse information. Nodes also detect others within the communication range to synchronize information. With these functions, the system can still work as an integrated unit even when part of the hardware is damaged in a disaster. Figure 2 illustrates the hardware configuration of the nodes. We selected only devices that can function approximately 72 hours with either dry-cell or rechargeable batteries. In addition, dedicated PCs can be equipped with server functions for information entries. This means that users can initiate the registration of information even if no communication channels are established.

However, in previous studies, there were still some issues such as:

a) The synchronization of the information was often delayed,

b) The distance between nodes with a vertical interval which can be communicated is short.

This study improves the following points:

a) Improvement of the node detection logic and the information synchronizing logic,

b) Using two types (vertical no directivity and horizontal directivity, wide directivity) of anntena in order to be fit to our target area.

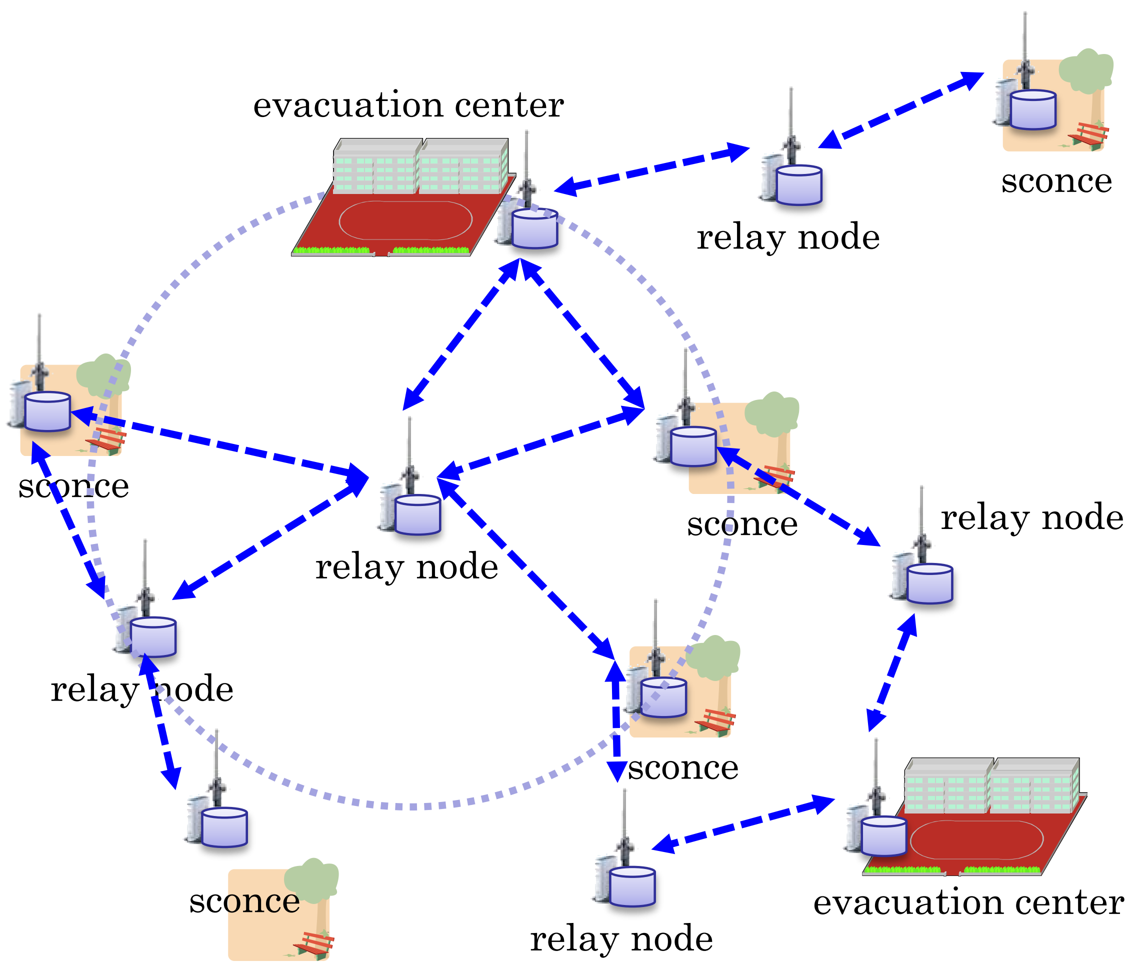

Figure 1 Whole image of the system: all nodes search another sub system, and then they communicate to each other in order to exchange information they had.

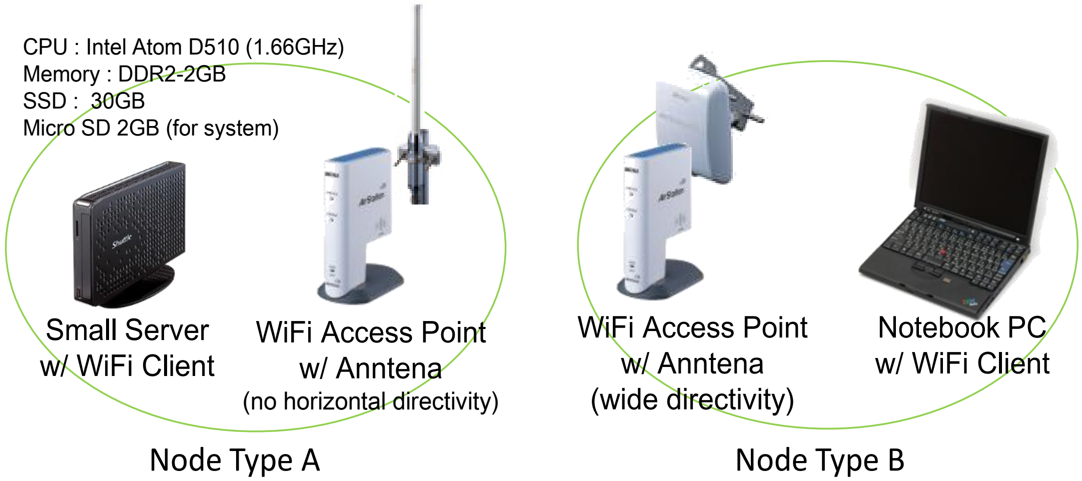

Figure 2 Elements of the nodes

III. RESULT

By the first improvement, the delay in the synchronization of the information was decreased.

A. Node Detection Method

Each node executes the following procedures by a timer process in every minute.

1. The node scans APs (: Access Points) in range, and makes a list of available APs. Then the node selects a suitable AP (: Access Point) using an ESSID filter pattern and the connection history list.
2. The node connects to the selected AP. Then a server connected to the AP via Ethernet, gives IP address to the Wi-Fi client of the node (Figure 3).
3. The node calculates the IP address of the server from the given address of Wi-Fi client. Then the node executes synchronization program with the server.
4. The node disconnects from the AP, after the synchronization program finished.

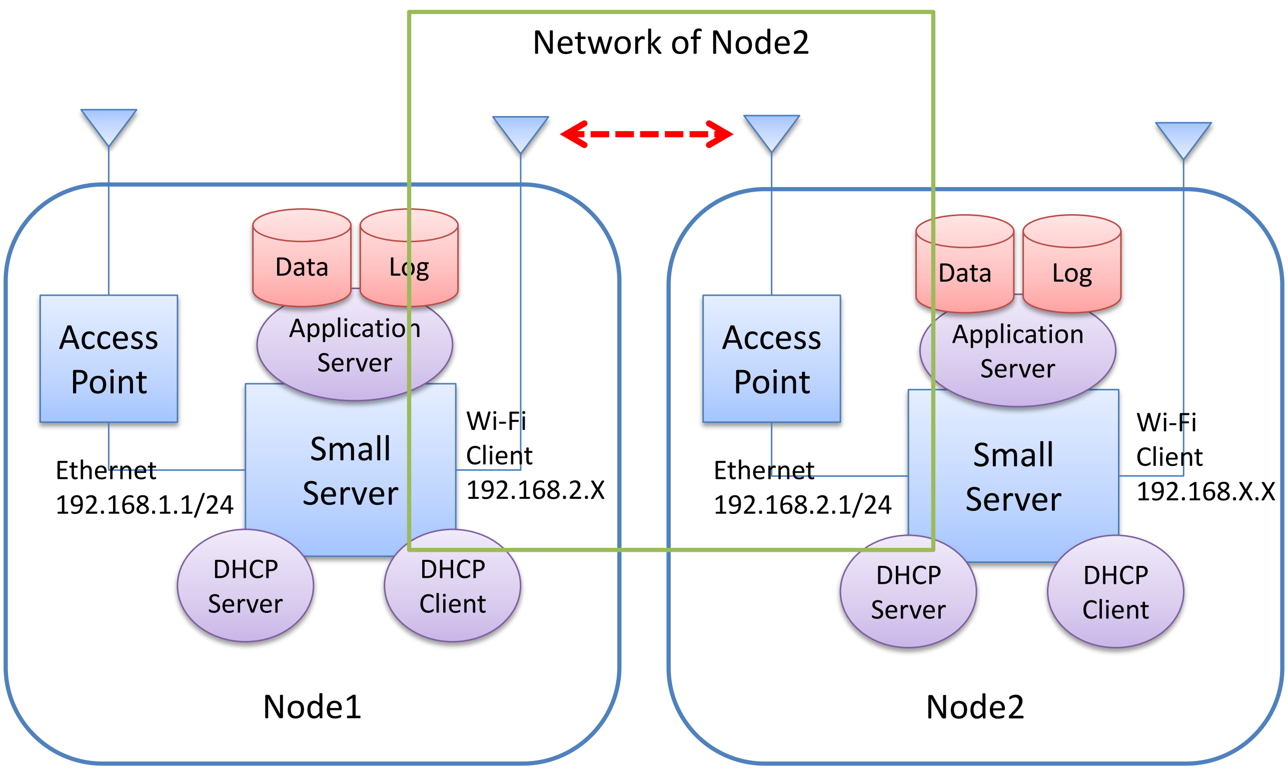

Figure 3 Network between the nodes

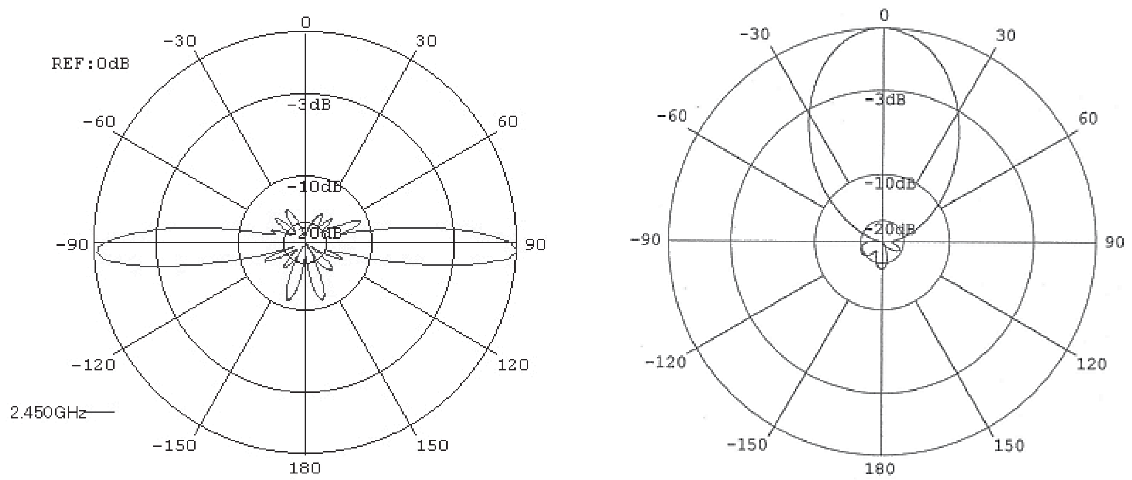

Figure 4 Vertical no directivity and horizontal directivity, wide directivity

B. Data Synchronization Method

Applications on the server such as registration of someone's safety, update the database table using special driver. The driver updates both of data and log tables. The log table contains node id, sequence number, operation type (create/update/delete), table name, update time and the data. Synchronization process is a client server model. The client makes list of the holding data as array of the range of the sequence numbers and the node name. Then the client sends the list to the server. The server finds and sends back the data that the client doesn't have. The server executes same process as the client, if the list sent by the client contains entries the server doesn't hold. While this process is executing, the client becomes a server.

By the second improvement, the system will become the form of being suitable for use in actual evacuation areas. Moreover, in a simulation, it carries out as a result for the layout planning of nodes, by using three-dimensional (instead of two-dimensional) geography data and taking the characteristic of antennas (Figure 4) into consideration.

IV. CONCLUSION

By those improvements, the system will be more practical. At present, the functions are well working in the field. However, only four nodes were evaluated at actual evacuation area. In order to deploy the system for real disaster, evaluations are needed with more nodes at wider actual evacuation area.

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