WLAN | Position Information | Presence

Technology Reports

Indoor Presence System Using Wireless LAN

NTT DoCoMo has developed an indoor presence system using mobile terminals with a wireless LAN module to estimate user position and permit the reference and use of position information between users. The efficacy of this system has been proven in a field test.

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1. Introduction

An increasing number of companies are introducing a new style of office where employees have no specifically assigned desks (hereinafter referred to as the 'non-territorial office'). In such offices, it is sometimes difficult to know where one's colleagues and superiors are, and this adversely affects the efficiency of the office due to the difficulty of smooth communication in the workplace.

A presence system that makes presence information (position and status) (hereinafter referred to as 'presence') available has been developed as a solution to this issue. A variety of presence services such as presence monitoring, the provision of methods of contact in response to presence, and reminders in response to changes in presence are possible as a means of improving of work and communications efficiency within the office (**Figure 1**). Position information is the key component of presence provided by these services, and implementing a system using low-cost and highly accurate estimation of position is important within the context of operating a business.

This article describes a method of area estimation indoors using mobile terminals with a wireless LAN developed for low-cost, highly accurate estimations of area, and a Wireless LAN Presence System (WPS) developed using this technology. It also describes the overview and result of an experiment with the WPS conducted within the offices of a corporate user.

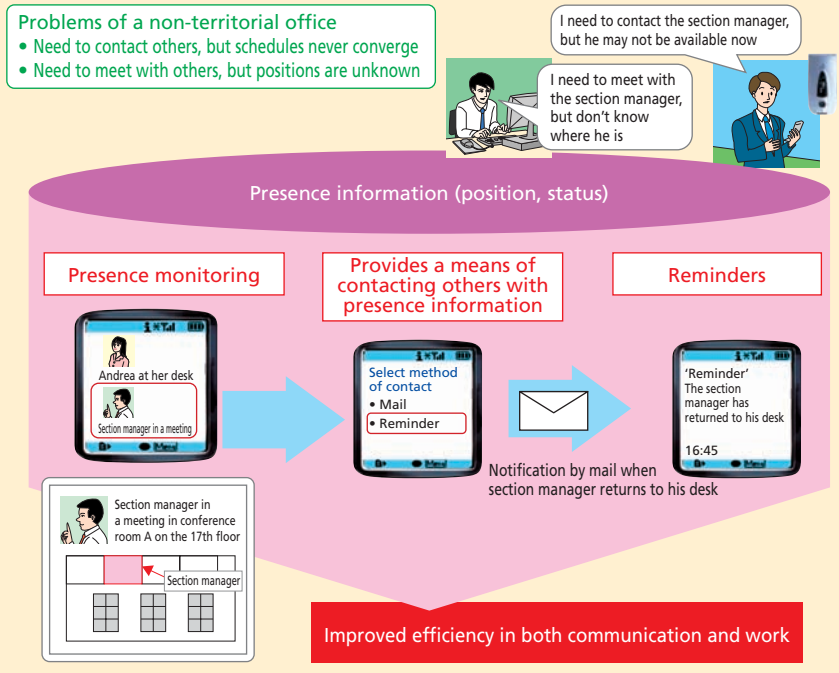

Figure 1 Presence service usage

2. Area Estimation Using Mobile Terminals with a Wireless LAN Module

2.1 Conventional Methods of Position Detection

Various methods of position detection indoors have been proposed, including the use of Radio Frequency IDentification (RFID)[*1] tags and ultrasonic sensors. All such methods require the installation of many dedicated devices along with their high introductory costs, however, and are therefore problematic from the business point of view. On the other hand, there is widespread use of wireless LANs today with Voice over IP (VoIP)[*2] commonly available on mobile terminals through a wireless LAN. In terms of business, implementing a position detection system using wireless LAN-enabled mobile terminals therefore offers great potential.

Conventional wireless LAN-based systems detect position by measuring the signal strength of beacons[*3] from multiple wireless LAN Access Points (APs) with mobile terminals and using a statistical model of reception level [1], or by triangulation using the difference in arrival times of signals at multiple APs from a mobile terminal [2]. These methods respectively require a system to learn the positions of many points beforehand in order to construct the statistical model, the use of dedicated hardware for measuring differential arrival times, and the installation of dedicated software on the mobile terminals. Consequently, implementing such a detection function is no simple matter.

Since these methods use the signal attenuation characteristics and differential arrival times between APs and mobile terminals separated by a distance from a few meters to little over ten meters, both are readily susceptible to noise and changes in the office environment, such as the movement of personnel and equipment.

2.2 Proposed Method

Presence services provided within offices do not necessarily require user position in terms of two-dimensional coordinates, and it is possible to provide a service knowing only the position within specific areas such as a conference room or individual desks. The proposed method requires the installation of equipment (hereinafter referred to as 'positioning units') used for measuring the reception level of signals directly emitted by mobile terminals within the area where presence or absence of the user is to be detected. By detecting user position (within about three meters of these positioning units), the distance from the mobile terminal to the nearest positioning unit is short, and the difference in signal reception level between the nearest positioning unit and other positioning units are greater than with conventional methods. Therefore, it is possible to estimate the area with high accuracy without using a previously learned statistical model, even if the reception level varies over time. Furthermore, it is possible to install software used in detecting area on the office PCs at each desk. By connecting these PCs with wireless LAN adapters, the PCs can be readily adopted as positioning units. The use of such positioning units affords an area estimation system without having to add the hardware as a positioning unit.

Figure 2 shows the proposed method. To estimate the user's position,

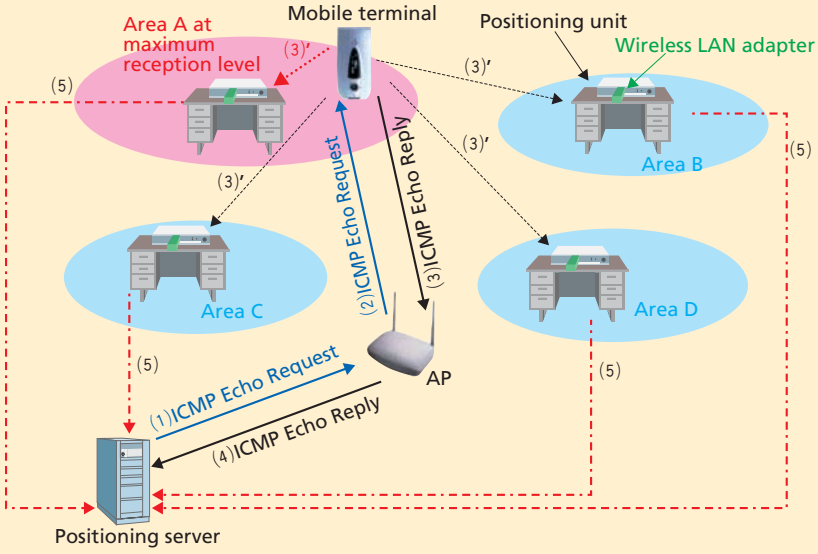

Figure 2 Proposed area estimation method

*1 **RFID**: A system for recognizing and managing persons and objects using a wireless LAN by acquiring ID information from a small IC chip storing ID information.

*2 **VoIP**: A technology for converting voice into packets and the real-time transmission on an IP network using normal circuit switching.

*3 **Beacon**: Synchronized packet data sent at fixed intervals from an access point on a wireless LAN. Notifies the existence of an access point and the presence or absence of data to wireless LAN terminals within the range that the data is sent to.

the positioning server periodically sends an Internet Control Message Protocol (ICMP) Echo Request[*4] to the target mobile terminal via the AP (Fig. 2 (1), (2)), and the mobile terminal similarly returns an ICMP Echo Reply[*4] to the positioning server via the AP (Fig. 2 (3), (4)). The wireless LAN adapter fitted to the positioning units in the vicinity also receives the ICMP Echo Reply returned by the mobile terminal (Fig. 2 (3)′). The reception level of the signal measured at a wireless LAN adapter is sent from the positioning unit to the positioning server (Fig. 2 (5)). The positioning server then estimates the area of the mobile terminal by determining the highest reception level. Since this method requires no dedicated application running on the mobile terminal, it offers the advantage of low power consumption by the mobile terminal. Measurements of the N900iL using a Delivery Traffic Indication Message (DTIM) interval[*5] of 10 have shown that a continuous wait time of at least three days is possible even with continuous transmission of the ICMP Echo Reply at one-second intervals. Furthermore, simulations of the effect of the ICMP Echo Request/Reply sent on the VoIP communications band for area estimation have shown band occupancy of only a few percent, even when area is estimated at two-second intervals with 20 mobile terminals connected to one AP.

3. WPS

A WPS was developed to provide an office presence services using the wireless LAN-based method described in Section 2.2. **Figure 3** shows the configuration of the WPS. The WPS consists of a positioning server providing area estimation capability, APs, mobile terminals (FOMA N900iL, N902iL) with a wireless LAN, a positioning unit with a wireless LAN adapter, a presence server running the application functions, the client mobile terminals using the service, and a PC. The period during which the positioning server sends ICMP Echo Requests to each mobile terminal may be varied dynamically according to the user, presence area, and duration in an area. For example, users who are relatively stationary and those in conference rooms are assumed not to move for a while, and the period during which ICMP Echo Requests are sent may be extended to reduce the demand on the wireless LAN band. Positioning units set in the various areas may be connected to multiple wireless LAN adapters via extension cables. Thus, area

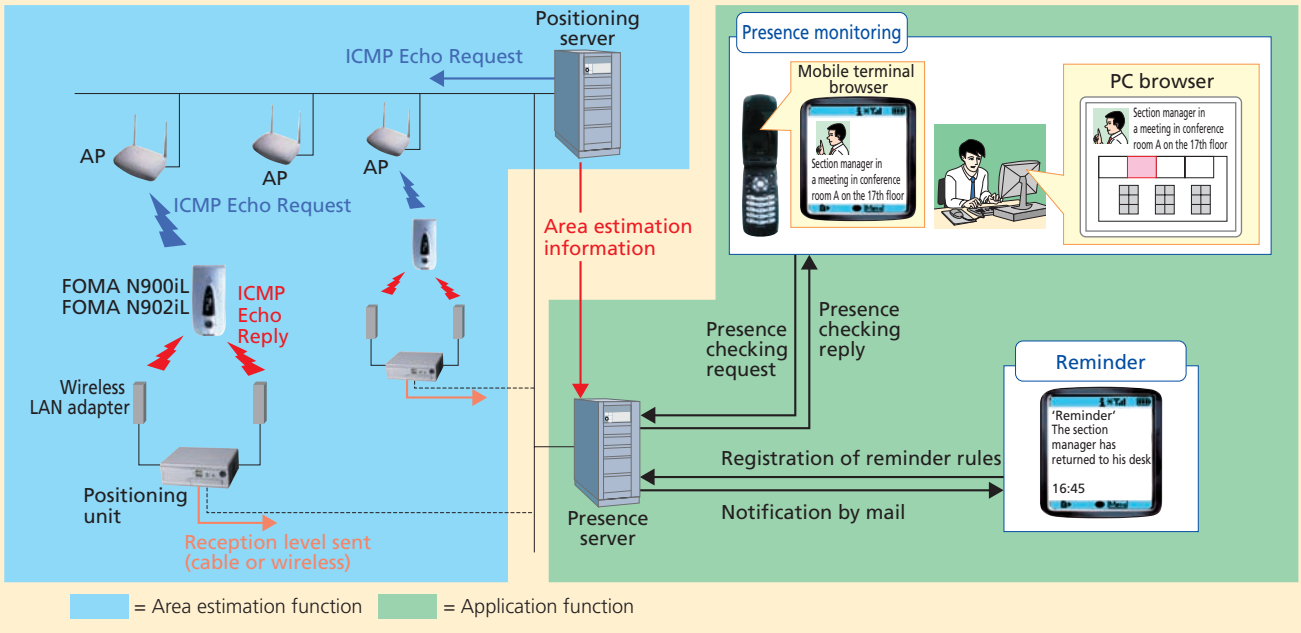

Figure 3 WPS configuration

*4 **ICMP Echo****: A type of protocol for verifying communication on a network, and implemented as the Ping command. When an ICMP Echo Request is sent, the receiving device returns an ICMP Echo Reply to the originating address.

*5 **DTIM interval**: DTIM is a message included in a beacon providing notification to a wireless client waiting in power saving mode for packet transmission. When "3" is set, for example, the beacon including the DTIM is sent once every three transmissions.

estimation at multiple points may be done using a single positioning unit, thereby reducing the introductory costs for the system. The results of measurement by the positioning unit with each wireless LAN adapter are sent to the positioning server by cable or wireless (IEEE 802.11a/b/g*6) for comparing the results collected to detect the area where each mobile terminal is located.

The presence server provides presence monitoring and reminder services. The presence monitoring service returns a result in response to a presence checking request sent from a PC or mobile terminal. For example, when a specific user is selected for a presence checking request, the user position appears on a map displayed on the PC, and by area name on the mobile terminal. Moreover, by designating a specific area, such as a conference room, it is also possible to show the users present at that position. The reminder service provides reminders (mail notifications) to users when a particular user enters or leaves a specific area. To use the reminder service, the user sets a reminder rule on the mobile terminal or PC. This function may be used to provide notification such as, 'The section manager has returned to his desk.'

4. Field Test

A WPS was installed in the offices of a corporate user as a field test to evaluate the system's performance and usability.

4.1 Experimental Conditions

The field test was conducted on a single floor of the office building, and required 30 users to carry N900iL mobile terminals. **Figure 4** shows part of the test area. Areas were classified as conference rooms, areas where employees are assigned a specific desk ('territorial area'), and areas where employees can freely choose their desks ('non-territorial area').

The positioning units were set under the employees' desks and the wireless LAN adapter connected to the positioning unit was mounted on or under the desktop. **Table 1** shows the other conditions pertaining to this experiment.

4.2 Experimental Results

1) Area Estimation Accuracy

The area estimation accuracy was evaluated for conference rooms, territorial areas, and non-territorial areas. Each subject carried two mobile terminals (one in the breast pocket and one in a trouser pocket), and the proportion of area estimation accuracy when the subjects were seated in Positions P_1 to P_5 (see Fig. 4) was evaluated. **Figure 5** shows the results. Since the conference rooms are closed spaces divided by glass partitions, no misrecognition of area occurred at positions P_1 and P_2. The same was true at position P_3 in the territorial areas due to the position of a wireless LAN adapter directly in

Table 1 Experimental conditions

Experiment period	January 24 to February 9, 2007
Number of users	30
Size of experiment area	One floor (3,527.68 m^2)
Mobile terminal used	FOMA N900iL
Number of positioning units	30
Number of wireless LAN adapters (for packet capture)	64 (maximum of three per positioning unit)
Communication between positioning units and positioning server	IEEE 802.11a (W53)
Area estimation period	Equivalent of two-second interval (sent twice at one-second intervals for four seconds)

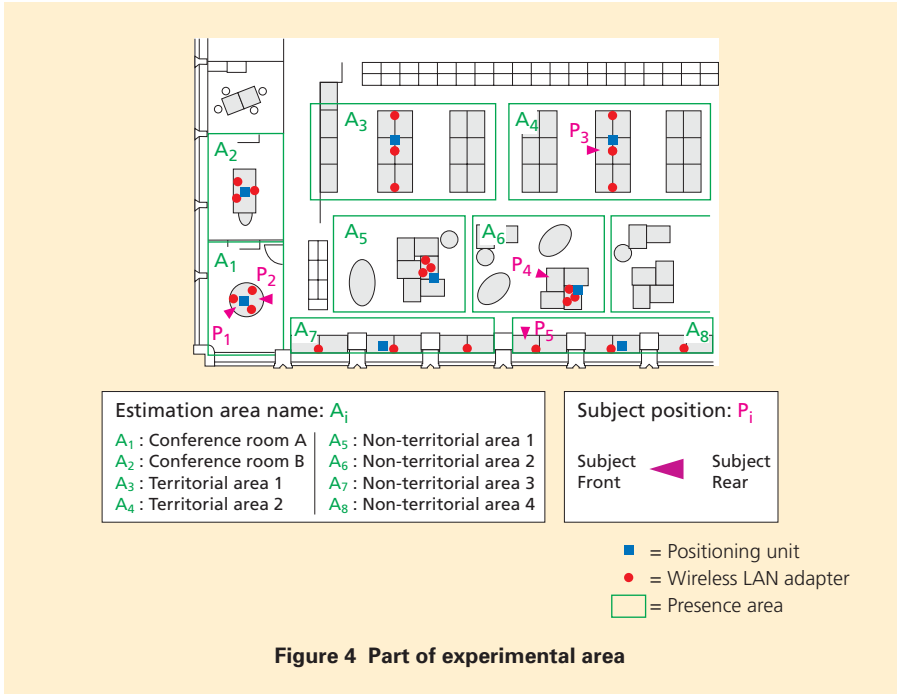

Figure 4 Part of experimental area

*6 **IEEE 802.11a/b/g**: A standard for wireless LANs defined by IEEE. Classified as 802.11a, 802.11b, or 802.11g according to the wireless band used, modulation method, communications speed, etc. 802.11b specifies a maximum transmission speed of 11 Mbit/s in the 2.4 GHz band through the use of Complementary Code Keying (CCK).

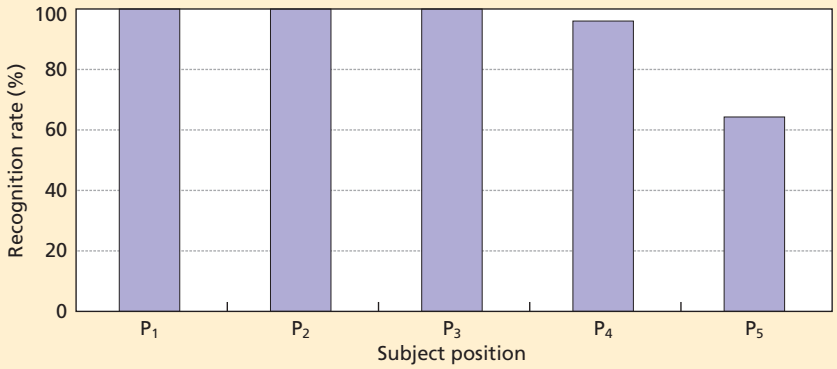

Figure 5 Area estimation accuracy

front of the subjects. On the other hand, at positions P_4 and P_5 in the non-territorial areas, wireless LAN adapters for other areas were closer to the seating positions of subjects than in the conference rooms and territorial areas, and variations in reception level and changes in sitting posture, etc., occurred over time, resulting in recognition rates of 96% and 64% at P_4 and P_5, respectively. In all cases, misrecognition resulted in recognition of the adjacent area and therefore did not have a major effect on providing the presence service. However, the parameter settings for more stable area estimation and other methods of installing wireless LAN adapters must still be investigated.

2) Band Occupancy with Position Detection

Occupancy of the IEEE 802.11b band used for the ICMP Echo Request/Reply packets sent and received for area estimation was measured and evaluated. Two mobile terminals were used for this measurement, with ICMP Echo Requests sent twice to each mobile terminal at one-second intervals over a period of four seconds (equivalent to a period of two seconds) for measuring occupancy. Throughput in the IEEE 802.11b band was measured at 4.5 Mbit/s and band occupancy was calculated based on that value. **Table 2** shows the results.

Up to 15 mobile terminals are assumed connected to a single AP in a typical VoIP communications environment. On this basis, the maximum band occupancy using this method is only 0.12% during a measurement period of about two seconds, thus verifying that VoIP communication is only minimally affected.

3) User Questionnaire

A questionnaire relating to system usability and changes required to ensure commercial service was distributed among the employees upon completion of the experiment, and 24 valid replies were subsequently received.

In response to questions about the presence monitoring service, 68% of replies were affirmative regarding 'reduces the need to look for other employees' and 'no need to manually enter one's own presence.' In contrast, 62% of replies were negative in response to questions about the reminder service regarding 'don't have much opportunity to use the service' and 'I feel like I'm being watched.' Such results are attributed to the short duration of the experiment and complexity of setting the reminder rules, both of which resulted in very little use of the service and subjects not being convinced of its utility. Further improvements and verification of the system are scheduled.

Table 2 Band occupancy with area estimation

	Band occupancy (%)
Average value	0.08
Maximum value	0.12
Minimum value	0.02

With regard to changes required to ensure commercial service, comments were received concerning 'embedding the positioning unit in a desk,' 'creating a more sophisticated positioning unit design,' and 'presenting WPS not as a system, but as a tool to change a work place and work style.' These points will be investigated in the process of improving commercial service.

5. Conclusion

This article described a method of area estimation indoors using mobile terminals with a wireless LAN, the overview of WPS, a presence system using this method, and the results of an experiment being conducted at the offices of a corporate user. The experiment conducted using this system verified that the desired accu-

racy is achievable in an actual office environment, and that the presence system was useful. Future experiments will be conducted in order to investigate solutions that utilize the position information in offices and to develop a commercial system within a short period. Studies regarding acquisition of status of a mobile terminal (e.g. busy) via Session Initiation Protocol (SIP) server[*7] and Groupware[*8], as well as synchronization of the scheduler function and presence information are also scheduled.

REFERENCES

[1] Ekahau: http://www.ekahau.com/
[2] AirLocation™: http://www.hitachi.co.jp/wirelessinfo/airlocation/

*7 **SIP server**: SIP is a protocol used for the conversion of audio into IP packets, and real-time transmission. The SIP server is used to register clients conducting voice calls and manage such statuses as session establishment and termination between clients.

*8 **Groupware**: Systems and software shared between employees in corporate network, and such supporting functions as a scheduler, electronic bulletin board, conference room reservation, and settlement of accounts.