RFID-based Automatic Area Detection System

Masamitsu Nakura†, *Junichi Iwatani, Hiroki Shibayama, and Hideaki Kimata*

Abstract

NTT Access Network Service Systems Laboratories is developing automatic area detection systems and wireless local area network (WLAN) middleware that improve the usability of WLAN systems to promote WLAN services. This article describes a recently developed automatic area detection system based on radio frequency identification (RFID).

1. Introduction

Public wireless local area network (WLAN) services have rapidly become popular because many users use WLAN systems at home and in the office. Though the hot spots for WLAN services have increased, the areas are limited because they are spot-based, unlike cellular phone services which are available almost everywhere. Therefore, when using WLAN services, a user must go through the following steps: make sure that he/she is within the service area, power on the terminal, activate the application software, download content, and then power off the terminal. All of these procedures should be done step by step by hand. To simplify this complicated process, we have developed an automatic area detection system based on radio frequency identification (RFID). Users need not recognize the service areas, and all steps are done automatically by the system.

2. System outline

The system uses a combination of RFID and WLAN technology (**Fig. 1**). It consists of RFID tags, RFID readers, and WLAN middleware installed in a personal digital assistant (PDA). It is targeted at the users of public WLAN services. RFID tags, which transmit ID signals intermittently, are installed at the boundary of each WLAN spot area. An RFID reader is connected to a PDA that has WLAN middleware installed. When a user enters a WLAN spot area, the RFID reader detects the signal from the RFID tag and powers on the PDA. When the WLAN middleware detects that the PDA is active, it establishes a connection to the network via the WLAN, activates applications, and finally powers off the PDA. Thus, the user only needs to carry the PDA with its power off. When the user enters the spot area, everything is

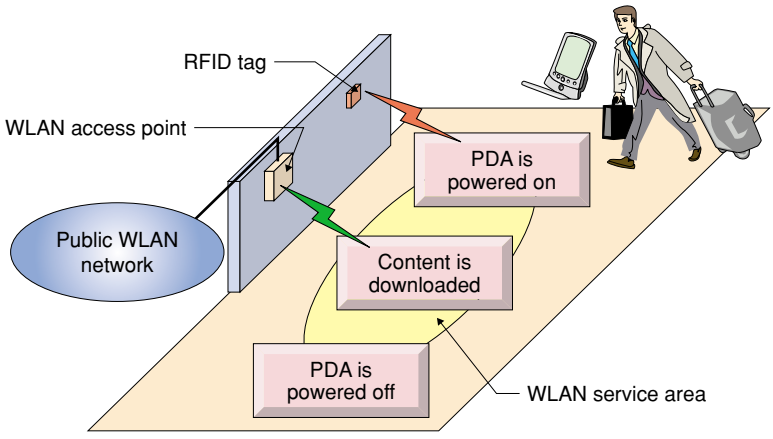

Fig. 1. Outline of RFID-based area detection system.

† NTT Access Network Service Systems Laboratories
Yokosuka-shi, 239-0847 Japan
E-mail: Nakura.Masamitsu@ansl.ntt.co.jp

done automatically. This improves convenience and reduces power consumption.

3. System specifications

This section describes the specifications and functions of the RFID tag, RFID reader, and WLAN middleware (**Tables 1** and **2**; **Figs. 2** and **3**).

The RFID tag is a license-exempt radio device that transmits weak signals in the 315-MHz band. The transmission range is about 10 m. The ID length for RFID is up to 128 bits. The administrator can change the ID to support different public WLAN services. We have also developed various types of power supply for RFID tags because they may be used at various places. They support AC power, primary batteries, and solar batteries.

The RFID reader should be designed with careful regard to its robustness and shape because it should be attached to a PDA. The RFID reader we have developed is designed for the Pocket PC e830 series from Toshiba Corporation. The power supply for the RFID reader is a secondary battery, which enables both the RFID reader and the PDA to be recharged at the same time. The ID information of RFID tags is registered in the RFID readers in advance. When it receives a signal from the RFID tag, the RFID reader compares the received ID with the registered one. Only if these IDs coincide does the RFID reader power on the PDA. This reduces the PDA's battery consumption because the PDA is powered on only when necessary.

To extend the life of the primary battery of the RFID tags and the secondary battery of the RFID reader more efficiently, we made it possible to change the transmission intervals of the RFID tags and the reception intervals of the RFID readers. Assuming that the system is used in railway stations and that the users carry PDAs and walk within the stations, the battery life of the primary battery is about three months and that of the secondary battery is about one week. If AC power or solar power is used instead of the primary battery, the transmission intervals of the RFID tags can be shorten. This allows the reception interval of the RFID reader to be longer and the life of the secondary battery should be up to one month.

The WLAN middleware, which supports Pocket PC 2003 and Pocket PC 2003 Second Edition, has three functions: WLAN control, application control, and PDA power control.

Table 1. Specifications of RFID tag.

Radio I/F	Extremely lower power radio
Band	315 MHz
Modulation	FSK
Rate	9.6 kbit/s
Transmission	Intermittent
ID length	Max 128 bits
Power supply	• AC adapter • Primary battery • Solar battery

Table 2. Specifications of RFID reader.

PDA	e830(W) by Toshiba
Size	W80, D52, H23 (mm)
Weight	40 g (including battery)
Reception	Intermittent
LED	• Low battery warning • Recharging indicator
Power supply	Secondary battery (rechargeable with PDA)

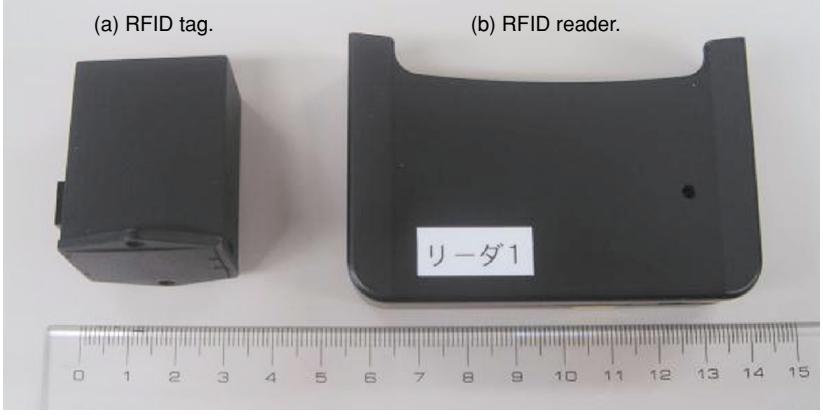

Fig. 2. RFID tag and RFID reader.

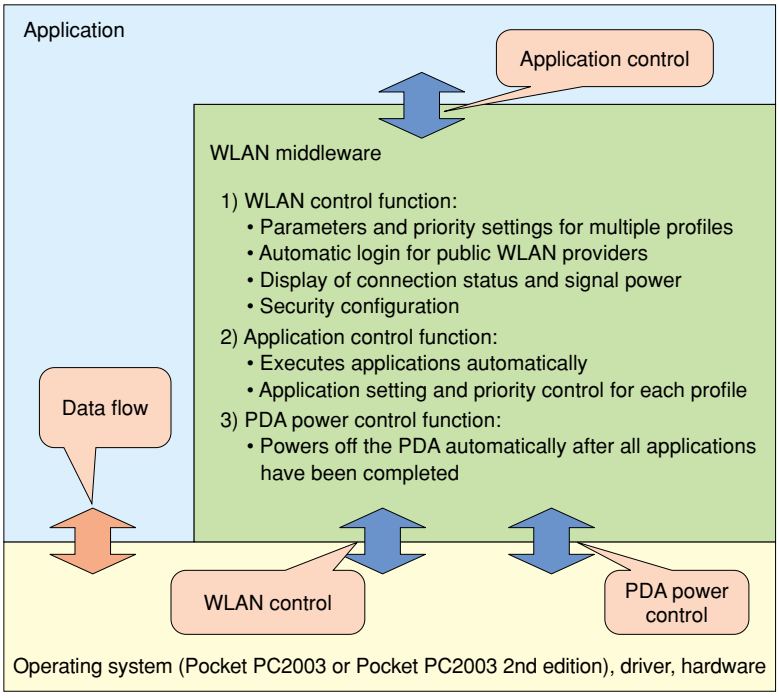

Fig. 3. Functions of WLAN middleware.

The WLAN control function is as follows. The user sets one or more WLAN profiles and their priorities. Basic WLAN utility functions include connection control, automatic authentication for public WLAN service providers, status indication, and security configuration. In addition, the WLAN middleware supports roaming between different WLAN service providers. For this function, two or more different sets of security information can be assigned to the same WLAN service provider. They are registered and used as different WLAN profiles.

The application control function works in the following way. For each WLAN profile, one or more applications are registered to be executed automatically. The priority and execution interval of each application is variable. This makes it possible for the user to receive e-mail and news continuously. In addition, if there are two or more access points near the user, the PDA tries to connect to an access point, execute applications, and change the connection to the other access point.

The PDA power control function powers off the PDA after all of the applications have been completed or the WLAN connection has been disconnected by the user leaving the area. This function conserves the PDA's battery.

The WLAN middleware is available even when it is used without the RFID tags and readers. In this case, the user should manually power on the PDA and then operate the WLAN middleware to establish wireless connections and execute applications. The details of this operation mode depend on the user's circumstances.

4. Examples

Some examples of system usage are shown in **Fig. 4**. We assumed that three WLAN profiles were registered in the WLAN middleware: one for a home network and two for public WLAN service providers (A and B). Their priorities are set in this order. The network information, authentication information, and applications are also registered.

When using the PDA at home, the user should power on the PDA by hand because no RFID tag is used at home. The WLAN middleware detects the access point at home and then connects to the WLAN network, executes applications, downloads content, and powers off the PDA automatically. If the PDA is already powered on, this automatic process is initiated by operating the WLAN middleware. After the automatic process, the user can browse the received content.

Next, when the user goes to work, he keeps his PDA in his bag with its power off. When he passes a ticket gate in a railway station that is within the service area

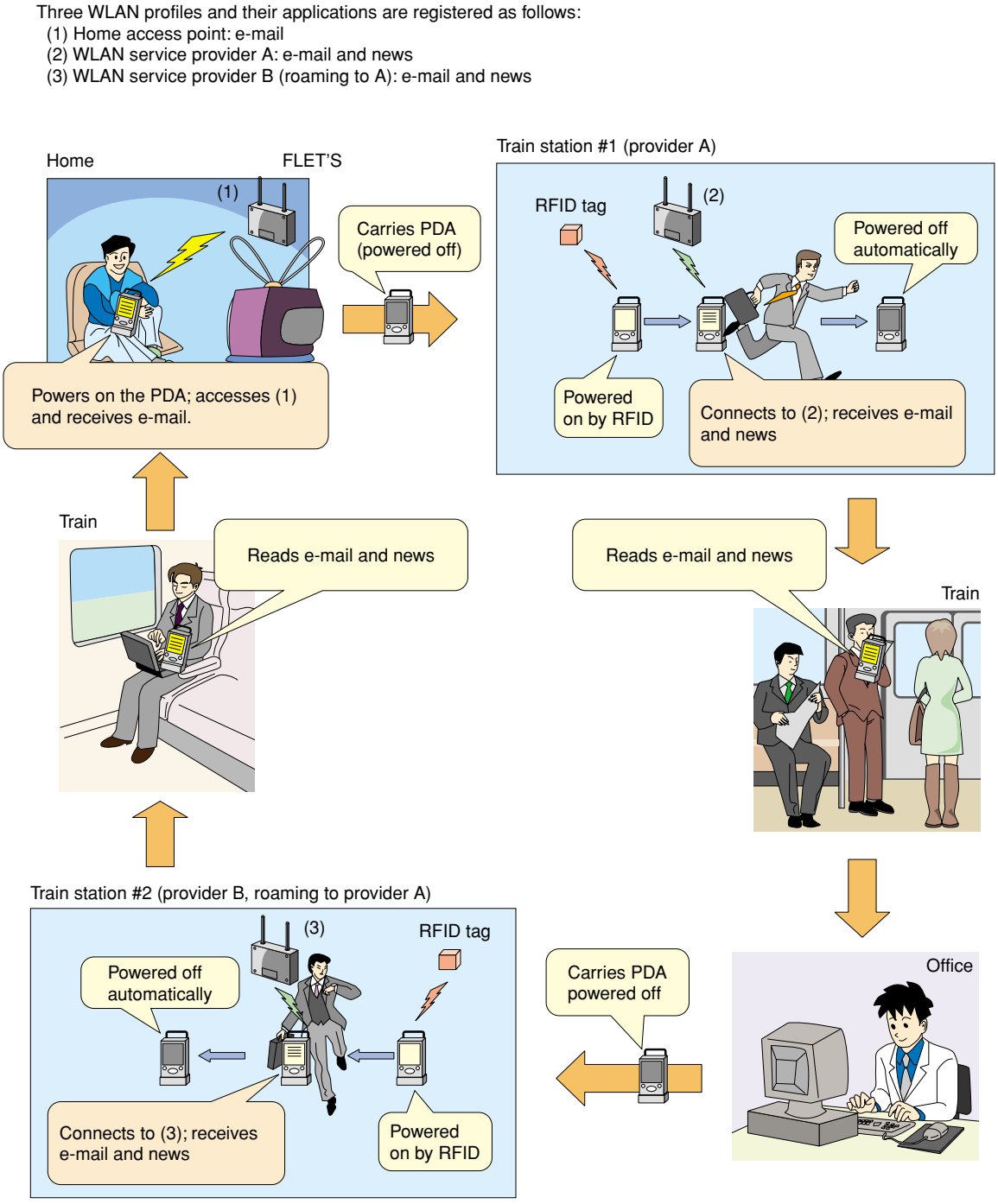

Fig. 4. Examples of RFID-based automatic area detection.

of the public WLAN service provider A, the RFID reader receives the signal from the RFID tag mounted near the ticket gate and powers on the PDA. When the WLAN middleware detects the PDA's activation, it automatically detects a WLAN access point of service provider A, establishes a connection to the WLAN network, executes applications, receives content, and powers off the PDA. The user can browse the content anytime on the train or at the office.

Next, when the user goes home and enters the service area of public WLAN service provider B, the RFID reader powers on the PDA in the same way as for service provider A. It detects an access point of service provider B and moves on to the automatic

execution part. In this case, the PDA can connect to the network of provider A via a roaming service while in the service area of provider B. To support this function, authentication information for roaming access to provider A is registered as a different WLAN profile than that for service provider B. In this way, the PDA can connect to the network of provider A via the roaming service within the service area of provider B and execute the applications for roaming access to provider A.

As described above, users can control WLAN connections and applications more flexibly for various environments and use WLAN services more easily than in existing services.

5. Future plans

To promote public WLAN services, we plan to carry out field trials on our system and evaluate its usability.

Masamitsu Nakura
Senior Research Engineer, Third Promotion Project, NTT Access Network Service Systems Laboratories, NTT Corporation.
He received the B.E. degree in electronic engineering from Tokyo Denki University in 1985. Since joining the NTT Electrical Communication Laboratories, Tokyo in 1985, he has been engaged in R&D of a network control scheme for satellite communication systems. Since 1995, he has been engaged in R&D of wireless access systems. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan.

Junichi Iwatani
Engineer, Third Promotion Project, NTT Access Network Service Systems Laboratories.
He received the B.E. and M.E. degrees in electronics engineering from the University of Tokyo in 1994 and 1996. He joined NTT Wireless Systems Laboratories in 1996. He has been engaged in R&D of high-speed WLAN systems, especially in the development of software for access points and network interfaces for HiperLAN2-based WLAN systems. He has also been engaged in a WLAN joint experiment in Scotland. His present research interests are in nomadic broadband wireless access systems. He is a member of IEICE.

Hiroki Shibayama
Engineer, Wireless Access Systems Project, NTT Access Network Service Systems Laboratories.
He received the B.E. and M.E. degrees in electrical engineering from the Science University of Tokyo in 1996 and 1998. In 1998, he joined NTT Wireless Systems Laboratories. He has been engaged in R&D of broadband wireless access systems. He received the Young Engineers Award from IEICE in 2005. He is a member of IEICE.

Hideaki Kimata
Senior Research Engineer, Third Promotion Project, NTT Access Network Service Systems Laboratories.
He received the B.E. degree in electronic engineering from Kitami Institute of Technology in 1987. He joined NTT Network Systems Development Center, Tokyo in 1988. Since then, he has been engaged in the development of satellite communication system and wireless access systems. Since 2001, he has focused on R&D of wireless access systems. He is a member of IEICE.