Collaboration Projects

Personal Area Networks Using Mobile Terminals

DoCoMo has been proposing mPAN, which is a network model that allows users to access various devices in their vicinity using mobile terminals while moving. We extracted various service scenarios where the mobile terminals and devices communicate directly with each other and investigated the main issues that must be resolved to implement the technologies supporting such scenarios, including address resolution and device selection methods as well as authentication and access control. This research was conducted jointly with the Mizuno laboratory (Professor Tadanori Mizuno), the Department of Computer Science, Faculty of Information, Shizuoka University.

Kiyoko Tanaka, Hideharu Suzuki and Norihiro Ishikawa

1. Introduction

The total number of mobile terminal subscribers has reached 88 million (as of the end of August, 2005) and it appears that the diffusion rate will soon reach 70%. Through the popularization of mobile Internet services including i-mode, various data communication forms spreading on the Internet, such as Website browsing and e-mail exchange, were made possible via mobile terminals as well. Moreover, with the introduction and diffusion of Third-Generation mobile communication system, not only has the network bandwidth become broader, but the availability of additional mobile terminal functions, including Infrared Data Association (IrDA), cameras and credit settlement ICs, has also become significantly advanced. New demands for direct communication with peripheral devices via mobile terminals to simplify operation of information appliances, printing of camera images and settlement processing at cash registers are rising.

Moreover, due to the progress of short-range wireless communication technologies such as Bluetooth™*1 and ZigBee,*2 the ubiquitous network environment that allows connecting to networks of omnipresent devices at all times has become a reality. Not all devices that are connected to public networks, however, a fair number of them are configured in local ad-hoc communication networks. As a communication form to make better use of such local devices, it can be considered that mobile terminal users establish communication with the devices using their mobile terminals while moving closer to the devices. If mobile terminals are equipped with short-range wireless communication functions, the roles of mobile terminals will be expanded to acting as gateways that can connect the devices to the Internet. Through such diversification of the communication means as well as growing availability of communication enabled devices, it can be expected that the usage applications of mobile terminals will expand.

As one of the methods to implement such communication environment, we propose a network model where a direct-link network is established between mobile terminals and surrounding devices, so that the devices can be operated and data can be communicated with other terminals by linking the local communication network and cellular networks covering the area. This article introduces the service framework of the network model we propose, and discusses the main technical issues.

2. Service Concept

A Personal Area Network (PAN) is a communication network in which a user connects directly to devices existing in a closed area within a short range (1 to 10 m) of the user using short-range wireless communication; such networks are typically used for the purpose of connecting between information appliances such as TVs and air conditioners. In general, it is assumed that the devices comprising a PAN are fixed. Conventionally, most operations of information appliances using existing mobile terminals are performed for the purpose

*1 Bluetooth™: A registered trademark of Bluetooth SIG, Inc. in the United States.

*2 ZigBee: Wireless communication standard being promoted as an international standard under the name IEEE802.15.4. Although the data transmission speed is low and the range is short, it has powerful advantages in terms of compactness, low cost and low power consumption.

of remote operation where the user is away from home, i.e., the user only uses the network to connect to and remotely operate the devices when necessary. On the other hand, if the user's mobile terminal is able to establish a PAN with the surrounding devices directly, it can use not only information and services available on the Internet, but also information and services only available locally at the places where the user is situated. In other words, the information and services that can be used with the mobile terminal can be expanded from those accessed via the Internet to those provided by devices right in front of the user.

Figure 1 shows examples of various service scenarios. Consider a situation where a user carries a mobile terminal with him/her and goes out for shopping. So far, the conventional approach to acquiring information about products one wishes to buy, special sales in stores, various coupons has been searching through sites on the Internet, scanning through newspaper advertisements beforehand. In the towns, however, there is a wide variety of information available such as posters, commercials projected on street displays, leaflets handed out on streets, calls at storefronts and many others. Such information is only available locally, but can be obtained by directly downloading the information to the user's mobile terminal via mobile Internet services, such as Websites and e-mails.

In cases where there are many customers shopping in a certain store or in a specific area with similar purposes, it is very likely that there is potentially valuable information that can only be obtained on that spot, such as opinions on the products right in front of customers and price information of other stores. If users can communicate such information directly to each other using mobile terminals, they can exchange word-of-mouth information, price comparison with other stores, coupons acquired elsewhere via mobile terminals.

It is even possible to envision a results-based reward advertisement model on the Internet by direct communication via mobile terminals, where users deliver word-of-mouth information and coupons via mobile terminals as they move. The advertisers will be able to gain easy exposure, while the users will be able to exchange information focusing on characteristics and interests of certain customer groups and areas, and obtain some form of reward in return.

Moreover, operation of surrounding devices, such as transmitting content from a mobile terminal to large displays and speakers nearby, can be considered. Multimedia content played on a mobile terminal can be enjoyed with a headset on a train or transmitted to a high-definition display and high-quality speakers at home; that is, the way information is used can be changed according to the users' purposes and immediate situation, as well as the types of devices available in a given setting. Alternatively, even those devices that are not connected to the Internet can, for example, use the cellular network of a mobile terminal to download the latest firmware and add new functions; thus, those operations that were only possible at specialty shops can be performed on the spot as necessary.

Requirements for realizing these services would be as follows:

1) Device Connectivity

Mechanisms where mobile terminals are able to recognize and connect easily to omnipresent devices are necessary, not only in the situations where users use devices on a daily basis,

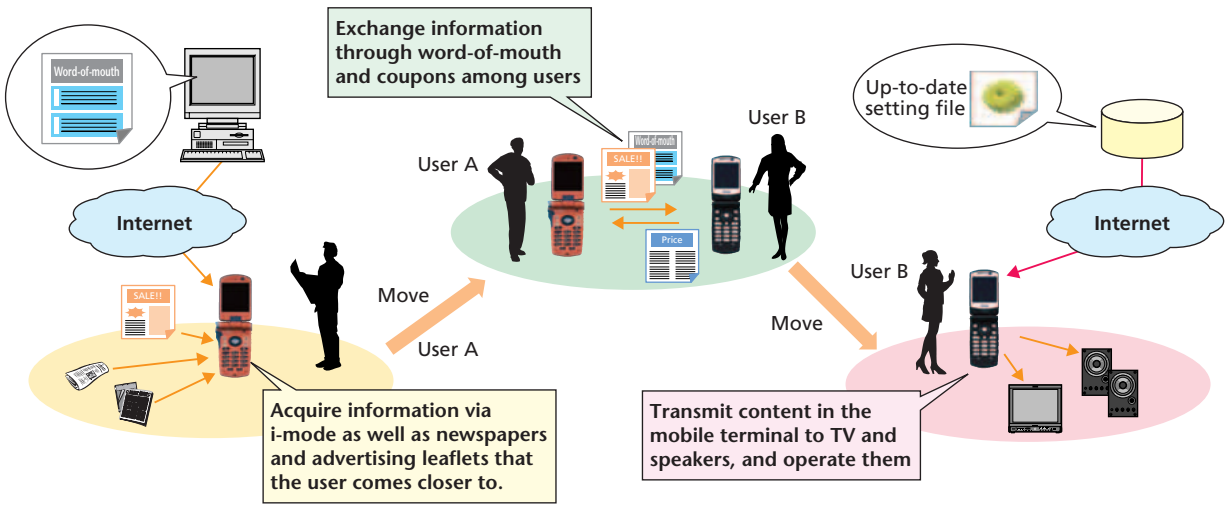

Figure 1 Service scenario examples

but also when users go some place and want to use devices there even though those devices are new to them. Moreover, mechanisms are required which allow users to readily select right devices to connect to even when there are many devices in the vicinity.

2) Personal Use of Devices

In order for users to be able to use various devices found in locations they visit according to their personal purposes, mechanisms that allow safe and secure communication processing are essential. Mechanisms for mutual authentication between a mobile terminal and a device are necessary to achieve a level of access control that allows connection and execution of services only for users with legitimate rights and for service providers to charge according to usage.

3) Device Operation

When operating heterogeneous devices found in various locations through a single mobile terminal acting as a common controller, mechanisms that are able to handle individual differences among devices, such as different functions, features and control interfaces, such as by sharing device control interfaces are required, so that applications can run flexibly without having to be aware of such differences. Moreover, achieving efficient services by handing over processing to devices with higher capability requires session control mechanisms, such as assigning applications run by a mobile terminal to appropriate devices.

3. Proposal of Mobile Personal Area Network

To achieve the service scenarios described above, we propose the mobile Personal Area Network (mPAN) model. The mPAN is a network model where a user uses omnipresent devices by means of a mobile Internet-capable terminal while moving. **Figure 2** shows an example of mPAN system configuration. In this example, a mobile terminal plays the role of control point for establishing PANs with devices, and provides the following functions.

The mobile terminal recognizes devices found in the vicinity of the user and assigns closed, local addresses to each of the devices located on the PAN to connect them to the mobile terminal. In the mPAN framework, the mobile terminal and omnipresent devices automatically construct a PAN as the user moves. In order to identify devices to be connected, not only Internet Protocol (IP) addresses and host names used on the Internet, but also actions taken by the user to select devices directly are considered.

The mobile terminal operates as a gateway linking the PAN and the cellular network, and provides functions for the devices to access the Internet through the communication interface of mobile terminal. The device communicates with an authentication server on the Internet via the mobile terminal to exchange security information including certificates.

As discussed above, by providing Internet access via a mobile terminal to local devices not connected to the Internet and other public networks, it allows authentication and access control between the mobile terminal and devices, device operation in coordination with content available on the Internet and information exchange with mobile terminals and devices comprising other PANs. Moreover, when exchanging data between devices that are far away from each other, session control facili-

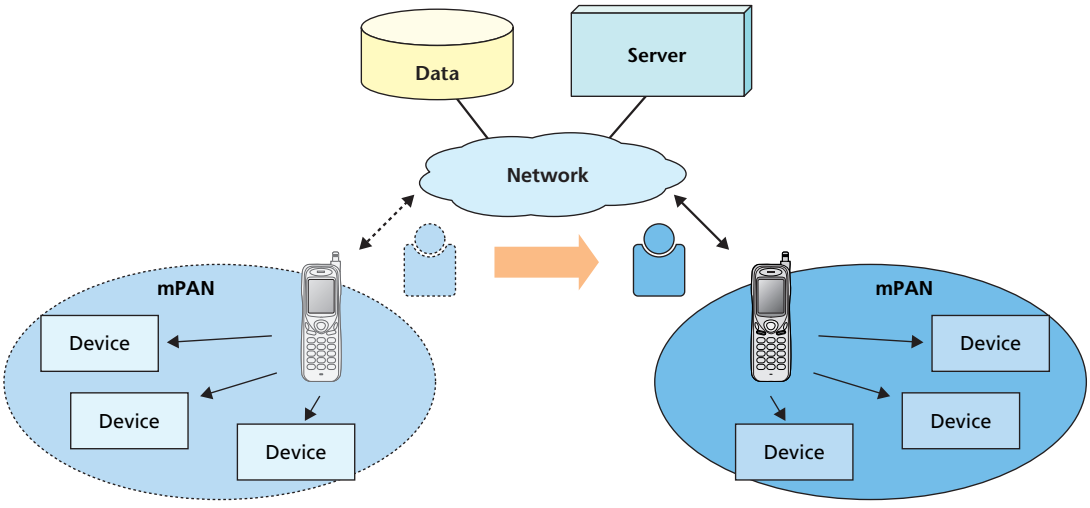

Figure 2 mPAN system configuration example

ties can be implemented so that data can be shared among multiple PANs.

4. Main Technical Issues and Approaches

This chapter describes the technical issues and approaches used to meet the function requirements to implement the services involved in the mPAN model explained before.

4.1 Address Resolution

In order for devices connected to a network to communicate with each other, each of them must have a unique identifier such as an IP address or a specific ID. In an Intranet, a Dynamic Host Configuration Protocol (DHCP) server or similar is typically used to assign addresses to devices. In the local environments where mPANs are assumed to operate, however, DHCP servers do not always exist; the mobile terminals and surrounding devices must collaborate to assign their addresses in the PANs. Moreover, in ad-hoc wireless network environments, two terminals may not be able to communicate directly because the range where each device can communicate is different, but they may be able to communicate with each other via another terminal located between them, a so-called hidden terminal; thus, it is also required to take hidden terminals into consideration and resolve potential address conflicts. Various methods for address assignment, such as Internet Protocol version 6 (IPv6) Stateless Address Autoconfiguration, AutoIP, MANETconf [1] can be considered, but they still pose issues in terms of usability with the current Internet and low efficiency that must be taken care of. We are currently examining protocols for detecting address conflicts.

4.2 Device Selection

In conventional communication, it is necessary to obtain information related to identifiers of the connection target, such as IP address and host name, before starting communication. Such methods are difficult to apply to the mPAN model, however, since it is characterized by dynamic configuration of a PAN on an on-demand basis. Moreover, unlike connection with WWW servers on the Internet, the mPAN has the characteristic that it allows selective connection to a certain device in the vicinity of a user; a new device specification method is required for the users to operate intuitively. We are currently examining a mechanism where identifiers required for communication between a terminal and a device are acquired automatically based on selection operations performed directly by users, such as pointing at or touching the device, before starting communication.

4.3 Authentication/Access Control

Since the mPAN is configured in an ad-hoc manner, it is necessary to check that the devices constituting the network should allow access from a mobile terminal and that the mobile terminal belongs to a legitimate user of the devices; mutual authentication and access control are thus important issues. Access control is performed by referencing an Access Control List (ACL) that defines a set of access regulations. It must be possible to update such ACLs, so that they may reflect access history data and be referenced from a wider area in which the user can be expected to move around. In order to achieve mutual authentication, a device must be able to connect to a public network to access the certification server that issues its certificate. As stated before, however, the majority of devices do not necessarily have communication interfaces with public networks and implementation of methods for devices to access the public networks is an issue that must be addressed. A realistic solution is to adopt a method where an authentication server that authenticates devices is set up on a local communication network, but since mobile terminals have communication interfaces to public networks, it would be more convenient in terms of private keys management of mobile terminals to place the authentication server on a public network. Further details are mentioned in [2], which describes various concepts for adopting hierarchical structures in certificate management functions in large-scale distributed systems. Since mobile terminals and devices with various characteristics co-exist in the mPAN as discussed above, we are examining schemes for network division and placement of authentication servers.

5. Conclusion

In this article, we proposed a network model that allows a user to construct a PAN around a mobile terminal linking to devices found in the vicinity at the locations to which the user moves, making it possible for the user to realize operation of the device collaborating local network and cellular network. This article also presented the service framework of the proposal and technical issues to be solved for the implementation. In the future, we intend to examine the details and protocols of the

proposed model and demonstrate/validate various service scenarios, as well as to propose new local communication services utilizing mobile terminals.

REFERENCES

[1] S. Nesargi and R. Prakash: "MANETconf: Configuration of Hosts in a Mobile Ad Hoc Network," IEEE INFOCOM (INFOCOM 2002), 2002.

[2] A. D. Birrell, B. W. Lampson, R. M. Needham and M. D. Schroeder: "A Global Authentication Service without Global Trust," Proc. IEEE Symposium on Security and Privacy, No. 716, pp. 223–230, Apr. 1986.

ABBREVIATIONS

ACL: Access Control List
DHCP: Dynamic Host Configuration Protocol
IP: Internet Protocol
IPv6: Internet Protocol version6
IrDA: Infrared Data Association
mPAN: mobile Personal Area Network
PAN: Personal Area Network