UBIQUITOUS NETWORKING SERVER

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Abstract

A ubiquitous networking server that enables cross-device as well as cross-network mobility with a location sensing system for context-aware seamless network services is introduced. The context includes the user's presence, position of the user and neighboring devices, network interfaces attached to the mobile terminal, availability and available bandwidth of each network, priority in selecting networks, capabilities of the mobile terminal and devices, and installed applications. By integrating these technologies into one packaged system, communication can be initiated in a style that the recipient prefers and connections can be seamlessly handed over from one network to another and from one terminal to another. The system allows users to enjoy communicating without being concerned about their positions and the availability and performance specifications of individual networks and neighboring devices.

1. Introduction

In order to create networking technologies that allow users to access the network without being aware of individual networks and devices, we had been developing three separate technologies for cross-network handovers [1], cross-device handovers [2], and a location-sensing platform [3]. Cross-network handover was enabled with a seamless networking platform called MIRAI [4] in which a MIRAI agent provides functions such as location update, paging, and handover management necessary in heterogeneous networks. Cross-device handover was provided by a service mobility proxy (SMP), which switches a connection from one device to another. The previous experimental system of cross-network handover was demonstrated at Ubicomp 2004 [1]. Then, we came to integrate those three technologies into one packaged system to provide users with context-based cross-network and cross-device mobility.

2. Design and Implementation

We integrated the server functions offered by the MIRAI agent and the SMP by logically reorganizing the software and adding new features to make one functional entity, creating a ubiquitous networking server. The client functions of the two systems were also integrated.

The ubiquitous networking server is designed to be placed at the entrance of a home or enterprise network (Fig. 1). A mobile phone and a mobile terminal comprise a PAN that moves outside and inside the local network. The PAN is always connected with the ubiquitous networking server through a basic access network (BAN), which is a favorable network selected by each user. The signaling path is shown as the green line, and 3G is used as the BAN. The ubiquitous networking server forwards packets to the PAN through a network, chosen for the position of the PAN, using

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the cross-network handover capability. It also forwards the packets to any device the user specifies, such as PCs and AV appliances, using the cross-device handover capability.

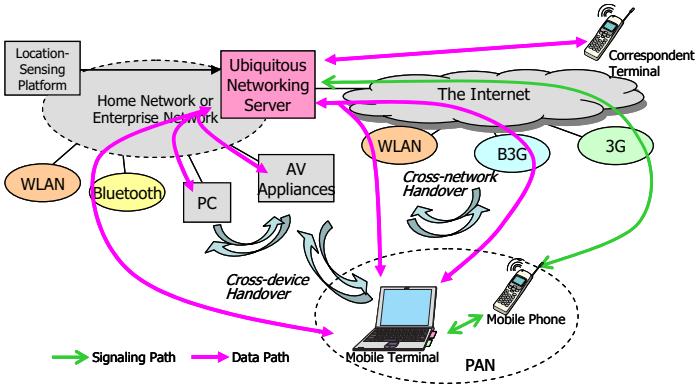

Fig. 1. *Network-configuration image.*

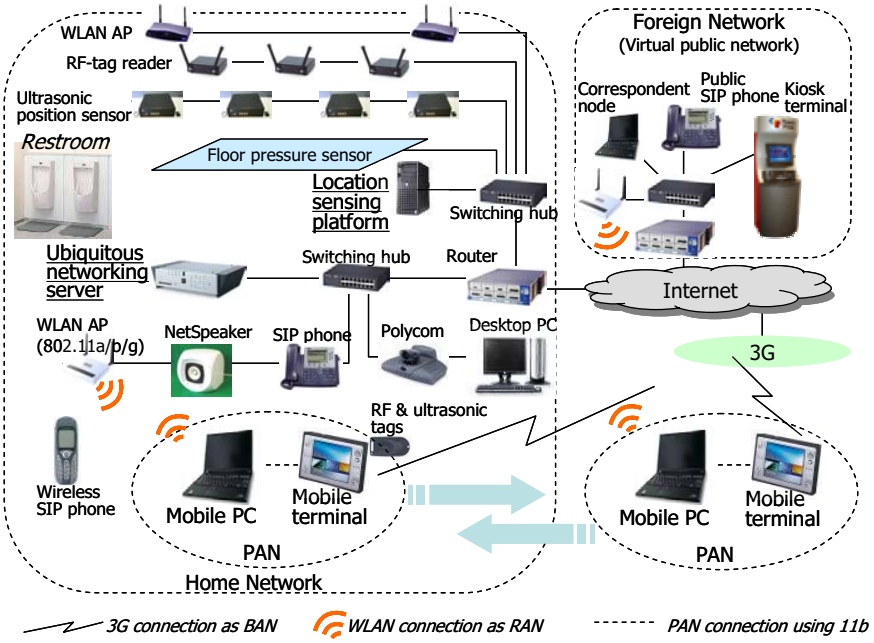

Fig. 2. *Experimental network setup.*

On the basis of this architecture, we constructed an experimental network shown in Fig. 2. We created a home network and a foreign (public) network. In the upper part of the home network, sensing devices and a location-sensing platform server are illustrated. The server collects information on the positions of users and devices from sensing devices such as WLAN access points, RF-tag readers, ultrasonic position sensors, and floor panels with pressure sensors. The mobile phone in the PAN has an accelerometer and a direction sensor as well as RF and ultrasonic tags. We installed SIP phones, a Polycom tele-conferencing system, and PCs to the network as the end devices for cross-device handovers. Mobile terminals have a W-CDMA or an EV-DO data card to connect to the 3G network. WLAN ad-hoc mode is used to connect the mobile terminal and the mobile PC.

In the previous system, the available applications (such as “leave a message,” “voice phone,” and “video phone”) were determined based on the user’s presence, location, available network inter-

faces, etc. One problem was that a callee might not want to accept the application the system chose based on the context and offered to him/her. Only callers were able to select applications. One significant feature of our new system is that callees can select applications in advance based on their contexts.

Applications available on each terminal (the mobile terminal, the mobile PC, and the neighboring devices) were first determined following the process shown in the left of Fig. 3. For instance, applications available on the mobile PC were determined by logical AND and OR operations among contexts such as the types of WLANs, the availability of wired LAN, the remaining battery energy, and the capabilities of the mobile PC. Then, the context information that would be shown on a caller's mobile terminal (in the right of Fig.3) was determined. The callee specified his/her preferred applications for each position. Position information came from the location-sensing platform in the Universal Position Identifier (UPI) format we propose. The logical OR operation was performed on the lists of available applications (determined by the process in the left of Fig. 3) on terminals neighboring the user, and the AND operation was performed on the resulting list of available applications and the list of desired applications. This determined the information to be transferred to the caller, including the presence of the callee and his/her desired applications. Finally, the AND operation was performed between the desired applications of the callee and the available applications of the caller to determine selectable applications for the mobile terminal and mobile PC.

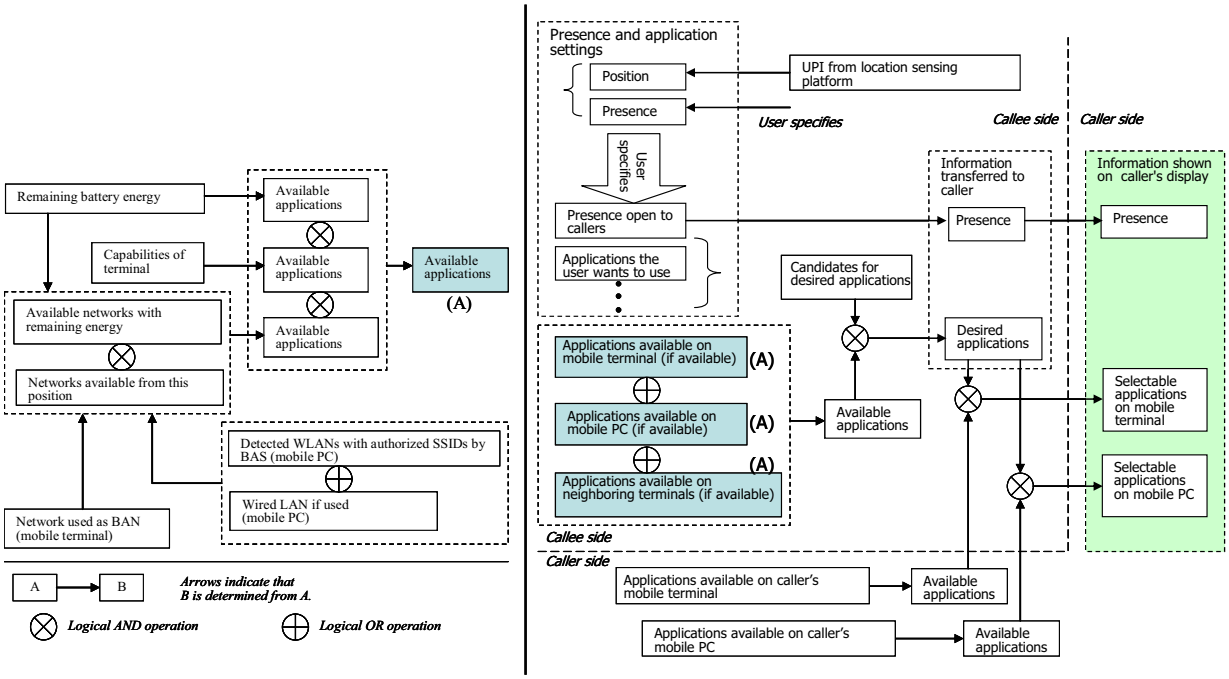

Fig. 3. *Process of determining the available applications on each terminal (left) and process of determining context information shown on the caller's mobile terminal (right).*

Figure 4 shows the GUIs for the control application on mobile terminals. When the telephony tab was selected, the GUI shown in the left was displayed; otherwise, that in the right was displayed. The upper part of left GUI shows the status of the user while the lower shows that of a selected member. The user's position came from the location-sensing platform. Below the position, the user specified his/her presence and preferred applications. In the lower part, the applications that the selected member preferred were shown. In device mode, a map showing the user's position was displayed. The estimated position and direction of the user was indicated. The positions of

neighboring devices and other members were also shown. Users were able to distinguish between available and unavailable devices through their colors. If the selected device was receiving or sending packets, the user was able to switch the connection from that device to another using a device switcher.

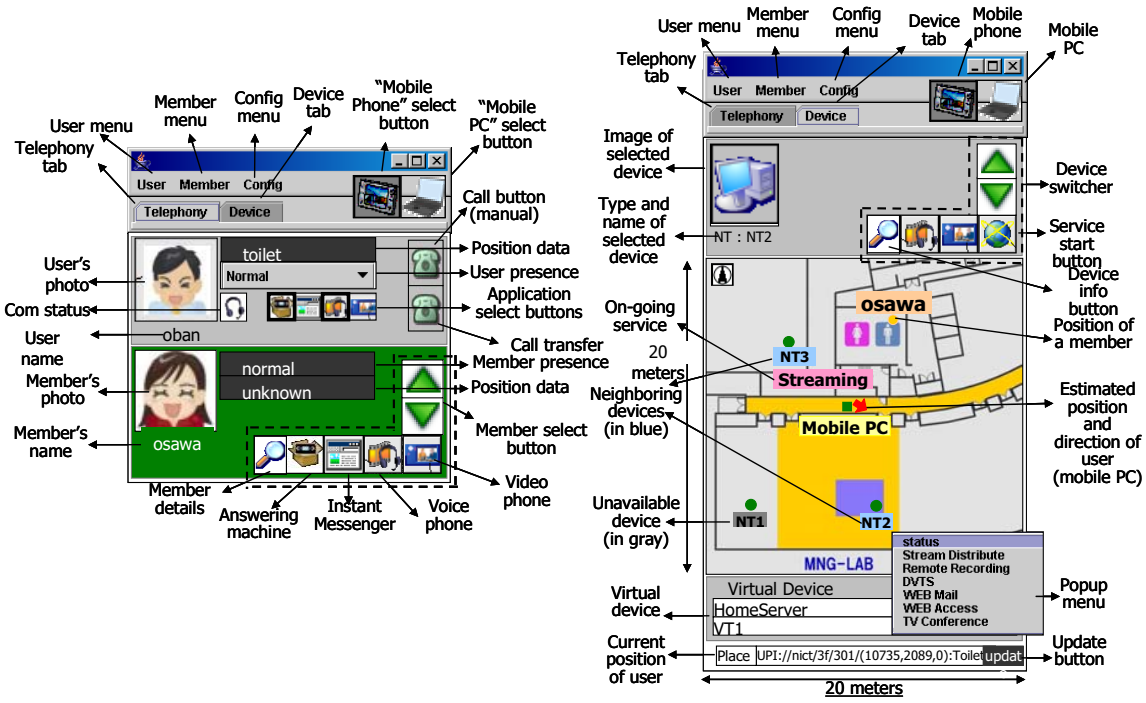

Fig. 4. *GUIs for controller in telephony (left) and device (right) modes.*

3. Features and Demonstration

The major features not included in the previous system [1] are as follows. (1)We integrated cross-network and cross-device handovers, which were formerly performed by separate mobile terminals, into one virtual PAN terminal. (2) The system allows users to inform their callers of their preferred applications, avoiding initiating undesired applications. This, for instance, allows a user to accept no calls when he/she was in a restroom or to accept only chat when in trains. One typical application scenario is watching video files. The user can preview a TV program stored in the content server anywhere, anytime, and with any terminal. If a kiosk terminal is available and the user is permitted to use it, he/she can switch the preview terminal from his/her terminal to the kiosk. In a home network, he/she can switch the end device for the audio signal from his/her terminal to the NetSpeaker, which is a networked speaker we developed, and the visual information to a large screen.

4. References

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