Design of a User-Support System Based on Cooperation Between a Smart Phone and a Personal Computer

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Abstract

In this study, we design a user-support system based on cooperation between a smart phone and a personal computer. This system consists of a phone-monitor tool that checks the use state of the smart phone, and a user-support tool that gives the user advice on the personal computer. The phone-monitor tool recognizes and manages the state of the smart phone, including outgoing and incoming calls, and sends information via wireless communications to the user-support tool, which operates on a desktop or a laptop personal computer. These tools can select the suitable type of wireless communication (Wi-Fi or Bluetooth), depending on the situation. Our system determines the user's state by using the sensor system on a smart phone and achieves secretarial user support, including advice on the response confirmation, for telephone correspondence by cooperation between these two tools.

1 INTRODUCTION

Recently, many multifunctional cellular phone terminals, such as the smart phone (e.g., Android cellular phone and iPhone), have been developed as a result of the evolution of the computer, network infrastructure, and lightweight technology of the battery; thus, the number of users is rapidly increasing [8]. Many use the smart phone as a daily support tool by taking advantage of various services (e.g., downloading free or paid applications), in addition to talking on the telephone through the Internet connection. However, these applications are limited to the functions of one smart phone, and few applications cooperate with other terminals (e.g., smart phones or laptop computers). Those that do exist temporarily enable intelligence sharing through a connection between the smart phone and the computer terminal, using the USB. Additionally, general research on user support intended for the cellular phone specializes in the function of the portable terminal that can connect with the Internet [1, 2, 5, 6]. In such studies, when the portable terminal is used by the office and the home in a private network, an external server machine is needed [2, 6].

Considering this background, we have designed a system for wide user support by enabling cooperation between a smart phone and other computer terminals (e.g., the laptop personal computer that the user carries, and desktop personal computers that the user uses in the home or the office). This system automatically selects the communication facility that is appropriate for the situation when cooperating with the various communication facilities of a smart phone (e.g., wireless LAN, Bluetooth, and 3G), and dynamically monitors the use state of the smart phone. By using these functions, we have designed a system to enable casual support without disturbing the use of the smart phone. For example, we achieve a secretarial user-support system that manages the sending and receiving of calls on a smart phone (Android phone).

Our design enables user support by cooperation between a smart phone and other computer terminals (e.g., laptop personal computer and desktop personal computer). Cooperation includes dynamically gathering information on a smart phone and transmitting the information to a computer terminal, depending on the situation. The telephone call situation and sensor information can be collected from the smart phone. This system recognizes the user's situation and the state of the smart phone from obtained sensor information, and decides the content that should support the user.

Our support system dynamically manages outgoing and incoming calls on a smart phone, enabling management by wireless communications on a specific desktop or laptop personal computer. Thus, this system provides user sup-

port for response confirmation over the telephone through a smart phone and checking the content of the telephone call by reproducing the voice data on a personal computer.

2 RELATED WORKS

Various studies have focused on portable terminals such as smart phones [1, 2, 5, 6]. Brezmes et al. designed a user-support system that understands the user's position and behavior by using the sensor system and GPS installed in the cellular phone [1]. This system recognizes the user's daily behavior and abnormal movements, and can send an emergency call by e-mail when it detects an emergency. In this study, the Support Vector Machine (SVM) [7] is used to understand the user's behavior using the sensor system as well as our research [4]. However, it is assumed that the server needs global IP because the method of transmitting the user's state to the server is not described clearly. Additionally, privacy may become a problem when an individual's position and information are transmitted to a specific server.

Fujino et al. and Takasugi et al. designed a system that accommodates a portable terminal (e.g., cellular phones in a private network (PN) with different offices and homes) and enables the cooperation of various information devices and information appliances [2, 6]. Our system also accommodates a portable terminal in a private network via the connection between a smart phone and a personal computer. It can even accommodate smart phones by combining Bluetooth communication with Wi-Fi communication in a private network, and does not require a server that manages each terminal's information.

3 PERFORMANCE OF THE SMART PHONE

In our study, we use HTC Desire SoftBank X06HT as a smart phone (Android phone). The performance of this smart phone is partially described as follows (from a Softbank Mobile press release).

- OS: Android 2.1 with HTC Sense
- CPU: Qualcomm Snapdragon 1GHz
- Internal memory: ROM 512MB/RAM 576MB
- Extrinsic memory: microSDHCcard Max32GB
- Communication facility: Wireless-LAN(IEEE802.11b/g), Bluetooth, 3G
- Display: 3.7InchWVGA (480 $\times$ 800)
- Other functions: GPS, several sensors.

A smart phone is similar to a small laptop personal computer. However, a smart phone has a telephone call function, and it is easy to carry because it is small and light. Its display is rather small, and it does not have a keyboard. Moreover, the development of an Android smart phone is comparatively easy because the development language basically conforms to Java in the Android application. In our research, we regard a smart phone as a general portable computer terminal that has a telephone call function, and enable cooperation with the various personal computer terminals that the user uses.

3.1 Communication Facility of the Smart Phone

Three kinds of communication facilities can be used with the smart phone, and the performance of each is as follows.

- The wireless LAN is a wireless communications function that can communicated at a maximum speed of 54Mbps, which the computer terminal uses. Its use requires a connection to a wireless LAN router.
- Bluetooth is a wireless communications function that connects to a computer terminal by a PtoP connection and can communicate at a maximum speed of 2.1Mbps. Connection requires paired setting with a connected terminal (only once).
- 3G high speed is basically a communication facility intended for the cellular phone, and the wireless communications function can communicate at a speed of 7.2Mbps or less. Its use requires a contract with the communication enterprise, and the cost corresponds to the wire traffic.

The use of a wireless LAN is considered suitable, considering the transmission rate and the cost, based on the performance comparison above. However, the use of a wireless LAN is difficult because the connected access point changes when the smart phone is used at many bases.

3.2 API for Telephone Use

By using API of the Android SDK [9], the Android application can call another phone and recognize the use state of its own phone. Additionally, API (android.telephony.TelephonyManager) dynamically identifies calling and receiving, and the following information can be collected.

- Ringing State (CALL_STATE_RINGING):
  The ringing state is the state by which a telephone call is received. The calling person's telephone number can be identified.
- Off-hook State (CALL_STATE_OFFHOOK):

When the telephone receiver is raised in response to a received call, the ringing state changes to the off-hook state. It can be assumed that the smart phone is calling another phone when the idle state changes to the off-hook state.

- Idle State (CALL_STATE_IDLE)：
  A change from the ringing state to the idle state of the standby mode means no response to a call. A change from the off-hook state to the idle state means the telephone call ended.

The API is a function basically intended for receiving; when sending, not much information can be obtained. The obtained information involves calling and ending only, and the telephone number and whether it was possible to talk over the telephone cannot be confirmed. Therefore, it is necessary to acquire information about the calling telephone number and the calling person's response after the end of telephone call by using the API (android.provider.CallLog.Calls) to acquire the vita information prepared for the Android phone.

An API (android.media.MediaRecorder) can also record the voice. Using this API, the telephone call can be recorded, and the recorded data can be saved in the record media in a smart phone. (The recorded voice data is saved in formats such as MPEG4 and 3GPP.)

3.3 Sensor System and API of the Android Phone

The Android phone has a variety of sensor systems (e.g., acceleration sensor, brightness sensor, and temperature sensor), besides the GPS function. Each sensor can confirm a change of sensor value by using the sensor manager API (android.hardware.SensorManager). For example, the acceleration sensor can measure acceleration in three directions (X axis, Y axis, and Z axis).

When a user is carrying an Android phone, the user's behavior can be detected with the use of the acceleration information [1, 4]. Moreover, a brightness sensor can detect whether the smart phone is put away in the bag at the office. Additionally, the API (android.media.AudioManager) of the phone's manner mode and silent mode sets and confirms it exists, too.

4 SYSTEM ARCHITECTURE

In our study, we have designed a system that enables user support through cooperation between a smart phone (Android phone) and computer terminals (e.g., laptop personal computer and desktop personal computer). We achieve user support as cooperation by dynamically gathering information on the smart phone and sending the information to the computer terminal, depending on the situation.

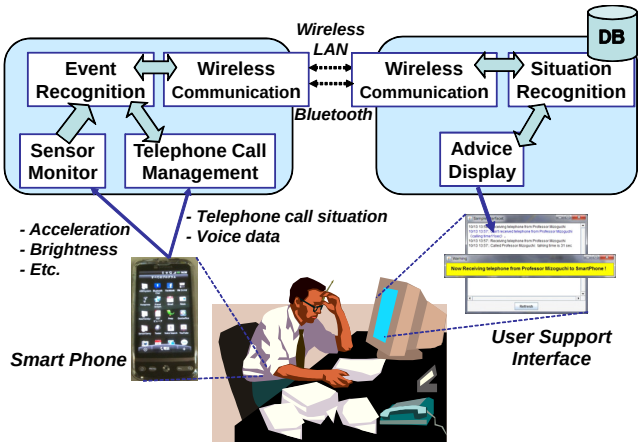

Figure 1: System configuration

Information collected on a smart phone includes the telephone call situation and sensor information described in the preceding section 3. This system decides what content should be supported by recognizing the user's situation and the state of the smart phone, based on the sensor information.

The system configuration is depicted in Fig. 1. The smart phone consists of four modules that monitor the state of the phone. The user-support interface consists of three modules that support the user with a GUI that displays advice.

In the smart phone, each module monitors the telephone call situation and the sensor situation. When a change is recognized, information is sent to the event recognition module. This module requests the transmission of information from the wireless communications module when it judges that the recognized change should be transmitted to the user-support interface. The wireless communications module sends information to and receives information from the personal computer that is operating the user-support interface by wireless LAN or Bluetooth.

In the user-support interface of the personal computer, when event information is received through the wireless communications module, the situation recognition module recognizes a change in the situation. When it is judged that the change requires user support, information is transmitted to the display module, and advice is displayed on the GUI.

4.1 Information Sharing by Wireless Communications

Communication between a smart phone and a personal computer is executed by the correspondence procedures

of wireless LAN and Bluetooth. To give priority to the use of wireless LAN for the reasons described in section 3, we have established the following correspondence procedure.

- Step 0: Wait until entering the range of communication by Bluetooth.
- Step 1: To Step 2 if both terminals can use wireless LAN and to Step 5 if otherwise.
- Step 2: Share IP address with wireless LAN according to Bluetooth communication.
- Step 3: Send and receive information by wireless LAN.
- Step 4: Repeat Step 3 as long as it is in the range of Bluetooth communication.
- Step 5: Send and receive information by Bluetooth.

This system usually uses a wireless LAN for communication; Bluetooth communication is used only when a wireless LAN is not available. However, the file for the recorded voice data can become too large to send via Bluetooth from a smart phone, so it must be sent via a wireless LAN (When a wireless LAN can again be used, the unsent voice data is retransmitted.)

5 SYSTEM IMPLEMENTATION

In order to achieve the system depicted in Fig. 1, we implemented each module on the smart phone (Android phone) and a personal computer. Each module in the Android phone can be implemented using Android SDK [9] via a computer terminal. Since the programming language is basically similar to Java, we used Java language for the implementation of all modules.

5.1 Monitor Tool on the Android Phone

The content of the processing of the modules in the monitor tool on the Android phone is as follows.

The telephone call management module dynamically monitors the telephone call situation of the smart phone using the Android telephone API described in section 3.2. When the API recognizes a change in the situation, this module sends information to the event recognition module with additional information (e.g., telephone number). Moreover, this module can call the other phone using the given number. In addition, when receiving a call from or making a call to another telephone, this module records the telephone call voice and sends the recorded data to the personal computer via the wireless communications module when the telephone call ends.

The sensor monitor module dynamically monitors information, such as the acceleration sensors using the function of the Android sensor API described in section 3.3. The user's state can be recognized from the information of each sensor by registering the user's behavior beforehand with the SVM [4]. When a change is recognized in the registered state of behavior, this module sends the information to the event recognition module. This module monitors mainly the acceleration sensor and the brightness sensor, as well as the state of the smart phone's speaker (e.g., manner mode and silent mode).

The event recognition module recognizes information from the telephone call management module and the sensor monitor module as an event, and sends information to the user-support interface, according to the content of the event, through the wireless communications module. This module recognizes the state by which the smart phone receives or sends calls as the main event, and sends the state of the user and the cellular phone as additional information.

The wireless communications module sends to and receives from the personal computer according to the procedure of section 4.1. This module regularly confirms the range of Bluetooth communication and confirms whether the personal computer with which the user-support interface is operating is in useful range. When it is outside the effective range, this module postpones the transmission of information until entering a useful range.

5.2 User Support Interface on a Personal Computer

The processing content of the modules in the user-support interface on the personal computer is as follows.

The wireless communications module for the personal computer sends to and receives from the Android phone according to the procedure described in section 4.1.

The situation recognition module recognizes the receiving and sending situation of the phone through the wireless communications module, and records this information in the data base (DB). Next, this module transmits advice to the user by collating new information with the vita information in the DB and sends the advice to the display module. For example, a smart phone receives a call; the smart phone is in manner mode, and the brightness of the smart phone is low (e.g., put away in the bag). This module considers the possibility that the user does not notice the call and sends advice (an alert) on the user-support interface.

The advice display module displays the advice information received from the situation-recognition module on the user-support interface. There are several advice display methods. For example, this module generates a new supplementary window and displays important advice in large

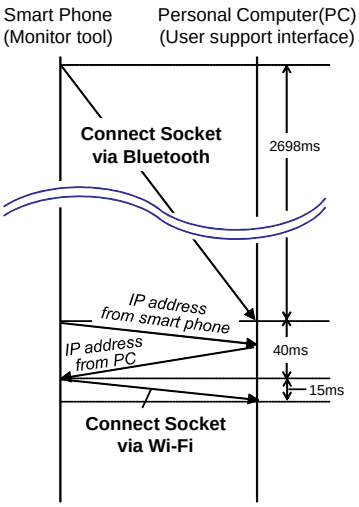

Figure 2: Flow of connected processing of the smart phone and the personal computer

Figure 3: An alert display that presents a strong warning that the user is receiving a call

characters. Additionally, the user can confirm the content of telephone call by reproducing the voice data on the interface.

With these modules, the user can dynamically confirm the receipt of a call even when the phone's sound is off and the phone is in a bag. Moreover, the user can confirm the history of the smart phone while the user is moving, after the user arrives at the office or arrives home.

6 SYSTEM EXECUTION

We assumed the following situations when executing the experiment.

- Experiment until the smart phone connects to Wi-Fi with the user-support interface on the personal computer, using Bluetooth communication when the user arrives at the office.
- Experiment with the smart phone placed in a bag and receives a call while the user is working in the office.

6.1 Connection Between a Smart Phone and a Personal Computer

When the user arrives at the office, it is possible to connect the monitor tool on a smart phone with the user-support interface on the office personal computer. As a precondition, the smart phone is assumed to connect with the Wi-Fi router in the office and to acquire the IP address. The flow of connected processing of the smart phone and the personal computer is depicted in Fig. 2. First, the monitor tool on the smart phone connects to the user-support

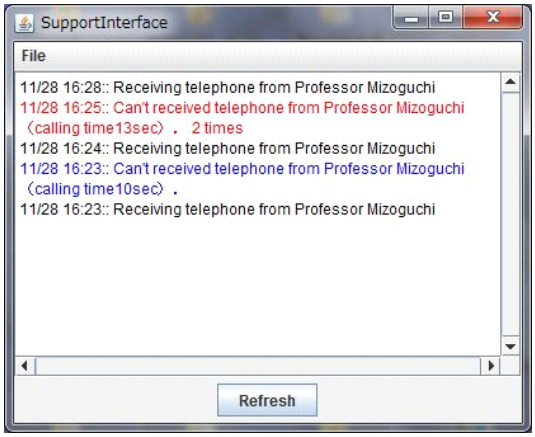

Figure 4: Display of the telephone's receiving and sending record

interface on the personal computer using Bluetooth communication. The tool sends the IP address of Wi-Fi of the smart phone to the user-support interface, and the interface sends the IP address of the personal computer (private IP address in the office) to the tool. Next, the smart phone's monitor tool tries the socket connection to the IP address of the personal computer that receives it. If successful, information is sent and received via Wi-Fi communication. If not, Bluetooth communication is used. Supplementary communication is executed by automatically using Bluetooth when the communication fails with Wi-Fi use. In addition, the monitor tool accumulates information and, after reconnection, retransmits the accumulated data when the Bluetooth communication fails.

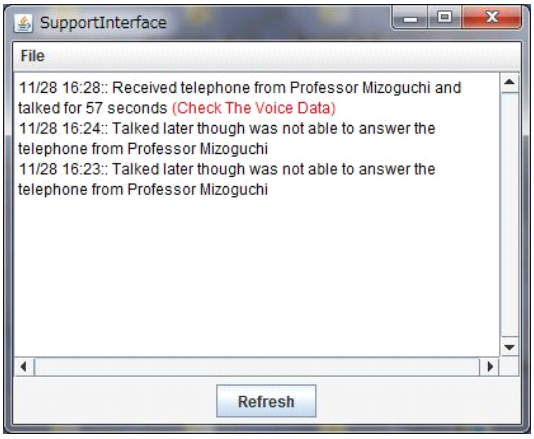

Figure 5: Interface to display the telephone call history and to reproduce the voice file. The user can reproduce the voice file by clicking on "Check The Voice Data" with the mouse.

6.2 Processing When Receives a Call

When a smart phone receives a call with the phone put away in a bag while the user is working in the office, the warning advice (Fig. 3 or Fig. 4) is displayed on the user-support interface. Figure 3 is an alert display with a strong warning that the user is receiving a call. This alert display assumes that the user does not notice the call because the smart phone is in manner mode or silent mode. When the smart phone is placed on a desk or the ring tone is the pronounced normal mode, it is not displayed as depicted in Fig. 3; instead, the vita information is displayed on the GUI (Fig. 4). Figure 4 depicts a user interface that displays the telephone's receiving and sending record; thus, the current sending or receiving situation is displayed. Our system selects the display method of advice according to the situation by confirming the state of the smart phone.

The interface in Fig. 5 is displayed when the user talks over the telephone. The interface presents information such as when and to whom the user talked. When the telephone call is completed, the interface receives the voice file from a smart phone through the wireless communications module. The user can click "Check The Voice Data" on the interface with the mouse to reproduce the voice file and confirm the telephone call content (Fig. 5).

7 CONCLUSIONS

We designed a user-support system based on cooperation between a smart phone and a personal computer. This system consists of a phone-monitor tool that checks the use state on a smart phone, and a user-support tool that gives the user advice on the personal computer. The phone-monitor tool recognizes and manages the state of the smart phone, including outgoing and incoming calls, via the smart phone, and sends information via wireless communications for the user-support tool, which is operating on a desktop or a laptop personal computer. These tools can select the suitable type of wireless communication (Wi-Fi or Bluetooth), depending on the situation. Our system determines the user's state using the smart phone's sensor system and achieves secretarial user support, including the advice of the response confirmation for telephone correspondence by cooperation between these two tools. We executed this study to make various equipment and devices cooperate [3] and will further develop it for a user-support system with various equipment through a smart phone.

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