Spontaneous Interaction using Mobile Phones and Short Text Messages *

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Abstract. Spontaneous interaction in ubiquitous computing settings requires a simple, well-understood means for users to communicate with devices in their nearby environment, some kind of equipment most people are familiar with, and a mechanism to determine whether certain entities can interact with each other. Mobile phones are a well-established means for people to communicate not only verbally, but also by using features such as the short message service (SMS). This paper shows how SMS can be used to interact with ubiquitous computing environments. It also presents a location service that associates particular entities with each other based on symbolic location. When spontaneous interaction is initiated by the environment and not by the human user, the concept of symbolic location is suitable to select entities to interact with.

1 Introduction

According to Forrester Research, in some European countries the mobile phone market is beginning to reach its saturation with coverage rates of about 80%. This shows that mobile phones are a technology that has become accepted and almost omnipresent. The short message service (SMS), which is supported by virtually all mobile phones in Europe, has become an overwhelming economic success and is widely used. According to [5], 78.7 billion SMS messages were sent in Western Europe in the year 2001.

In this paper we concentrate on interactions with smart objects based on short text messages that are sent via SMS. In contrast to speech, SMS messages usually have a simple structure and often follow repeating interaction patterns. This means, the difference in communicating with human and artificial counterparts via SMS can be small. We think this is important for this kind of interaction to be accepted.

There are several ways to access mobile phones. Besides IrDA and GSM also Bluetooth [2] as short-range wireless radio standard is integrated into an increasing number of mobile phones. Compared to IrDA, Bluetooth does not have the line-of-sight restriction and the range of approximately 10m covers well the immediate environment of human users. In the Smart-Its project [6], active tags — called Smart-Its — were

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developed that are equipped with Bluetooth modules. They can directly access the functionality of Bluetooth-enabled mobile phones. Smart-Its can be attached post-hoc to everyday items providing them with the ability to perceive their environment through sensors and to communicate their state to other "intelligent" objects.

When an interaction is initiated by the environment instead of being triggered by a human user, a Smart-Its has to determine people it can interact with. Here, the concept of symbolic location rather than physical coordinates seems to become more important. We describe a location service that allows devices to identify persons in the same room. It combines different radio technologies present in the user's environment.

The remainder of this paper is structured as follows: Section 2 describes the environment that we used to experiment with spontaneous interaction. In section 3 a location service is introduced, which smart objects can use to find people to interact with. Section 4 evaluates the possibilities of using mobile phones in the envisioned settings, while section 5 shows concrete interaction patterns using mobile phones and SMS messages. Section 6 concludes the paper.

2 An Environment for Experimenting with Spontaneous Interaction

Fig. 1. Some of the devices used in the experiments — a Bluetooth-enabled mobile phone (1), RFID tags (2), a Bluetooth access point (3), a Smart-Its (4), a Bluetooth-enabled iPAQ (5), and an RFID scanner (6)

In this paper, the following setting is used to evaluate proposed concepts for spontaneous interaction. Several Bluetooth-based Smart-Its are scattered in the user's environment. People are identified by their mobile phones; in the experiments, two Bluetooth-enabled phones, the R520m from Ericsson and the Nokia 6310i, are used. Devices are identified through small RFID tags. That means, Smart-Its as well as phones have RFID tags attached. Furthermore, we built a wireless RFID tag reader.

The tag reader is connected to a PDA, the iPAQ H3870, which has Bluetooth integrated. Data read by the RFID antenna is made available to the environment through the PDA's Bluetooth module. For the more sophisticated application scenarios, there is also a gateway to the Internet, which consists of a PC with an Ericsson Bluetooth module and an Internet connection. Figure 1 shows components of this setting.

3 Finding People for Interaction

When an interaction is initiated by the environment and not by the human user, a mechanism is needed to find people in the nearby environment. For example, in warehouses with sensible products, smart devices attached to the products need to trigger nearby workers when physical parameters get out of bounds. In another scenario, active tags keep track of the activities in a room and inform users when their security and privacy settings do not conform with those of the institution the room belongs to [4]. Here, the concept of symbolic location, e.g. the information whether a person is in a room where a certain event occurred, is suitable to trigger an interaction. We describe how Bluetooth-enabled Smart-Its detect persons in the same room.

The physical communication range of Bluetooth is suited to determine entities in an area where immediate interaction could possibly take place. However, as Bluetooth penetrates walls, another technology is needed to make sure that two entities can physically interact. RFID technology was used to identify people that enter or leave a particular room or place, that is, when they change their symbolic location. Identification takes place over their mobile phones, which have RFID tags attached. Alternatively, RFID tags could also be integrated into their clothes. However, using only RFID to determine whether entities can interact is likely to be inaccurate. Using RFID gates on doors, the only conclusion that can be drawn with certainty is whether an entity is in the — rather limited — range of a door. It cannot be decided whether the person actually entered or left the room.

By combining Bluetooth and RFID technology the accuracy of the location service can be improved: if an RFID tag is scanned for the first time, it is assumed that it changed its symbolic location to the room the RFID antenna belongs to. The RFID tag contains information about the tagged device, e.g. a telephone number or a Bluetooth device address. This information is broadcasted by the wireless tag reader. Other Bluetooth devices in the room (e.g. the Bluetooth-based Smart-Its) or an infrastructure access point verify the presence of the device by trying to access it afterwards. When a person accidentally came into the range of the reader but did not enter the room and therefore left the Bluetooth range of devices in the room afterwards, the environment does not start an interaction with that person.

RFID technology was used because it is a proper method to cope with the multitude of different supported technologies in the envisioned scenarios. We assume that every entity has an RFID tag with basic information of how to access the entity. This is not futuristic, RFID tags are very cheap and there are companies that even plan to tag all of their products with RFID technology [1]. RFID tags contain information of how to access devices, which is made available to the environment and used to increase interoperability. Due to the tag data, the environment can decide how to access and communicate with devices, e.g. via Bluetooth, WLAN, or GSM.

4 Evaluating Mobile Phones for Spontaneous Interaction

In this section, some technical possibilities for integrating mobile phones into ubiquitous computing environments are listed:

- **Direct transmission of AT commands to the phone.** Bluetooth-enabled phones usually support the Bluetooth serial port profile, which simply emulates a serial port over Bluetooth connections. Smart devices (in our setting the Smart-Its) can connect to the phone directly — that is: without support of a background infrastructure — and transfer AT commands to the phone. AT commands can be used to access most features of mobile phones, e.g. the delivery of SMS messages, access to phone books, and initiation of calls and alarms.
- **OBEX put and get.** As in IrOBEX, the Bluetooth generic object exchange profile (Bluetooth OBEX [3]) can be used to transfer objects such as vCards and vCals between two entities. Of course, data from the environment or a user can be exchanged via vCards and used for simple interactions, but displaying general information within a vCard is rather fussy and not intuitive. The major advantage of OBEX is that it does not require authorization.
- **Mobile phones as access points.** Mobile phones can be used by smart devices as access points to a background infrastructure. Most Bluetooth-enabled mobile phones support the Bluetooth dialup networking profile, which is suited for this purpose. As phones are carried around by their owners, they are also present when resource-restricted devices need the capacity and features of more powerful computers. With an infrastructure, more complex interactions can be implemented. When data is transferred from a smart device to the infrastructure, the infrastructure can also contact the phone via a GSM or UMTS network. This allows for more complex interactions to be implemented.
- **Using access points to a background infrastructure.** When a mobile phone does not support Bluetooth, interaction with it can only take place over the public GSM or UMTS infrastructure. In such a setting, smart devices transfer data to a nearby access point and afterwards SMS messages and calls — that is, the whole interaction with the user — are initiated by the infrastructure.

To summarize and contrast the four possibilities, solutions (1)–(3) require Bluetooth-enabled phones, whereas the phone in scenario (4) needs only to support the transmission and reception of SMS messages. However, in scenario (4) access to a supporting fixed infrastructure is mandatory. Furthermore, in (1) and (3) the environment — that is, at least one Smart-Its in range — must be paired with the phone in order to be allowed to send AT commands.

5 Interaction patterns using SMS

An interaction triggered by the environment can be processed as follows: If an event occurs in the environment (triggered by distributed sensors or other sources) that requires interaction with human users, the location service described in the previous section retrieves the phone numbers of all mobile phones in the room where the event occurred. The phone numbers are stored on RFID tags attached to mobile phones and broadcasted by the wireless tag reader. This information is received by an access point and stored into a tuple space in the background infrastructure. The environment then initiates the interaction by sending an SMS message to the mobile phones sharing a certain symbolic location using the background infrastructure. The user is notified by her mobile phone of the incoming SMS message, reads it and replies with another SMS message. The response message is received by the infrastructure access point, relevant data are retrieved by the background infrastructure, and distributed to subscribed entities. Afterwards, these entities can send subsequent SMS messages to the users.

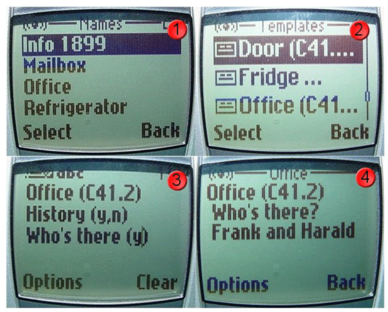

Fig. 2. Phone book entries (1), a list of SMS templates for smart objects (2), an edited SMS template with activated command (3), and the response SMS message (4).

When a user wants to initiate an interaction with an intelligent object via SMS, another approach is necessary as an interaction can be started while the user is far away from the object itself. Each smart object is assigned a phone number and a set of commands the object can process. Technically, this was done by implementing an access point for smart devices that maintains a Bluetooth serial connection to a mobile phone; data received by this phone are processed by the infrastructure access point. The access point transfers received SMS messages and embedded commands to all interested parties. Only one mobile phone is required for many augmented objects; the phone number of this mobile phone is the phone number of the objects. However, this phone number and the commands that can be sent to the objects are initially unknown to users. Therefore, a user once must have been in the proximity of an augmented object. When a user comes into the communication range of a smart item, the attached Bluetooth-enabled Smart-Its connect to the phone of the user (which must support Bluetooth) and transmit phone book entries to the phone using AT commands. Furthermore, an SMS template is written to the phone, that contains the commands the smart object supports. When far away, the phone book entry and the template can be used to interact with the object. The SMS template contains a range of commands, which the user can activate with minimal effort. When a smart object has processed the commands embedded in an SMS message, it uses the infrastructure access point to send a response message back to the user's phone. Figure 2 shows an example of this kind of interaction.

In order for the environment to be able to interpret the users SMS messages and respond accordingly, messages have to be structured in some way. Here, it is important to investigate how people react when they receive an SMS message and what behaviours are supported by most mobile phones. As typing text on their small keyboards is somewhat tedious, most phones offer predefined answers to SMS messages like: 'Yes', 'No', 'OK', 'Thanks', and 'Congratulation'. One reason is that many SMS messages are just simple questions that require only such simple answers. Therefore, interaction with ubiquitous computing environments via SMS should also be simple. Questions and notifications sent by the environment that require only a simple answer are suitable. Then, the user's effort is kept to a minimum because the predefined SMS templates can be used, and interpretation of the answer in the environment is straightforward. Another approach is to embed predefined answers or commands into SMS messages. After receiving the SMS message, a user can then copy the original into the reply and just mark commands or correct answers. Thereby, the effort for the user is small and the environment also knows the semantics of the answer because it suggested it as a possibility.

A problem when using SMS for interaction in ubiquitous computing settings is the delay that occurs during delivery of a message. According to our experiences, sending SMS messages over a commercial service in Switzerland takes only about 5–10 seconds. Furthermore, the limited length of SMS messages restricts the complexity of interactions.

6 Conclusion

SMS is well suited for interactions in ubiquitous computing settings when the input from users can be restricted to simple decisions, confirmations, or input that is based on a set of predefined answers. As interaction among human users using SMS messages is usually very simple and restricted, the difference between human and artificial communication partners is small. Therefore, the metaphor of using SMS messages for interaction in pervasive computing settings is likely to be accepted.

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