Utilizing Mobile Phones as Ambient Information Displays

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Abstract
Mobile phones have become a ubiquitous technology and for many people a daily companion, primarily used for communication and information access. The fact that the phone is accompanying the user makes it an interesting platform for building applications that utilize the phone as an ambient display. We explore the domain of ambient displays and persuasive technology with regard to communication. In this paper we first analyze the technical capabilities of mobile phones that can support the collection of information. Then we present designs of how the screen saver on a phone can raise users' awareness of their personal communication behavior.

Keywords
Mobile phones, ambient displays, information art.

ACM Classification Keywords
H5.2. User Interfaces, D2.2 Design Tools and Techniques, H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
In many parts of Asia, Europe, and America mobile phones are used commonly in daily life to communicate, coordinate and access information. The

majority of people in these areas nearly always carry a phone with them, either directly on the body or in close reach [4]. Due to the usage in various different situations, mobile phones function as probes of the users' everyday life environments. Mobile phones contain communication logs of messages and calls, as well as user created content, such as calendar notes and photographs. These features make a mobile phone a versatile storage of user's personal data.

Mobile phone usage has created cultural trends of its own, especially among teenagers [6]. Numerous ways for personalizing the phone accompany this phenomenon. Choice of the model, changeable covers, ring tones and wallpaper selections are commonly regarded to show personal preferences or be part of the image the user wants to reflect.

Interaction with the phone and through the phone reveals and reflects on the user's behavior. Although mobile phones are commonly used in public, they are perceived as very personal items [3]. Users do not tend to reveal personal information contained in the phone to others, and privacy related to this data is highly valued. With regard to younger users (teenagers) initial interviews reveal that communication meta-information is regarded as very private information. Sharing of this information requires trust. Typical examples of such information are:

- Number of short message service (SMS) messages received from a certain person
- Who did call you recently
- Whom did you call recently

Such information is of interest to the user and showing it on the screen saver is an option. However, as the information is very personal, it is not appropriate to visualize it in a way that is obvious to everybody. This was the initial rational to further investigate the concept of ambient information visualization [10].

Visualization of information related to communication can help to increase the user's awareness and hence make it a persuasive technology to push for a certain behavior [2]. If a user decides that communication with her parents is important, ambient visualization can become a central means providing this awareness [7].

Even though smart phones offer a variety of additional applications (reaching from address books to video play-back), their potential as a platform to display ambient information and for persuasive technology has not yet been utilized. Nonetheless, they represent a potential platform for such applications by offering various kinds information for input data, sufficient computing power and display technologies, and existing personalization culture.

Previous research has introduced information art concentrating on public spaces and large physical elements [8]. An example of personal information art is an ambient display, showing user-defined information, e.g. traffic or temperature measures, as personalized elements on a wall display [10]. Information visualization for large audiences has been demonstrated e.g. in IN-Visible system, where ambient presentation of subway information is displayed in public urban spaces [1]. Utilizing personal mobile devices has so far not been considered as platform for information art.

In this paper we introduce how mobile phones can be used to present personal information in an ambient manner by creating information art. We present design cases that utilize communication patterns as input.

Using the Mobile Phone as Sensor for Persuasive Technologies

Current mobile phones contain a lot of information that can be used as input data for persuasive technologies. Considering the use of mobile devices and research that assessed the inclusion of sensors into the phone [9] there are the following parameter that can become a source of information for persuasive applications: activity with the device (e.g. calls, messages), user location (e.g. based on cellular-id or GPS information), co-location (e.g. proximity to other devices), and physical activity (e.g. sitting, running).

In this paper we concentrate on information that is available in existing phones on the mass market. The focus of the design cases is set on the communication meta-information (e.g. number of calls send and received, number of messages sent and received, communication with a certain person).

Communication Behavior

Meta-data for communication is typically available on the phone in a list showing recent calls, missed calls and received calls. Similarly the information about sending and receiving messages can be extracted from the sent folder and the inbox of SMS and multimedia messaging service (MMS) messages. Additionally, many service providers make the information about calls made and received available in the form of itemized bills which can be downloaded from the user's account at the provider. Such itemized bills usually include further information, such as duration of the call and cost of the call. For the designs presented in a later section we assume access to this information. For prototyping, meta-data for communication can be traced either from the phone of by accessing the online itemized bill. For a deployment of such a concept in the large we would expect that one model is that the service provider offers such a screen saver as additional service (and basically selling the itemized bill in a different visual appearance).

It can be assumed that the communication patterns represent information which the user herself is interested in for both for affective and practical reasons, but which is also considered to be private as outlined before. Communication logs reveal information not only about people that have been regularly contacted, but also about how communication patterns (frequency, duration, content length) to a certain person change over time. Thus, communication logs offer a potential information source for information art presented in an ambient manner. To explore the possibilities we constructed a design exercise with about 50 students in an HCI class which is reported in a later section.

User Location and Activity

The phone can provide information about the user's location in the physical world. Depending on the technology used, location information is available with a different level of detail. All mobile phones, when operational for communication, have the information which base station they are connected to. This can provide a location cue. Not all systems do reveal this information to the programmer. Phyton for Nokia Series 60 provides the cell-ID and JAVA J2ME specifies an API

Figure 1: Solar System.

Figure 2: Aquarium.

(still not supported on many phones). The cell-id information, even though it is coarse, can in most cases provide meaningful information, e.g., the cell-id for the user's home differs very often from the cell-id of the workplace. Moving between places can be detected by monitoring changes in cell-ids and signal strength. Storing the history of visited cell-ids and the frequency and duration of visits provides a basis for reasoning about the user's behavior. Using more advanced reasoning on a set of more cell-ids in the vicinity can provide a more precise location, as demonstrated in [5]. Several phone models also include GPS which can give higher resolution location in outdoor settings.

Co-location offers information about encounters with mobile units (other users) and stationery objects (equipment in the office). This can be detected by using short range communication technologies, such as Bluetooth or WiFI. Encounters offer fine grain location information and identities of persons met. Co-location information can be used, e.g., for tracking social patterns and places where people meet. Physical activity can be detected with accelerometers integrated in the device. Several phone models also have the ability to measure the environment temperature and noise level.

Design Exploration of Ambient Displays using Mobile Phones

Using communication logs as the basic data we started exploring potential designs for ambient information displays. We assumed in this design phase that information typically present in an itemized bill (all calls made with time and cost associated, all messages sent and cost related) as well as information about incoming calls (as in the call lists of the phone) is available.

After a number of initial informal interviews with potential users and developers of mobile phone applications we decided to prototype the concept. To investigate the potential design space we gave 13 teams of 3 to 5 people each the task of designing a screen saver and a setup screen for the given task. The participants were mainly students of computer science and media informatics at the University of Munich in Germany. In a time frame of about 3 weeks they were expected to create sketches and a functional prototype (on a PC) of their concept. Requirements were that the visualization can be customized and has the properties of an ambient display. The task was that the application enhances the user's ability to follow the overall communication activities, keep track of frequency and intensity of communication with different people. Again, the changes over periods of time and other ideas can be included into the designs.

The teams were free to include additional elements as parts of their visual design. The temporal resolution, e.g., communication happening daily or weekly may be incorporated in the visualization using colors, shapes, or other details. Deviations in the visualization show the changes over time, e.g., when the current visualization is compared to the one of the week or month before.

Design Cases on Ambient Visualization of Communication Behavior

To document the intermediate results we selected four example designs that provide peripheral awareness for personal communication patterns. Those examples are suited to show the potential design space and the options available for the ambient visualization of personal communications behavior on a mobile phone.

Figure 3: Circles.

Figure 4: Flowers.

Screenshots of the designs are presented in Figure 1-4. The animated designs of the prototypes are available on our website, http://www.hcilab.org/ambientphone/.

Case A: Solar system

This prototype uses the solar system to visualize the information, see Figure 1. The planets are all constantly moving around the sun (the center). In the initial prototype each planet represents one communication partner. The size and velocity of the planet reflect the communication events. The bigger the planets the more messages exchanged, and the faster the planet moves, the more call conversations have taken place with the person. In the set-up screen of this prototype contacts can be assigned to planets. E.g., a user can assign her best friend Max to the Earth and her grandmother to Mars. The communication behavior with these people is then reflected by these components in the visualization.

This visualization offers further parameters that could be used to map information, e.g. activity of background stars, rotation of planets, or appearance of comets. During the discussion of the result one idea was to automatically add a comet to the visualization if there is a lot of communication with a new person. The user would then be able to look up in the set-up screen who this is, and potentially update the mappings.

Case B: Aquarium

The aquarium prototype reuses a common screen saver scheme. In this case each chosen communication partner is represented by a fish, see Figure 2. The fish are animated. In this prototype the size of the fish reflects the money the user spent on communication with this person; the bigger the fish the more money was spent in communication with this person. The speed of the fish is related to the time since the last call. A very slow fish indicates no communication for a long time. The direction on the fish visualizes the direction of the initiation of calls. If the fish swims from left to right you call more often than you are called. Options available to convey further parameters are bubbles from the mouth of a fish, the animation of the mouth of the fish, and plants in the water.

More design examples

In Figure 3 an abstract representation is used. Each circle (distinguished by color) is associated with a person and the size and speed of motion of the circle represents communication meta-information with this person. Likewise each circle can be used to represent one call. The color links it to a person and the size shows the duration of the call.

The flowers in Figure 4 are similar to the fish in the aquarium. In the basic version only the size of the flower is used and it represents the communication activity over the last weeks with the associate person. In the setup a contact can be assigned to a flower.

Next Steps

Creating a large number of prototypes by a diverse group of people proved to be very effective to generate ideas and to assess the design space for this type of application. The designs are prototypes implemented in Macromedia Flash MX and Java running on a PC. The implementation of prototypes for use on the phones is currently under development. Additional studies on the topic have been designed and will be carried out in the near future. Our interest is in particular on how users want to customize their personal system (e.g., what options to associate contacts and their visualization are

preferred). The other area currently under investigation is privacy requirements for the visualization. In particular, we will look at what level of abstraction in the ambient visualization is appropriate to allow users of the phone to be aware of the parameters without making it too easy to guess for others.

Conclusions

Mobile phones are a widely deployed platform and for many people a central instrument for communication. We have experienced that using the phone's screen to convey information of interest to the user in an ambient way is feasible and interesting. Our initial designs show that especially the phone as a mobile companion can become a meaningful ambient display and potentially a platform for further persuasive technologies.

The usage model of mobile phones makes them suitable to be used as ambient display. The personalization culture (currently mainly background images and ring tones) invites further investigation of means for personalization. The design example shown in this paper maps a design space for novel services where information of interest to the users is visualized.

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