Elastic Mobility: Stretching Interaction

Lucia Terrenghi
Vodafone Group Services R&D
Chiemgaustrasse 116, 81549 Munich
Germany
lucia.terrenghi@vodafone.com

Thomas Lang
Vodafone Group Services R&D
Chiemgaustrasse 116, 81549 Munich
Germany
thomas.lang@vodafone.com

Bernhard Lehner
University of Applied Sciences,
Friedberger Straße 2,
86161 Augsburg, Germany
info@bernhardlehner.com

ABSTRACT
Based on a consideration of usage and technological computing trends, we reflect on the implications of cloud computing on mobile interaction with applications, data and devices. We argue that by extending the interaction capabilities of the mobile device by connecting it to external peripherals, new mobile contexts of personal (and social) computing can emerge, thus creating novel contexts of mobile interaction. In such a scenario, mobile devices can act as context-adaptive information filters. We then present Focus, our work in progress on a context-adaptive UI, which we can demonstrate at the MobileHCI demo session as a clickable dummy on a mobile device.

Categories and Subject Descriptors
H.5 [**Information Interfaces and Presentation**]

General Terms
Design

Keywords
Human-Computer Interaction, Mobile Computing, Cloud Computing, Ubiquitous Computing, User Interface Design.

1. INTRODUCTION
Starting from a critical analysis of computing trends, both in terms of usage patterns as well as emerging technologies, we describe how we envision the evolution of human interaction with data, applications and computing devices, and reflect on the evolution of the role of mobile devices in particular. On that basis, we highlight the implications of such scenarios on the design of conceptual models for ubiquitous interaction and introduce Focus, as an example of our work in progress.

2. COMPUTING AND COMMUNICATION TRENDS
In the last decade we have assisted to a progressive migration of functionalities and communication capabilities from the desktop PC to laptops and mobile phones. The portability of such smaller devices has enhanced people's mobility: Furthermore, communication capabilities and web applications have allowed for ubiquitous access to personal contacts and information. This fact in turn has stimulated nomadic lifestyles, in which social and business relationships could become geographically stretched, and still maintain their core bindings thanks to those novel communication capabilities.

As this phenomenon has evolved, it has increased people's expectation of being connected independently from their physical location. Besides, people have developed the expectation of doing some activities - like buying a train ticket, checking weather forecasts, reading news, and looking at maps - by using computing technologies independently from the device on which the interaction takes place. In other words, "Human-Computer" interaction has been shifting to "Human-Service" interaction, where the specific device plays a minor role. Personal computing, in this sense, does not refer any more to the device that people use for their activities.

This trend has been further stimulated by the distribution of several applications on the web (e.g., Google Docs, flickr, YouTube) which can be used from every device and allow for the storage of personal data (e.g., documents, photos, videos) in the network.

We could actually argue that Weiser's vision of ubiquitous computing [4], where "many computers serve one person", has been mostly interpreted with a focus on the device - i.e. computers everywhere - more than on the activity - i.e. interaction with computers everywhre. In this latter sense, one could claim that the main enabler of ubiquitous comptunig is not necessarily the interconnection of multiple distributed devices, but rather the availability of web based applications and data. Web applications allow people to manage their data from everywhere, and have enhanced the possibility of sharing those data with other people across the world at any time, thus overcoming the limitations of physical tokens such as CDroms and memory sticks. Shareable data access has been a key factor for the development and success of social applications (e.g., Wikipedia, Facebook) and is the core of the so-called Web2.0 internet age. Personal computing has then extended to social computing, where "computing" indicates for us the human activity of interacting with computers, and does not specify from which device.

3. CLOUD COMPUTING AND THE EVOLVING ROLE OF MOBILE DEVICES
Cloud computing is a general concept that considers software as a service, and builds on network-based data storage, where the main feature is reliance on the Internet for satisfying the computing needs of the users. For example, Google Apps provides common business applications online that are accessed from a web browser, while the software and data are stored in the network.

MobileHCI'09, September 15 - 18, 2009, Bonn, Germany.
ACM 978-1-60558-281-8.

This shift from a traditional local PC environment towards a web based environment is partially driven by the users' desire to be independent from a traditional desktop PC setting in order to accomplish some activities and interaction tasks: This trend is enhanced by the increasingly available and cheap broadband access.

Some of the activities that users already today expect to accomplish in a ubiquitous manner are, for example, writing a text, sending an E-mail, surfing in the internet, watching a video clip, listening to music, showing a picture slideshow up to playing a video game. All these activities can be summarized under the term personal computing.

As mobile devices continue to improve in processing power and functionalities, they have the potential to become a general personal computing device, in the enterprise and consumer space. As the recent success of Apple Applications Store for the iPhone confirms, users tend to perform an increasingly diverse set of computing activities via their mobile. In such a scenario the mobile phone and other personal mobile devices gain a new role, which goes well beyond the one of voice communicator: The mobile device becomes a gateway to data and applications which are stored in the network.

Along the increase of the amount of data and applications in the cloud, i.e. in the network, rather than in a fixed physical location (e.g., the hard disc of a desktop PC), the conceptual model of how data, applications and devices are related is necessarily changing. Today several users have a set of data and applications stored on their home PC: Those are often different, and differently structured, than the ones on their office PC. Users tend to navigate in their file systems in different contexts thanks to their personal hierarchical structure and to human spatial navigation. When data and applications migrate to the cloud, a new kind of ubiquitous desktop metaphor (or, more radically, a new paradigm) needs to be thought through, which allows users to access and manage their data across different peripherals, and according to their different contexts of activities (e.g., private and business), independently from the specific device at hand.

As mobile broadband brings the possibility to access web based applications and data from mobile devices, these can potentially become the favorite access point to the cloud, and then the preferred device for initiating activities of personal computing. But what are the challenges and potentials for this to happen? This question is addressed in the following section.

4. STRETCHING INTERACTION: BIG EXPERIENCES FROM SMALL DEVICES

Mobile devices have some shortcomings in serving users' needs of ubiquitous personal computing. The restrictions are mostly related to usability issues: the small sizes of the display, keypad and limited input/output interfaces. These aspects have so far prevented positive user experiences for many of the personal computing activities on mobile devices, but could potentially be solved by connecting peripherals to the phone.

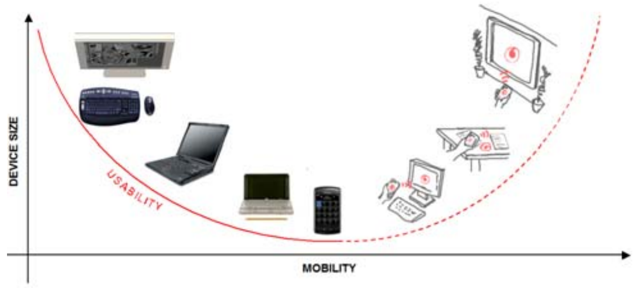

Figure 1. Stretching usability of personal computing through connected peripherals.

Figure 1 illustrates our reasoning. As the size of the device which serves users' interaction decreases, mobility is enhanced, thanks to portability. On the other hand, the usability decreases, due to the restrictions mentioned above. The trade-off between portability and interaction capabilities on a small display is probably going to persist for several years, until new flexible displays will be available. On the other hand, a trend is already evident that shows that displays and peripherals are getting more and more distributed in public as well as private domains (e.g., stations, cafes, and home). By connecting the mobile device to external peripherals, usability and interaction capabilities can be enhanced while maintaining a high level of mobility and location-independent access to data and applications.

Our approach builds on such an observation and extends the interaction affordances of the mobile device by connecting it to external peripherals. Technologies and protocols are being developed to make the wireless connectivity of devices and displays possible, faster, and reliable: Thus, the space limitations of the mobile display's real estate can be overcome when the mobile is connected to a larger display. This enhances what we address with *stretching interaction* across displays and peripherals, which in turn allows for elastic contexts of mobility. Mobile interaction, indeed, shows different levels of mobility: Whether we use our mobile devices as stand alone in a train, or connected to an external display in the office, at an airport, in a café or at home, we are still "mobile", but the peripherals and infrastructure around us make such contexts of mobility different in terms of focus of attention and privacy, for example. Those peripherals could make ubiquitous personal computing possible, where the mobile device becomes the initiator and director of temporary interaction set-ups.

To realize such a potential, some design implications and challenges emerge, which are discussed in the next section.

5. ELASTIC INTERACTION: CROSS-DEVICE ADAPTIVE UI

As we envision a scenario in which the mobile device becomes a ubiquitous "magic wand", which allows users to access peripherals, data and applications in a personalized manner, a number of issues need to be addressed, as discussed below.

5.1 Context-Adaptive Information Display on the Mobile Device

If the mobile device is destined to become the access point to media and services, as well as peripheral devices in different contexts, the user needs to discover, visualize, and manage an increasing amount of information and functionalities on a small display. In order to optimize the use of the small real estate, context-adaptive interfaces can become powerful tools for filtering the information visualization. In this respect, one needs to take into account that mobile devices are increasingly being enhanced with sensors, and are ubiquitous users' companions. Thus, the device can learn about individual's usage patterns so as to distinguish different contexts (e.g., private content at home, private content in the office, business in the office etc.). Inferences can then support the adaptation of the mobile interface by prioritizing access to certain services, as well as content, rather than other. On the other hand, interfaces must be designed so as to allow users to maintain control, and arbitrarily manage their interaction with services and content in a spontaneous way.

5.2 Understanding Different Contexts of Mobility

Another main challenge is to understand what are the computing activities that people have traditionally performed on a desktop PC that could be performed in a mobile context, and how those activities might change when embedded in a different situation. The availability of different peripheral devices in different environments, together with the different social, temporal and domain conditions (e.g., private vs. business), open up a variety of mobile contexts in which different activities of personal computing are more or less likely to take place. Investigating the relevance and privacy concern related to those activities in combination with different contexts is a first step towards the design of context adaptive user interfaces.

5.3 Interaction Paradigms for Coupling Devices

In order to stretch the interaction capabilities of the mobile device, peripherals need to be connected. Coupling techniques need to rely on technical standards and technology availability, as well as on the understanding of users' needs and usage paradigms. To this end privacy, intuitiveness and simplicity issues need to be considered, so as to convey a conceptual model of how the user interface can migrate and be extended across peripherals. In particular, paradigms for wireless coupling need to be thought through. Touch and proximity (e.g., Near Filed Communication) between devices appear as promising paradigms, as they imply an explicit action by the user. At the same time, a consideration of what kind of gestures and interaction acts are feasible and socially compatible in different contexts is necessary (see [3] for a review of interaction paradigms for multi-display systems).

5.4 Gesture Vocabulary for Multi Display-Interaction

Once displays are coupled, the user needs to interact with the information displayed on the external periphery. In this case different transducers can be used, such as mouse and keyboards. The sensors embedded in the mobile device, for example accelerometers and capacitive screens, can additionally turn the mobile device into an interaction tool, thus overcoming the need of other input devices such as mouse, mouse pads and pointers. 2D gestures on the screen of a mobile phone with touch display, or 3D gestures performed by holding the mobile device in the space, can become the input language for pointing, moving, and selecting objects on other screens which are coupled to the mobile one. A good example for this is the Air Mouse Pro application for the iPhone (see [2] and Fig. 2). In this way the mobile device becomes a handle for interaction, and turns from output into input device. This possibility becomes particularly relevant when on the same screen multiple input sources are possible (i.e., shared displays), as it allows for a personal handle on the information display. Accordingly, these interactions imply the definition of a gesture vocabulary for 3D gestures (i.e., mobile device as remote controller); for 2D gestures (i.e., mobile device as a mouse); for marking gestures (i.e., mobile screen as mouse pad).

Figure 2. Thanks to the Air Mouse Pro application [2], the iPhone can be turned in a remote controller (left) to manipulate information on another display (right).

6. FOCUS: AN EXAMPLE FOR A CONTEXT-ADAPTIVE UI

Focus is our design concept for an interaction metaphor based on the idea of a stage, with applications that are in "focus", i.e., in fore- or back-ground, depending on the context of the user.

We distinguish four different activities/application categories: communication, information, web surfing and multimedia. Within such categories we expect that people use different applications and data depending on the context in which they are. For example, in a business context a user may use an application such as Microsoft Outlook for her/his e-mails. In a private context, s/he may use Mozilla or Google mail. The social network applications used in the business context might be Xing and Linkedin: In a private context are more likely to be Facebook and Myspace. Similarly, the content users engage with is normally different depending on the type of context they are in. The pictures a user might look at in a private context are mostly different from the ones s/he uses and shares in a business one.

Based on these observations we conceived of a stage which adapts the focus to the context (see Fig. 3). In different contexts the UI adapts in terms of application (represented by different colors in the illustration above) as well as content (represented by the character). Applications may or may not be on stage (e.g., blue and green in the example), and have different weight in different contexts (e.g., B).

Figure 3. Focus adaptation to different contexts.

We defined four different types of contexts, i.e. private (e.g., the user is alone at home), semi-private (e.g., the user has guests at home), public (e.g., the user is at a station) and business (e.g., the user is in the office). Our assumption is that the user is more or less likely to use some applications rather than others, and that different privacy concerns are related, according to the different context. On this basis we conducted an online survey with 35 participants in which given a certain activity (e.g. e-commerce, chatting) associated to some examples for applications (e.g., e-bay, Facebook) we asked participants to specify the relevance of this activity and their privacy concern on a Likert scale from 1 to 5, for each of the four different contexts.

Based on the survey results, we attributed a different focus to applications depending on the context: I.e., within the same category (communication, information, web surfing and multimedia), different applications are available (see Fig. 4) and in fore- and back-ground depending on the context (see Fig. 5). Our concept builds on the idea that as devices are increasingly becoming "intelligent" and sense each-other, the context can be inferred based on the devices available and detected in the environments (e.g., home vs. office display). At the same time, though, the user maintains the capability of easily switching from one context to another one in the interface, by simply selecting another environment: Indeed, a user might want for example to access her/his private contacts and data while at work, and can do so by changing from "business" to "private". Similarly, although a set of applications are in focus, the user can use an explorer to set more and different applications on the stage within a category.

Figure 4. The figure illustrates the information category in the overview modus: In private (above) and business (below) contexts, different applications are used for the same functional category.

By tilting the device, the user can switch from overview (Fig. 4) to stage visualization modus (Fig. 5), which enhances the preview of the most current data and applications in that context.

Finally, as the user connects to an external display, for example at work, s/he can take advantage of the larger real estate of a stationary display: When migrating to the external periphery, the elements of the mobile UI re-arrange to accommodate the different affordances of the desktop display.

Fig. 5. As the mobile device connects to an external periphery with a larger real estate, the elements of the GUI re-arrange to accommodate the different affordances of the desktop display.

7. CONCLUSIONS AND FUTURE WORK

In this paper we have discussed the possible implications of cloud computing on mobile interaction, and have presented our work in progress on a context-adaptive UI for the ubiquitous access to data, applications and peripherals. Focus was implemented in Flash and can be demonstrated at the MobileHCI demo session as a clickable dummy on a mobile device.

Further work is needed to understand how people identify and distinguish different contexts of their everyday lives, and what kind of support and control they want to have on context-adaptive visualization. In doing that, we need to take into account the current social trends and evolving perception of privacy, shareability, and blending borders between office and home, and business and private, for example.

Similarly, further design work is necessary to make the migration of the user interface across displays understandable and consistent, while at the same time efficiently exploiting the input/output capabilities of the device at hand. As shared displays such as multi-touch tabletops and interactive walls become more available, new paradigms for visualizing and sharing data in a co-located context need to be thought through, taking privacy issues and social protocols into account. Larger, multi-user displays provide specific physical and social affordances (e.g., orientation, reachability) that raise further challenges in the layout of data and applications which must be used by multiple users simultaneously.

8. REFERENCES

[1] Apple Application Store http://www.apple.com/downloads/

[2] Apple Air Mouse Pro, demonstration movie http://www.youtube.com/watch?v=TG4MFCNGnpE.

[3] Terrenghi, L., Quingley, A., Dix, A.. A taxonomy for and analysis of multi-person-display ecosystems. In Personal and Ubiquitous Computing Journal, Springer, available online.

[4] M.Weiser (1991). The Computer for the 21st Century". Scientific American.