TOWARDS TRANSPARENCY OF PRODUCT DEVELOPMENT PROCESS

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Abstract: To cope with the integration of various life-cycle stages and disciplines in design, concurrent design in various forms is needed. The paper describes a case study of concurrent design of digital communication services and devices. Our particular objective is to show how a particular blend of methods and approaches can be used to reach *design transparency*, ensuring that all design stakeholders can timely access information on the design process, its background information, and the accumulating product information. Moreover, the viewpoints of the various stakeholders can be integrated smoothly.

Keywords: Transparency, product development, product concepts, service models, prototyping.

1 INTRODUCTION

Design is knowledge intensive. To create a successful design, the designer (or group of designers) must collect and balance a great deal of knowledge not only on customer requirements, technological opportunities, market aspects, and other constraints.

While this is probably true in all types of engineering design, these characteristics are particularly relevant in fast moving high tech industries such as the mobile communications market. To stay competitive, these companies must not only predict and control the future roadmap of technologies relevant for their business, but also perceive and interpret weak signals from the end users to identify "killer applications" that drive future generations of services and products.

Our research is motivated by these needs. Hence, our longer-term aim is to identify and implement approaches, methods, and supporting techniques for service and product design that address the pressures faced by the mobile communications industry. More specifically, we concentrate on *design methodologies* that facilitate design knowledge identification, collection, and systematisation, and *design information management methodologies* that facilitate the sharing and reuse of design knowledge, once it has been collected and systematised. Our main qualitative objective is to improve the *transparency* of a design process, requiring that all product development stakeholders can access accumulating product information during the process, along with relevant background information.

This paper reports on the experience gained so far in an ongoing project dealing with product development of services and devices for the nomadic Internet users of the future. It is structured as follows: First, in section 2, we set the stage of our work by describing our design domain and some of its key challenges. Section 3 gives a general description of the design framework we have chosen for our work. Section 4 gives a design case study of a wireless MP3 music service to illustrate the framework. Finally, section 5 gives our conclusions and discusses the future directions of our work.

2 WIRELESS SERVICES AND PRODUCTS

The Internet revolution was undoubtedly the most significant change in computing during the 1990's. It connected the standalone home or office PC to a whole world of information so that all the sudden almost any imaginable piece of information was just a few clicks away. Even the most advanced societies are only starting to feel the whole impact of the Internet with the explosive growth of applications such as e-commerce and digital media.

Similarly, wireless services and products are expected to transform the world of computing during the next few years. If anything, the impact of the "wireless revolution" is expected to be even more radical than the Internet. In effect, it will transform the mobile phone to a terminal that can access the full range of Internet services. By 2003, the number of wireless Internet users is expected to have surpassed the number of the regular ones; some authors believe that by 2010, it may have reached a billion.

Figure 1 gives a roadmap of some wireless technologies mainly responsible for the revolution [1]. A major transition is imminent with the introduction of the General Packet Radio Service (GPRS), scheduled to take place in Scandinavian countries late 2000. Unlike circuit-switched GSM data, GPRS provides a packet-switched service that can be "always on". The Universal Mobile Telephony Service (UMTS), to be introduced around 2002–3, will provide connection speeds sufficient for hi-fi-quality music or live video. Apart from GSM evolution, other networking technologies of interest include the evolving wireless LANs (WLAN) and the Bluetooth technology.

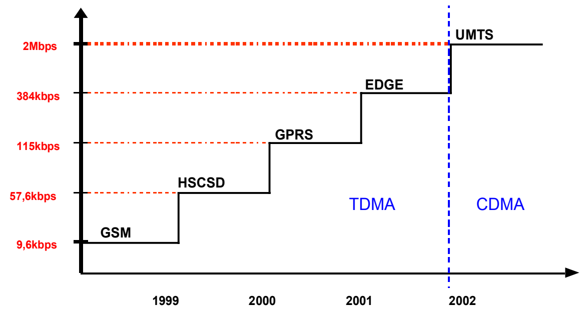

Figure 1: Evolution of GSM towards third generation.

Of course, wireless devices will also benefit from progress in areas such as low-power processors, micromechanical components, novel power cells, and software technologies such as multicasting, mobile IP, and mobile ad-hod networks (MANET). In combination, these make it possible to create entirely new types of devices that combine familiar products such as mobile phones, portable digital assistants, or digital video cameras.

Unfortunately, only a small subset of users are likely to be willing to invest in radical new devices for the sake of the technology alone. Most people will consider replacing their mobile phones or regular cameras with new devices only if they provide some useful new services that add value to them.

What are these novel services? How can they be made attractive enough to convince a billion users to replace their existing devices with wireless Internet devices? At the present, most developers seem to have only vague ideas of the answers: the public literature mainly mentions wireless versions of regular Internet services such as e-mail, WWW, video conferencing, or remote access to file servers.

While we believe that these services will be important during the initial penetration of wireless computing, we don't think they are candidates for the "wireless killer application" that can attract the bulk of users. In our opinion, these services are analogous to the "horseless carriage" thinking of early automobiles.

We believe that just cutting the wires of present services will not be sufficient. Instead, wireless services must be designed from the ground up by taking fully into account the new design dimensions made accessible by the new technologies:

Mobility awareness: Wireless devices are not just wireless, they are mobile. Users can wear them wherever they go, and access services almost independent of their location. This observation may sound trivial, but it is far from so. To fully exploit and support mobility, services will have to be "mobile-aware", i.e., they must adapt to the mobility profiles of individual users to cope with issues such as variable wireless bandwidth or limited battery power.

Location sensitiveness: Users are not mobile all the time; instead, they move from one place to another, and are likely to spend most of their time at certain locations. The resulting *macro mobility patterns* consist of locations such as home, office, shopping mall, sports facility, and a few trips in-between. During the day at the office, the *micro mobility patterns* might involve locations such as the office room, co-workers offices, conference room, cafeteria, and many trips between these. Again, we hypothesise that wireless services that can recognise and adapt to the various locations have much higher potential than "dumb" fixed services.

3 A SERVICE DESIGN FRAMEWORK

In nutshell, we conclude from the previous section that a design approach that can fully exploit mobility awareness and location sensitiveness is needed to create added value to mobile users.

Obviously, any such approach must aggressively collect and exploit background information of users, user segments, their characteristics, their macro and micro mobility patterns, and the locations. During the design process, this background data must be combined to other information such as available technology, business aspects, and market conditions to yield superior designs. In sum, mobile services provide a particularly striking example of knowledge intensiveness in design.

3.1 Layered design

Apart from knowledge intensiveness, a successful design approach for wireless services and products must recognise the rapid rate of development of the underlying technologies and the fiercely competitive nature of the wireless industry. Indeed, to stay ahead of competition, successful companies must be able to introduce new services and products to the market at a constant and rapid rate.

This means that during the actual service or product realisation, there is precious little time for extensive background studies or assessment of various alternatives. As a consequence, many companies have adopted a layered design process approach that separates new service and product development in two separate processes as follows:

- The *concept generation process* develops proactively new service and product ideas that identify possibly attractive future requirements of the markets.
- The subsequent *product generation process* creates and releases to the market competitive new services and products that implement one or several new ideas determined earlier during concept generation.

Observe that the two layers are not sequential, managed as a whole, or performed by the same designers. This makes the following issues critical:

1. How should new product concepts be developed, documented, and validated to facilitate their rapid implementation in a subsequent product generation process?

2. How should the documented product concepts be employed during product generation so that the information they convey is utilised to the maximum feasible extent? Observe that this includes not only exploiting documents directly related to the concepts, but also the related background information such as use patterns, mobility, and location sensitivity.

In our work, we view these issues from an information management perspective and utilise aggressively methods and techniques from product modelling, document management, and knowledge sharing to facilitate acquisition, systematisation, structuring, storage, and exploitation of design data. As a result, we include a third process in our work, the *information management process,* responsible of maintaining an information-rich interface between the concept and prototyping processes.

3.2 Concept generation process

As stated above, the concept generation process is responsible of identifying and documenting new service and product concepts as a continuous process. To comply with the characteristics of our design domain, we chose to follow a user-centred approach in this process [2, 3].

First, user data is gathered by carrying out user studies with a variety of methods. It is important to recognise that the use patterns of mobile devices, unlike those of fixed devices sitting neatly in the office or at home, combine work-related aspects with personal life styles and preferences. This makes the user studies much more challenging than those related to normal office work. To address this, we have experimented with a wide variety of methods and documentation techniques:

- *information gathering:* interviews, web diaries, and ethnographic research
- *analysis:* interpretation sessions and affinity diagrams
- *idea generation:* gaming, brainstorming, and storyboards
- *validation:* prioritising and refinement.

The deliverable of concept process is a growing pool of well understood use scenarios that describe a service, its user(s), their mobility, and the locations. Moreover, rich background data is collected and stored along the data created through designer activities such as analysis and idea generation. Section 4 will give examples of some of the design methods and documentation methods that we have found useful for our work.

3.3 Rapid prototyping process

Instead of attempting to deal with a complete product generation process, we focus on generating rapid product prototypes only. Hence, our work covers a prototype process, the objective of which is to build prototypes based on the use scenarios. Prototypes are implemented either as "lo-fi" mock-ups, "wizard-of-Oz" concept prototypes, or functional prototypes as may be needed. The challenge is to be able to test how well users accept the chosen service concepts and to demonstrate their technical feasibility.

To be useful for this, a prototype must embody the crucial features of a service or product concept in a form that facilitates their evaluation. This is challenging because new data from user studies may have to be incorporated during the development of a prototype. On the other hand, prototyping should be capable of incorporating also new technological alternatives as rapidly as possible to avoid premature lock-in to a certain choice.

To tackle with these requirements, we put emphasis on transparency by employing ideas of knowledge management and information sharing combined with change management. In particular, we try to maximise the reuse of cumulating design specifications and expertise. For this, we generate design rationales to ensure that all requirements are taken into account during each design decision. The design rationale is a record of the background data and reasoning of design decisions so that the design process produces not only the final prototype, but also the reasons of why e.g. certain components or their features were selected [4]. This makes it possible to retrace the design decisions if the requirements are changed or a new technology offers new implementation alternatives.

3.4 Information management process

Each of the two processes proceeds independently by repeating iteratively its sequence of development activities. Thus, the concept process carries repeatedly out user study rounds for different user groups to discover new use scenarios. Similarly, the prototype process repeatedly chooses a scenario or a combination of scenarios, implements it, and continues the iteration again from the beginning.

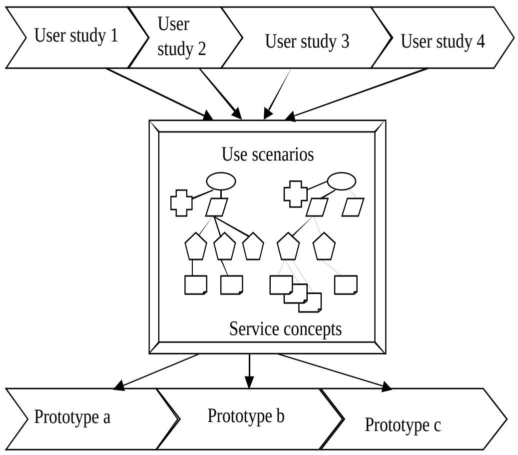

Figure 2: Method management and criteria control.

The information management process provides the needed integration and transparency for the two processes through information structuring, modelling, and methodologies; see Figure 2 for illustration.

4 THE WIRELESS MP3 SERVICE

To illustrate our approach towards transparent concurrent design, we discuss the development of the a wireless MP3 player prototype and the related service that we have studied in our group. To test our design framework, we decided to pursue the concept generation process and the prototyping process simultaneously. Thus, we had to meet fully the challenges of change management and the other information management issues in our work.

4.1 Concept generation process

A wireless MP3 device and the related service differ from the conventional devices in the crucial aspect that the music played is not prefetched and stored in the memory of the device. Hence, instead of 30 or so pieces of music, the device can access as many tracks as provided by the server. This opens up many issues such as the user interface metaphor of the service.
To gain deeper understanding of this and related issues of the service, we chose a focus group of users and studied them by applying the process of concept generation as outlined in Section 3 above. Information was gathered using a combination of research methods such as open and closed interviews, web diaries, and focus group discussions. All data was carefully documented and stored in a form accessible through our group's Web server.

During the analysis stage, the rich background data was studied using interpretation methods such as affinity diagrams constructed from user observations and other background data. Similarly, idea generation used methods such as brainstorming and role games. To facilitate gathering feedback from the focus group, we found role games enhanced with a concrete representation of a space where users could play various mobile scenarios to be particularly useful; see Figure 3 for an illustration. Similar methods were also used in the validation and refinement stage.

Figure 3: A role game enhanced with Playmobil toys.

To record the resulting rich data in a form readily accessible to all design group members, we use Web methods aggressively. In particular, we found the Web-based information management system BSCW [5] to be useful to facilitate activities such as document management, discussion threads, and meeting management.

4.2 Rapid prototyping process

As the result of concept generation, several use scenarios of a mobile music service were recognised and documented. As shown in the example of Figure 4, our use scenarios are basically small stories where a user with a specific profile needs to make use of a service in some specific location with known main features. The scenario also specifies some main service quality parameters. The textual representation of a scenario can be enhanced with a mobility model such as the one shown in Figure 5 that combines a graphical illustration of a scenario with textual information of its main characteristics and issues.

<u>Scenario:</u> *Mobile music at the booking office*
<u>Participants:</u> Booking office (selling tickets)
Peter (going to opera) (profile: 24 year old researcher, hobbies: music, bicycling)
<u>Data to be transferred:</u> Concert/event music
<u>Quality of content:</u> Radio quality (since free)
<u>Tolerance to network/system quality:</u>
Noise/Bit Errors: Allowed to a reasonable extent
Dropping, Blocking, Delays: Not allowed
<u>Start:</u> Peter wants to buy a ticket to an opera but he must choose from two alternatives. The booking office offers its customers a listening service so that they can familiarise themselves with the forthcoming shows. Unfortunately there are too few headphones to serve all customers queuing inside the office.
<u>*Scene 1:*</u> At 17.30 Peter arrives to the booking office. He takes a queue number.
<u>*Scene 2*</u>: The queue number turns out to be at a token that can be attached to his Magic Device so that he can listen to and get information on the operas.
<u>*Scene 3:*</u> At 18.01 is Peter's turn and he walks to the desk. He has had half an hour to make his choice. Having reached a decision, he happily buys a ticket.

Figure 4: A sample use scenario.

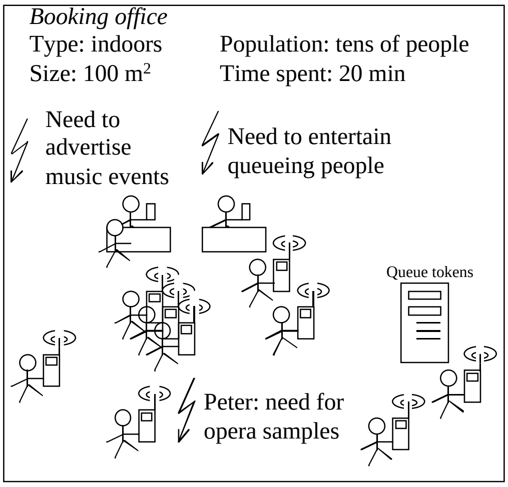

Figure 5: Mobility model of a use scenario.

To provide a sound basis of prototype development, our design process must study use scenarios from several viewpoints: *the interaction view,* the *service architecture view,* and the *business model view* of a service [6]. We use semiformal graphical modelling notations to facilitate this analysis. An interaction model is simply a mock-up of the device with enough detail to explain how the service can be accessed and used. A service architecture model, shown of Figure 6, outlines the main network components that are required for rendering the complete service. A business model view describes the various stakeholders of the service and the transactions that are needed to establish a service, provide it, and arrange payments in needed.

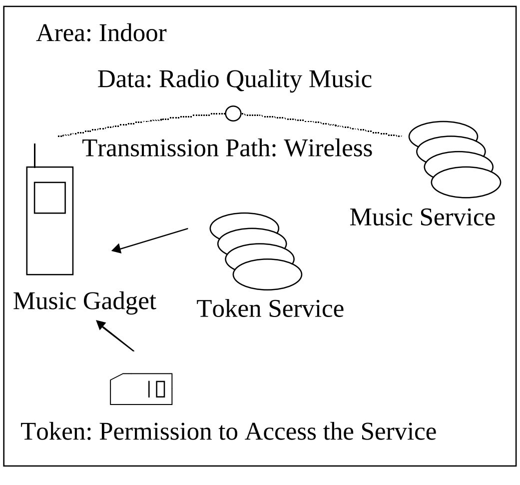

Figure 6: A service architecture model.

A prototyping process might well stop at this stage: often, the models already provide enough information to assess qualitatively the service and the device. In the case of the MP3 service, we decided nevertheless also to build a functional prototype that can be used to assess the effects of varying radio network bandwidth to the user-perceived service quality. The prototype is presently being developed on the basis of standard PC components and WLAN.

4.3 Information management process

To act as a glue of the various processes, their activities, and the viewpoints to the design artefacts, we collect design rationales that maintain information of the design issues, alternative designs, their assessment criteria, and the resulting design decisions. To illustrate this approach, we give two snapshots of prototype design showing how a design rationale can facilitate nonmonotonous design where new information may occasionally need to be integrated.

The first snapshot of Figure 7 shows the initial design rationale, at which stage a decision had been made to build a lap-top based prototype. At this stage, the designers learned that a related project provided a suitable basis for building an embedded system. Furthermore, the technology expert of the design team innovated a new alternative of a on-line/off-line hybrid mode for the media stream. After reconsidering the design in light of this new information, the status of Figure 8 was reached.

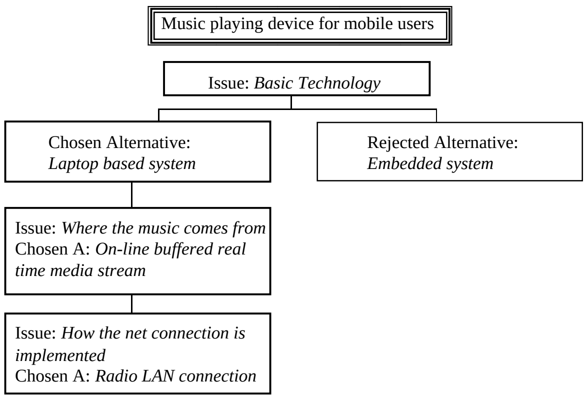

Figure 7: Snapshot 1 of prototype design.

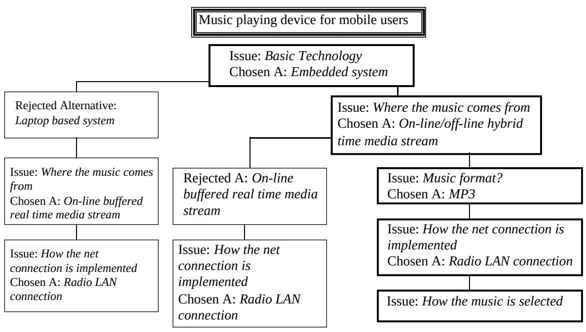

Figure 8: Snapshot 2 of prototype design.

5 CONCLUSIONS AND FUTURE WORK

We have described a framework for structuring and managing design information during mobile service development that provides increased transparency for the entire process. In particular, we have introduced modelling concepts that facilitate structuring design information in categories such as use scenarios, mobility models, location models, user profiles, and various types of design issues and alternatives related to the viewpoints relevant for prototype development.

Our approach provides concurrency at two levels. First, concept generation and prototyping can proceed concurrently by virtue of the separate information management process. Second, various issues relevant to prototype development, such as interaction, service architecture, and business that typically are distinct disciplines represented by different experts in a design team can be dealt concurrently by virtue of the design rationales that force design decisions and their reasoning to be made explicit. Hence, we combine the organisational and technological approaches of CE.

Our work is still at an intermediate stage, and proceeds along several directions. First, we are developing a specific information management tool to maintain design background data generated during the concept process. At the present, the tool used is still at a rudimentary state.

Similarly, as yet we have not attempted to structure our product model as a formal data model. At the time of writing this paper, work in this direction is just about to commence. We are also developing a design rationale tool that would facilitate us to structure design information further on the basis of a suitable ontology that covers the various viewpoints. Another topic of further work in design rationale modelling is capturing the dynamic evolution of the rationale and its viewpoints in time.

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