User Centric Services Without the Guesswork: The MobiLife Approach

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Abstract— **Context-aware services focus on the users current context: Where they are, what they are doing. Users act in various roles during the day, however, and there is a need to keep these roles apart.**
During the MobiLife project, a process for rapid development of applications was created. A set of scenarios for context-based services were created, and existing scenarios integrated, e.g. from the Ambient Networks project and Wireless World Research Forum, WWRF. These were evaluated by users. The feedback from users was then used to modify the scenarios; this was used as a basis for the development of a set of applications, and the applications will be tried on users, which will be used to give feedback to the continued development process. An architecture was developed to support the applications, and iteratively tested in the same way.

***Index Terms*—User centered design methodology, User interface, Visualization, Application Development, Architecture**

I. Introduction

Developing mobile applications which succeed in the market place is currently a hit-or-miss process. While there are ways to determine whether an application is adapted to the needs and wants of a specific user group, there is no way to determine if the services will be successful in the marketplace.
Mobile applications are characterized by a richer set of information about the user being available than, for instance, the PC environment. At the same time, the user interface in a mobile application is more difficult to develop, and consequently more costly. The cost of development, due to market dynamics, is also more expensive. In addition, the model is different – the user is charged for using the service, making payment incremental instead of a one-off, as in the fixed environment. Hence, the business dynamics of the mobile environment can be expected to be different, and development according to a user centric process would enable savings through decreasing the potential cost of development, by selecting the most appropriate applications.

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II. The MobiLife project

The strategic goal of European Union research the MobiLife project is to bring advances in mobile applications and services within the reach of users in their everyday life by innovating and deploying new applications and services based on the evolving capabilities of 3G systems and beyond [1].
Users are already able to communicate with each other anywhere, anytime. But the way they are interacting with the technology is still the same, since the telephone system has been invented: They are using a pipe to transmit information, and the user himself has to make some sense out of it. Because the speed of communication and the amount of information pushed to the users has increased rapidly over the last decade the users are flooded with far too much information.
There is also a lack of trust. Some users refrain from the usage of these new technologies because they feel overwhelmed by its information amount and complexity, others because they do not trust the integrity of the information management. Therefore innovations are needed to help users in the mobile life in a meaningful way to deal with and handle information in the right way. This is particularly important since, in pervasive user-centric communication, establishing trust and protecting privacy are key to user adoption of the services. To address the above challenges in user-centric services, the MobiLife project focuses on developing support comprising personalization, context awareness, user interface adaptation, privacy, and trust

Figure 1. Applications and Services for Mobile Groups.

The research challenge of MobiLife is to address problematics related to user requirements, different end-user devices, available networks, interaction modes, applications and services. Future environments give new possibilities, but also new challenges due to increasing heterogeneity of technological environments, user needs and expectations (see Figure 1). MobiLife will address the multi-dimensional diversity in end-user devices, available networks, interaction modes, applications, and services. As is called for in the ISTAG report [2]:

"*MobiLife makes Ambient Intelligence controllable by ordinary people.*"

In a pervasive user-centric computing system, trust creation and privacy protection are the key to success or failure, yet

have been little considered by researchers and system designers. Their focus usually lies on the security of the system and the irrevocable user authentication. Hence, trust and privacy are a major focus of the MobiLife project.

III. What is additional mobile information?

A user of an ordinary, fixed telephone creates a very limited amount of information by the very use of the device. This includes the time of the call, the connection the call is placed from, and not much else [3]. A mobile user, however, is creating large amounts of information about himself and his situation, compared to users in a fixed system. This is due to the mobile network creating this information as part of the mobility management (e.g. location information) [4], but there have also been attempts to gather additional information about the users situation (using sensors in various ways), usually with the intent to provide services (or, indeed, make sure services are not provided) [5]. Depending on the service type and user personality these are sometimes considered either as privacy intrusive or as useful.

The additional information that can be gathered about the user is often of quite sensitive nature, if applied in the wrong situation. Scenarios for this abound [6], but while there have been attempts to determine what the threats are, the situations where this would be useful to the user are not as frequent in the literature, usually occurring in scenarios which ultimately are intended to sell the system (see e.g. WWRF [7]).

In order to tailor the performance of the user's applications and services to his or her situation, there must be some way for the technologies surrounding the user to know what that situation is [8]. Is the user inside or outside? Walking, driving, or standing still? At home or at work or school? Certain features of the user's situation, such as his or her location, can be gathered without the use of sensors (for example, by using the user's cell-of-origin to approximate his or her physical location). To detect other information about the user, it is possible to use various kinds of sensors [9].

Sensors can be built based on many different enabling technologies (for example, piezo-electric materials, VLSI video, optical gyros and MEMS (Micro Electro-Mechanical Systems) [10]; bio-sensors measuring, e.g. respiration, alcohol percentage, blood volume pressure, skin conductivity, and muscle tension [11]). The use of sensors can determine many characteristics of the user's context, including:

- Location and position information (for both the user and objects in the environment)
- Auditory context
- Visual context
- Physiological context (sometimes used to make inferences emotional context, for example, measuring the sweatiness of someone's palms to determine his or her stress level)
- Environmental characteristics (temperature, etc.)

In addition, individual sensors can be combined into sensor networks, which enable the system to make inferences based on a wide array of context information rather than a single data point such as the ambient temperature [12]. The hope of sensor-based (in general, context-aware) computing is that we can dramatically improve the user's interaction with services by, for example, adjusting the interface mechanisms to suit his or her current situation (using various multimodal interaction techniques, such as pointing, speaking, and gesturing) and filtering incoming messages to suit his or her personal preferences. In addition, context information about one user can be shared with other users, for example for presence and awareness services.

IV. Contextual information services

In a pervasive computing environment, communication needs to be compact and robust, as well as secure and user-friendly; the description of the users situation must be simple and efficient [17].

Mobility, context awareness, and ubiquity will bring computer networks even into the most intimate places and walks of life. Future computing and communication devices are not only capable of accessing people's private information but many useful services are highly dependent on it. There will be an increasingly important dilemma: people are requesting and can benefit from services that jeopardize their privacy. Also, it is often more difficult and expensive to build technical systems that secure private information than to ignore privacy needs. Therefore service providers easily disregard privacy unless customers insist upon it or a legal system forces them to honor it, and have ways of monitoring that it is not violated.

In the same way traditional limits between devices become fuzzy, a significant change in application boundaries has to be expected: going back and forth from private activities to professional tasks is already symptomatic for our everyday schedules. Typical examples for this phenomenon are the usage of a phone, car, calendar, laptop for private and for professional tasks. With services and devices promising to become more and more pervasive this will even increase in the future. As a consequence, making mobile devices and applications able to support this continuous cross of roles and boundaries in different spheres of life will be a major goal of MobiLife [5]. Today, if there is a separation, it is frequently maintained through the use of different devices; i.e. one mobile phone for work uses, another for personal use.

To provide users with services that best match their personal preferences, intention, wishes and dislikes in a given situation privacy should be targeted at a cooperative best-effort discovery and delivery of services. In the highly context-sensitive MobiLife applications it will only rarely be the case that users find their perfect match of personal preferences (possibly deduced from their context) to available services [18].

Group modeling creates adaptive profiles for groups (including ontology or language extensions) which enable users to establish trusted relations to other users and services and items. The use case specifications and application data models are input to the modeling of groups with members' shared assets and services [19] [20]. These aspects include the following:

Adaptation: Establish the utility of and determine the properties of mechanisms and strategies for adaptation for

presenting relevant views of user groups and shared spaces. (e.g. utilizing learning and behavioral history; adaptive and collaborative filtering of group states and ambience; cooperative search techniques for context related information).
Profiling: Model a taxonomy specifically accommodating the dynamics of (ad-hoc) group memberships, including knowledge about dynamic group processes, sharing (and willingness to share) context information, etc. [21].
The privacy dimension looks slightly different depending on whether we are trying to establish privacy on an ad hoc basis, or if we try to secure communication towards a third step in a communication chain behind the server we have logged into in one form or another [22]. For ad hoc privacy, cryptographically verified identities or generation of cryptographic key material based on mobile identity look like possible ways forward.

V. Analyzing Users Privacy Wants Using Scenarios

MobiLife's general approach is to integrate different perspectives, such as user-centred views, business and marketing views, and technology development views. In order to give increasing definition to the concepts being designed, the project description lays out a phased, iterative approach, in which demonstrations and prototypes of increasing levels of fidelity are developed [5].
MobiLife's iterative approach consists of several cycles of user research, technical design and development, and user evaluation. The first step of this process is the creation of scenarios, followed by the creation of mock-ups and probes. At each step of the process, some kind of user evaluation should be conducted to help identify the most promising concepts from the users' point of view and to gather detailed user requirements for these concepts.
The MobiLife project is divided into nine work packages, some of which do not pertain to the discussion here. Those that do are the work package 1, which is focused on user experience; and work packages 2 to 5, who are concerned with various technical aspects of the project. The interaction between the user experience, the end-user applications, and the architecture in which these applications are performed, is the main investigative focus of the project.

A. MobiLife Scenarios and Analyisis Process

In the MobiLife project, we have developed a method to analyze the user interactions before a prototype is created. This method is briefly outlined as follows:
The MobiLife scenarios were developed based on an analysis of the user tasks and behaviours found in an extensive review of scenarios from other projects and from within the MobiLife technical work packages. A collaborative scenario development workshop was then conducted with representatives from most of the MobiLife work packages. The resulting four core MobiLife scenarios are described in detail [23]:

- "Monday": A busy working family with two young children gets ready for the day.
- "Friday": A mother and her young daughter experience a minor car accident, which requires them to use their MobiLife services and applications to reorganise the family's plans for the day and arrange a way to get home.
- "Sunday": A family with two children at home and one child living away from home spend a leisure-filled day together.
- "Olympics": An older couple whose son is at university go to Turin for the Winter Olympics, and have an impromptu meeting with their son when one of his exams is cancelled.

These scenarios formed the basis for qualitative user research with families. 17 families (10 in Italy and 7 in Finland) were interviewed in their homes, first about their general communications behaviour and then specifically about the tasks and behaviours shown in storyboards of the scenarios. Two to three scenarios were reviewed in each family interview [23].
The next step within each technical work package is to develop mock-ups that demonstrate particular applications and services. The high-level user requirements described in the previous section have been discussed with the technical work packages and are helping to guide the selection of focus areas and concepts for the mock-ups. As these concept ideas become more defined, the user-oriented work package may be able to supply even more detailed user requirements based on additional review of the available user data. The technical work packages will hand the mockups over to the user-oriented work package for evaluation, and the feedback will be included in the first prototype of the system, Probe 1.
During the mock-up definition process, it will be worthwhile to consider general user acceptability criteria for application and service design. All of these criteria have been confirmed as important by the user evaluation [23].

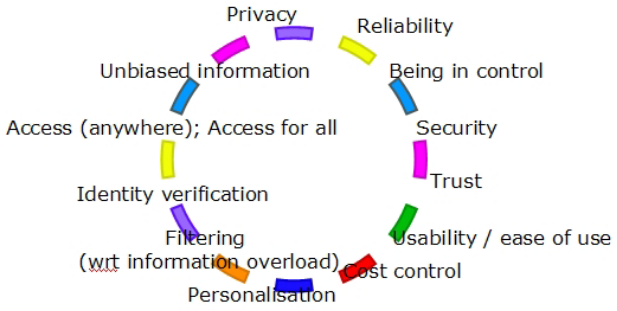

Figure 2. User acceptance criteria for new service design.

In addition, while selecting mock-up concepts, attention should be paid to the related services that are already available, so that the clear user benefits added by our ideas to existing service concepts can be identified. In addition, this information will help us understand the business models (including development and deployment costs) that will affect these concepts if (when) they are actually developed as commercial services.

B. *Preliminary results from scenario evaluations*

The scenarios were used as the basis for interviews with 17 families in their homes. Because the user research was conducted with family members, our findings pertain to the core family members rather than to all of the reference groups for the families.

Finally, both an Italian and a Finnish family took up the notion of security. The concern was expressed that location information of an individual may well be used for dishonest purposes.

In general, commercial services were seen as useful for specific tasks such as buying books, CDs, or movie tickets. However, some users doubted whether the services would ever be integrated enough so that the most unpleasant parts of consuming, such as queuing, could be avoided.

A lot of the described interactions included suggestions made by the system. The idea of utilising user profiles or preferences to suggest services in the vicinity of the user resulted in different assessments by the participants. Some participants seemed to be willing to accept plenty of personalised "push" with even more advanced techniques, such as virtual images of the user wearing the clothes sold in the nearby shops. In contrast, some users strongly rejected these ideas. Rejection was based either on general unease with being monitored at all, or on some negative experiences on analogous systems. For example, it was suspected that despite all the intelligence of the system, it will result in unfit suggestions and spam, since there will always be commercial players who want to manipulate the ranking of the items.

It was also noted that location-aware commercial services could be misused for criminal purposes. Security issues were thought to be especially important if users' location, profile, preferences, shopping lists and financial status were displayed to actors in the vicinity of the user. Hiding information from people other than trusted parties was only part of the solution. For example, if a downtown department store was trusted as an organisation, this would not mean that all its employees were also trusted.

Intelligent and adaptive systems face the dilemma that the more appropriate inferences they make about users' wants and needs, the more out of control users will feel. Users want to make decisions themselves.

The same concern was raised for another of the applications described in the scenarios, the "multimedia sharing" application, which intends to create something akin to "blogs", but with a real-time component. Some participants noticed that there could be a problem of privacy, especially when another person registers and broadcasts an event in which they are involved. Therefore they asked for an important privacy control. A typical quotation was: "I wouldn't like to know that someone is watching me on a TV, it seems like 'Big Brother'..."

VI. Discussion

Using scenarios to create services, and using a structured process in doing so, has already helped us to derive valuable research results and create mockups for services which can be user tested, despite the project only having run for 6 months. The use of scenarios is a simple mechanism to select appropriate services for development (and de-select inappropriate services) when combined with a user evaluation. Since the intent is to develop services which are more appropriate for users than the traditional "hit and miss" method, and since the mockups will be tested on users and reveal any additional misconceptions about the service (through the analysis of the user interactions). This analysis will have an impact of the architecture of the underlying system, since the functions needed to deliver the services will be described in a way that highlights the commonalities between the services, and the functional constraints on them. Selecting the appropriate services through scenarios also facilitate both user testing and visualization further down the road, as the service developers can refer back to the scenario evaluation and get user feedback on the intentions of their services.

This puts some weight on the service creation process, and while it was noted early on in the project that there are plenty of scenarios available for future mobile services, it was nevertheless determined worth-while to develop a specific set for the project, since these scenarios would reflect the specific aspects of the architecture which would subsequently be developed, depending on the scenarios.

However, and important matter of timing emerged. When the project started, there was the assumption of the workpackages 2 to 5 that the scenarios would be delivered from WP1. WP1, on the other hand, waited for WP:s 2 to 5 to come up with scenarios. The lesson from this is that before the work starts, all such dependencies must be sorted out and the responsibilities be made crystal clear. On the other hand, this is no different from any software development project.

VII. Conclusion

The scenario evaluation clearly points to the importance of further work in the area of personal privacy in ubiquitous mobile applications. User concerns are evident, and European, as well as other legislation, highlight the importance of the issue. Scenario analysis is a powerful and useful tool in service and system design, but the creation of the services have to be carefully managed, so that different parts of a project do not stand waiting for each other.

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