ESPOO 2004 VTT PUBLICATIONS 539

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VTT Information Technology

ISBN 951–38–6396–4 (soft back ed.)
ISSN 1235–0621 (soft back ed.)

ISBN 951–38–6397–2 (URL: http://www.vtt.fi/inf/pdf/)
ISSN 1455–0849 (URL: http://www.vtt.fi/inf/pdf/)

JULKAISIJA – UTGIVARE – PUBLISHER

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Technical editing Marja Kettunen

Otamedia Oy, Espoo 2004

Kolari, Juha, Laakko, Timo, Hiltunen, Tapio, Ikonen, Veikko, Kulju, Minna, Suihkonen, Raisa, Toivonen, Santtu & Virtanen, Tytti. Context-Aware Services for Mobile Users. Technology and User Experiences. Espoo 2004. VTT Publications 539. 167 p. + app. 3 p.

Keywords Context-awareness, mobile applications, mobile Internet, context adaptation, user evaluation, human-centred design, service providers

Abstract

Mobile services and applications are used in varying contexts and surroundings. When the services are made context-aware, they can offer contextually relevant information to the user. This facilitates the finding of data and creates new purposes of use.

The Kontti (Context-aware services for mobile users) project (January 2002 – December 2003) designed and implemented a context-aware service platform and services. The platform enables management and sharing of contexts, presence information and contextual content, and it provides context adaptation and context-aware messaging. Also, personalisation and context tools were implemented.

A human-centred design approach was adopted throughout the project: the acceptance of users and service providers guided the design process from the very beginning. The developed applications were evaluated in field trials. The results provided outlines for meeting the usability challenges in context-aware services and for adapting content from one context of use to another.

The results of the Kontti project indicate that the most promising applications for context-aware services are event guides and professional use. Also, conveying context information proved to be very interesting for the users. Further, contexts can be used for opening new communication channels for messaging. Context can be used as a mediator where any recipient can pick up a public message.

The commercial viability of the Kontti concept was also evaluated with a round of interviews with service providers.

Preface

This publication contains the results and experiences of the two-year project "Kontti - Context-aware services for mobile users" which took place between January 2002 and December 2003. The project was part of the "NETS Networks of the Future" research programme run by the National Technology Agency of Finland (Tekes).

Tekes and VTT Information Technology financed the project with three companies: Nokia, Radiolinja and Teamware. Each partner was represented in the project board. The project also had a technical support group including participants from the same companies. Both the project board and the technical support group made a major contribution towards ensuring the success of the project. In addition, the Finnish Broadcasting Company (Yle) provided content for the field trials.

The project team at VTT Information Technology included Matti Aaltonen, Ari Ahonen, Matti Alatalo, Tapio Hiltunen, Veikko Ikonen, Eija-Liisa Kasesniemi, Juha Kolari, Minna Kulju, Timo Laakko (project manager), Juha Leppänen, Sari Mokka, Raisa Suihkonen, Santtu Toivonen and Tytti Virtanen. In addition to technical experts, the multidisciplinary project team included experts on human-computer interaction, cultural research, psychology and business studies. We thank the reviewers of the publication: Heikki Ailisto, Eija Kaasinen, Jaakko Lähteenmäki, Jukka Perälä and Maria Lahti (language check) for their contributions.

Sanna Lehtonen and Saija Raskulla demonstrated the service during the Tampere Theatre Festival. We thank them for their enthusiasm and effort. We also wish to acknowledge all the participants of the user trials, who gave us their time and insight. They were essential for the project.

Contents

List of abbreviations

CC/PP	Composite Capability/Preference Profiles
GPS	Global Positioning System
HTML	Hypertext Markup Language [HTML]
HTTP	Hypertext Transfer Protocol [RFC2068]
IMPS	Instant Messaging and Presence Services [OMA-IMPS]
LIF	Location Interoperability Forum
LIF MLP	LIF Mobile Location Protocol [OMA-LIF]
MIDP	Mobile Information Device Profile
MMS	Multimedia Messaging Service
OMA	Open Mobile Alliance
PDA	Personal Digital Assistant
PPG	Push Proxy Gateway [OMA-PUSH]
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SI	Service Indication [OMA-SI]
UAPROF	User Agent Profile [UAPROF]
UI	User Interface
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
W3C	World Wide Web Consortium
WAE	Wireless Application Environment
WAP	Wireless Application Protocol
WLAN	Wireless Local Area Network
WML	Wireless Markup Language [WML]
XHTML	eXtensible HyperText Markup Language [XHTML]
XHTML MP	XHTML Mobile Profile [XHTMLMP]
XML	eXtensible Markup Language [XML]

1. Introduction

1.1 Background

Mobile Internet services enable access to information in a more flexible manner than SMS-based send-and-receive. The information can be browsed much like the Internet, although more slowly at first. Colour displays and the growing capacity of more developed mobile models have brought about enhanced visual appeal and easier user interfaces. However, the services are still mostly unaware of the context the user is in. The service is the same regardless of changes in the user's surroundings or her information needs that would be very apparent to a human onlooker. The mobile device is not aware of its mobility.

The recognition of context means that the user's information needs can be anticipated and responded to in a more automatic manner. Information and service needs vary according to the user's immediate situation. A context-aware service responds to this by offering contextually relevant information. For example, in the case of messaging, only messages that conform to the user's currently active contexts may pass the "contextual filter." Contextual information can also be used to make the user more aware of her social surroundings. When the context of a user has been recognised, it can be communicated to others, if the user so wishes.

Since the variety of mobile devices, applications and networks is growing rapidly, the challenge of developing usable applications becomes all the more important, a critical success factor. Personalisation and adaptation of services for different users, different contexts of use and different devices are the most promising factors in matching the service with the user and thus improving the usability of the services.

1.2 Project objectives

The initial objectives and requirements included the following:

- To develop concepts and tools for offering context-aware services

- To develop adaptation methods
- To develop and implement context-aware example applications
- To evaluate the applications and concepts in user trials
- To assess the viability of context-aware mobile services with a round of interviews with service providers.

The goal of the project was to develop concepts and tools for offering context-aware mobile services. Methods for adapting and personalising these services were to be created during the project. Development goals included example services, which would adapt to the terminal, network, context of use and user preferences.

The needs and wishes of users regarding the features of the system and the user interface provided the basis for development. The match between the services, users' and service providers' requirements was ensured by using human-centred design methods, as described in the international standard for human-centred design processes for interactive systems. [ISO]

The design process was started by defining user requirements through a series of interviews. All through the project, user requirements were gathered to ensure that user-friendly implementations and concepts of technology would be used. As the project progressed, the iterative design process provided constant feedback to developers about the design and features of the system and its user interface.

The field trials and use cases focused on different features of the service to give a more complete view of the concepts and key issues that context-awareness involves. These evaluations are reported in the same order they were conducted: Context study, Everyday use, Historical route, Theatre festival and Social circle. A parallel line of research studied the opinions of service providers about the viability of context-aware mobile services in their line of business.

1.3 Overview

This report summarises the results and experiences gathered by the Kontti project. First, in chapter 2, the groundwork is described for the user requirements of context-aware services. After that, in chapter 3, the overall system architecture and components are outlined. Then, the adaptation proxy component and aspects related to the content adaptation are considered in chapter 4. Next, the example application, context manager, is described in chapter 5. In chapter 6, a comprehensive description of the evaluations is provided. After a general service description, five test cases are desribed and usability issues and future concepts are discussed. Next, in chapter 7, the results of service provider interviews are considered. Then we analyse and discuss issues related to the obtained results in chapter 8. Finally, the conclusions are presented and directions for future work are pointed out in chapter 9.

2. Groundwork for a context-aware prototype

The project began with gathering initial user requirements for development. As a whole, the groundwork was derived from the following three sources:

The topic of context-awareness has been a part of several projects at VTT and under study internationally in mobile research. **Existing publications** on context-awareness were reviewed both in Kontti and in parallel projects, such as KEN [KAA02]. The basic issues related to context-awareness are discussed in section 2.1.

The **results of the WAP-UAPROF project** [KOL] outlined the initial user requirements. The project developed an adaptation proxy that converted web pages and images for mobile use. The service was evaluated and used by 81 people as part of their everyday lives. Especially the ease of personalisation and a close connection to the user's daily life were considered important when designing the prototype. The results clearly indicated that generic, made-for-all solutions were not as appealing to users as personal and topical content. The findings were well in line with the goals that context-awareness in mobile use aims at achieving.

The **context study** (section 2.2) conducted at the beginning of the Kontti project aimed to identify how users describe the contexts in their lives and what their information and communication needs in those contexts are.

2.1 Definitions of context-awareness in mobile services

Mobility is often understood as independence from context, "the same applications as on your PC - everywhere". In other words, mobile devices often attempt to reproduce the desktop PC [GRO]. However, the information needs of the user can be facilitated if the proper context of use can be recognised. A context-dependent service will display information by sensing cues in the overall context and adapting the service accordingly. Rodden et al. [ROD] maintain that context-awareness and personalisation are not an added extra. The limited screen

display means that highly adaptive interfaces are a necessity for mobile computing.

The currently available mobile services do not yet offer such material, or do not offer it contextually. Other kinds of displays (Figure 1), on the other hand, have been making use of contextual information for a long time: arrivals and departures at bus and railway stations or the seating status for a movie are typical examples. Some information, such as event schedules, are just waiting to be converted into context-aware services.

Figure 1. A display for arriving buses at a bus stop. The dynamically updated times of arrival present context-awareness. The information is also location-specific.

The concept of context. There have been several classifications of context. Although the "context of use" is sometimes equated with "location", it can have several other meanings. A context can be understood at different levels of abstraction, for instance, as "in a meeting", "it is cold", "in the field" or "at work" [SCH]. These abstractions can be classified under *environmental context*, because they refer to external conditions. On the other hand, *personal context*

refers to the user's internal factors. For instance, Cheverst et al. [CHE00] described a portable tourist guide system, in which the personal context can consist of factors such as the visitor's personal interests and previous visits to a location. Thus, the context of use approaches also the concept of personalisation.

Schmidt et al. [SCH] proposed a context classification that contains two general categories:

1. Human factors

   User – personal habits, mental state, etc.
   Social environment – proximity of other people, social relations, collaboration
   Task – goal directed activities or more general objectives

2. Physical environment

   Location – absolute (e.g. co-ordinates) or relative (in a car)
   Infrastructure – computing and interaction environment
   Conditions – level of noise, brightness, fixed vs. changeable conditions

Dey [DEY] criticized earlier definitions of context as being either too specific or just using synonyms for the word 'context'. He maintains that context entails all information about the situation that is relevant to an application and its set of users. Dey presents a more general definition of a context-aware system: "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task."

The elusive nature of context is also present in Abowd and Mynatt's [ABO00] description of *everyday computing*. Everyday computing is characterised by informal, daily activities, in which:

- There is rarely a clear beginning or end.

- Interruption is expected. The activity may continue in the background only to be focused on later again.

- Multiple activities operate concurrently.

- Time is an important aspect of everyday computing. Past events are examined frequently.

- Associative models of information are needed. Information hierarchies are not stable, but change over time.

Recognition of context. Since context is a broadly defined and ever-shifting target, its recognition remains a challenge. In addition to time and location, other sources of information can be consulted to complete the picture and to insure a more detailed recognition of contexts. Abowd and Mynatt [ABO00] describe the handling of different sources for context recognition as *context fusion*. Not only can an individual context source (location, sensor reading) identify a separate context, it can also add to the accumulated information from other sources to increase the reliability of the recognition of a particular context.

It is important that the system can manage several operational contexts without limiting itself to certain aspects of the context. The contextual recognition will be handled separately. Salber et al. [SAL] describe 'Context widgets' which provide applications with access to contextual information, but which are separate from the application. The applications can use the contextual data, but the handling of sensor readings, location etc. is up to the widgets.

Adapting the service to the context. After the context has been recognised, the system can react by adapting its services or the manner in which they are presented to the user. Norros et al. [NOR] list four categories of adaptation:

- Adapting the interaction – changing the look and feel of the user interface, changing the interface to better fit the terminal features, utilising modalities best suited and supported by the technology at hand, taking into account the user's experience in using a certain application, etc.

- Adapting the service – providing personalised services by pre-filling forms, tailoring offers, recommending products, offering easy access to services relevant for the user's location, task, etc.

- Adapting the content – providing information relevant to the user's context, task, and interests.

- Adapting the environment – changing the environment to better suit the user's wishes (music, lighting), adapting ventilation according to the number of people, adjusting car seats individually for each driver, etc.

Context-aware services have been studied with example services, for instance, event navigation [ABO97], tourist guidance [CHE02, CHE01] and context-aware messaging such as W-MAIL [UED00], GeoNotes [ESP] and E-graffiti [BUR].

Abowd et al. [ABO97] developed prototypes for event navigation, using a PDA device with GPS for outdoors and IR (infrared) for indoor positioning. Experiences with the tourist guidance system GUIDE [CHE01] provided feedback for discussing issues such as the reliability of information push based on context recognition. The effective prediction of the user's goal is critical. If the prediction fails, the system is actually less usable than a system without context awareness.

The WMAIL system [UED00] supports commands that can make e-mail more adaptive to the environment. Messages can be targeted e.g. to a particular location for the recipient. GeoNotes [ESP] allows the posting of virtual notes to the surrounding environment. Espinoza et al. argue that location-aware notes can enhance the social awareness of people who share a location. The E-graffiti application [BUR] provided similar features. A group of university students used a laptop with a positioning system to attach virtual text notes to places around the campus. The study found a need for a highly relevant contextual focus, the users did not necessarily think of the messages as location-specific.

The **sharing of contextual information** to other users makes the context itself the information. Common terms for this are 'presence' or 'status information'. By knowing the status of other users, contacts can be made in a more flexible manner. Similar features have already been use in PCs, e.g. ICQ and Microsoft Messenger. Both enable the user to convey their status or availablility to other users. Mobile research has often focused on location as the context that is conveyed. Colbert [COL] used a location-based system to facilitate flexible

meeting between friends. A similar system was also used by Fithian et al. [FIT] for event planning. Nakanishi et al. [NAK] introduced a Java-based solution for viewing the social surroundings and location of friends. Our approach to presence was less location-centric. We assumed that any context that is relevant to the user could be conveyed to others, whether the recognition of the context is technically viable at this point or not.

2.2 Context study

A context study completed the user requirements phase for the creation of the prototype. The objective of the context study was to create categories of the contexts that people use in describing their lives. Since we assumed that people have a myriad of contexts in their lives, we aimed to find generalisations that would help in creating a flexible enough system to be used in everyday life.

Interviewees. The interviews for the context study were conducted between March and April of 2002. The participants were contacted through the social networks of the researchers and by contacting sports clubs (bowling and golf) for volunteers. 28 people were interviewed, 15 of which were male and 13 female. The age of the participants ranged from 14 to 72 years. The users' experience with the Internet and with mobile services varied from little experience to very experienced.

The interviewees were chosen to assess five different approaches. The approaches were modified to represent context-awareness from slightly different angles from everyday use to location-specific activities and business-related views. The approaches were as follows: Circle of friends, Event participation, Hobby, Household and Business case. In the hobby approach, the chosen activities (bowling, golf, and event participation) take place away from the users' home and include location-specific information needs.

Sessions. The interviewees were asked about the places, times and situations in their everyday lives and hobbies. All interviewees were also presented with three concepts related to context-aware services. The concepts were illustrated as paper prototypes of the user interfaces of each service concept (Figure 2). The

concepts were used also as a basis for wider discussion about different mobile services. The service concepts were:

- Communication with other users within the same context; leaving either personal or public messages at a location,
- Tourist information, history and images of the city of Tampere, and
- Context-sensitive information at an event (Theatre happening).

Figure 2. The participants gave their views on different context-aware concepts, such as context-aware messaging and event guides.

2.2.1 Results of the context interviews

The data was analysed in discussions among the researchers in order to arrive at a general view on what kind of contexts and related information were relevant for users. The system needed to be designed in such a way that enough variety would be available to cover all context categories. At the same time, the user interface would have to allow other contexts to be added in a flexible way.

Information needs

The location or **current context of friends** was one piece of information that most interviewees felt they wanted. When arriving to a hobby, an event, school

or a new place, the first information needs usually included questions such as "Who is here today?" or "Where are my friends?" The use habit and acceptance of a technical device for this task did seem stronger among the younger interviewees, while the older interviewees had doubts about a system which would allow them to check on their friends in this manner.

The information that the users would like to display to others varies. Users should have the option to choose the way a context appears to others. For instance, "At school" can appear as "Not available, send SMS" for one group, and to others as "At school, movies in the evening." There is a need on one hand to limit the number of people who can access the information and on the other hand to describe it differently also within the group who have access.

Event and tourist information was appreciated by many users. When a particular event takes place, users were keen to access current information and especially programme changes. The need for such information increases if the events or attractions are spread geographically.

Simple news material received contradictory comments. Some users could identify the moments when they were most likely to read news ("In the morning", "in the tram"), but often general news items were not found context-specific enough to warrant a context-adaptive approach. People simply access the news when they have time.

Messages

Personal communication divided opinions. The main division was between how younger and older interviewees perceived the need for and/or fun in location-based peer messages. Younger interviewees were more excited about peer messaging than older interviewees. However, context-based messages for peers would need a more precise recognition of location than is possible with the current infrastructure. The chosen contexts that younger users mentioned were '5th floor of the mall' or particular places at school. The more general locations "Mall" and "school" were not accurate enough for the way in which the younger interviewees expected to use the system.

Using contextual messages among friends in every-day communication came up more rarely than other types of context-aware messaging. One interviewee could imagine a situation where a group of friends decide to do something together "once they are in the same neighbourhood". So, when the users arrive in the same building or the same neighbourhood at the same time, they would be reminded of their plans to do something together.

Public communication is directed at a wider audience, at an event or in a particular location. For location-based public messages the feedback from the older interviewees was more positive than for context-awareness in personal communication. Public context-aware messages would be like a location-based guest book or a bulletin board and not a directed message to one recipient. Some users had little interest in writing on such a forum, but could imagine reading it.

Contexts

The following general context categories were found: **Location**, **Time**, **Mode of spending time**, **Mood**, **Virtual context and Social context**.

Location is an obvious choice to describe a context**.** Location could be a *fixed location*, such as a suburb, centre of the city or "5th floor at the mall". The location could also be *relative*, such as home, work, the movies, which get their meaning only once the user defines what or where "home" is for her; the location of a home needs to be "filled in" by the user. A *moving location*, such as a vehicle is also possible. A context such as a bus route, may also be defined by location, even though the people on the route are moving.

Time is the easiest context to identify. Users mentioned weekdays and weekends as contexts with different informational needs. The division was often related to work/school and leisure. Morning was mentioned as the time of day when people would read news and e-mail. Seasonal changes may also affect information needs, also in relation with holiday seasons.

Mode of spending time. The division between work and leisure is also a function of time for many. For others it is not as easy to discern whether the user is "at work". Work can take place at irregular times and places. Whether the user feels that he or she is at work is reflected, for instance, in his or her willingness

to receive work-related mail. If the user is sleeping or otherwise not available, someone contacting him or her may wish to have at least the information that the user is not available for contact. This category also contains *organisational context*, which can differ from the location and social setting, even though it is likely to overlap with them as well. An organisational context could be, for example, “management board”, “project meeting”, “Economy Committee” or “plenary session at parliament”.

Mood is a context least likely to be automatically recognised. Contexts such as “partying” or “relaxing” may not be connected to a certain place or time, and as such will need to be chosen actively by the user. In these states of mind, the user may not have contextual information needs herself, but conveying her mood to other users may help fill their information needs.

Virtual context. The context can be something virtual as well. The younger interviewees wanted to connect mobile materials, such as mobile photos, video clips or alerts to virtual places. A group of girls had created their own virtual places or worlds, such as wizard castles, dog kennels and horse stables. These virtual worlds mixed reality and imagination. On their web sites the girls had virtual animals, which they could equip and buy food for with virtual money.

Examples of virtual contexts can be found in adults' life, too. Environment can be seen as layered with virtual contexts and realities, much like the reality is layered with personal meanings and interpretations for each person.

Social context runs through all other contexts. Reminders and personal messages could be seen in relation with social contexts. One could imagine a user sending a message, which activates once a certain group of friends are at the same place (town, campus, mall) at the same time: “You’ve all arrived at the campus. Remember we were supposed to have lunch together when all of us were nearby! Call!”

User requirements

Many of the contexts the users described would be difficult, if not impossible to identify. Users may want a more precise recognition of location than is currently possible. Moreover, an automatic recognition of context is not always desirable.

A balance is needed between an active selection of context by the user and an automatic selection. Some manual selection will be needed, but too much will dilute the ease of use. The following requirements for creating, selecting and accessing contexts were identified in the study:

- The service should allow users to select and activate contexts, since all contexts cannot be recognised automatically. When using a context to filter information, or to simplify the specification of a task, it is crucial that the adaptation does not over-determine the user's intention. This issue is derived from the fundamental design trade-off between prescription and freedom or flexibility [CHE01].
- The context-aware service should respond to two different kinds of information needs. There could be contexts that offer information about the user's surroundings to the user, e.g. event information. Contexts created for communication between users convey the information of users' current status to others. The user interface should support an effortless viewing of other users' current contexts.
- The system should be designed to cover all context categories (e.g. location, time, mode of spending time, mood, virtual context, social context).
- The service should allow the user to define contexts regardless of how the context is recognised. Cities, regions within them, landmarks and other points of interest are contexts of which there is a high degree of agreement regarding what the context consists of. The location could also be *relative*, such as home, work, the movies, which get their meaning only once the user defines what or where “home” is for him or her. Highly personal contexts need to be defined by the users themselves.
- The service should offer ready-made contexts from which the user can choose, but it should also offer the option of creating and editing one’s own contexts. The user interface should allow adding contexts in a flexible way.
- The service should allow users to select whether their context is accessible to other users and in what form. Users find this more acceptable than pinpointing their actual location. The requests for context information should be separated between ones that come from the user's friends or acquaintances and ones that come from other sources. For instance, the user could choose to recommend a method of contacting when at the movies,

showing the text: “At the movies. Use SMS” for friends and perhaps: “Contact at work” for his or her workmates.

- The service should respond to the need for receiving information in a defined location or area (5th floor, corner of McDonalds, classes at school).
- The system should enable leaving messages to the active/inactive contexts of other users. If the context is not based merely on location co-ordinates there needs to be an agreement about which context corresponds with the recipient’s context.
- The system should indicate to the sender if a message has been delivered or “left hanging” if the intended recipient did not, for instance, arrive at the specified location. With e-mail or SMS, you can assume that once the message is sent it will also be delivered unless complications occur. However, with context-aware messages, the gap between sending and delivery can be intentionally quite wide.
- Connecting mobile material, such as photos, video clips, notes and documents to the contexts should be enabled.
- Inactive contexts should be accessible as well. There should be a way to override the automatically chosen context.
- Handling parallel contexts is an issue which needs to be solved in a simple and straightforward manner. If active contexts conflict (“at work”, “weekend”, “Hervanta”), there should be a clear indication of which context is the primary one. Some contexts, such as time and location, can appear at the same time, if the user has not identified priority.

In conclusion, solutions are needed both for managing and for recognising contexts. Our definition of context is centred on the user’s perception of context: whatever is a relevant context to the user is also a relevant context for us. The number of parallel and shifting contexts can be restricted by choosing a specific setting, but at the initial stage we did not wish to limit ourselves to any particular category or technology for recognition

2.2.2 Context ontologies

The categories that emerged from the context study were used for creating context ontologies. One goal of the Kontti project was to enhance the functioning of a distributed system by generating compatible profiles for different kinds of entities in the system. The earlier WAP-UAPROF project produced profiles for mobile devices. These profiles were utilised when adapting diverse content for the devices. The profiles were based on recommendations specified in W3C (CC/PP) and OMA [UAPROF]. The Kontti project aimed at extending this profile-based approach to other kinds of entities.

One essential candidate to be characterised by a profile-based approach is the user. The properties and preferences of the user are explicated in profiles. The profiles of a user are matched with other users' profiles, as well as with the profiles of devices and services. Profiles are created and maintained with the help of ontologies. More specifically, the information contained in profiles is structurally based on ontologies, as depicted in Figure 3.

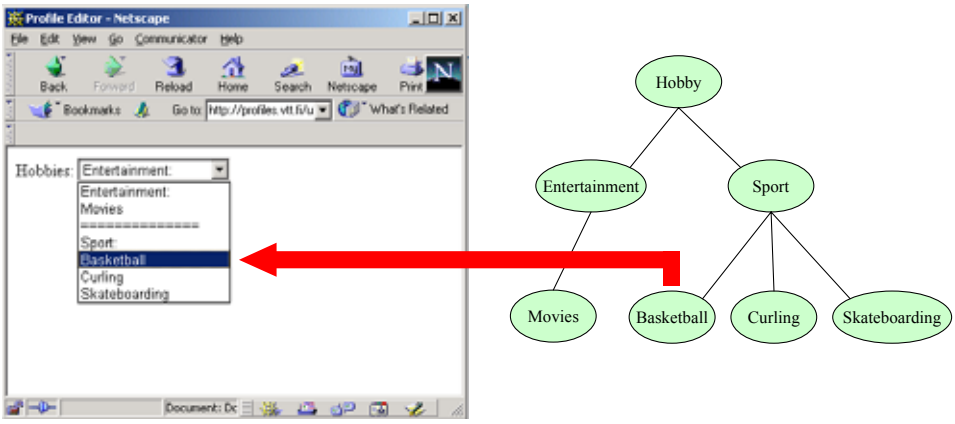

Figure 3. Choosing a profile from a drop-down menu.

The context interviews were taken into account when designing ontologies for users. The properties of a user are divided on the uppermost level into permanent and contextual properties. Particularly the contextual information is based on the results of context interviews. Important examples are information about location, time, social context, sphere of influence, and state of mind of the user [AIMS].

Besides the context interviews, also existing standards efforts such as OMA/IMPS (Instant Messaging and Presence Services) [OMA-IMPS] were utilised in designing ontologies.

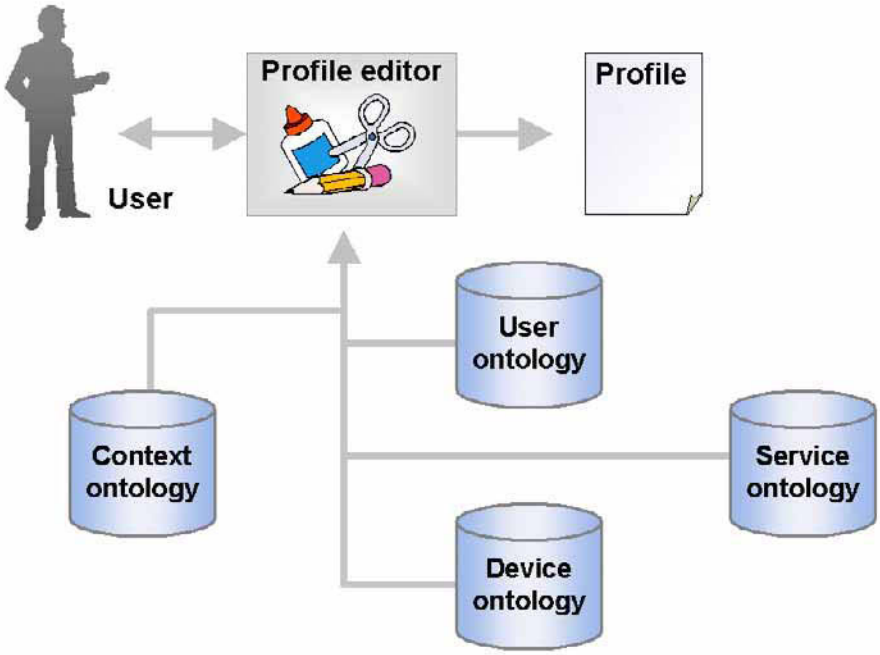

Figure 4. Creating a contextual profile.

Ontologies are designed to be modular so that one ontology encapsulates one functional element or function. There are ontologies at least for devices, users, context data, and services. When generating profiles, information from several ontologies can be mapped together as one whole. This is depicted in Figure 4. For example, the user can select a device she wants to use from the device ontology, a set of services she subscribes to from the service ontology and information about time and place from the context ontology. She can then incorporate the information together as her contextual profile. Depending on the implementation-specific details, these ontologies can be grouped together or stored separately. Functionally they are nevertheless separate units.

The ontologies in the Kontti project are frame-based and thereby highly flexible [AIMS]. It is possible to implement frames in virtually any kind of language.

One frame defines one concept by spefifying its properties. For example, a frame for the concept of `address` might have `streetname`, `streetnumber`, `zipcode`, and `countryname` as its properties

The values of properties can also be other frames. For example, consider a frame for `company`. Among other things, it can have a property `address` that has the above-mentioned address frame as its value. In an ontology, frames are organised as a hierarchical structure. When generating profiles, frames from different ontologies can be imported and integrated.

3. Overall system architecture

This chapter outlines the overall architecture and the components of the system developed in the Kontti project.

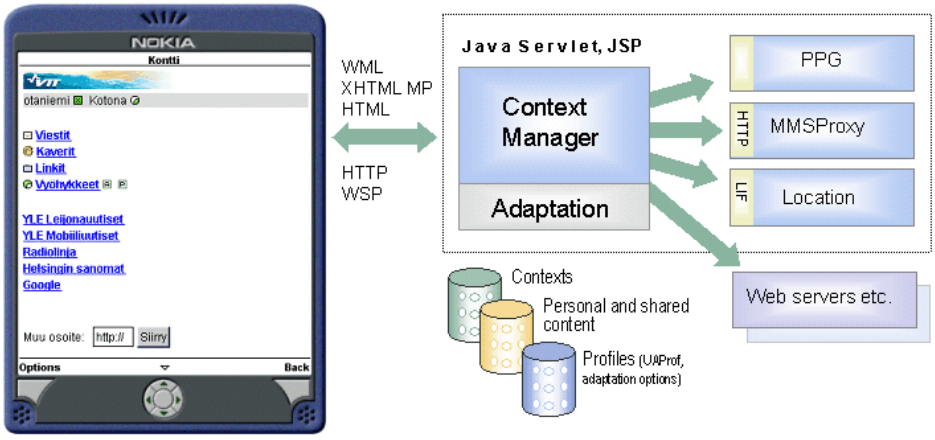

Figure 5. The overall architecture of the system.

The context-aware service platform consists of several software components as shown in Figure 5. The overall environment includes:

- The Context Manager main application
- An adaptation software module
- User repositories of contexts and contextual content
- A storage of profile information (UAProf, adaptation options)
- An external WAP push proxy gateway (PPG)
- An external MMS proxy
- External location servers
- Access to external Web servers etc.

The Radiolinja MMS proxy and WAP PPG were used for sending MMS and WAP Push messages from the Kontti system to the recipients.

The location servers included a location server accessed via the LIF MLP protocol [OMA-LIF] and a WLAN-based location server.

The adaptation software module (chapter 4) performs (X)HTML to XHTML MP and WML conversions, media conversions, and content and terminal adaptation. The adaptation proxy communicates via HTTP with other proxies and servers, and can access applications stored on external Web servers. The adaptation and its configuration are based on profile information, obtained dynamically or from an XML storage managed by the system.

The context manager (chapter 5) was used for demonstrating the overall functionality of the service platform. The application manages the user (group) repositories of contexts and contextual content. It also includes facilities for context-aware messaging and content sharing. It utilises the adaptation module for adapting the content to the requesting terminal. Further, it communicates with the external servers/proxies of the demonstration environment: the location servers, the MMS proxy, and the Push Proxy Gateway.

The context manager application and the adaptation software were implemented with the Java programming language. In the implementation of user interfaces, Java Servlets [SERVLET2.2] and Java ServerPages (JSP) [JSP1.1] have been applied.

4. Service adaptation

4.1 Introduction

Adaptation of a web page is needed, for instance, when a WAP client requests an HTML document from a Web server (cf. Figure 6). HTML documents are designed for large, high-resolution colour displays. Considerable processing and re-organisation of the document are needed in order to enable its presentation on a mobile device. The variety of mobile devices is increasing, and the diverse properties of the devices should be considered in the design of applications.

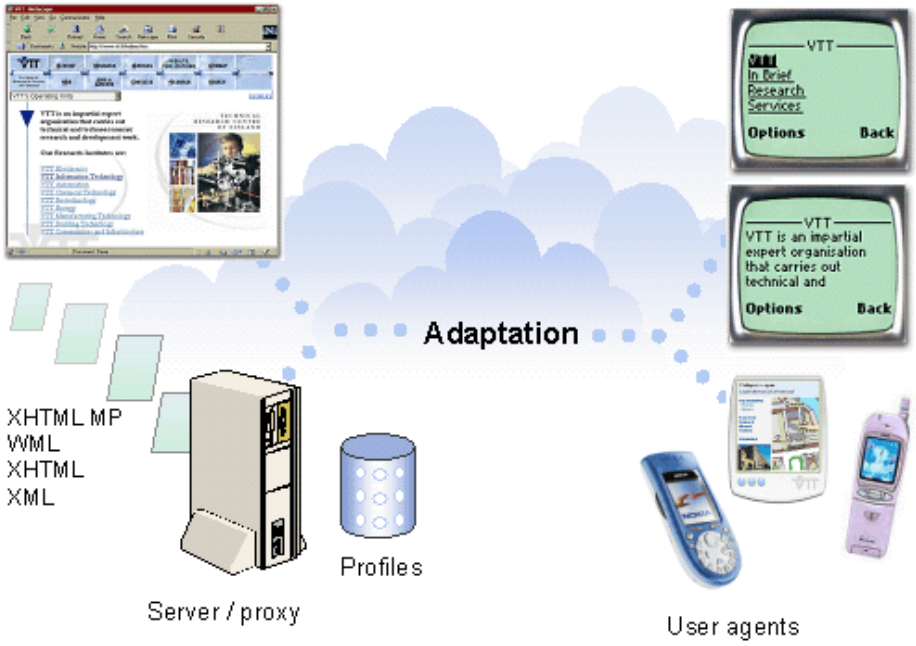

Figure 6. Adaptation of Web content to different kinds of terminals and browsers.

The adaptation software allows the mobile user to access most web pages that are not directly accessible by mobile devices. It also encourages a device-independent authoring approach, which means that the web developer maintains only one version of the web application. The web application is automatically adapted for the requesting device during servicing of the request.

The HTML application developer may safely assume that the user agent has a large colour display, a pointer and an alphanumeric keyboard. In the mobile world, however, user agent capabilities vary and are generally modest when compared to the desktop browsers. The display sizes and capabilities vary from small text-only displays of mobile phones to moderate colour screens of PDAs. A pointer is rare, and text input may be elaborate. Because of this heterogeneity, the mobile application should be tailored to the particular device or device class to guarantee acceptable quality. Instead of manually tailoring web applications, an adaptation proxy can be used for an automatic adaptation of the application. The adaptation proxy must be aware of the properties of the mobile device and its software.

4.2 Content adaptation

The document is presented according to the capabilities of the requesting user agent and the configuration parameters for the adaptation (cf. Figure 7). The adaptation process involves splitting the content into smaller parts, formatting tables, setting references, and a number of other steps. It is possible to use the information about the user agent, network connection, user preferences, and other context.

Reorganising content and translating the markup language can be considered separate tasks. In practice, both tasks are accomplished in parallel.

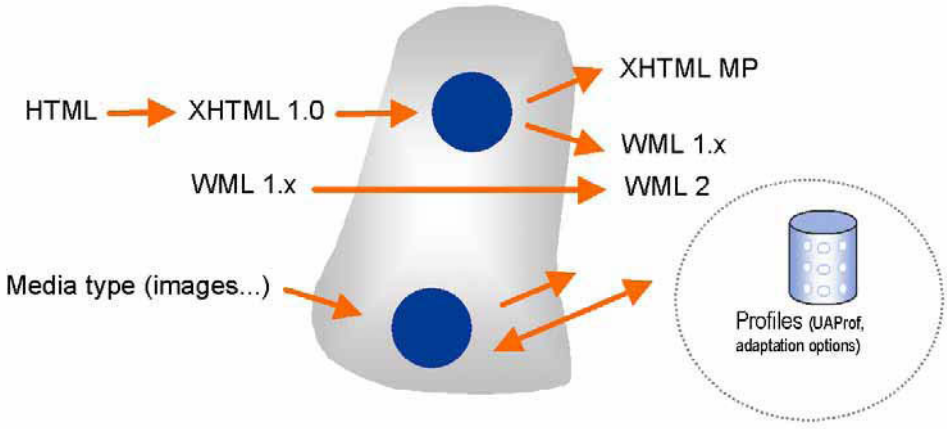

Figure 7. Content adaptation.

4.2.1 XML, XHTML MP, WML

XML (eXtensible Markup Language) is a meta language for describing other markup languages. As a meta language, XML makes it possible to define customised markup languages for different purposes. For instance, XHTML 1.0 [XHTML] is a reformulation of HTML 4 [HTML] in XML 1.0. XHTML includes better support for separating content and presentation, and it provides new ways of having alternative content formats.

XHTML is also modular [XHTMLM] and, thus, easily extendable. Consequently, browsers have to support several different modules. In particular, XHTML Mobile Profile [XHTMLMP] (a part of WAP 2 specifications) is based on the modularization of XHTML and is the core authoring language for WAP2 services and applications. It is a strict superset of the XHTML Basic document type [XHTMLB]. The WML 2.0 document type extends XHTML Mobile Profile. WML 2.0 includes WML 1.x compatibility and other extensions. XHTML Mobile Profile is a compact core module, which is to be supported by most of the browsers. WAP 2 also includes style sheets (WCSS) targeted for XHTML Mobile Profile and WML 2 documents.

4.3 The adaptation proxy

The Kontti adaptation proxy aims at automatically adapting documents and media resources to mobile devices. The current implementation includes modules for (X)HTML to XHTML MP and WML adaptation, and for media file adaptation. Most content and functionality on web pages can be made available for mobile devices.

Documents and pages

An XML document is a segment of a markup language that has a single document element at the top level. The document element is a special element in each XML language and it usually has a tag name similar to the acronym of the language ('wml' in WML, 'html' in HTML and XHTML). A document is usually also the unit of transmission, i.e. it is transmitted in its entirety in one network transaction.

In the following, the term 'page' is used in a special meaning. The page denotes a part of a document that may be viewed without following any links. Ideally, it is a part of a document with relatively independent and semantically coherent content. The optimal length of a page is one screenful in a device. In practice the division to pages is performed with little information of the semantic content, so the page borders are not always semantically meaningful. For devices with a small screen, it is not always practical to limit the page size to only one screenful. A large HTML document would produce dozens of small pages which would be very difficult to navigate. Each page also adds markup overhead. Adaptation should adjust the page size so that content may be viewed with a reasonable amount of scrolling.

Markup languages differ in how pages relate to a document. HTML fragments (named anchors) are used to divide one HTML document to several logical pages. HTML fragments are presented as one large page in most browsers. In WML, the card element corresponds to the concept of the page. A WML document may contain multiple pages.

All formatted documents are based on a tree structure. In XML the hierarchy is presented by nested elements. The tree may have arbitrarily many levels. HTML

documents, for example, commonly have a hierarchy depth between three and ten levels.

Adaptation

The most important task of the adaptation software is to divide the source document into smaller parts. The adaptation software identifies suitable pages from the source document, converts the content to a target markup language, splits the resulting document, and serialises the result. The layout of an HTML page is modified and images are either discarded or simplified.

Horizontal partitioning means that the current document (or page) is finished and the rest of the content is moved to a new document (or page). This is essentially what the splitting algorithm does. The adaptation rules suggest breakpoints for horizontal partitioning on the basis of inferred markup semantics. For example, a named anchor is a good position for a page break.

The quality of the result is enhanced by doing **vertical partitioning** as well. This means that a subtree inside a source document is extracted as a page. Vertical partitioning is performed by the adaptation rules. The combination of horizontal and vertical partitioning produces a hierarchical arrangement of pages. Upon serialisation, the page hierarchy is flattened, but the linking between pages conveys the hierarchical structure to the user.

Vertical partitioning is used, for example, when table cells contain lengthy content. In this case, each cell is converted to one lower-level page and links to these pages are inserted in the original position of the table. Another reason for deepening the hierarchy is a more restricting content model in the target document type. For example, tables in XHTML Basic may not be nested, whereas in HTML, table nesting is allowed and widely used. Only one of the nested tables may be converted to a table, the others must be presented by other means, such as a hierarchical page structure or a list.

The hierarchical arrangement of pages decreases the depth of markup by increasing the depth of page hierarchy. The page arrangement is reminiscent of the structure of a web site: the user may navigate from the main page deeper into the site hierarchy.

A **hierarchical arrangement of the pages** has two benefits. 1) The content is decomposed in smaller units, which are more convenient to view on a device with a small screen. 2) Access to information is better than if only a linear structure would be used. The drawbacks include: 1) The hierarchy may be difficult to navigate. Especially on lower hierarchy levels, the relative location in the document structure is easily lost. 2) The links connecting the pages should have descriptive labels, but often the adaptation rules fail to provide these.

The **adaptation rules** do the actual adaptation. In principle, there is one adaptation rule for each tag type of the source document. In practice, not all source tags need to be processed, and an adaptation rule may handle several tag names. The adaptation rules produce the target content, maintain labels, and add links as well as break directives.

The **quality** of adaptation depends strongly on the authoring style of the source HTML. HTML authoring is often quite ignorant of the design principles for accessibility, so the semantics of elements must often be guessed. If the authors would follow, for example, the W3C mobile accessibility recommendation [W3C], many ambiguities would be resolved, and the quality of adaptation results would consequently improve. The mobile accessibility recommendation contains instructions to include alternative content and stresses the importance of using the HTML elements only in well-defined semantic roles.

The most challenging elements are ones that require a large space, and ones that use spatial arrangement to express hierarchical structures. HTML tables are used for both of these purposes. An example of table usage that requires a large space is a timetable. A common usage of HTML tables is for page layout. Each table cell is like a small HTML document and it may contain nested layout tables. This arranges the content in an HTML page hierarchically. Frames are also used for layout purposes, but their adaptation is different, because the content of frames is not available during the adaptation of the frameset.

Optimally, the adaptation software should identify semantically coherent parts of the source document in such a way that the adapted content would fit in the display of the target device. To achieve this, the adaptation software should recognise the intentions of the author and categorise the elements accordingly. Some categories could be, for example, "site menu", "layout table", and "a table

heading row". To a human reader this is easy, but automating it would probably require AI techniques. Currently, only simple heuristics are used.

Document splitting

The user agent constrains the length of a document. In current devices, the maximum document size is much less than the length of the adaptation result of a typical HTML page. The target document must be split into several parts to avoid exceeding the length limit. The adaptation software attempts to place the split points in suitable positions, such as at the beginning of a table, paragraph, or header element. A “more” link is added as the last element before the split point to allow for navigation to the next document.

Break directives

The adaptation rules suggest good splitting points. The **breakpoints** have priority values indicating how desirable it would be to split the document in that position. The split algorithm uses these suggestions for deciding where to split. Good breakpoints come, for example, before headings, tables or other block-level elements.

Sometimes it is useful to avoid splitting a segment of the target document. The segment may then be denoted as a **nobreak segment**. If the maximum document length is exceeded during the nobreak segment, the splitting is done just before the beginning of the nobreak segment. If the entire nobreak segment does not fit into one document, splitting is forced. If a nobreak segment contains multiple pages, they are combined into one page.

Labels

The term ‘label’ denotes a short text string that describes a part of the content or tail of a link. Labels are of special importance when downscaling the markup language. The need for labels arises from the fact that often it is not practical to present a part of the content in its original place. Then a separate fragment (page or document) is constructed, and a link to the fragment is inserted instead of the fragment. The link should describe the content as well as possible. Labels are

used to describe parts of the content for example in the following cases: (1) frame in a frameset, (2) table, (3) table cell, and (4) image.

Links

The adaptation software maintains a database of links. Each link defines the position of the link head, tail URL or element, and label. External links refer to a resource external to the source document, and the link tail is specified by the tail URL. Internal links refer to an element in the target document, so the link tail is specified by the referred element.

Help

The adaptation software optionally creates a help document that can help the user find a page containing a desired word. Currently the help document contains a page index. The index provides links to all the pages in the document. Each page is described by a list of keywords extracted from the page in question.

State management

The adaptation proxy also performs state management on the behalf of the client. This is often required because the most of the mobile browsers are not capable of maintaining state information, such as cookies. The state management with the adaptation proxy is based on cookies and user authentication. This enables the proxy to access many websites that require user login (with cookies).

Caching

The adaptation proxy is able to cache the resulting documents. It should be noted that if an original document produces several partial documents, each part should be stored with a generated unique name, which can be used as an URL address of the document.

Error messages

Each time an error takes place, the adaptation proxy generates a document which informs the user and gives her instructions on avoiding the error. The error

message consists of a short description about the error case, followed by links for additional information and an instruction.

4.3.1 Media conversions and adaptation

Media conversions and adaptation is required when a client (user agent) requests media content that is in a format that cannot be displayed by the client browser or the content cannot fit into the limits of the memory of the device. Other criteria include whether the display supports colours, what number of bits per pixel are supported, etc.

The adaptation proxy handles images of type WBMP, GIF, JPEG and PNG. GIF, JPEG and PNG images can be converted to other formats if required, and the resulting format can be any of the following JPEG, PNG or WBMP. Images can be scaled, and image quality parameters can be tuned during adaptation in order to fit the image into the display of the requesting user agent.

Audio and video formats provide several possibilities as well as challenges for media adaptation and conversions. The current version of the Kontti adaptation proxy is used to filter out audio and video formats not supported by the target user agent.

4.4 Profiling

The adaptation process is governed by a set of options. A subset of these options (parameters) comes from the profiling information of requests, such as UAProf (cf. section 4.4.1) or the HTTP user-agent header. The options are internal to the proxy and the UAProf parameters must be mapped to these internal parameters. If UAProf is not available, the user-agent header of the request is examined. If it is not present or the specified user agent type is unknown, a default set of options is applied.

The options are also used for setting general properties for the adaptation software, such as breakpoint priorities for various HTML elements.

The options are divided into four categories:

- system default options,
- user preferences and context information,
- UAProf attributes, and
- device class specific options.

Each category produces options that are either internal to the system or belong to a restricted set of options that the system is able to handle.

In configuration, options in each category are assigned a priority value. Options with a higher priority replace options having the same name with a lower priority.

In the same way as the default options, also user and context specific options can be included. The current version supports the selection of options based on user authentication information.

4.4.1 User agent profiles

The OMA specification defines the user agent profile (UAProf) [UAPROF] that is used to transmit information about the client. It uses the generic framework of W3C CC/PP (Composite capabilities/Preference Profiles). The UAProf includes device hardware and software characteristics as well as other attributes. Based on the UAProf attributes, the services can adapt the content and the presentation for each client. Typically, the UAProf is a URI reference to a shared set of preference data stored on some repository on behalf of all similar devices.

The UAProf includes a Default description block, which typically contains characteristics common to a group of devices or user agents across multiple profiles. Each parameter in the UAProf is associated with one of three resolution rules that define whether the parameter can be changed during a session or not and if the parameter has one or several attributes. The profile can be enhanced to describe additional personal preferences, characteristics of other user agents (e.g., email software) or characteristics of hardware extensions.

The UAProf was not yet commonly supported by devices during the development of the adaptation software. If a client does not support the UAProf, a fallback solution is to examine the user-agent header of the request. For that, the proxy has a database of the capabilities of the most common user agents. This database maps the user agent type to a static default profile for that user agent.

5. Context manager application

The main tasks of the context manager application include:

- allowing the user to handle and share personal links and media files, and to associate contexts to these objects
- context-aware messaging
- personal management and sharing of contexts: creation, monitoring and publishing
- adaptation of context-aware content.

Context manager is implemented as a Java-based web application. It demonstrates the overall functionality of the service platform. The user interfaces of the application are discussed in section 5.1 and the basic functionality provided by the platform is described in sections 5.2 to 5.8.

There are different types of *contexts* defined by the user interface such as:

- location-based,
- time-based, and
- user-defined (manually activated) contexts.

The *contextual information* managed by the service platform can be divided into the following categories:

- *Contextual content: Link*, *note, file* and *directory objects* for the user's personal use and sharing, linked to specific contexts.
- *Friends* and *groups* contextual information: querying of friends' current contexts. Associating and publishing contexts.
- Context-based *messages*: creating messages which are delivered only in a certain context.

The contextual information can also be divided into *objects* and *messages*. See Figure 8.

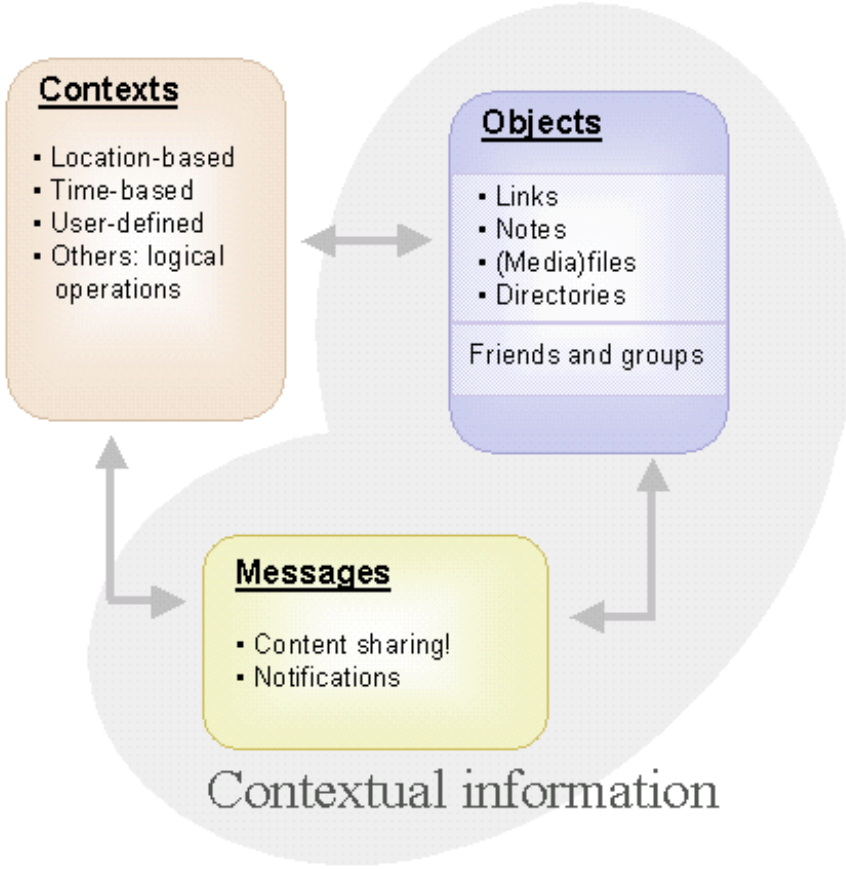

Figure 8. Contexts, objects and messages.

5.1 User interfaces

The system detects the properties of the requesting device and browser. Content is adapted according to the requesting user agent and other information (see section 4.5).

There are separate user interfaces for WML, XHTML MP and HTML (Figure 9). The variations within these three document types are handled via the detected user agent properties and the other options for adaptation. All images and other media types in the documents go through the adaptation module of the system.

Several user interface variants were designed and implemented for field trials (see sections 6.2 to 6.6). Also, mock-ups were used in laboratory evaluations (see chapter 6).

Figure 9. Different kinds of terminals.

5.2 Basic concepts and functionality

The front page of the Kontti service (Figure 10) includes access to the currently active contexts ("zones"[1]), messages, friends and groups, links, contexts, fixed links and other URLs.

Figure 10. The front page of the context manager application.

The concepts and functionality related to each section are described in the following subsections. In addition, there are many illustrative examples in section 6.1 that explain the functionality of the application.

5.3 Links

The Links shortcut on the front page opens a repository of the user's personal and shared *content*. The repository consists of the following types of objects: link, note, media file, or directory.

[1] The word 'zone' ('vyöhyke') was chosen as the equivalent of 'context' ('konteksti') in the user interface. The word "konteksti" in Finnish was deemed ambiguous and difficult for users.

A *link* object is specified by a name (i.e., "VTT") and a URI (http://www.vtt.fi).

A *note* object is a simple object consisting of a title to be shown and the text of the note.

A *media file* object is any file loaded from a given URI. It includes a given name of the file.

A *directory* object is a container that denotes a directory of the repository. It includes a name of the directory.

Each of the object types can be associated with a context object. The links (i.e., HTML pages) and media file objects are adapted to the user's terminal (mobile device).

5.4 Contexts

The Contexts shortcut opens a repository of user-defined context objects. A *context* object specifies a context that can be associated with other types of objects handled by the context manager application. The context objects that can be currently handled in the user interface are of the following basic types: time, weekly, location and user-defined.

In addition there are system internal context types such as the *Logical operations for contexts*: "and", "or", "xor" and "not" which can be used to connect other context instances to form context hierarchies of any level.

Location-aware contexts

A context can be location-aware. The state of the context (active or inactive) is determined by a positioning method if enabled for the user.

Currently, two different positioning methods are used: network-based positioning via the LIF protocol [OMA-LIF] and WLAN-based positioning.

5.5 Friends and groups

The Friends shortcut opens a repository of friend and group objects. The names of friends correspond to users of the system, and groups correspond to user groups. A user can manage her own repository of friends and groups.

A friend object provides:

- an operation to send a message directly to the friend,
- a direct way to make a phone call [WTAI],
- means to monitor the state of the public contexts of the friend, and
- contact information of the friend.

A group object provides:

- an operation to directly send a message to the group,
- the list of users (friend objects) belonging to the group, and
- additional information about the group.

The friends and group objects can also be associated with a context object.

The repository may also include directories (folders) that can contain other directories or friend and group objects. A directory can also be associated with a context.

5.6 Messages

The system provides a repository (accessed from the Messages shortcut on the front page) of received and sent messages of the user.

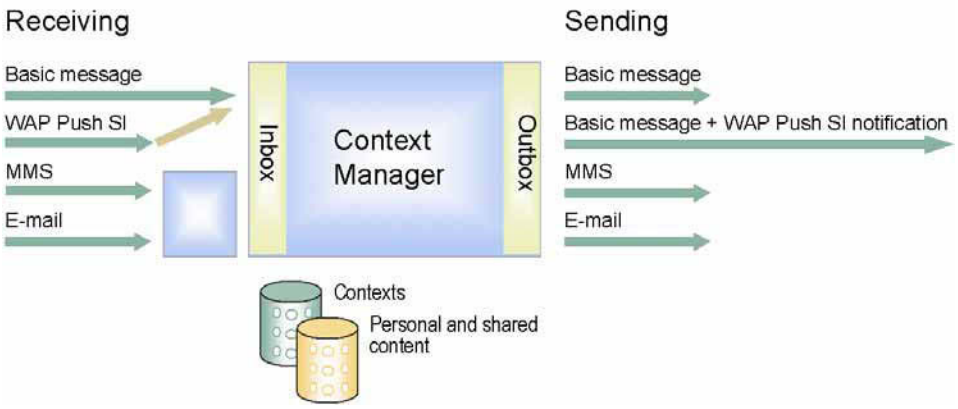

Figure 11. Sending and receiving of different kinds of messages with the context manager.

There are four kinds of messages handled by the system: basic message, WAP Push (SI), MMS and e-mail (cf. Figure 11).

A message can be composed of subject, text, and any kind of object attachments (links, media files, notes, directories, contexts, friends, groups) stored in the user's repository. A message can be sent to any user or group of the system.

A message can be made context-aware by defining the target contexts. There are four alternatives for delivering a message:

- *no target contexts.* The recipient receives the message directly, because no target contexts are associated with it.
- *one-by-one.* One-by-one as each recipient enters the target context.
- *all-after-one*. For all recipients once a single recipient has entered the target context.
- *all-after-all*. For all recipients once all recipients have entered the target context.

It is also possible to assign an expiration time for the message. (For example, see Figure 16.)

Sending push messages. The system implements WAP Push messages [OMA-PUSH, OMA-SI] in order to notify the recipient about an incoming message.

The service indication message includes a subject text and a link providing access to the incoming messages folder of the user.

Sending and receiving MMS messages. An MMS message can be created by attaching any kind of content object to the message. The context manager acts as an MMS initiator and sends the message to the external MMS proxy in order to deliver the message to the recipients.

The system also enables the receiving of MMS messages from other applications. For this, e-mail addressing is applied. The received MMS messages are transformed into the format of a context manager message.

This feature also enables the sending of local files to the context manager by MMS or e-mail (if enabled by the client device).

Sending and receiving e-mail. Each Kontti user has an e-mail address. Also, groups are associated which corresponding e-mail addresses.

The received e-mails are transformed into the format of a context manager message. E-mail attachments can be stored as context manager objects. For instance, a file attachment is stored as a context manager media object. Access to an e-mail server is required in order to send and receive (via SMTP) e-mails in the Kontti system.

5.7 Adaptation

Links and media files are adapted and visualised according the properties of the requesting client device and browser and currently active contexts. See chapter 4.

5.8 Content sharing

Novel aspects of the system include the way in which content sharing between users and groups is implemented within the message sending facility.

The user can send messages to other users and groups in the system and attach any kind of objects with the message. The properties of the facility include:

- The attached objects of the message are copied into the message outbox of the user, and, the recipients of the message are given the access rights to these objects.
- The recipient is allowed to read and copy these shared objects.
- If the message is context-aware, the access rights are given at the time when the notification of the message is shown (i.e., the associated target context conditions are fulfilled).

6. Evaluations

The design principles (see section 2.2 Context study) were used for designing the user interface and key features of the service. The design solutions and the early drafts of the user interface were tested with users in the laboratory in two usability tests. The design also benefited from two laboratory tests that had been made in an earlier project (WAP-UAPROF).

During the course of the project, 98 users took part in the evaluations (See Table 1). Several field trials studied the subject from different angles, thus gaining more information than a single large field test would have yielded. In addition, 131 visitors took part in a survey about the Tampere Theatre Festival guide, which was demonstrated to them at the festival.

Table 1. The evaluations conducted during the course of the project.

Evaluation	Date	N	Demon-stration	Labo-ratory	Field Trial
Context study	Mar-Apr'02	28	●		
Context and MediaBank, UI	Aug '02	5		●	
ContextManager, UI	Nov '02	5		●	
Pilot trial: Everyday use	May-June'03	13			●
WLAN trial: Historical Route, UI	June'03	4		●	●
Theatre Festival: Festival Guide	Aug '03	12 / 131			●
High School: Social surroundings	Sep '03	13			●
Business case: Parliament	Nov '03	8	●		
Service providers	Aug-Nov'03	10	●		
	Total	98 interviewees 131 survey respondents			

The laboratory evaluations consisted of a single interview per user. In the longer field trials (Pilot trial, High school), three interviews were held. The first interview was usually an introduction of the concept, the device and the prototype. The second interview focused on issues that were unclear or problems with the system. The final interview dealt with use routines during the trial and future concepts.

The plain interview studies (Context study, Business case at the Parliament and the service provider interviews) included a demonstration of the service or a mock-up but not actual test usage.

After the Theatre festival case, we had the users fill in a questionnaire to appraise the concepts that had been discussed. The users expressed their opinions on a six-step Likert scale. In the user requirements phase, the users were contacted through hobby clubs and social networks. The same method applied to the field evaluations. Some users continued from the user requirements phase to the pilot trial. This induced some learning effect for the users, but on the other hand they were able to concentrate more on the service functionality and not the novelty of the concept itself.

In the field trials, the users were provided with mobile subscriptions (Radiolinja) and mobile media phones (either Nokia 7650, Nokia 3650 or SonyEricsson P800). It was important that the users could explore the service without additional costs. There were loose limits for use, about 100 euro per month. The use was not restricted technically and each user had to monitor his or her own use or check the accumulated bill with a current bill query service. The purpose was to generate natural use without having to worry too much about the bill. Natural use also meant that the users could use the services in public and share them with friends and family.

Information about actual use was gathered in all trials. Each time a user accessed a page through the proxy server, the request (HTTP GET or POST) was registered into the log along with the date and time of the event. Within a page, requests for page elements were also registered. When an image was displayed to the user – i.e. the image was either displayed on the page or the user followed the image link – an extra request was logged.

Methods used in the evaluations

At an early phase of the design, **mock-ups** of user interface designs were created. Paper mock-ups have images that depict the user interface. When the user selects a function from the image, another image is shown to represent the response of the system. A simulation of a functional system can also be used, sometimes on the actual device. The user is encouraged to think aloud and comment on the mock-ups. The evaluation of mock-ups guide the design before the technical implementation begins. The mock-ups are usually tested with 3-5 users.

Laboratory tests were conducted to ensure the usability of the prototype. Users tried out the service during the test, usually for up to two hours. Each user went through certain features by performing simple tasks. Bottlenecks in the design were detected through observation and discussion during the tasks and a short interview afterwards. A laboratory test is typically carried out with 3-5 users.

Short-term field trial. The laboratory test can be conducted in the field. The course of events is the same as in a usability laboratory. Users experimented with the device and the service. They performed tasks and thought aloud during the tasks. Depending on the tests, the trial took up to two hours. The recommended minimum number of users is 3-5 in short term field trials.

Field trials were larger scale evaluations, with more users than in the laboratory and often with several weeks of use. The users were provided with a mobile device and a mobile subscription. The prototype service was used as part of the users' everyday lives. The device was introduced to the users so as not to let problems with the device interfere too much with their opinions of the prototype. The users were instructed to try out and use the features that felt natural for them. Their experiences and opinions were discussed in the following interviews. In Kontti, the trials lasted from 1 week (Theatre festival) to 6 weeks (Everyday use).

Semi-structured **interviews** were used to gain opinions on the concept of context-aware services. The interviews included a demonstration of the Kontti system and its features. Naturally, interviews were used as a method in the laboratory tests and field trials as well.

6.1 Service description

For the users, the service appeared as a web-based portal. When needed, the service was adapted to fit the separate field trials that were conducted. For the purposes of the Festival guide (section 6.4), a service package was made to provide information based on time segments. For the Historical route (section 6.3), an HTML-based PDA version was implemented. The modifications to the basic service are described under each case in sections 6.2–6.5.

The portal was optimised for use with Nokia 3650, Nokia 7650 and Sony Ericsson P800. For these devices, WML (Nokia 7650) or XHTML MP (Nokia 3650 and SonyEricsson P800) versions of the user interfaces (cf. section 4) were used. The service consists of four main items: Messages, Friends, Services and Zones.

Figure 12. The context-aware portal. The original service was in Finnish.

Figure 12 shows the front page of the portal. The context-sensitive and personalised features are shown with an icon next to the links. The contents of the portal were existing mobile services, converted web pages as well as personal notes and files. Any link, note and message could be given a context in which they were active. In addition, any context-aware messages that were sent would be delivered once the intended context was active for the recipient.

The trial service supported location-based, time-based or manually activated contexts. The system allowed users to create their own personal contexts, such as, ”At home”, ”At work”, ”Out partying”or ”Feeling blue”. The users could link personal notes and existing services to the contexts relevant to them.

In the trials, the front page had fixed links that were common to all users. The fixed links included mobile news by Yleisradio, a WAP portal by the Finnish telecom operator Radiolinja and the Google search engine.

Zones

The contexts that were created in the system are referred to as “zones”. It was determined that “context” as a term was too abstract to use in the interface. We also wanted to use a relatively open term, so as not to exclude time-based, mood-based or any other contexts. Users could create zones for many purposes: to provide information to other users of their current context, to attach information to a certain context or even to create a set of zones with a theme to send to others. The zones could be time- or location-based or manually activated. When creating the zone, the user could also define how public it is; i.e., if others can see whether the zone is active.

Manually activated zones (Figure 13). were ones that the user selected as active, i.e., context activation was not automatic. (Manually activated zones are referred to as “user-defined zones” in section.5). The advantage of a manually activated zone is that they can be based on contexts that are difficult to recognise automatically. They can also be more accurate than automatically updated zones if maintained regularly. The downside, of course, is the effort that is needed from the user.

Location-based zones were defined by co-ordinates and a radius. These created a circle-shaped area. The co-ordinates could be retrieved with whatever positioning system was available. Once the zone was created, it was active within the defined area. The sufficient accuracy for positioning was determined by the purpose and nature of the zone.

Figure 13. Creating a manually activated zone. First, the zone is named and its type is set. Second, the setting for zone activation is set. As the third step, one can publish the zone for others to see when active.

A **time-based** zone could be defined either as a single or a weekly event. Time-based zones are automatic, accurate and ideal for recurring routines.

After creation, the zone was available for use. Once a zone was active, it had four effects:

- Any messages attached ("dropped") to that particular zone were delivered to the user.
- The active zones were displayed at the top of the front page as links. The links were used to access the zone content.
- Links that were connected to an inactive zone were blocked from view. Links that were not connected with any zone were visible all the time.
- Other users were able to view the status of the user as determined by the currently active zone. Only users with the permission for viewing were able to see the status.

Links

The portal provided access to a personalised set of links. By adding notes and files to the set, the portal could be turned into a personal media bank. The system allowed operations on files remotely, without having to download them to the client device.

Figure 14. The user has a set of zones that can be linked with content. The information is shown once the zone is active. A zone can be used to filter out non-contextual information as well as to bring context-related content to the front page. The active zone "Työni on iloni" is the first link on the front page.

When the links were connected to a certain context, they only appeared when that particular context was active (Figure 14). Active zones were shown at the top of the front page to allow easy access to the zone-specific content.

Friends

One motivation for creating and maintaining zones was to convey information of one's own context to others; e.g. whether a user is available for contact or what plans for the evening they have. The feature could also act as a mood indicator, telling others about e.g. being tired, willing to go out etc. The idea for viewing your social surroundings came directly from user interviews at the start of the project.

It was clear from the beginning that the users should be given full control over what was public. We took a very flexible approach to how the users' contexts could be observed. The service allowed the user to choose which zones were visible to others, who they were visible to and what kind of description was shown. The actual location or context itself did not need to be revealed. The information that was published was a public name for the zone and a longer, public description of it.

Figure 15. The Friends view. The current contexts can be seen next to each friend's name.

In Figure 15, the list of friends is displayed along with the public name of their current context(s). The user can see in one glance the status of her friends. The friends list can be contextual as well; a football team can be in view only on the practice day, for instance.

Messages

The system allowed users to send context-aware messages to each other (Figure 16). The message was "dropped" to a target zone, i.e. the zone of the recipient that has to be active for the message to be delivered.

Figure 16. Sending a context-aware message entails the usual creation of a message, but also the selection of the target zone and the social context to which the message should be delivered. If no delivery options are set, the message will be delivered instantly.

Targeting the message allowed, for instance, a work-related message to be directed to a work zone. The message was delivered once the recipient entered the zone. If no target context was chosen, the message was delivered immediately. The service used WAP push to inform users of the delivered message.

In addition, the message had an expiration date after which it was no longer valid and would be automatically deleted. The user could set the expiration date.

The sending of the message was carried out with a wizard-type interface. It allowed users to easily pass the extra options or use them if they wanted to.

Attachments. All content within the service could be sent as attachments to other users; links, contexts (zones) and notes. This allowed the creation and dissemination of context-aware services. A coach, for example, could create a training schedule along with instructions and send it to the trainees. The schedule would be active at pre-defined times in pre-defined places.

6.2 Case 1: Everyday use

A pilot evaluation of the system was carried out in 2003, from mid-April until the end of May. The trial studied context-awareness in everyday routines. The users were provided with 'smart phones', i.e. phones with enhanced media capabilities and capacity. The models were Nokia 7650, 3650 and Sony Ericsson P800. Near the end of the trial, six users were able to use cell-based positioning for location-aware contexts.

The Everyday use trial

- The prototype was evaluated in the field with users for the first time.
- Context-aware features (contextual content and conveying one's own status to friends) were evaluated.
- The concept of context-awareness was introduced to the users and expanded to possible future concepts.

Users: 13 users in four user groups.
Age: 14–44.
Duration: 6 weeks.

Users. There were 13 users (Appendix A), who tested the portal for 6 weeks. Their ages varied from 14 to 44. The users were divided in four groups. The groups had different interests in the service: two teenaged girls and one boy; three friends in their twenties; three men with work-related interests, and a family with four members. We chose groups instead of separate users to study the sharing of contextual information and messages.

The users' experience with mobile Internet services was very limited, so in this sense they reflected the general public quite well. Their experience with mobile devices was rather versatile. A few of them had tried advanced features, such as WAP, but there was no regular use. All users were at least familiar with the PC and the Internet.

We wanted to know both how the users created zones and where they felt the feature would be the most useful. During introduction, the service features were demonstrated to the users. The users were instructed to get to know the service and use the features that they felt were interesting in their own personal lives.

6.2.1 Results

Zones created by users

Everyday use of the service relies on the users creating and updating their set of zones. The main finding about the actual use was that users found it easy enough to create zones with the user interface, but keeping them current manually was elaborate. The zones were created mainly to inform others of the user's current context. The zones often suggested activity or availability (school, work, university).

The most active users usually added a description that referred to their state of mind (Table 2.). Some users commented that there was little need to create several zones, when their life varied mainly between school and home. For the most active users, the tailoring of zones, activating and de-activating them sometimes raised a few eyebrows in social life, as commented by one user:

> *"It's like when a colleague asked me if I'll be going to work out in the evening. I said that I created a zone for it already. She was like 'Excuse me? Enough with your zones already, are you coming or not!?'"* Female, 41.

Users also viewed each other's zones quite frequently. This meant that switching one's current zone and/or changing its public description was the most often used feature. The frequency of updates also meant that the feature should be well accessible.

Table 2. Samples of zones from different users.

Centre By a coffee cup, universally useful, saving the world & whistling.	**Relaxation** The freshness of mountain streams.	**Training** Heartbeat through the roof, bring on the sweat!
University Busy, but prone to temptation.	**Bar** A light touch on the dashboard...and on we go	**Practice** Saves and slapshots.
Sleeping at Sandman's Zzzz...	**London** Shopping till I am dropping.	**Off** Spring chores at home. Resting and planting.
At home And won't leave anymore. Phone is a good companion!	**At work** Teaching at the moment, cannot answer if you call. Text me, I read them during recess.	**Weekend at home** Yes! Home alone. Busy writing with PC. Rest of the family going around Finland.
Office Little things to do. Available.	**Free time** Best time a man can have!	**At work** Won't answer the phone during the lesson. Text me to contact.

Friends – Social Surroundings

As the user requirements indicated, the social surroundings are an important aspect of the personal context. In the pilot, the users created their own context mainly to inform others of their current situation. Almost all users felt this was a promising feature for them, both fun and useful (Figure 17).

One user was away abroad for a week during the test period. She felt comforted to see what her friends back home were doing. The friends at home, on the other hand, felt they were with her on the trip because she kept them up to date through the service. The feature could also be used for a simple availability check. Seeing the other person "lying around at home" could spark a phone call and an invitation to meet somewhere.

Figure 17. The Friends-feature was by far the most popular with the pilot users.

It was difficult to predict beforehand what groups users would like to communicate by using the friends feature. In the pilot, there were groups of three to four persons each. Some users remarked that the number was not large enough. The electric subcontractor we had as a user said that a work team of 30 people could be the ideal amount. For the user below, the feature would work with even two people if the pair was suitable.

> *"With Kaija, we're so remarkably aware of each other's coming and goings that I was just thinking that perhaps it would make more sense for my hubby to be using this as well. He's quite a lot at work or at school and I never know exactly where he is and he doesn't know where I am. That would make more sense to me."*
> Female, 26.

The pitfall of the service was whether the context information was trustworthy. Towards the end of the trial the users realised that if they are not active in

keeping their zones up to date, perhaps others are not either. The accuracy of the information becomes questionable.

> *"Don't know if that would help if it could update itself like, I dunno, every minute or so. [..] And then I could just see like PLING Teuvo is at home, 'cause it changes [...] That it would be more like Click, that's it, this it what I wanted. But when it doesn't have that it kinda works against the whole feature."* Female, 25.

The parents in the family group felt that the children had too much control over what the parents see of their context. The feature leaves much to trust. On the other hand, if there were changes in hobby schedules etc., then the parents would like to keep up with the changes and see them with the service.

Using mood descriptions. As was mentioned earlier, manual activation was used for zones that could not be automatically identified. The overall context was sometimes enlivened with descriptions of the user's mood. For example, one user (Table 3) used the public name to indicate the place and public description to fill in the physical and mental context.

Table 3. A sample of the Home zones from a female user in her twenties.

At home Home sweet home.	**At home** Curing hangover. Quite a trip last night...	**At home** Resting after rollerblading
At home Cozily in the couch after a tough workout	**At home** Emotionally crippled after a visit, recovering in my nest.	**At home** Hangin' and chillin', king of the castle.

The findings complement results gained from an unpublished VTT concept study of visual messaging [FRE]. The concept of a "buddy list" included icons, which reflected the mood of the friends in the list (Figure 18.). In the same study, the most popular form of visual messages were animations that reflected the user's activity level or state of mind.

Figure 18. In a concept study of visual messaging, mood icons were used to complement the written context shown on a buddy list [FRE].

Using images to convey a more complete picture of one's context was also suggested. There should be a way to attach a photo to the zone for others to view. This would make good use of the media phones' camera as well. The photo makes the feature more personal and fun, but it can also be informative.

> *"You could add a bit of fun like when you're playing basketball you could take a photo of your own jump shot. Can I attach photos so that it would show [to my friends]? [..] It would be cool, even a video clip [..] Little things like that would be fun."* Male, 25.

The importance of topical information

Any context-aware content should be tightly linked to a particular context and not be of much use elsewhere. The results confirm earlier findings about the highly topical nature of location-aware services [KAA03]. Although we had initially selected material for each user to represent his or her hobbies, jobs and interests, users did not link much material into their zones. Users felt that there was no need to filter out content in any context, as it did not seem context-specific enough for spontaneous use. They did not see why the existing content could not be available all the time.

Figure 19. Ideally, a context-aware service should be very topical and not offer generic information where context-awareness is added only as an afterthought.

One example of too general information was when one user added the mobile service of the local chain of cinemas to her "Out on the town" context. A truly context-aware service would not show the whole movie schedule (Figure 19), but show only the movies that will be showing at a nearby cinema within the next hour and whether there still are seats. The same applies to bus schedules: the user should be given the next buses that will be leaving from the nearby station, not the complete timetables.

If the content is generic, the need to see the material outside the designated context is greater. But even material that is tightly linked to a zone is sometimes needed in another context. In principle, the user should have the option of seeing all the material regardless of the context if he or she so chooses. There could also be an option to show the material in an inactive state.

Context-based messages

The current system uses target zones that are published by the recipient to the sender. It is not possible to attach a message to another place than a user's personal zones. A precise positioning system would open up new possibilities for context-aware messages. The message could also be sent to an open number of unknown recipients. The contextual message could be public instead of targeted and personal.

During the six-week trial, a total of 147 messages were sent by the 13 test users. Most messages were sent directly into the zone the user was currently in, to be delivered instantly. The users were very happy with the push feature, as it allowed them to view the service only when they needed to. Without the alert they had to check the messages "just in case". However, context-aware messages were scarcely ever used. The lack of automatic context recognition, such as accurate positioning, watered the feature down. Also, the web-based interface was more cumbersome than using, e.g. existing messaging applications in the device. However, some conceptual features relevant to context-based messaging did emerge from the study, as the users realised the gist of the service based on the prototype.

Friends. Users felt that among friends who see each other constantly, sending a message immediately, like SMS, was more practical than personal messages targeted at a certain context. As one user noted:

> *"They [messages targeted at a context] can't be very important messages, because if I have, let's say a "Resting here" zone, then my friend can drop a message like there saying "It's nice to take it easy once in a while". And then I'll find it there some day and the message will feel pretty insignificant. So, planning appointments and other such that you're used to you handle with text messages or short calls 'cause you're used to that."* Female, 25.

Work. Context-awareness was seen useful in filtering work-related messages. Deferring the message to work, instead of instant delivery, will not bother the recipient off duty.

> *"The thing that's the best about it would be if I could use it for work. [...] Somehow it feels bad to be sending someone a work-related text message on a Sunday night. And then if you do send it, the recipient might not remember it once he's back at work and it needs to be taken care of. It would be really useful if I could send work mail to a friend so that he would receive it at the right moment and when he's able to do something about it immediately."* Male, 33.

Visitors. The users anticipated messages being used more among event visitors, i.e. people who may not know each other but would exchange opinions if there were a chance to do it anonymously. Anonymous live chat among people in the same location was considered promising. Location-based messages could also be used as a peer-guidance system. As a user suggested, tourist areas could be littered with reviews and tips of the surrounding area.

> *"Of course, if you're a home critic it would be immense fun to leave reviews of shows."* Female, 26

Business use

The users did appreciate the relevance of context-awareness when the content was relevant to them and topical. We had three users who viewed the system mainly from the point of view of their work. One of them gave examples of existing work practices that would benefit from a context-aware system. He worked for an electric company that does subcontracts for construction companies. There were usually 3-6 construction projects they were working on, which he saw as ideal for contextual handling. He saw the distribution through a mobile media bank very important as well. Human resources could also be more efficiently managed if the contexts were more easily available. Listed below are three of the existing work practices that match the concept of a context-aware media bank quite well.

1) **Work sites on magnetic board.** The work shifts are laid out on a magnetic board. The top level contains the names of the contracts, the lower level the people working on it. A more dynamic board would mean fewer calls to

arrange changes and a more accurate view of the current resources in each project.

> *"Well at the moment the chief of assembly has a magnetic board, where all projects that we're involved with are written. Underneath the projects are the names of the chaps who are working on them [...] But sometimes there are occasions when this ideal is interrupted [...] Another project manager has called the chap without conferring with the chief saying 'You were there at Hermia a year and a half ago, weren't you? Would you mind seeing what the problem there is.' That's the thing about this zone concept: if this kind of information could be logged so that you would know where the chap is in reality. Because frequently there are people in the wrong place on the board."* Male, 44.

2) **Project file and folders.** All the material for the user's 3–6 projects had to be carried around from site to site just in case it was needed. A mobile media bank would solve this issue. The basic package would need to contain the contracts, contact information for the project management and for proper authorities as well as photos and prints that are needed to do the electric wiring.

3) **Work journal.** For each project, the employees report their working hours and the work that was done. This requires a lot of paperwork. If the registering of contextual history in the projects could be automated and distributed more easily, the paper work could be reduced.

The examples indicate that the system could be used to keep work management up to date by feeding the system with context-aware information from the mobile devices. On the other hand, a centralised distribution of material to mobile devices is important as well. As suggested by Kaasinen [KAA03], work-related areas could profit from well-defined applications, where the contextual needs are easier to predict.

6.2.2 Conclusions

In our pilot study, 13 users used the context-aware portal for 6 weeks. We gathered comments of actual use and used it as a stepping stone to discuss the concept of context-awareness more widely.

The results from the pilot trial led to a better understanding of the structure of context-aware services. We divided them into three categories: Everyday use, Service packages and Spontaneous service.

Everyday use is characterised by the fact that the services fit with the user's daily routines. No one else knows what these routines are and which context he or she feels is relevant. Matching the daily routine means automatically that the user needs to personalise and adjust the service, thus increasing the effort needed from the user.

Our test users felt that the user interface enabled an easy creation of zones. They usually needed only a few to characterise their activities. Users tended to create zones mainly to inform others of their current context. The effort comes from keeping the service up-to-date daily. The automatic recognition of contexts is essential for the service to reach its full potential. Especially an accurate and non-expensive method of identifying the user's location would increase the level of automation a great deal.

Context-aware messages in personal communication divided opinions. The users found that their groups were too small and tightly knit to benefit much from context-aware messaging. Its benefits were seen to be 'surprises' to friends, but mainly filtering and directing communication in business use. On the other hand, it was difficult to predict beforehand which group the users would like to use context-aware communication with.

With **service packages**, there is less need for tailoring than in everyday use. The subscribed service package does not require the user to make her own connections between the context and the content, they are inherent in the service. The user orders a suitable package and further modifications are not needed. The service may be an event schedule or a thematic route, for example. The users of the service are linked by a common theme, such as the event. The results suggest

that context-aware messaging may be more promising to use as a public method of communication than between a group of close friends. The messages can be left "in the air" for anyone to see, whereas among friends contextually linked messages may cause a lag in communication.

At the other end of the dimension are **spontaneous services**. The category is characterised by minimal personalisation. The context is identified as accurately as possible, taking into account time, location and other variables. The user only needs to view what's available, not subscribe or personalise. Services of this kind are still some time away. They will need accurate positioning, including sensor-based context-recognition of RFID. Services will also need to be very topical and pinpointed. If the user expects to find information quickly, he or she cannot be offered the same old static service, with only mild contextuality. It would seem that the context-aware content would need to be tightly linked to the context *and* not of much use elsewhere.

Many of the context-aware features would benefit from more **integration with the device** itself. It is difficult to compete with SMS or MMS with a separate, web-based communication system. Adding context-awareness as an option to the existing message applications would be beneficial. Access to files within the device is needed to fully use the service as a kind of media bank as well. Many users commented that personalising the service with their own images as well as storing them for future use would greatly increase the usefulness of the service.

The similarity between contexts and the phone profiles was noticed. Instead of accessing the browser, the user should be able to switch profiles, with the changes affecting the device and its services.

6.3 Case 2: Historical route

The trial and evaluation of the historical route took place in the summer of 2003. The aim of the trial was to study the concept of a context-aware tourist route. The service identified the user's current location and offered historical information (pictures, text and video) of the location. The images depicted mainly buildings and city views from the 19th and 20th century. The Tampere Museum's Photo Archives allowed their use for research purposes.

The Historical route trial

- A ready-made context-aware service package, the Historical route, was evaluated.
- The Kontti service platform was demonstrated in a WLAN network for PDA use.

Users: Four users took part in a short-term field trial.
Ages: 23, 30, 70, 73.
Duration: 2 hours per user.

Users. There were 4 users, who tested the service in a WLAN network. The network covered the central square of the city of Tampere. The users varied in age from 23 to 73. All test users lived in the Tampere region.

All of the users were familiar with mobile phones and web applications. Only one had not used a PDA device before the test. Three others had experience in PDA use both in their work and in leisure activities.

6.3.1 Service description

The user accessed the content through a web-based mobile portal which was used with Compaq iPAQ. The service displayed automatically the nearest points of interest with thumbnail images (Figure 20). After clicking a thumbnail, the user could view more information and a larger image. From there the user could return to 'Nearest sights'. If there were messages to the user in the current spot, an envelope icon appeared at the top of the screen. By clicking on the icon, the user could access unread messages.

Several WLAN base stations covered the test area. Our initial aim was to use WLAN positioning in the user trial, but due to technical problems and time constraints, positioning was simulated in the actual test. One of the researchers switched the zones and hot spots manually with another PDA. For the users, positioning appeared seamless; there was no indication that the positioning was manual.

Figure 20. The service displayed the nearest points of interest. The user could choose from a set of thumbnail images the sight that he or she was interested in.

Method

The evaluation was carried out as an observational walk with users, a sort of laboratory evaluation in the field. The trial followed a pre-determined route and an average session took two hours per user. Figure 21 displays the route and the hot spots. We had a total of five spots with varying topics and information:

- **Tour start** (Instructions, sight information, message from a friend)
- **Hämeensilta bridge** (sight information)
- **Central square south** (sight information including video)
- **Central square north** (sight information, message from another service user, future ideas)
- **Fast food restaurant** (sight information, location-based ads)

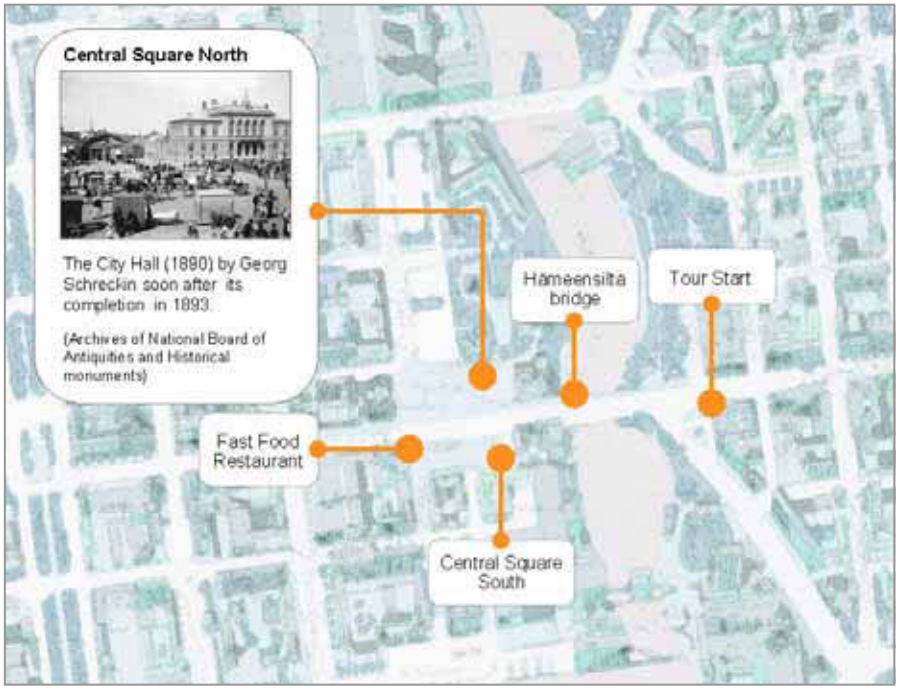

Figure 21. Hot spots and an example of sight information in the context-aware historical route.

The hot spot areas (areas with content available) were approximately from 50 to 100 meters in diameter. In the final spot some of the information covered targets that were almost 300 meters away from the central point of the spot. With the

variation in size we demonstrated to the users how the contents could be linked to either a more pinpointed area or an area covering several points of interest.

6.3.2 Results

Service concept

The users liked the idea of the context-aware historical route. The contents of the prototype service fit the idea well. The pictures and descriptions of the sights were considered interesting by the users. The video clip was seen as a very nice extra in the service (Figure 22). The users would also like the option of listening to information about the sights with headphones.

Figure 22. The video clip showed the central square on May Day 1930.

Ordered or offered service? An ordered service would usually be selected and downloaded beforehand to the user's own device. An offered service would not need such preparation. The users found use for both kinds of services.

Services could be offered to the users if they are in an unfamiliar region. For example, if a user has not made detailed plans in advance for her holiday in Spain, she would probably want to get information of the services available there. Different kinds of organisations could offer the service, e.g. stores, companies and cities. The service could be offered to the potential users who have given their permission to have services offered. The user could then choose whether to order the service or not. The user could also rent a device to which the service is downloaded, for example, from a tourist information office.

In a more familiar environment a service of this kind might be less used or valued in everyday life. Ideas for different kinds of service packages and/or routes came up, e.g. shopping guides and/or routes, event service (ref. Tampere

Theatre Festival, see section 6.4), communal services, event calendar with a list and links of services, art gallery route.

Maps, routes and positioning. The lack of a map was seen as a shortcoming. Maps were seen as an essential part of the service where people are moving in an unfamiliar environment. Maps give people confidence about their location, especially if the pictures (like the ones in the Historical route) do not match the current environment. Route suggestions should also be presented on a map.

Accurate positioning was commented as necessary for this kind of service. The route and the user's own position should be presented on the same map. Attitudes towards positioning were mainly positive: users were not afraid of potential misuse of their location information, even when the interviewer suggested the idea. The positioning of the device should also be a choice for the users.

Zones and hot spots

The users wanted some kind of an alert or indication for when a new zone is activated, i.e. when the user enters a new area of information. Since the different partitions or zones looked so similar in the service, the shift from one area to another could be notified by a sound and/or vibration. The sign should be discreet but noticeable because the service is used in outdoor noise and in other crowded environments (e.g. exhibitions).

The zone should be activated in a close vicinity of the sights, clearly referring to the sights that are in view. However, people should also have manual access to the information of points of interest further off.

> *"There's always the danger that you get too confused to get information out of it. You just whirl around looking where the target is when it's not in sight. It's a big problem if the user has to take pains to do that."* Female, 30.

The user should be able to browse also the previous zone and its sights while moving. He or she may also want to view the following zone or other nearby

zones in advance. This would allow the user to return to the target information if necessary and even to choose between optional route alternatives.

The users were also asked if they would be willing to design their own routes e.g. for their friends. This idea did not attract the users. One reason for this was that they expected the making of zones to be pretty laborious.

Messages

Context-aware messages between friends were seen as an interesting idea. It took some time before users could think of concrete usage scenarios, but in general people liked the idea:

> *"That's excellent...terribly good, but we can already do that" [makes a reference to SMS – the differences in location-based messages are further clarified]..."What would the significance be then?...Like if someone knows that I'm going to the market, they can send me a message – they assume I'm at the market hall – like 'buy some horse sausage while you're there'. That would be one where it would work and then if the train is leaving or there are changes to the plane schedules and if the person is going there...Like in connection with sudden unexpected changes, that could be it. When he steps off the train, he gets one of these messages like 'there has been a change', like if he has one of those phones that do not work all the time [on the train]...Not all people like to talk on a train."* Female, 70.

One problem that was mentioned by the users was the trouble to know where there might be a context-aware message for oneself. Should there be a kind of agreement between users where the messages are left, or should there be another message to announce the existence of the context-aware message or some other option? Some indication for context-aware messages waiting to be delivered was expected.

Context-aware messages left by other users concerning attractions or nearby surroundings were considered a "nice to have" feature. The recommendations could also cover areas that are not seen directly from the user's current spot. Event or restaurant critiques were mentioned as possible uses.

The users realised that once the service were in use for large masses of users, the moderation of discussion and the control of the volume of messages would have to be solved.

One content type available at the end of the route was context-aware advertisement. At first, context-aware advertisements were commented mainly negatively. In the trial, the ad for a fast food restaurant (Figure 23) that was used as an example also contained information about the place: “Did you know that this is the Finland's first McDonalds.” The information was found rather interesting despite the fact that it was part of an advertisement. Advertisements would be more readily accepted if they made the service otherwise free of charge and if the user could moderate and personalise the ads somehow.

Figure 23. An advertisement that was used in the trial. A location-based message offers a discount and information about the restaurant.

6.3.3 Conclusions

In the trial, a context-aware historical route service prototype was demonstrated and tested. The service was built on the context-aware portal. The service was evaluated with four users.

Context-awareness is added value for the service. Users saw real advantages in identifying geographic contexts. Automated shifts from zone to zone were seen more comfortable than manual ones. Location-based information and messages were commented useful within the demonstration service. In addition, many other possible service packages, such as an event guide, were mentioned as potentially beneficiary. Positioning the users was not a real fear but seen more as a benefit.

User should have options. One clear result based on the trial is that the users of the service really wanted to have a choice in receiving, ordering and using context-aware services. Users mentioned that they could use different kinds of devices in different kinds of contexts. They want to choose services with or without advertisements and this should have an effect on the price of the service. Users want to have different kinds of routes for different kind of purposes (shopping, art, etc.) and they want to have alternative routes/choices even within the one service (e.g. Historical route). They were willing to adjust the zone shifting and zone radius according to their own abilities and needs. They also wanted options in positioning, maps and in zone shifting alarms. These options should be simple to select. Context-awareness could be used to make the selections so simple that the users may not even notice they are making choices.

6.4 Case 3: Theatre festival

The Tampere Theatre Festival [TTF] is a showcase of international and Finnish theatre. In 2003, the festival took place from August 6th to 10th. The event lasts for "6 days and 6 nights" and includes performances for all ages of drama, street theatre, music theatre and dance theatre, as well as workshops, seminars, exhibitions and meetings. Altogether, there were 371 events and an estimated 100 000 visitors.

The festival was an ideal case to demonstrate context-aware services for visitors. The programme schedule was spread out geographically and many events took place simultaneously. A one-off event, happening in a single location, would not have benefited as much from context-aware features. Also, many events were free, thus enabling users to attend them at short notice, based on information about upcoming events.

Trial users. The user group (Appendix B) consisted of 12 interviewees, of whom 5 were male and 7 female. Their age ranged from 19 to 30. The users were chosen by contacting visitors from previous years and volunteers in the festival organisation.

Two users were experienced with mobile Internet services, while others had little or no experience in using them. The users' experience with the Internet varied from very limited use (e-mail from time to time) to professional use. The make-up of the group fit the service concept well, because we assumed that users with little experience with the mobile Internet technology might be interested mainly in how the system added to their festival experience, not in the technology itself.

Survey respondents. A total of 131 participants submitted a feedback form. The number includes the 12 test users. 75 of the respondents were female and 56 were male. Their age ranged from 15 to 72. Most of the respondents lived in Tampere, a total of 77 people. 45 respondents were from out of town, nine left the question unanswered. The form consisted of questions regarding the usability and usefulness of the guide features, which the users could respond to on a six-step Likert scale. The users could complement their views in open-ended replies.

6.4.1 The festival guide

The service was optimised for use in media phones such as Nokia 3650 (Figure 24), Nokia 7650 and SonyEricsson P800. The Nokia 3650 with its XHTML browser was used in the trial.

Figure 24. The Festival Guide was used on a Nokia 3650. The festival guide was presented in XHTML.

The festival guide contained three main features:

Festival programme. The Festival Guide listed events at the Tampere Theatre Festival sorted by time. The user could click on the programme category (OFF Tampere, Encorebaana, Main Programme and Great Nocturnal Happening) and view upcoming events within a time period. There were also descriptions of the events. The whole Festival guide package could be sent to users of the portal as an attachment.

Messages. Visitors could send and receive location-based messages to and from one another. There were four places where the messages could be left: programme tent, two pedestrian streets with performances and a nearby park.

The messages could also be sent to everyone as a regular message, not based on location. In this trial the locations were manually activated.

Event news. The third main feature of the service was event news. The National Broadcasting Company Yle offered background stories and reviews about the event. The content was automatically adapted for the mobile device by the trial system. The news contained text, photos and media clips.

The concept of viewing the status of friends, other visitors or performers was introduced to the users in the interviews. The concept was discussed as a possible part of the Festival Guide.

6.4.2 Survey results

Acceptance of the festival guide

The service was demonstrated to voluntary visitors during the festival. The demonstrator either went through the service and its features or the visitor could try it on her own at the stand. The demonstration lasted for a few minutes. After the demonstration, the visitors were asked to fill in a questionnaire about the concept and the features they would like added.

Overall, the feedback from the respondents was very positive. One must of course keep in mind that most of those with a negative or indifferent attitude towards such a service were likely to skip the demonstration. The biggest variation in the replies was about the relevancy of the service features.

Positive replies. Replies to the open-ended questions were highly positive and supportive. Especially the concept itself, having the essential event information in one's own phone, was welcome. Many commented that the demonstration service was rich in content and features.

As pointed out by Kaasinen [KAA03], users may only the need a fragment of information that can be shown on a small screen, but there should always be the option of delving more deeply into the matter. Almost every comment said that the service was "interesting", "practical" or "handy".

"It seemed simple, informative and very topical right now." Female, 22.

"Good especially when you're from out of town and haven't found out too much in advance." Male, 33.

Most did not comment on the user interface itself and wrote that it would take a longer period for them to be able to suggest improvements. The comments concentrated mainly on the content, features and the sources of information. Some respondents made a difference between the concept and its implementation. Some of the disgruntled comments reflected connection problems that occurred while the service was demonstrated.

"Partly very versatile, partly too difficult." Female, 21.

"As an idea very nice, implementation a bit jarring" Female, 35.

There were also comments that referenced other sources where the users get their information. On the other hand, there were replies which recognised the fact that the other sources are not always available:

"I suppose it could be handy, although most of the information can be found in papers etc." Female, 24.

"The programme information is useful, lets you get rid of all that paper garbage." Male, age unknown.

As was apparent in the interviews as well, at least one respondent was worried that using a phone might diminish her festival experience:

"I'd rather party than ogle my phone." Female, 35.

The respondents made it clear that the system should in no way replace the current leaflets and flyers, but rather add to them. Several comments stressed that a mobile service of this kind should be updated in real time, to be as current as possible. Especially ticket sales and information updates would need to be

prompt. A number of respondents also recognised the messages between visitors as a new development.

Lack of suitable phones. Both the replies to the open questions and the other feedback to the demonstrators indicate that there was a big hurdle in using the service: the lack of suitable phones. Most people still have a model without WAP or they have no idea how to use it.

> *"The only problem is the lack of a suitable device (wap)"* Female, 20.

> *"A handy idea! Currently available to quite a marginal group..."* Female, 24.

> *"Seemed simple! I don't have the right phone for it, though..."* Female, 35.

At the demonstration stand, there was an option of adding the service for the visitor's own phone as a bookmark. Of the hundreds of visitors, six visitors with a suitable phone took up on the offer.

Relevance of Features

The positive attitude toward the demonstration was evident also in the responses about relevant features for such a service (Figure 25). The neutral point for the replies lay at 3.5. Even the features that were judged the most irrelevant did not go far below that point. The five most relevant features gained between 4.8 and 5.7 points. As such, their average relevancy lay between 'Relevant' and 'Highly relevant'.

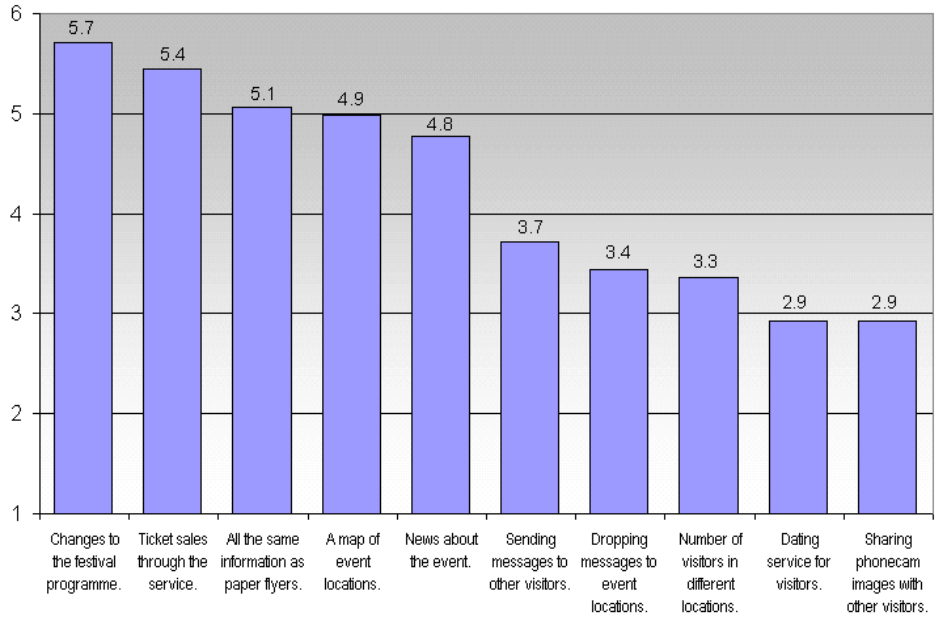

Figure 25. The relevance of the festival guide features. (6-Very relevant; 1-Not relevant).

As expected, the users would like the service to add to their existing sources of information. All existing programme information has to be there. The added value of a mobile festival guide can be seen in the fact that the most valued features were 'Changes to the festival programme' and 'Ticket sales through the service'. The features deemed least relevant were not tightly connected to the traditional routines of a festival visitor. A dating service for visitors and sharing phone camera images could make the Theatre festival a different experience altogether.

Social or informational connections between visitors would be a new concept to bring to the event. We performed statistical analysis on the data to find whether we would find clusters of respondent groups. We ran both factor and cluster analysis on the data. Cluster analysis is used to produce a hierarchy of variables and their relations. The dendrogram in Figure 26 was created by using the Ward method. The nearer the variables branch into one another, the more related their variance is. The composition of the two groups seems to support previous data, based on the relevance of features, about the make-up of the groups.

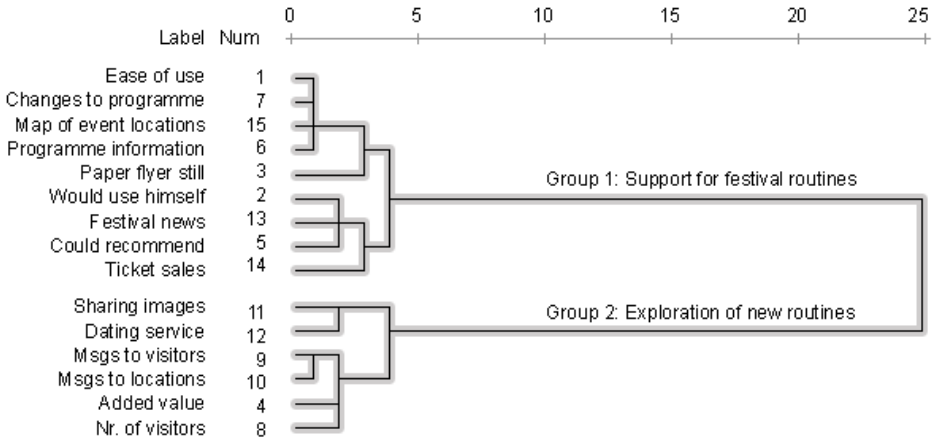

Figure 26. A visual presentation of the cluster analysis provided a hierarchy with two groups of variables.

The first group entails statements about features that support the 'traditional' festival visit: "Changes to the festival programme", "Ticket sales through the service", "A map of event locations", "News about the event".

The second group shows statements that could be described a new way of experiencing the festival: "Sending messages to other visitors", "Dropping messages to event locations", "Number of visitors in different locations", "Dating service for visitors", "Sharing phone camera images with other visitors".

The groups appear to be different enough to warrant a separate approach in catering to their information needs at the event. The preferences of the first group are closely connected with their existing routines. We may assume that for them, the issue is in making the technology as transparent as possible. For the second group, the new-fangled features themselves may be the attraction. Both groups respond to different service concepts, which could be taken into account in marketing this kind of events in the future.

6.4.3 Field trial results

The field trial group was composed of 12 users. Their task was to acquaint themselves with the service and use it as a part of their festival visit. We asked that they should use the features they felt were interesting, but think about reasons for the way they used the service. The users were interviewed twice: once to introduce the service and for the second time after the trial.

The system logged the trial use during the festival. There were 470 requests for the front page of the service, an average of 23 a day. The most frequent user loaded her front page 83 times during the week, the least frequent only 19 times. The average number of accesses to the front page per user per day was ~5 times.

Figure 27 depicts the distribution of use during the festival week, based on front page loadings. The figure reflects only how often a session was started. Thus, a long session of reading articles and viewing schedules is only one unit as is one quick glance of the front page. We can see that the most use is centred on Thursday, when a fast rotation of different events took place throughout the day and night. On Sunday the festival was already winding down.

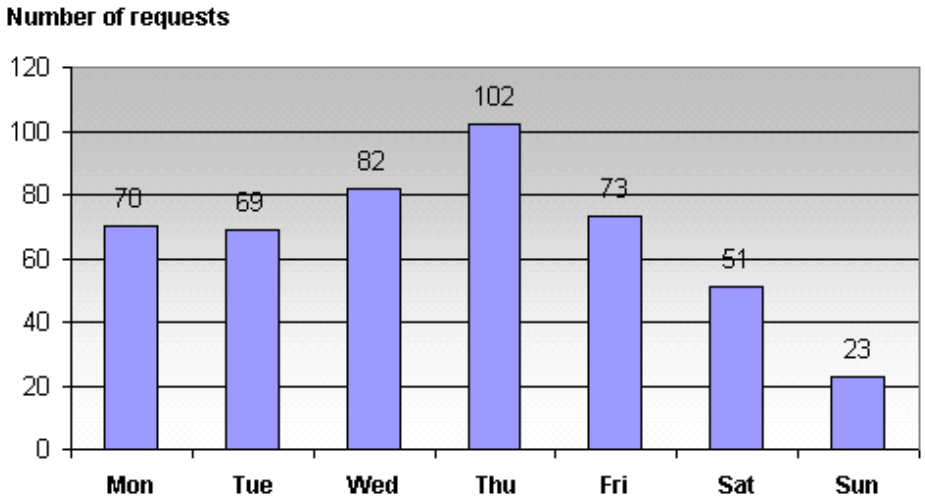

Figure 27. The number of front page requests by the users during the festival week.

Figure 28 depicts how the use was distributed along the day. The peak hours appear to be around lunchtime, after work and once in the evening, before heading off to a night out.

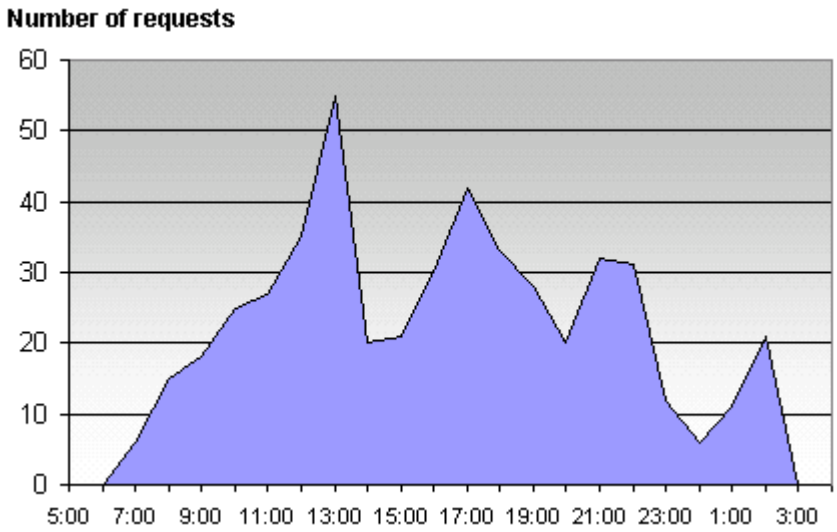

Figure 28. The distribution of use according to time of day.

One of the main findings is that at a festival of this kind, time can be an adequate trigger for context-based information. From the user point of view, the service provided them with just the right information at the right time.

Time-based information. As we had assumed, the benefits of topical time-based zones seem to depend on the nature of an event. The smaller events, many with free attendance, are by nature more spontaneous for the visitors. The users believed that the performances of the official programme were usually sold out in advance. Therefore some information should be about remaining tickets to be considered useful. We demonstrated it by sending Kontti messages containing information of sold-out performances. The users would prefer that information to be included in the actual event information.

Figure 29. Overviews of the festival programme were available as leaflets and posted signs. The Kontti Festival Guide concentrated on current and upcoming information.

Some users remarked that the service did not support planning ahead days in advance (Figure 29). If the user wished to see what was happening tomorrow, it was not as practical as leafing through the paper programme. Users did comment themselves, however, that the service cannot provide all alternatives.

The Festival guide presented the programme both as segmented according to time and as separate links to complete programme entities. The users felt that both types should be supported. Providing programme information in shorter time segments highlights also more unknown performances:

> *"I had scanned through the programme leaflet in advance, but when the service kind of pushed the next two hours information, it revealed performances that I wouldn't have otherwise paid attention to. There were just a few visible at a time, so I happened to pay attention to them."* Male, 30.

Location-based content. The time-based segmentation was useful for a visitor who spontaneously glanced the programme to see what will be happening and headed to the chosen event. Users described scenarios where location-based information would be useful. The user may happen to come across a site or an event he or she did not plan on seeing. If the user does not know what he or she is seeing, the service could identify the time and the location and display the event information.

> *"I think that's the best for a situation where you walk around and want to know what's where. And especially like when you end up somewhere and start looking like hey, what's that happening over there?"* Male, 29.

Personalisation. The concept of user preferences and a certain amount of tailoring were discussed in the interviews. The service was very much offered "as is". It meant that there was no need for setting up the service. It was ready to be used the moment it was accessed, and this approach was very simple for the users.

In a festival such as the Tampere Theatre Festival that offers a number of diverse events, some visitors are interested in selected parts of the programme, e.g. in 'free entrance events in a restaurant'. There could exist a number of packages with different themes according to e.g. type (Children's Theatre) or ticket price to choose from.

Context-aware messages

The users were encouraged to send messages to other visitors. In this case, the 'other visitors' were the 12 test users and members of the project group. This was quite a small number for demonstrating messages, but it was enough for the users to get the idea. 36 messages were sent.

In addition to sending messages to visitors, messages could be left ("dropped") in four locations: the program tent, two pedestrian streets and a nearby park (Figure 30). At the first three places, there were also performances. The park in question did not have performances. The trial only demonstrated location-based messaging. In reality, the users needed to activate each location manually to let

the system know where they were. Once the system knew where the user was, the messages that had been left at that location were delivered. 16 of the 36 messages were dropped to one or more of the four locations.

Figure 30. The users could target messages to different locations in the city centre.

Event messaging. The idea of being able to communicate with other visitors was very well received, since there was no other way to reach them. It would be both useful and fun to have peer opinions on performances, hints of nearby restaurants or just to contact like-minded people. Many of the interviewees also preferred peer views to more official news material.

The messages that were sent (Table 4) concentrated on asking views on existing performances and writing recommendations about others. The service became more useful as the festival progressed, because after having seen more performances there was more to comment on and to recommend.

A member of the festival staff also suggested using the service for customer feedback: After the festival everyone disappears and there is no concentrated way of reaching them for feedback.

The project group and the staff also sent notifications of sold out shows and programme changes. When asked, the users said that the programme changes do not necessarily need to be updated in the actual schedule, as long as there is a notification with a message. The messages are more noticeable in any case than changes within the programme pages.

Table 4. A sample of messages sent during the festival.

Seitsemän veljestä 6.8.2003 16:57 Onko kukaan menossa pe esitykseen? Ite menen la, olis hyvä tietää mitä odottaa. Ainakin Heiskasen ohjausta on kehuttu...	Seven brothers 6.8.2003 16:57 Anyone going to show fri? Goin on sat and would like to know what to xpect. At least Heiskanen's direction has been applauded...
Lisäesityksiä pe-la 6.8.2003 13:06 [viesti projektiryhmäläiseltä] Teatteri Telakan kehuttu näytelmä Telakan Kristus saa 2 lisäesitysaikaa: pe klo 20 ja la klo 13.	More shows fri-sat 6.8.2003 13:06 [a notification by a project member] Telakka Theatre's popular play Telakan Kristus gets 2 add. performances: fri at 20 and sat at 13.
Oconnels ihan täynnä 5.8.2003 20:03 Standup on näköjään suosittua	Oconnels is packed 5.8.2003 20:03 Standup seems to be popular
Jimmy aka d'ya see me? 7.8.2003 19:22 Upeaa! Brassardia ei turhaan kehuta! Se nainen rokkasi taloa, kuten toivottavasti Paprika Korps myös Klubilla!	Jimmy aka d'ya see me? 7.8.2003 19:22 They don't praise Brassardi for nothing! The lady rocked the house, as I hope Paprika Korps did at Klubi!
Paprika korps 8.8.2003 16:11 Tuo puolalainen reggae oli kyllä erittäin jees!!	Paprika korps 8.8.2003 16:11 Gotta say, Polish reggae was excellent!!
Alastonkuvia? 7.8.2003 10:20 Komin ystävänä kaipaisin arviointia Alastonkuvista. Onko kenenkään suunnitelmissa käydä katsomassa?	Naked pictures? 7.8.2003 10:20 As a friend of Kom I'd like a review of Naked Pictures. Is anyone planning to see it?
Kom ja alastonkuvat 7.8.2003 12:40 Oon menossa katsomaan su. Ei kai se huono voi olla...	Kom and naked pictures 7.8.2003 12:40 Goin to see it. Can't be bad, eh...
Plastilin 6.8.2003 17:12 Toivottavasti tämäniltainen teltta on ohjelmistoltaan enemmän minun makuuni kuin eilinen.. Näkki oli valloittavan energinen! Ensin kuitenkin venäläisiä tsekkaan..	Plastilin 6.8.2003 17:12 I hope the tent this evening is more to my taste than last night. Näkki was disarmingly energetic! First checking out the Russians though...

Location-based messages at an event. Communication between visitors was in itself a benefit for our users. In contrast, the benefits of location-aware messages seemed elusive.

The users could attach messages in four locations, named "Koskipuisto" (a park), "Kävelykatu" (a pedestrian street), "Tuomiokirkonkatu" (another pedestrian street) and "Ohjelmateltta" (the programme tent). When the users were described the idea of location-based messages, they were quite interested in

the concept. In practice, however, they preferred sending a message immediately and did not choose a place to drop it in. We identified several reasons for why this would be:

Message content was not location-specific. The messages that were sent during the trial were meant to gather as many recipients as possible: who saw this show, what should people see tomorrow. It was natural for the users to maximise the number of recipients by not limiting themselves to a certain location.

No need for filtering. 16 of the 36 messages were dropped to one or more of the four locations. This meant that when the users arrived at a location, there wasn't likely to be many messages there. The users were tempted to activate all locations to view every message to find at least something. Once the message load reaches a certain point, however, we expect the users would start filtering by activating only the pertinent location.

More seamless implementation is needed. The place should be automatically recognised. The users should also be able to quickly read messages and drop one to the place they're at. Manual selections both water down the concept of location-based messages and make them more difficult to use.

The ideal use for location-based messages requires a scenario in which there are a significant number of messages, so that there is enough likelihood of finding messages. The messages should be left for anyone to find, much like digital graffiti. One user suggested likeness to the Eiffel tower, which is covered with scribbling from all over the world. People might like to use a specific location to leave their mark, perhaps a photo image as well. Message content should be tied to the specific location and not be viewable from further away.

Social surroundings

Although not used in the trial, the possibility to view the status of friends, other visitors and performers was discussed on a conceptual level in the interviews (Figure 31). The feature allows visitors to see the current context of users who have given them access to their status information.

Figure 31. The social surroundings of friends or even performers can make the service more personal.

Visitors. As reminded by a user, visitors currently check on their friends already, using short calls and SMS. The list of friends would make this routine quicker and easier, possibly even cheaper. There were users, though, who felt that the current routine of using messages for checking on others is quite enough.

The status display should be limited to the user's friends. There was little interest in viewing the status of unknown visitors, unless it means the number of visitors at a location; whether the place is packed or half empty, for example.

A context-aware festival package could also contain ready-made manually activated zones, e.g. mood-based zones such as "feeling festive" or "stage-struck". The users liked the suggested idea of using manually activated zones in a social context, between friends, for communication.

Staff. The festival staff could organise some of their work more efficiently if they knew where each member of the staff was. The event related tasks could also be monitored, if the staff used the system to inform others of completed tasks.

Street theatre. If there is a theatre group on the move, with performances around town, it can be difficult to know where each performance is. Users felt that in such a case, their list of Friends could also include performers.

> Q: *"How about the idea that there could be a theatre group on the move and you could see where it is and where it's heading?"*
>
> A: *"That is really, that would be very nice. Like what we had with [a pair of performers] when their first performance was cancelled when their luggage was left in Berlin. People were like "What?" and they didn't know where the performers were since they added one – no, two extra performances. People didn't know where or when they took place. 'Cause the group was wandering between The Old Library Park and Central Square and Tullikamari and Kuninkaankatu. Like people knew the times but not the places. And if they changed their plans they could sort of update them somewhere like ok, this is the route were taking now and like...update the plan."* Female, 21.

Event news service

The response to the event news service (Figure 32), produced by Yleisradio, was interestingly contradictory in nature. In general, the news content with its media clips was seen as enriching and useful. The interviews and entries from survey respondents indicated that any information regarding the event was most welcome. The visitors to the demonstration stand assessed the relevancy of a festival news feature at 4.8 out of the maximum of 6. 67 out of 101 found "News about the event" relevant or highly relevant.

Figure 32. Access to event news was available from the front page of the Festival Guide.

The interviews revealed a wider picture about the matter. Those who liked to read the background stories felt that the articles were interesting. They read the material before a performance to found out more about what they would see. On the other hand, in the interviews it became apparent that there were users who felt that news (even about this particular festival) were available everywhere in the general media. They favoured peer reviews and opinions to edited content. The fact that the news was related to this particular festival heightened the interest. The response was still somehow muted when compared to the survey results:

> *"It was quite informational and topical. Perhaps I did not read the news often because you saw practically the same information if not in the day's paper then on the next day. I'm sort of more used to using those. One reason could be also that you usually sat somewhere when using the service and there wasn't much time to delve deeply into anything. There could be five people shouting in your ear at the same time."* Male, 29.

Interviewees favoured peer reviews. One interviewee, for instance, wished for a rating scale among users as in the Internet Movie database. Adding more interactivity with other visitors could be a way to attract users. One user commented that to reduce the feeling of familiarity, the news items could be more controversial and critical, to deviate slightly from mainstream journalism. They could also rely on a critic's persona to attract readers.

Some mentioned that background stories require more concentration than just a quick glance through messages and the upcoming events. The interviewees saw, unfairly or not, the news material as something that requires more time from them. Both approaches had their supporters.

> *"It's nice to read your daily paper and watch the news once. You get the feeling that it's expected that you have to be so aware of everything at every possible moment. Like you're completely out of it if you don't know what's been going on in the last five minutes. Sometimes I watch only one set of news a day on purpose. There'll be more tomorrow. There is not that constant flow of now there is this and then there's that."* Female, 21.

The mobile service seems to struggle along at least two dimensions. There is the dimension of *peer-generated material* and *journalistic content.* Some of the interviewees viewed the journalistic content as somewhat impersonal and widely available. The peer-generated material, on the other hand, was seen as more personal.

The second dimension appears to be *very topical information* as opposed to *general information*. The topical end was realised in the context-aware features, with the information of events that were relevant at just that moment. The general information can be viewed at any time, when the user has time to involve himself/herself in background stories. Although the event news were certainly in the correct context, some users still viewed them as mainstream news that could be acquired elsewhere.

This contradiction regarding news material was also apparent in the user requirements study in 2002 (See section 2.2). Some users could identify the moments when they were most likely to read news ("in the morning", "in the tram"), but often general news items were not found context-specific enough to

warrant a context-adaptive approach. People simply access the news when they have time. As the specificity of the news items increases, the viability of linking them to a certain context would no doubt increase as well ("line-up at a sports event").

6.4.4 Conclusions

The Tampere Theatre Festival case both created and demonstrated a functional festival guide with context-aware features (Figure 33). The overall response to the festival guide was very positive. The results showed that a highly useful festival guide could be created by using just time-based contexts. The users felt that they simply accessed the service and it presented the current information. The time-based guide afforded a seamless user-experience.

The preconditions users mentioned were that the event should be large enough and spread around quite wide an area. Dozens of small events also make the festival more difficult to follow without such a service.

> *"I think the service fits the Theatre Festival well. Especially when there are events taking place all the time all around the place. It's good to be able to have a quick look at the programme. What I did not look...the leaflets have all the performances in the main programme, you can see them there. But these smaller events happening all around, that's what this is handy for." Male, 29.*

The fact that the festival lasts several days and contains repeat performances was another factor which increased the usefulness of the service. As one user put it: if there are no repeat performances, what is there to ask or send reviews about? No matter how much someone recommends it, you can't see it again.

Most festival visitors expect at least the same programme information that is available elsewhere. There should also be dynamic, real-time updates and perhaps the possibility to reserve and buy tickets as well. The survey responses had characteristics of two types of users. The first group favours features that support a more traditional festival visit with programme schedule and changes to it. The second group would be willing to use the system to get in contact with

other users. They might be willing to accept even more untraditional features, such as location-based messages and the sharing of images.

Figure 33. The service fit the festival concept well. The information could be viewed in a spontaneous way and disregarded if not needed. Similar festival packages could be created for other events as well.

The survey responses indicated that any information regarding the event was most welcome. In general, also the news content with its media clips was seen as enriching and useful. However, some of the interviewees felt that the edited content was too similar to news that are available elsewhere.

The peer reviews from the event visitors of Tampere Theatre festival could not be read anywhere else. Messages can be valuable for finding reviews and asking opinions. As suggested by the content, the users preferred sending their messages instantly and did not select a place in which to leave them. The ideal

use for location-based messages requires a scenario in which there are a significant number of messages, so that the likelihood of finding messages is quite strong. There is a need for automatic and accurate positioning as well.

The festival guide trial gave a glimpse of a successful implementation: immediate access to current and contextual information. Similar packages can be envisaged for other occasions or topics as well. They could provide the user with a richer festival experience, complete with programme information and a new communication channel for visitors in their mobile phones, together perhaps with theme ringtones and logos.

6.5 Case 4: Social circle

After the pilot trial, it was evident that context-aware communication should be studied further. The other cases (Historical route and Festival guide) provided us with feedback on ready-made services, but one further case about everyday use was included in the trials. The High School trial was designed to extract information about social surroundings and context-aware messages.

The trial involved the students of a video course in Messukylä High School. The user group (Appendix C) consisted of 14 users. The students were 17 to 18 years old and the teacher was 57. Eight users were male, six female. The participants were loosely acquainted with one another, having attended the same school but not necessarily the same courses. There were both second- and third year pupils in the video course. Most of them were also taking some parts of their matriculation examination during the trial.

The social circle trial

- The Kontti platform was used for contextual communication within a loosely joined work group.

Users: 14 users, 13 students and a teacher of a high school video course
Age: 17–18, teacher 57.
Duration: 3–4 weeks.

The video course carried out a film project together. During the course of the project, the film was planned, scripted, filmed and edited by the participants. The beginning of the course involved joint gatherings in the classroom, but after the start there were groups that worked in different locations.

The evaluation took place in 2003, from early September until the beginning of October. The users started the trial on the same week. Twelve of the trial users were supplied with a Nokia 3650 phone and two were given a Sony Ericsson P800 for the duration of the trial. Radiolinja test subscriptions were provided for the trial. The trial use did not involve telecom costs for the users.

The users were instructed to get acquainted and use the friends service and context-aware messages in a way that felt natural to them. If there was a feature that did not feel interesting or fun to use, they were asked to think about reasons for this. The users could also keep a voluntary journal of their experiences with the system.

The users were interviewed three times each. The first interview was an introduction of the concept, the device and the prototype. The second interview was a one-hour meeting, in which we went through issues that were unclear or solved problems with the system. The third and final interview handled use routines during the trial and future concepts.

6.5.1 Results

On the average, each user accessed the service 5 times per day. The use routines included the manual activation of zones, checking on friends, sending messages and viewing other available material. The students were surprisingly interested in the fact that they could read web pages through the service. Especially bus timetables and mobile news were popular. The main activity was still the switching of zones:

> *"I have been updating my whereabouts daily. My zones cover such a large area that I've been bouncing between three zones. But I have switched zones if I'm at home, at school or somewhere else."* Male, 18.

The log statistics indicate that the service was used the most during free time. The observation is supported also by the interviews. The users checked on their friends when making plans for the evening or the weekend (Figure 34 and Figure 35). Most messages were also sent on Friday or Saturday (Figure 36).

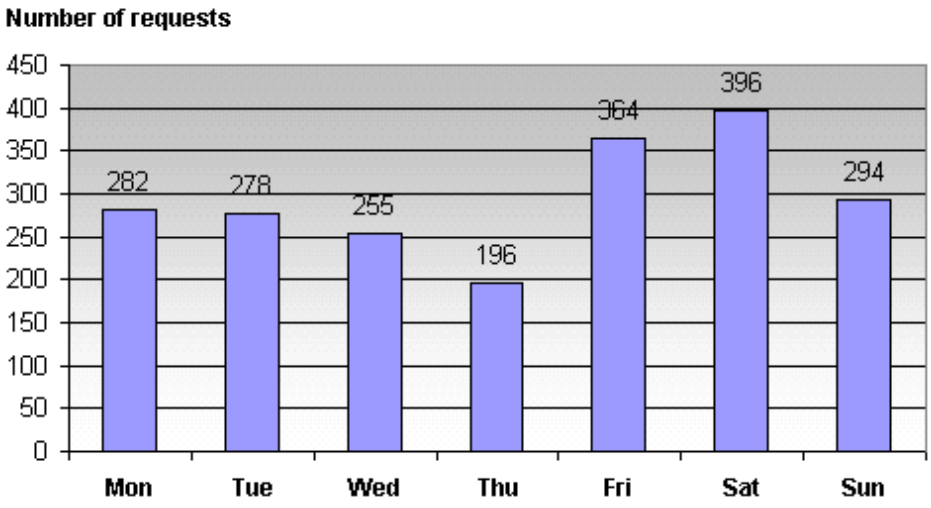

Figure 34. Use per weekday.

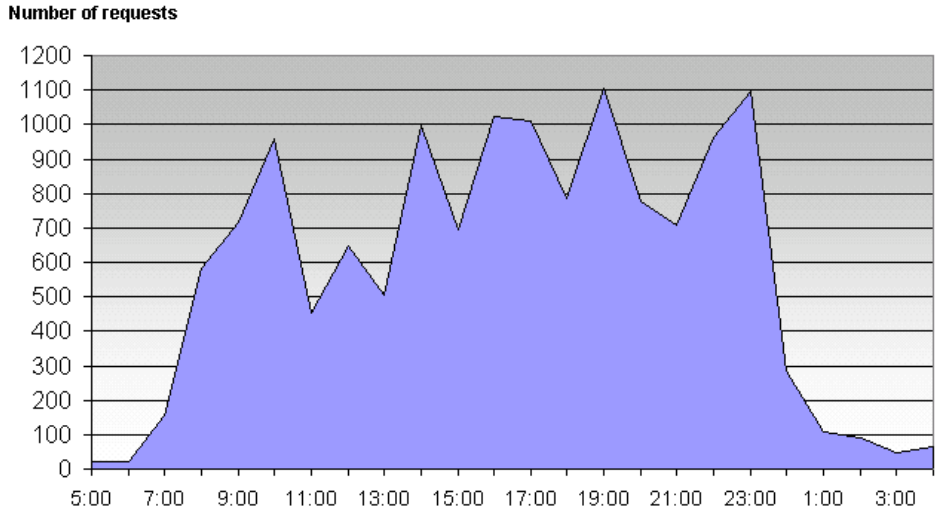

Figure 35. Use per hour.

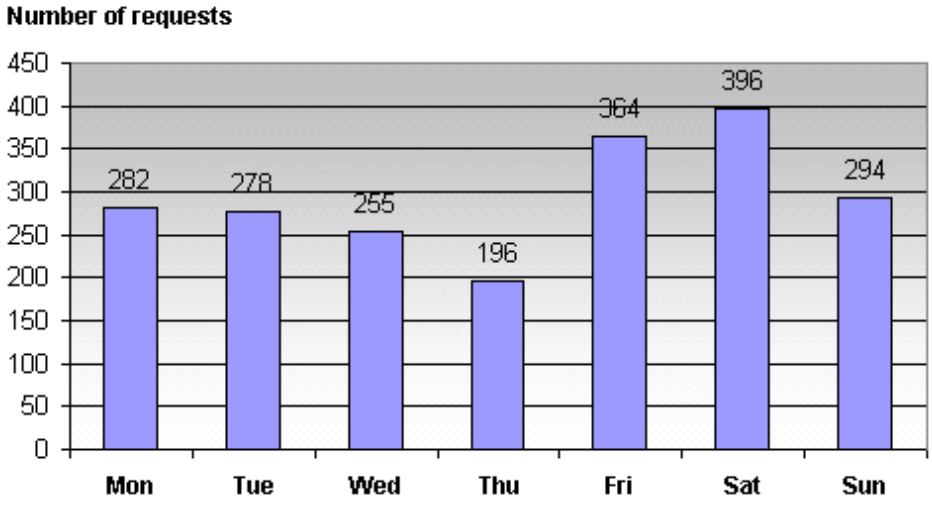

Figure 36. Messages sent per weekday.

A total of 171 messages were sent, an average of 12 messages per user. It is interesting to note that while the most use was on Saturday, there were relatively few messages sent on that day. This means that the user concentrated more on other features of the service, such as viewing the social surroundings.

Social surroundings

The students used the system to let others know of their current situation, to check on their friends and to read the messages. This was done a few times a day. The users noted that the use tended to concentrate on school breaks, evenings and weekends. The system was more useful during times when they were not aware of each other's contexts. Over the weekend, for instance, the users could check on their friends' zones before planning their evening.

The users liked the fact that they could describe their situation without restrictions and define which users were able to see the zone. The zones sometimes commented on the user's mental state. Especially during the examinations users communicated their stress to others by using the zones.

The zones were also used to trigger a response from others: One interviewee commented that quite quickly after activating his "Life sucks" zone there was a message from someone asking what had happened. The zones were created to entertain others as well as to inform:

> *"I've checked whether Maikki is at home and then maybe called anyway. And I have checked to see if there are any fun zones by someone."* Female, 17.

The users also sent zones to each other. One user created the zone "YO-kokeiluissa...!" ('Having the exams'), which was sent to others in the group. The users created zones mainly to inform others (Table 5.). Two users even remarked that informing others was more relevant to them than viewing the contexts of friends. It was important to know that information about them was available to those who needed it, but they might not be interested in the contexts of others as much.

We asked the users to evaluate the usefulness of three features; checking the zones of friends, seeing their actual location on a map and letting others to see your information. While the users suggested that the map feature would be fun, it lost slightly in comparison with the zones. Just the location on a map does not give the full picture of the user's context. One could envisage a zone-based system, where one could click for more details and only then receive the actual location. This would combine the benefits of both approaches. At least for these users it was not a problem to let others see their location. For this group, the teacher was the natural exception, as described by one of the users:

> *"Zone blunder. I was at [a bar] having fun and I wrote something there – and it wouldn't have been a problem if it had been our group only but it went to the teacher, too, and I wrote some pretty crazy things and in the morning went 'Oops'...."* Female, 17.

The readiness to let others see their status can be explained by the fact that the users felt they were in control of what information is seen and who sees it. They felt the information is not something that is extracted *from* them, but rather a way of sending a signal *to* others.

Table 5. Samples of the automatically activated zones created and used by the students. Some descriptions have been modified to exclude personal references.

Hälytystila	Mestoilla	Unilandiassa...
State of emergency	*Out and about*	*Dreamland...*
Yo-valmis(tuva) syksyn yo:t lähenee... lukemista, lukemista, lukemista	Henkisesti nukuksissa Väsyttääääää	Ohi on syksyn yot ohi on
(almost) ready for exams	*Mentally exhausted* *Tieee-eeeeerd*	*It's over* *the fall exams are over*
Nostalgiakierros Vanhoja paikkoja kierrän ja moikkailen VANHOJA naamoja...	Luen hulluna...	Erittäin isoa paniikkia ilmassa!
Nostalgia tour *Seeing old places, greeting OLD faces...*	*Reading like mad...*	*Major panic in the air!*
Läksyt puurtamista, puurtamista vielä 2 jaksoo	Kiire! ostetaan viikkoon muutama lisävuorokausi ja vuorokauteen muutama lisätunti	Kotikulmilla Varmaan jossain kissanmaa/leinola akselilla pörräämässä.
Homework *Toiling away, 2 more terms*	*Hurry!* *Wanted: Extra weekdays and extra hours for the day*	*Home turf* *Buzzing around kissanmaa/leinola*
Baarissa Kylmää: bissee, siiderii	Lenkillä laskuvarjojääkärikoulu häämöttää(?)	Vituttaa Hävittiin jollekin vitun heinähatuille 9–2. Jumalauta!
At the bar *Chilly: beer, cider*	*Jogging* *Paratrooper training in the horizon(?)*	*Life sucks* *Lost 9–2 to some bloody hicks. Bugger!*
Sängyssä... ...ihan ypöyksin :(	Keitolla Juoppo mikä juoppo =<	Vetäytymässä Kontista Se on loppu ny
In bed... *...all alone :(*	*Sipping* *A drunk's a drunk =<*	*Getting out of Kontti* *Over and out*

Context-aware messages

In the trial, most messages were addressed to the whole group (often excluding the teacher). There were brief exchanges of information regarding the matriculation, Swedish listening comprehension, cheers for those taking part and plans for parties. One user would also send images of his experiences out on the town.

The messages were also used as a communication channel between certain subgroups. Three of the students were working on a television project and used the service to send group messages. The teacher could also use the service to send instructions or changes to plans through the service.

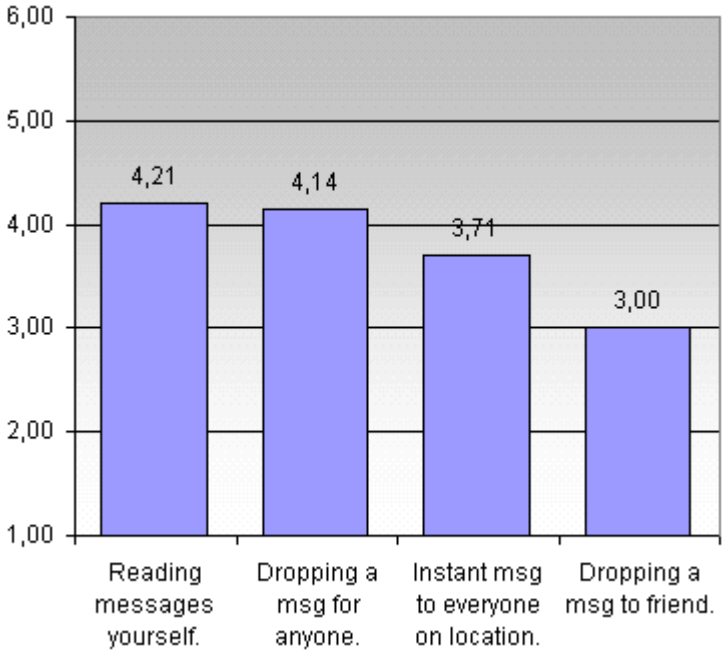

Figure 37. User responses to different aspects of context-aware messaging (N=14, 6=Highly relevant;1=Not at all relevant).

The way that the messages were used was in line with the results from the two previous trials (everyday use, theatre festival). Once a certain group of users has been established (video course, circle of friends, festival visitors) users favoured immediately delivered messages. Figure 37 depicts how the users rated different

aspects of context-aware messages. The differences that were evident in the interviews can also be seen in the diagram. The aspects were as follows, in order of perceived relevance to the user.

Reading location-based messages yourself. As expected, users were more willing to read messages themselves than to compose them. Composing a message requires more activity than reading messages which others have left. Three users suggested that they would enjoy dropping a recorded voice message more than writing one.

Dropping a message for everyone. Using context-aware messaging to drop a message for anyone who happens to come upon it was the most popular of the message concepts.

If the exact recipient is not known, there must be something else to hang the message on; a context, a location. The recipients cannot be contacted by other means. The context is the intermediary that limits the number of potential recipients and also, in a sense, defines them.

The concept also allows a delay between sending and receiving the message. Location-based messages can be considered as a context-aware guestbook. They will not be delivered immediately, but the users can access them once they arrive in the target context. A notification of messages in the area can be supplied.

Instant location-based messages. The messages are delivered instantly to users of the service who are currently in the same location as the recipient. They are not left waiting in the location for users who arrive later. The messages are delivered in a similar manner as SMS.

> *Female A: "Instant messages to all in the same place sounds kinda neat."*
>
> *Female B: "It would be like a chat. There's been a festival chat, if I remember right, people could text everyone in the festival."*

The concept was slightly favoured over using similar system between friends. The benefits are having no delay and establishing communication between otherwise unknown users.

Dropping a message to a friend. The trial users found fewer uses for context-aware messages between friends. If the recipient is already known, the sender usually wants the message delivered as soon as possible. Opening up the communication channel in the first place is where context-awareness in messaging is at its most useful.

> *"It depends really. Like, we're all young and active and you don't really know where everyone is. That makes it sorta hard. School, of course is a place where everyone ends up, but I see no point in dropping a message to school. When you want something delivered, you want it delivered right away. It could work for some business person, though."* Female, 18.

In addition to the delay, the users also pondered on reliability: One has to be sure that the recipients' contexts are identified reliably to guarantee the delivery of the messages. The user experience of reliability could be enhanced by visualising the existing and pending messages in a way that makes them more concrete even when not delivered.

Ad hoc contexts

Tamminen & al describe [TAM] ad hoc situational acts within planned ones, such as when friends meet and claim group space by forming a circle. The context exists for a moment and dissolves after the gathering is over. Our users often described the Friends feature as being of most use for a group "with something in common". At the start of the trial, we considered the groups "with something in common" to be quite steady, such as circles of friends and work groups. This was often the case when users described the peer group they would find the system most useful with: "My hockey team", "My family" or "My friends outside school."

However, even if the baseline for the social surroundings is formed by less transitory groups, there are a number of contexts and communities that only

briefly touch the users' lives. For the duration of that encounter, they are as relevant or even more relevant than the more durable social surroundings.

Figure 38. The contexts users share can be more abstract and difficult to identify. Nonetheless, communication between members who share the context may prove valuable.

For our users, these fleeting contexts were more abstract (Figure 38), for instance, the matriculation or listening comprehension tests:

> *"N. sent me the zones 'At bar' and '(almost) ready for exams'. Took a few pictures as well... A lot of talk about studying and the exams in Kontti. Glad to know I'm not the only one who hasn't been cramming!"* Diary entry, Female, 18.

The messages that were sent during the trial also indicate that for such groups, there is a need to communicate:

> *"Sep 18th. Cramming leave before D-Day. Not much can be done anymore... There was a pile of messages waiting when I got to Kontti in the evening. Nice to read that others had not been prepared, either. Good wishes were flying all over the place, nice atmosphere. Relieved my panic. Kontti is a good service for friends or a class or a group with similar circumstances in life."* Diary entry, Female, 18.

The basic characteristic of these ad hoc communities is that the members do not know who all of the other members are (Figure 38). For short-lived groups, the desired function in this brief social context is just to have any communication channel whatsoever.

How could communication channels for these brief encounters be established? One way of distribution could be the way the students created and distributed the "At matriculation" zone. The zone is created by one person and it spreads through the social network. Messages sent to this zone are delivered to recipients who have saved the zone as their own.

6.5.2 Conclusions

In the trial, an evaluation of the Kontti service was carried out, focusing on social surroundings and messages. 13 students and a teacher of a high school video course used the prototype for 4 weeks.

Context-aware messages show their strength when opening up communication channels between recipients who are not yet known to each other. Public context-aware messages were prefrred over targeted, personal ones.

Users enjoyed viewing each other's contexts and did not feel squeamish about letting their peers see their own status. They felt they were in control of who sees it and in what form. They felt the information is not something that is extracted from them, but a way of sending a signal to others. While location is an important part of the context, a verbal description gives the user a feeling of more control and an opportunity for creativity when writing the descriptions.

The trial results also indicate a more fluid definition for social surroundings. The need for communication with a certain group of users can exist momentarily, only to be washed away when the context itself dissolves. Examples of such contexts were ‘everyone attending the matriculation exams’ or even more transitory ‘all students attending Swedish listening comprehension’. The students exchanged tips and best wishes for those using the service.

These transitory ad hoc communities can be identified in some cases by location (all people in a certain restaurant) or by a more abstract context, such as an event the users are attending. One way of distribution could be the way the students created and distributed the “At the exams” zone. The zone is created by one and it spreads through the social network. Messages sent to this zone are delivered to all recipients who have saved the zone as their own.

The trial gave a more precise view of how context-awareness should be approached when it comes to faciliating communication. The recognition of context by location or other method is not an aim itself. The context is the intermediary that enables the user to access more services and reach more people.

6.6 Case 5: Business use - the Parliament

A round of interviews at the Parliament of Finland completed the set of evaluations in the Kontti project (Figure 39). The evaluation represented a business-related case, which dealt with communication in an environment that requires flexible communication and management of data from a great number of sources.

The primary focus of the evaluation was in the current communication routines between the member of the parliament (MP) and his or her assistant. The secondary focus was on the distribution of different material within the parliament. The Kontti service was demonstrated to the users to evoke ideas of how the current routines could be supported by using different technological solutions.

Figure 39. The interviews at the parliament also gave insight to the working environment of the MP and the assistant.

The Parliament evaluation

- The current communication routines between the member of parliament and the assistant were reviewed.
- We found out how material is currently distributed to members of the parliament.
- The Kontti system was demonstrated in order to inspire ideas of how it could be improved to fit the work routines between the member of parliament and his or her assistant.

Interviewees: four members of the parliament, four assistants to the MPs.
Duration: 1-2 hours per interviewee.

Interviewees

Eight interviewees participated in the evaluation. Four of the interviewees were members of the parliament, four were assistants to the members. Three of the interviewees were female and five were male. Their age varied from twenties to fifties. The interviewees were volunteers who responded to a targeted mail at the parliament. The mail was targeted at members who had been interested in the area of technology before.

Since our interviewees were volunteers, they were naturally already rather interested in adopting new technology to their working environment; they often worked in a committee that had a focus or a link with e.g. telecommunications and the information society. Also all of the interviewees were naturally familiar with mobile phones and web applications. They were using SMS, e-mail and, e.g., mobile phone profiles regularly.

Method

The interviews took place 5–7th November 2003. In three cases, the representative and the assistant were interviewed as a pair. This enabled the pair

to interact freely about their methods of communication. Two cases were single interviews (one MP, one assistant).

The interviews took up to two hours. All interviews took place at the working quarters of the parliament building. First of all we examined the daily routines of the member and assistant. The second part of the interview was a demonstration of the Kontti prototype service. We introduced the service as an example of context-aware services and gathered opinions, new solutions, innovations and suggestions for improvement. At the end of the session there was usually a general discussion or conclusions based on the demo.

Current routines. The work of the MPs is very mobile by nature. The work entails mobility within the country, abroad and inside the parliament. The roles of the representatives in the political party and the parliament naturally affect their information needs. The member-assistant relationships are also very varied depending on the work philosophy, practical needs and general mindset of the representatives.

The office space allotted to each MP within the parliament is mostly occupied by the assistant, who receives incoming calls and e-mail. The assistants may also take part in business trips within Finland. Some members have their assistants in the province most of the time and some members have a part-time assistant in the province and another part-time assistant at the parliament. In the latter case the assistant usually co-operates with two MPs in Helsinki.

If the assistant works in the parliament, he or she usually meets his or her MP briefly a few times a week. The convention varies between the MPs. Face-to-face meetings are an important interaction channel for these pairs, but much of the interaction is still communicated through calls, e-mails and SMS. Naturally, if the assistant is staying in the province, e-mail and SMS are even more important. Assistants work flexibly: most of them work office hours but they may be working also in the evenings and weekends every once in a while.

The working routines between the member of parliament and the assistant vary individually. The work specification can be very close to that of a ‘personal assistant’. In other cases, the assistant may have a very independent role in a project e.g. doing research on some enquiry. Although there are exceptions,

many assistants handle contacts coming to the MPs. In many cases, the assistant has access to the MP's calendar and e-mail. Assistants often filter calls as well.

The flood of information and contacts that needs to be managed is quite an undertaking. The task is even greater, due to a huge amount of spam and virus messages in email. If the assistant has an access to the e-mail, he or she usually filters all the spam away and, in some cases, also, answers on the member's behalf to the mails. It was commented that since the importance of a contact to another person can be difficult to estimate, some emails of importance have occasionally been deleted by accident.

Usually the members themselves update and mark their calendar. For the assistant, the calendar is of great value when he/she has to check where the MP might be at the moment.

The assistant also has to keep up with current events and topics of public interest. News material is summarised into memorandums for the member. Some of the sources that are used are parliamentary bulletins, Fakta (speeches held in the parliament are available after two hours), major media, local media, STT news agency. The parliament also has a very efficient unit for data queries, which helps in more complex information needs.

Telecommuting is supported at the parliament. The members and assistants have the option of using a high-speed ADSL Internet connection also in their homes and province offices. This enables them to use the same PC environment as is available in the parliament building.

6.6.1 Results

Context-awareness in parliament use. Much of the content that is used by the MPs and the assistants is in general media or available through the parliament information systems.

Context-awareness could be used to anticipate the information needs in committee work. The committees that the MP is a member of also define the structure of his or her work. The work can be structured according to the

informational channels. The channels, as described by one interviewee, are depicted in Figure 40.

Figure 40. The structure of the work defines the focus areas.

The interviewees often stressed the fact that they need to be able to move flexibly between different sources of information. The data flow must be targeted properly. In many cases, the momentary information need could be deduced by identifying the organisational context.

> *"When you think about the work of an MP, the situation changes between sitting in one committee in the morning and another in the afternoon. It is a very distinct change in your daily life…. first you talk about educational issues, then transportation and communication. After that it's a faction for your party and in the evening local politics, with a different menu altogether…In our lives 'At home' is something where there is little need to put effort, technologywise. I expect that quite a few of us set aside all gadgets and your context is more or less 'Off'."*

In principle, the information needs in each context could be anticipated. For each member, the contexts can be created according to their own preferences. However, currently the automatic recognition of these contexts is troublesome. Even a simple manual switching of profiles could prove to be too much during a

busy day. The contexts could perhaps be recognised if the system was integrated with the calendar.

> *"...automatic in the sense that you won't need to adjust it every time like 'now I'm leaving the office'. That for five times you click in the phone what your current state is. That'll fall through, right out of the gate. It has to be automatic."*

Communication. There were two main findings on context-aware communication. First, when there is communication from the member to others, the preference is in messages that are delivered immediately. Dropping the message to a certain context for the recipient induces a delay, which breaks the rhythm in communication. The communication between the MP and the assistant is a good example of this. The cases where the message can afford to be left waiting are limited. And if the message is not urgent, one can always use e-mail.

Secondly, when it comes to communication to the MP, there is a need to filter contacts or to block them altogether at certain times. Information about the messages is delivered to the MP, often through the assistant. The recipient then chooses a proper context in which to respond.

One task in which context-aware communication would have a use is the automatic filtering of incoming communication. At certain times, the preferred mode of communication is mail or short messages only. The system could recognise these contexts and automatically suggest that the contact use a preferred channel.

One of the interviewees remarked that messages are not as intrusive as calls. When the recipient is at home, the device could passively accept incoming messages to be browsed through later on. However, calls have to be responded to. If the context could determine which group of callers gets through even at 2 a.m., all calls would not need to be blocked to get a good night's sleep.

In the work-related service, the privacy of communication is also an important issue. Context could also be used to automate encryption. Based on the task at hand and the recipient, the system could automatically identify how strict an encryption, if any, is needed for safe communication.

Presence information. The use of presence information would allow the member of parliament and/or assistant to convey their availability or current status to the relevant people. It was interesting to realise how unpredictable once again the relevant groups were. One MP/assistant pair remarked that it would be useful to know whether the other person is in the parliament building or not. More detailed levels would not be needed. For another member of parliament the relevant group for such a service would be the family:

> *"Very handy for my own rhythm in life. Those close to you, wife, they could know what you're up to".*

Currently the assistant can check the present situation of the MP in the calendar. However, the calendar does not convey impromptu changes in the schedule. Ad hoc meetings can be just as important as those that have been pre-planned. The benefit of using presence information is that those around you do not have to stick to pre-planned schedule. The schedules change during the course of the day and presence information could make it possible to inform others of the changes more flexibly.

The need for privacy and the ability to 'disappear' is also relevant. No one wants his or her context to be available to others all the time, at least not in specific terms or as an exact location. The system has to cope with varying degrees of presence. One interviewee described a state where he is 'present, but not interactively." That means that he is focusing on a task, but he is available to some degree. The preferred time and mode (mail, call, SMS) of communication could also be conveyed in the presence information.

The information chain between the people at the parliament was also discussed. The assistant may not have a personal need to know where the MP is, but he or she may need the information to give it to, for example, the head of the parliamentary faction.

As in the previous evaluations, presence information was equated with location information, which leaded to questions about privacy and tracking of the user. More than half of the interviewees raised the question of privacy and user control.

6.6.2 Conclusions

The case at the parliament involved eight interviewees, who gave their views on the current communication within the parliament and its potential problem areas. The concept of context-awareness was demonstrated by using the Kontti prototype.

Between the MP and the assistant, there was a slight interest in a system through which their current context could be conveyed. Even if the assistant personally has little interest in the whereabouts of the MP, there are situations where the information can be needed by, for example, the leader of the parliamentary faction. On the other hand, the system would allow a varying degree of presence within a certain group of people. Within the work community or the user's family, presence information could be used as a communication channel.

Focusing on the relevant task was one of the main issues in the interviews. With a flood of contacts and information from all sides, the best that new technological solutions could do is to help flexible movement between tasks. Sometimes this requires fading some information out of scope for the time being, sometimes raising relevant issues to the fore. The needed information could be anticipated by observing how the work is structured into committees. At a particular committee, the focus is very much on the issues handled there. But once again, the flexibility of the system must be stressed. The user is the only person who knows what information is relevant in which context. The system should reflect this and not make mechanic assumptions.

Managing the flow of incoming contacts is a challenge that context-awareness could to a certain extent respond. However, targeting a message to a certain context did not feel natural to the users, as it causes a delay in responses. The automatic filtering of calls based on the context was mentioned as a promising concept. Text messages are not as intrusive and may not need to be directed in this manner.

6.7 User views on further development

In each of the trials, the users were encouraged to present ideas for further development of the Kontti system. Ideas that would take the concept of context-awareness further into the future were discussed as well. The Kontti system is open with regard to how the context can be identified automatically, i.e. sensor-based approaches can be used if the device supports them. When more contexts can be identified and the actions and targeted information can be triggered in this manner, the concept of context-awareness will evolve towards ubiquitous computing.

The first step to take is to make the device itself context-aware (section 6.7.1.) The following sections expand the user's ideas on presence information and other service concepts.

6.7.1 Device integration

The web-based prototype was used in the field evaluations. For some concepts, web-based approach could be appropriate as the final product as well. However, for others, the prototype merely provided inspiration of possible concepts. Users mentioned how some of the features of our web-based service appeared to be too separate from the phone itself. In the long run, integration with existing device features is needed.

Easier access to services. The users pointed out that accessing the web is currently made cumbersome not only by the speed of the connection, but the several steps and confirmations the user has to go through to receive the first page of the service. For some routines, such as viewing the status of friends, a separate application could offer a more current view without the need to access the browser. The user could make his or her desired selections and the application would access the web only when necessary.

On PC these steps may seem trivial, but on a mobile device the steps to make the connection are a hindrance. Further difficulties that are not as apparent on a PC-based web service are e.g. access to file system, separate messaging system and

automatic updates. The cost of using a mobile web-based system may also be a factor, if the user interface is loaded repeatedly during automatic updates.

Profiles. Instead of accessing the browser, the user should be able to switch profiles as easily as now, with the changes affecting the device and its services more globally.

Positioning. When both GPS and cell-based positioning can be used in the background, the access to local services will become more seamless. A browser- and cell-based solution waters down a part of the idea of context-awareness due to the unnecessary steps it entails for the user.

Messages. Users have developed a routine for using the message system of the device itself, mainly SMS but also MMS and e-mail. While the prototype offers an example of contextual messaging, it cannot be completely separate from the existing messaging application. Users do not want to access the web for messages, if they can be delivered (with an alert) to their familiar mobile inbox.

Current mobile messaging applications have implemented a way to choose between sending options, whether it is SMS, MMS, Bluetooth or Infrared. There could be room here for contextual messaging as well, such as “Leave message here”. When retrieving messages, the user could also choose “View messages within radius” etc.

Access to files. There is a need to access the files within the device and to deposit them externally for storage or for further viewing with other devices. Especially images came up as something that the users wanted to save and view later from other storage media besides the phone. The current web-based solution does not provide access to the files within the phone.

All test users were in favour of more active context-awareness, where especially the location could act as an activator for a zone. Some users did point out that manual activation is the most accurate method of identifying the context, but that it requires too much effort. The maximum effort in long-term use could be similar to current switching of the device profile.

6.7.2 Sensors

We introduced our users to new ideas of how to use mobile devices and how to control the information about the surrounding physical and immaterial contexts. One of these ideas was to use pointing as well as positioning to increase the accuracy of the information. In general, the idea of pointing at targets (Figure 41) was accepted and found very interesting.

> *"Wouldn't that be grand...fabulous really...would I then point there [points at theatre] and get next year's programme from the theatre and what they're serving at the Kivi restaurant this week. That would be very nice...but like, being as versatile as it is, would people know how to use it. I can point well enough and then this would say by the Tampere Theatre like "Showing now" and "Reserve ticket" and "Description of this and that" and when you click it comes up correctly...Right? And then there'd be a historical fact like who designed it and next show with vacant seats and then here we go with information about the church and..."* Female, 70

To this idea, we added the option of pointing at the desired area for information and the possibility to zoom back and forth for the information. For instance, when the user points at a movie poster, does he or she want information about the poster or the building that the poster is attached to?

Information zoom. With one user the idea launched several different futuristic visions, where context-aware services could be zoomed back and forth beyond geographic and biological boundaries. The mobile service turned into mobile augmented reality.

> *"That brings me right away to something where I could just select a direction and find Tuula in Krabi, Thailand and she would have the same service. What would it mean when I reach Krabi? When I could just point and roll the wheel and go "Now! Krabi!" And would it then go to Krabi city or would it be someplace else you could move on from there in a kind of virtual reality like okay, I'm at the city centre: Go to Ao Nang Beach."* Female, 25

The focus could be set to look from the immediate surroundings to the user herself. Zoom back enough and you'll be getting your own blood pressure and heart beat. Zoom to the surrounding area and you will get information from the neighbouring block, the neighbouring town, the neighbouring country and perhaps your friends that are staying in that country. And while you're there, you could leave a message to say you dropped by. And actually, if your friend was at home, he or she could see you as a shadow in a display on the wall and decide to have a virtual meeting with you.

Figure 41. Pointing could be used to extract information about the surroundings. The picture presents a movie poster with embedded tags. Based on the tag information, the mobile device can download a corresponding URL to the device. [VAL]

6.7.3 Enriched presence

In the Kontti evaluations, the users could convey their presence information to others through the service. They could control both who sees the information and how it is described. To enrich this information, some users would have liked

to add photos or media clips (e.g. for a basketball context an image of the user shooting a hook shot.) The adding of audiovisual media to presence information allows for more creativity in the content of and emphasises the role of presence as a new communication channel.

Extended T-shirt. The 'extended T-shirt' expands on the idea of enriched presence by using elements such as RFID tags, pointing and presence with people close by. The users felt comfortable with the idea of using contextual information to convey their present situation to others. In some cases they could allow unknown people to see selected information about them. Pointing to receive information was received enthusiastically by the users, some presented even ideas about pointing at passers-by to receive information. This kind of public sign that can be read by other people could be an 'extended T-shirt', only this time the information could contain not only slogans, but media clips. You could, for example, point at a person and your device would display his or her hobbies and play a theme melody.

One high school user noted that it would be useful if one could find out more about a person he's interested in. The information that is given, if any, is of course up to the person being pointed.

> *"Might be fun in a bar to find out whether someone is single or not. And something else, too, like hobbies and stuff."* Male, 17

Family portrait. We wanted to expand the idea of the Friends feature beyond mobile devices. The "Family portrait" may be of any relevant group, not just a family (Figure 42). It can be a flat screen on the wall, which visually resembles more a decoration than a technological device. It could have the appearance of several photographs in a frame. The portrait could be dynamically updated according to the contexts of the person depicted in the portrait. Next to each image there is a name of the person and his or her current context. The images have been taken by the members of the group and attached to represent a certain context. An existing platform for the portrait could be the digital television.

In this concept, we saw possibilities for a family-based method of providing services for the elderly. The service would be communal: The grandparents can

keep up with what the rest of the family is doing and vice versa. Any safety features in case of mishaps could be added within the existing family portrait.

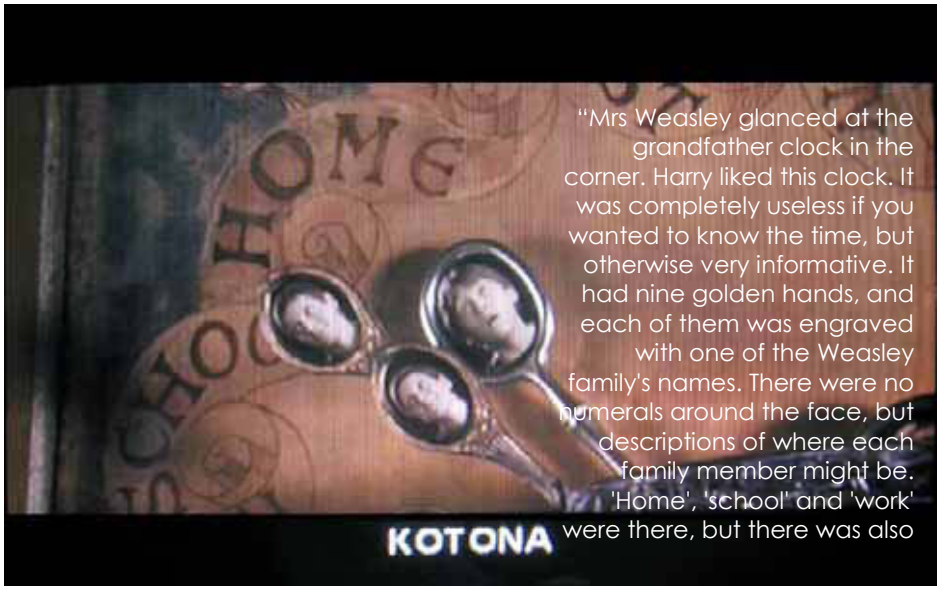

Figure 42. The idea of the family portrait as depicted in the movies: A grandfather clock shows where each person is. (Harry Potter and the Chamber of Secrets. Warner Bros.)

Also, the end of section 6.2.1 *Business use* mentioned the magnetic board used to keep track of work shifts. The family portrait could also be a dynamic version of the board that keeps track of where work is being done and by whom.

6.7.4 Complete solutions

The interviewees at the parliament expressed views on the information society in general. One interviewee described that up to the present day, technology has progressed too much in separate blocks which do not communicate with each other. No matter how technologically advanced the separate blocks are, the next step cannot be taken unless separate databases and protocols will interact seamlessly. The delivery of information across the systems that need it will increase in importance.

The interaction of these information blocks can have at least two repercussions. The free dissemination of data will be of informational value to the users. Also, the way users interact with the systems will change.

In the parliament, and in business use in general, it is important to be able to view the status of affairs as effortlessly as possible. The management of a project requires data from different sources. Ideally, the focus of attention will then concentrate on the issues that are not going in the right direction or are otherwise topical. Fragmentary pieces of information diffuse the focus. When a new solution is implemented, it is important that it does not add to the fragmentation of data sources, but gives the user more control over the big picture.

The integration of different system and data sources will help in the interaction between technology and users. Separate systems invariably use different interfaces, which creates more mental load for the users. In the future, the user may choose the device and the technology he or she feels comfortable with. The free dissemination of information will guarantee that the user is not isolated within one information block according to the interaction method that was chosen.

When the user no longer needs to choose the technology based on which information blocks they give access to, the control of higher level entities becomes possible. As one interviewee described, the basic lighting of a house could be set according to mood and occasion, not by adjusting separate light switches. The television channels could be grouped according to the same principles; not by their technical number but by the relevant context in the viewer's life.

> *"...when you change your state a bit, other things will change with it..."*

The principles are well in line with the context-aware approach. The integrated solutions would also mean complete solutions: Instead of developing technology on top of old routines, which may have formed due to imperfect technology, the whole process should be thought over as a whole. Partial solutions will *"solidify bad routines"* and one never gets to review the whole process from top to

bottom. Norros et al. [NOR] discuss the importance of understanding organisational and usage cultures. The technology should support the natural usage patterns of users, in order to avoid forcing certain usage models fixed in the design.

At the parliament, the technological solutions should also reflect the philosophy of an open society. Even if the parliamentary work is structured internally into committees, it may not be the best way to display it this way to a citizen who is interested in a concrete issue in his or her life.

> *"The whole [public] interface should be structured in a completely different way from our own… This is something that has not been recognised. The systems are still based on the organisation or function. Not on the customer or the citizen."*

The context of the citizen, the MP or the assistant should reflect how the information is presented to the user. This can only be achieved if the separate technological blocks and databases communicate freely and the use processes are reviewed as a whole, starting from the point of view of the user in question.

7. Service providers' interviews

Objectives

The round of service providers' interviews focused on getting immediate feedback about the concept of context-awareness and the developed prototype from the point of view of the each interviewed organisation. The interviews also acted as a useful counterbalance to the user trials by exploring essential views about the business field and exploitation possibilities of the Kontti concept. The interviews gave valuable input for assessing the business potential of a context-aware portal.

Conduct of interview sessions

Service providers' interviews were carried out in August-September 2003. The work conducted within the Kontti project was divided into two phases: Interviews of the project partners, and interviews of other service providers. The partners were interviewed mainly about the planned themes for the forthcoming service providers' interviews, and it was discussed which would be interesting organisations from the point of view of VTT and project partners.

Each interview session was divided into two phases: a demonstration of the Kontti portal, and a discussion about the exploitation possibilities of the concept from the point of view of the organisation. Interviews were conducted with ten organisations: three of them were project partners, and the rest were organisations that the partners and VTT agreed on.

Interviewed organisations

The organisations that attended the interviews are listed below in Table 6.

Table 6. The interviewed organisations.

Project Partners:	
Nokia	Device manufacturer
Radiolinja	Telecom operator
Teamware	Software company
Other Service Providers:	
Alma Media	Media house
The City of Tampere: Information Technology Center	Information Technology Center is e.g. responsible for the maintenance and development of some IT solutions of the City of Tampere.
eTampere Office	eTampere programme, a five-year development project of the City of Tampere.
Stockmann	Department store
Tampere Hall	Event, trade fair and conference organiser
Tampere Trade Fairs	Trade fair organiser
YLE	Finnish national public service broadcasting company

The interviewees were connected with, or responsible for, the technical development or research activities of the company they represented.

Material and methods

The interviews were carried out by using a semi-structured thematic interview as the research method. The demonstration illustrated to the interviewees contained the walkthrough of the Kontti Festival Guide service by using Nokia 3650 media Phone as the demonstration device. The Festival Guide used the context-aware system to display topical information about the event. The Guide was used to present the concept and the underlying features to the interviewees.

The following themes were discussed during the sessions:

- Background information
- Future visions for mobile industry
- First impressions about the Kontti portal after the demonstration, i.e. usability, ideas for further development of the portal and criticism towards it
- Use cases from the point of view of the organisation
- Business use
- Marketing aspects
- Technological aspects
- Co-operation possibilities and business field

7.1 Results

7.1.1 Future visions for mobile industry

Service providers believed in context-aware services and mobile communication between members of a community. Especially, communication from companies to their regulars, was believed in. In this context, societies and different assemblies were mentioned as well.

Here are some comments that came up with the representatives from different organisations:

- From the point of view of an end-user, monetary transactions and payments of new services should be made as easy as possible.
- *"Mobile Internet is coming (using HTML in devices)."*
- PDA:s will not *become* common as people are not ready to carry them along with mobile phones. It is also a matter of price.
- A new generation of mobile devices is needed before context-aware services will become common.
- In the first instance, context-aware services will become common in different kinds of events.
- *"In the future, people want their mobile services as personalised and targeted [at the right place and right time, according to needs of a user]."*
- Mobile videos will be used, e.g. in viewing news, movie trailers, advertisements and music videos. On the other hand, IPR problems must be solved first.
- One of the interviewees suggested that VTT, as an independent research organisation in Finland, should pressure some companies, e.g., to solve IPR problems together with organisations related to this area.

7.1.2 First impressions of the demonstration

Usability

In general, the Kontti portal was considered useful and the user interface quite easy to use. The usability of the context-aware portal or service was stressed as important. However, some problems came up and raised the following questions and discussion:

- There were doubts about the ease of the adoption phase of the new service for the customers of the service providers. The present Kontti system would demand a proper introduction for the end-users. However, this may not be possible when launching out a new product or service.

- The Stockmann representative mentioned that their typical average customer is 42 year-old office-worker lady. The services should be tailored from this point of view. He was also aggravated that mobile services are typically constructed "for young nerds who use all their money for music and the Internet".

- The interviewee from Tampere Hall stressed that an adoption phase of the service should be very easy. For example, the user should be able to download the context-aware service from the Internet via GPRS or another connection so that the service will be automatically saved as a bookmark in his/her mobile device.

- Most interviewees suggested that using the service demands too many steps to get to the relevant information (this is a problem with browser-based systems that is not easy to solve, as many of them pointed out).

- Accordingly, using the portal was considered as somewhat time-consuming, e.g. downloading the pages of the portal took relatively long. Some of the service providers mentioned that they could tolerate 2-4 seconds' response time and one of them even said that he uses the computer with a fixed connection as a comparison to his mobile use.

- The switch function between the zones should be carried out with one user action, e.g. clicking one or two links at the maximum.

Other comments:

- *"How can it be made sure that the service takes particularly my preferences into account, or my customer's preferences?"*

- Positioning (GPS) was mentioned as an essential prerequisite for a broader use of the context-aware portal or service. However, two of the service

providers believed that identifying the position of the end-users could set off discussions and even doubts. A ”Big Brother” debate was anticipated once again.

- Surprisingly, the manual activating of zones was, in some cases, seen as a permission for advertising. All three organisations that organise events as a part of their business, mentioned it as a positive outcome of the Kontti project and portal.

7.2 Use cases

Business use

Business use was not the primary use case that came up during the sessions with the interviewees, although the idea aroused interest when the interviewees were given examples of it. They thought it would be *”nice”* to view colleagues’ contextual information , but it was also stressed that using the system should be as effortless as possible, since many business users do not have time for switching the zones during office hours. The interviewees believed that *”changing the profiles”* would be the maximum amount of effort that users might be ready to make when using a context-aware service during a working day. An automatic recognition of the context was preferred for business use. If there is a need to change the zones manually, it was mentioned that changing them should be possible to do, e.g. *“in the lift or while walking along”*. In contrast to this, one of the interviewees suggested an opposite scenario; office workers could be obliged to use a context-aware portal by their employer.

Sending contextual information, e.g. a meeting agenda, was also considered quite interesting. One of the interviewees of the public sector mentioned that mobility would make the use of present office applications more effective. He also mentioned that he would not have wanted to prepare for his meeting of *”hospital network servers*” at his office desk. On the contrary, he just wanted to grab along his mobile device and get the agenda for the meeting as he arrives at the hospital:

> *”Dragging the documents along is excruciating. I always forget something or I have lost some document.”*

However, an effortless printing possibility should be guaranteed. Maybe a device or service could recognise the nearest printer in the future and suggest the printing option automatically?

Intranet content was not considered necessary to be viewed on a mobile device. On the other hand, a mobile extranet could be more useful and taken into consideration:

> *"I don't know if there is anything useful in intranets, except in the opinion of a personnel manager… maybe a phone book, but I don't know if there is anything REALLY useful. But a mobile extranet could be useful instead. Especially, if someone wants to browse product catalogues or recent prices of the products."*

> *"Using a mobile intranet demands a different kind of setting since it is not wireless. It is getting too complicated for the user. You should be able to use same connection."*

However, many interviewees pointed out that it would be essential to integrate their own existing systems and databases with the context-aware portal solution, an access to different files on servers was seen as interesting.

Events and Marketing Aspect

From the service providers' point of view, marketing can be seen as the most interesting and the most profitable use case for the future. The organisations that regularly arrange events were greatly interested in the Kontti concept (Figure 43).

The representative of Stockmann suggested the following usage scenarios for the Kontti concept:

- Firstly, the user could create his or her "own world" by making some kind of information package about him/herself: *"These are my hobbies, my interests, etc."*. If the users are mistrustful of giving any information about themselves, it is possible to use the information which has already been collected (e.g. department stores know quite a lot about their customers, especially regulars). And secondly, the user could be given contextual information about the topics he or she is interested in or has previously selected.

- Stockmann owns six department stores in different towns. All of them could be seen as separate contexts. Every time when a user is visiting Stockmann, he or she could be given contextual information according to his or her interests or about what is happening in the department store, e.g. today or this week. At the moment, many advertisements concern the department store of Helsinki but the user who reads the advertisement might be located in Oulu. The information that Anssi Kela is visiting the Helsinki Stockmann is totally useless for the customer in Oulu.

- The "Hullut Päivät" sale [a special event at Stockmann twice a year, lasting from Wednesday to Saturday] has usually been popular among customers who actually read the advertisements related to the event. In the "Hullut Päivät" case it could be possible to give the users contextual information in the different departments at the right time, or at least at the different department stores.

The representative of Tampere Hall saw that it would be useful to inform the users about the events or give some offers as a reward of participating in an event, e.g., discounts for the tickets of forthcoming concerts. He also suggested that the city of Tampere could be divided into segments, so that people who are registrated to an event could get information on different segments. For example, when a person first enters the town, the system could display information about the sights and transportation. Second, when she enters her hotel, there is information about how to get to the Tampere Hall, and about the services of the hotel; and third, when the traveller finally arrived at the event at the Tampere Hall, she would get information about the place itself and its services. In the end, it would be possible to create an extensive package of information around a particular event.

From the Tampere Hall point of view, the following was suggested:

- Special offers related to all services of Tampere Hall and forthcoming events, including the services of different entrepreneurs operating at the premises. The special offers should be exploited immediately so that the whole value chain is taken into account down to monetary transactions. The problem in the present services is the fact that the whole chain has not been considered thoroughly. Some good ideas have not become more common

because they haven't been considered carefully from the point of view of the customer, i.e. the end-user.

- The authentication instructions of Kontti could be sent to the users after the registration and payment of a conference.

- The mobile payment system should be seamlessly integrated with the context-aware portal, e.g. in events like concerts, it should be possible to pay for the tickets, food and drinks during the interval, programme bills and cloakroom fees with a mobile device.

- The Kontti portal could be a part of the facilities offered or hired to the customers of Tampere Hall: *"Our core business is to offer the facilities to different kinds of organisations that are arranging events. We could ask if they would be inclined to use context-aware portal too."*

Occupational Use

Similarly, the public sector would benefit from using context-aware services. The interviewee of the City of Tampere Information Technology Center, figured out three different use cases in which contextual information could bring added value to the daily working routines of city employees.

Health care. Communication between members of the nursing staff would be easier if the nurses had updated, real-time information about the health conditions of their patients.

At the moment, in some cases, the nurses use a log (book), which could be easily replaced with a context-aware service that would offer e.g. the patient's latest prescription to the right people at the right time, especially for visiting nurses. The interviewee also mentioned that at present, the tendency is to invest in home care instead of institutional care. This would support the idea of developing new health technology.

Figure 43. The organisations that regularly arrange events were greatly interested in the Kontti concept.

Fire and rescue services. The contextual information related to real estate, population register, route, etc. could be presented in a mobile or other handheld device. Moreover, ambulance drivers and paramedics would also need the latest information on the health conditions of the patient, preferably before arriving at the scene.

Information Technology Center, on-call duty. The Information Technology Center is responsible for different technological solutions of many public sector organisations in Tampere, e.g. the maintenance of servers. There are usually two people (called "supervisors") on call at the technical support if something unexpected happens. The hospitals, for instance, cannot wait for office hours if the system crashes. If something troublesome happens, the support person will estimate the situation and take the action which is needed to repair the damage.

The general description of the servers and systems of different public sector organisations are kept in physical folders at the moment. It would be useful to

get that information in a mobile device, especially if the support person is at home when something goes wrong. The interviewee also mentioned that the information collected by the help desk of the Information Technology Center could be combined with the server and system description information kept in [manual] folders. These two information sources could be exploited to build a new context-aware service for the purpose of on-call duty situations.

Messages and zones

Interviewees suggested that money can be saved if a message could be sent to several recipients at the same time. This was clearly considered an advantage. Sending attachments with messages was also an interesting idea from the marketing point of view. Material and messages would be easy to direct to different target groups. Especially the representatives of Stockmann and Tampere Trade Fairs were quite interested in this possibility since they have already collected information about their customers. Even the zones could be created as a package of information and sent to the end-users according to their interests.

Mood-based zones as a feedback channel

The interviewee of Tampere Hall mentioned an interesting idea about using mood-based zones as a channel for feedback. Voting, e.g. in union meetings or in the parliament, where many people are constantly voting for or against something, could be arranged via mobile devices. Mood-based zones could represent different choices which could be predefined.

Media houses

The representative of Yle was interested in a context-aware communication system inside their own organisation. The editorial offices, editors and reporters have a need for contextual information because they are exchanging information, e.g. of different events and news all the time.

> *"If there is a news item in a municipality or town, how can we share the information to everyone working in the world of news?"*

Similarly, the representative of Alma Media was also interested in news. She mentioned that end-users would probably be interested in news presented in different forms at different hours. For example, she said that in the morning, people might want just headlines or abridged versions of the most important news. The news could be tailored to different terminals or mass media according to these needs.

7.2.1 User groups

In general, it was assumed that the new generation mobile devices would be needed before context-aware services could become widespread. One of the interviewees saw that the marketing stage (e.g. salesmen) of the devices is the weakest link in the chain of production: *"They know absolutely nothing!"*. This is clearly a problem if a salesperson is not able to explain he possibilities a device can offer.

Furthermore, it was assumed that business users would be the first user group since they do not usually pay for their bills and devices themselves. The representative of Tampere Trade Fairs pointed out that business users can be reached by offering context-aware services also in events, not just in the office. For instance, IT business users often participate in international conferences and trade fairs that are related to their expertise. It could be useful for the business users to be able to exploit e.g. extranets (marketing material) with potential customers or business partners in a conference. Of course, in that case, it is important to be able to use a fixed connection to the Internet. WLAN was mentioned as an interesting possibility in this case.

Figure 44. Young people were mentioned as an interesting user group, although the first adopters were expected to be business users.

Young people were also mentioned as an interesting user group (Figure 44). For example, the representative of eTampere believed that mood-based zones would be popular among the group:

> *"They [mood-based zones] might be quite a success as the service could offer many communicational possibilities."*

7.2.2 Technology

Device Versus Browser

Blurring the line between device and browser was considered desirable for context-aware services. Service providers pointed out that their customers are not necessarily familiar with new technology, which stresses the importance of usability work and user-centred aspects in service development. It was stated

that, from the users' point of view, it does not matter whether the system is more browser- or device-based in reality. It is essential that the service looks device-based, even if it is not.

It was even mentioned that a browser-based system is better than a device-based system, because it allows use with different mobile terminals. It was also seen important that everybody would easily learn how to use context-aware services. Some interviewees saw concentration on only the Nokia models troublesome. One of the interviewees mentioned that *"Nokia and Ericsson can never fit into the same [context-aware] service"*.In actual use there are a number brands available and the services have to work most of them. To accomplish this, some kind of XML-based smart browser could be loaded into the mobile device of a user Therefore some kind of XML-based smart browser could be loaded into the mobile device of a user. However, it is worth remembering that users are probably not very keen on loading files into their mobile phones by themselves.

Connection

A few service providers mentioned that SMS-based services are quite limited from the customer's point of view and could be replaced with GPRS-based services. This is interesting, considering the bad reputation of WAP services in recent years. One of the service providers said about Kontti that

> *"This is a true alternative for SMS-based services because this is so modern."*

Another service provider gave the following comment:

> *"At first, we had so many ideas about what kind of services people might want to use via mobile devices, but how can you implement them over SMS? – It was really difficult! You have to create some kind of menu in there [SIM card] and all the responses a user might get, they are always in the same format."*

In addition, the possibility to include pictures in the service was seen as an advantage with a GPRS-based service. It appeared that what service providers really wanted, was an Internet connection in the mobile device, because *"it is*

possible to build anything in there!" As a consequence, WLAN was once again mentioned as quite an interesting possibility in the near future.

Content management tool

Service providers who are not operating in the IT business were quite anxious about the management of content in a context-aware portal. They were curious to know if VTT and project partners developed a tool for this purpose during the Kontti project. They also pointed out that IT business is not their core business but it is important that they can manage the content of the portal by themselves, without worrying about technology (the maintenance of the context-aware system should also be subcontracted to an IT company). A web-based tool was suggested since it was seen as the easiest way to access the system from outside. It was also mentioned that the tool should be versatile enough to create and control the material for different target groups. It was suggested that it should be possible to create quite large information packages with the tool, including zones and attached material. To compare, the festival guide alone included 371 events. Some service providers hoped that a company operating in the IT business could take care of this problem in co-operation with them.

Other needs

Additionally, there was a remarkable need for integrated systems in which the context-aware portal would be combined with the present systems of the organisation. Otherwise, the portal would not be as useful from the organisation's point of view.

In order to develop the Kontti concept further, it was also mentioned that sounds should be included in the system. The representative of Yle was particularly interested in the possibility as their work is based on different forms of communication. From the technological point of view, sounds are troublesome since *"it demands cutting off the WAP connection and using the Internet connection instead so that we are able to load the files from our server. There is still work to be done with sound".* Another major issue related to voice is IPR:

"The telecom operators should be active in the field since it is in their hands how to enable or prevent the forwarding of sound files. Solutions for technology are in their hardware configuration."

The representative of Yle also proposed that users could buy *"earmarked WAP connection time"* for using, e.g. a context-aware portal like Kontti. In that case, only the Kontti portal could be used, other WAP services would not be available. Thus it should be considered what we could do with prepaid services. She also mentioned prepaid subscriptions that are quite popular elsewhere in Europe, but not really in Finland. *"These are telecom operators' issues. They should think about these kinds of business scenarios."* The interviewee also suggested that this kind of earmarked service could be bought for the children, for instance, for a limited period.

7.2.3 Business field

Making business with context-aware services was seen troublesome. Service providers believed that services should evolve from true needs, based on a thorough analysis of business potential and service processes of the organisation in question.

Many service providers pointed out that they could operate or work in co-operation with a telecom operator, mainly Radiolinja or TeliaSonera as they are large enough in the Finnish scale. In the course of discussion it became evident that partners of the service providers should be trustworthy and reliable. It should be guaranteed that there is stability and longevity in the business of the partner. Small and medium-sized IT enterprises were seen as problematic partners since it is always possible that they might be bought out by a larger company. In that case, the rights and licenses might cause trouble, which could lead into a difficult situation for the service provider who still wanted to continue to offer context-aware services for their customers.

Additionally, it was mentioned that it is important to partner with companies of good eminence. Especially, the representative of Stockmann stressed that their brand stands for quality and can only be connected with a company of the same

quality level. The companies of the Kontti project were accepted as trustworthy and possible partners.

Basically, there are two kinds of service providers: independent, when it comes to technical solutions, and companies whose core business is quite far from the IT business. The latter ones need partners in order to construct a context-aware portal. It is not realistic to assume that they could do it alone. As mentioned previously, all service providers would need a tool for managing the content, since it is not realistic to assume that another company could create and manage the content for them.

The representative of eTampere argued that the business field in context-aware services is still quite fragmented. It is also worth asking whether the business field does indeed exist at all – at least in a clear form. The interviewee suggested that eTampere could take an active role in clarifying the field. There could be a single, centralised service the service providers need to contact for help. However, in that case invoicing should be as easy as possible. The possibility to make business in the area should be carefully mapped.

7.3 Conclusions

According to service providers' interviews, companies that are arranging events seem to have the most promising and interesting business possibilities for the context-aware portals or services. Particularly, the marketing point of view aroused a lot of interest. However, it is worth noticing that only three out of seven interviewed service providers are operating in this business and the sample of organisations was only ten, including three partners.

Furthermore, since business users (especially IT business users) were assumed to be the first user group in using context-aware services, it could be worth while to offer them services also in conferences, other events, and meetings related to their expertise area – not just in the office. In this connection, it is also useful to remember the idea of using mood-based zones as a feedback channel.

From a technological perspective, a content management tool for the context-aware portal would be essential for all service providers – even for those

operating in the IT business. The present Kontti system is not flexible enough from the service providers' point of view.

In order to construct new context-aware services, e.g. in a business use case, it would be beneficial or even crucial for service providers to integrate their present systems with the context-aware portal, even if integration might be troublesome in many ways.

Usability and the adoption phase of a new service were also stressed as important aspects to take into account in the development process of context-aware services. The development of easy-to-use devices, enabling the usage of the services, was also mentioned as a prerequisite for usable services. Both are important from the point of view of customers, i.e. end-users, who are not necessarily technology-oriented.

The results were used to outline a business model for the field of context-aware services. The most interesting business potential seems to be with the service providers who are not operating in the IT business and who need partners' help in order to construct new services.

A further challenge is creating services for the public and culture sectors. That would demand knowledge about the service processes of the organisations in this area. Communication between the people in the IT business and the people who work on the public and culture sectors is also needed. Service providers' interviews turned out to be quite an efficient way of spreading the word about context-aware services, portals and their future possibilities.

8. Discussion

In this chapter, the general concept of context-awareness is discussed as it appears through the results of the evaluations. The discussion highlights categories of context-aware services, messaging, presence availability and the business field. The overall evaluation results are viewed from a higher level of abstraction than each individual evaluation case.

There are certain limitations as to how the evaluation results must be viewed. The devices that were used were largely unknown to the users, as were mobile Internet services to a large extent. The users had to get acquainted with both of these before they could even access the prototype that was used. It must be noted that unlike many other projects on context-awareness, we were able to use smart phones instead of PDAs with our service. This is a much more natural state of affairs than carrying a more alien device (PDA) as well as the cell phone. For the duration of the evaluation, the users were able to replace their current phones with the one provided by the project.

The amount of material and mobile services that the users were accustomed to had an impact on how the prototype was used in everyday life. Context-awareness is often useful when there is a large amount of material that needs to be selected according to a certain criteria. This was the case in the theatre festival evaluation. However, the users were very reluctant to connect their existing material to contexts. One of the reasons was that they had few existing services they needed to use with a mobile device and linking them to a work or hobby or other context felt contrived. Why filter anything out if you have three services and two notes in your folder? If there were a lot of services available to the users, it would make more sense to use contexts in arranging the material.

8.1 Categories of context-aware services

We found the acceptance of context-awareness to be very sensitive to the overall concept of the service. The usefulness of a context-aware service appears to be sensitive to *how personal* the content is to the user and *how much effort is needed* to exploit the context-aware features. The themes of the trials were

chosen to present the variation in these variables. The structure is based on three categories:

1) **Everyday routines.** Everyday use is characterised by the fact that services fit with the user's daily routines. Matching the daily routine means automatically that the user needs to personalise and adjust the service, thus increasing the effort needed from the user.

2) **Service packages** do not require the user to make his or her own connections between the context and the content, they are inherent in the service. Within set limits, the context can be identified automatically and the user's needs and wishes are more easily predicted from the context. The service may be an event schedule or a thematic route, for example.

3) **Spontaneous services** are characterised by minimal personalisation. The context is identified as accurately as possible, taking into account time, location and other variables. The user only needs to view what's available, not subscribe or personalise.

The results of context-awareness vary according to which of these categories is considered.

Everyday routines. The use of context-awareness in everyday life is challenging for the design of the service. The relevant contexts of each user are known solely by the user. This observation has two consequences. First, the user has to personalise the service herself. A fit-for-all service cannot anticipate the needs of every user. The second consequence is that the service has to be flexible enough to make the personalisation possible.

The trials revealed that, in fact, users were willing to create zones (Figure 45). They found the user interface and the creation easy enough. The most difficult stumbling block was the maintenance of zones from day to day. The manual activation has to be integrated with the device profiles to be as effortless as possible. However, an automatic recognition of zones is needed in addition to manual activation.

Figure 45 . Users created zones to inform others of what they were up to.

Service packages were focused on in two field evaluations, the historical route and the festival guide. One of the benefits of a service package is that it can be a very complex entity, filled with context chains that include time, place, mood, sensor readings or other variables. The user does not need to see any of the complexity, only the topical information that the service displays. Within the limits of a service package, it is also easier to predict the relevant contexts and the information needs within them.

The service package can provide a context for communicating with other users, who would otherwise be out of reach. The usefulness of context-aware messages is greatly increased when the recipients are not part of your everyday contacts.

The concept of **spontaneous services** approaches ubiquitous computing. The information is available to the user, with little need for tailoring or pre-subscription of service packages. For example, the user can receive information by pointing at a desired object or to a certain direction. Users found this scenario very appealing.

Some of the categories above were also touched by Barkhuus and Dey [BAR]. The authors divide context-awareness according to the level of interaction or passivity required from the user. The first level of interaction is "personalisation", which requires manual settings, but where the users can exert greater control over the operation of the personalised feature. On the next level there is "passive context-awareness" and "active context-awareness", where the user has less control over the provided content. In passive context-awareness the

system alerts or prompts for user action based on the automatically identified context. In active context-awareness the system changes the settings automatically as well. In the accompanying study it was found that users preferred active context-awareness, even though it meant giving up some of their control over to the system.

One of the important aspects in both our studies and the study discussed above, is that the field of context-awareness and the concepts that are dealt with are taking shape. As more and automatic sensing will become available, the users' perception of control will be even more topical.

8.2 Messaging

We found context-based messages problematic. When introducing the concept, users found it intriguing. In the evaluations, however, they hardly ever used the feature. Some of the reluctance was based on the fact that it was slow to view and send messages through the mobile web. The lack of effective and accurate automatic recognition of context also hindered the implementation.

Based on the results from all trials, we now know that context-aware messages are helpful in some instances, but may seem contrived in others. The most promising cases for context-aware messaging are the following:

- **The need for a communication channel between recipients who can only be identified by the context itself.** When the users do not know who the recipient might be, but want to inform them of something, the proper recipient could be identified by choosing a proper context for the message, e.g. event, location (Figure 46). If the recipient is already known and, in a sense, the communication channel is open, users tend to choose immediate messages.

- **Messages which need to be targeted.** An instant message could be considered an intrusion. This may happen when there is a conflict between what is a convenient context for the sender of the message and a convenient context for the recipient. The most apparent example is the division between work and free time.

- **The communication needs to be filtered.** When there is a large number of messages or other data, it makes sense to target messages more carefully.

Figure 46. Public messages to anyone in the context showed promise in the field trials.

8.3 Presence availability

Making their presence available to others through the service was very popular among the users. A zone-based concept with a verbal description can offer 'fuzzy presence'. Unlike your location on a map, a verbal description gives you an unlimited degree of freedom to describe and control the information conveyed to others.

The importance of the viewpoint is obvious. This is not information that is extracted from you. Presence is information you communicate to others yourself. Users were at ease with the concept and felt they were in control over who saw which information.

One issue that was very difficult to predict was which peer group the user would find suitable for the presence feature. For some it was the family, for others, a circle of friends or a hobby group. The preferences were very individual. At the parliament, the assistant may not personally need to know where the MP is, but may need to respond to enquiries about it.

In some cases, the zones the users created became a statement, an expression of personality. The presence information can convey the mood or the 'slogan of the week' to others. Some users felt they would like to add a photo or media clip to their presence information. This way, presence information would become a more creative playground for those who are willing to express their personality through the feature.

Future visions were discussed at length with the high school students. They were willing to go quite far with what kind of information could be made available to others. RFID tags and pointing could be used, not just to gain information about objects, but about people as well.

8.4 Guidelines

The evaluation process of the Kontti service yielded results that can be used as general guidelines for the development of context-aware services. The guidelines emphasise the need to see context-awareness as several different ways of augmenting a service. The context of use needs to be looked at from the user's point of view and not the available technology. The service concept will define whether a web-based service or an application-based service is required. Active information push according to context requires a separate application.

1. **Make an effort to recognise the whole context.** When studying context-aware applications, it may be tempting to see the user's context only as the variables that can be automatically recognised. Location, for instance, is not the complete context, perhaps not even the most important variable that makes the context.

2. **Identify the context-aware characteristics of your service.** Highly active context-awareness requires a separate application to achieve an experience

of information push. On the other hand, more leisurely browsing of contextual information can be achieved with a mobile web-based service. The procedure for connecting with a browser can be slow for more frequent routines.

3. **Let users label the contexts that are relevant to them.** If the service is about the user's daily lives, then the users should not be restricted only to ready-made categories. The results of the user studies indicated that users were quite willing to create also their personal contexts and even had fun in making them. The automatic day-to-day recognition of contexts, on the other hand, is laborious and the technology should provide solutions to make it happen.

4. **Be prepared to modify existing service to avoid generic content.** Contextual information works best if it is highly topical. If there is a cinema nearby, it is all well and good to give people around the location access to its movie information. It is even better to run context-awareness through the whole service concept and present the upcoming movie, ticket price and available seats. The service will be sharper and more targeted.

5. **Study competing sources of information.** For example, paper event programmes are easy to view and lend themselves to quick browsing and planning. They are also static. The dynamic nature of mobile service should be used to your advantage. It may be difficult to plan days ahead on a small screen, but pushing current information to the user is something static leaflets cannot achieve. The transfer of existing sources of information to mobile devices should not be simple copying. It should be done in a way that exploits the benefits of the mobile medium.

6. **Consider both manual activation and automatic features.** All contexts cannot be recognised automatically, nor should they be. The manual activation should be based on actions the user already takes: switching profiles, adding calendar notes. A lot of information is already available, it just needs to be redirected to the context-aware system for re-use. Time-based zones are useful when there is a regular event. Living patterns tend to be irregular and time-based zones can be too inflexible to accommodate

spontaneous changes. Active context-awareness means that the service should constantly update itself without requiring effort from the user.

7. **Do not insist upon context-awareness that does not add to the service.** Sometimes context-awareness is not needed. At an event, for instance, time-based contexts and direct messages between the visitors can provide a highly useful mobile service. If the intent of the messages is to reach a maximum number of visitors, the messages do not need to be restricted to a particular location.

8. **Use context as content.** Once the context of the user is known and labelled, it can become valuable content for those close to the user. In everyday use, it should be possible to convey your context information to specified other users. Social context and presence can be communicated in this manner within a community. The user, however, has to have complete control over what information is shown and who has access to it.

9. **When appropriate, integrate context-awareness with existing applications.** Users are often accustomed to using a certain communication system in their mobile device: e-mail, SMS or MMS. To add a separate messaging application may involve extra effort from the user. As a trial demonstration, a separate messaging system does work, but for actual use there has to be integration with existing messaging applications.

10. **Consider context also as a communication channel between users who do not know each other.** When the recipient is not known in a way that allows the user to send a message, the context can act as an intermediary. The message will be picked up by users for whom the context (e.g. restaurant, event, work process) is active.

The main conclusion in the guidelines is to think of context in broad terms, underlining the context as experienced by the user. All contexts can never be recognised by technology, the user should be able to activate contexts manually.

Automatic information push requires a separate application instead of a web browser. One should also take into account other existing information sources,

e.g. a calendar or a system that learns from the user's behaviour, which can be used to identify the context.

8.5 Business field

The results of the service providers' interviews were integrated into a proposal of the business field for context-aware services. The proposal is depicted in Figure 47.

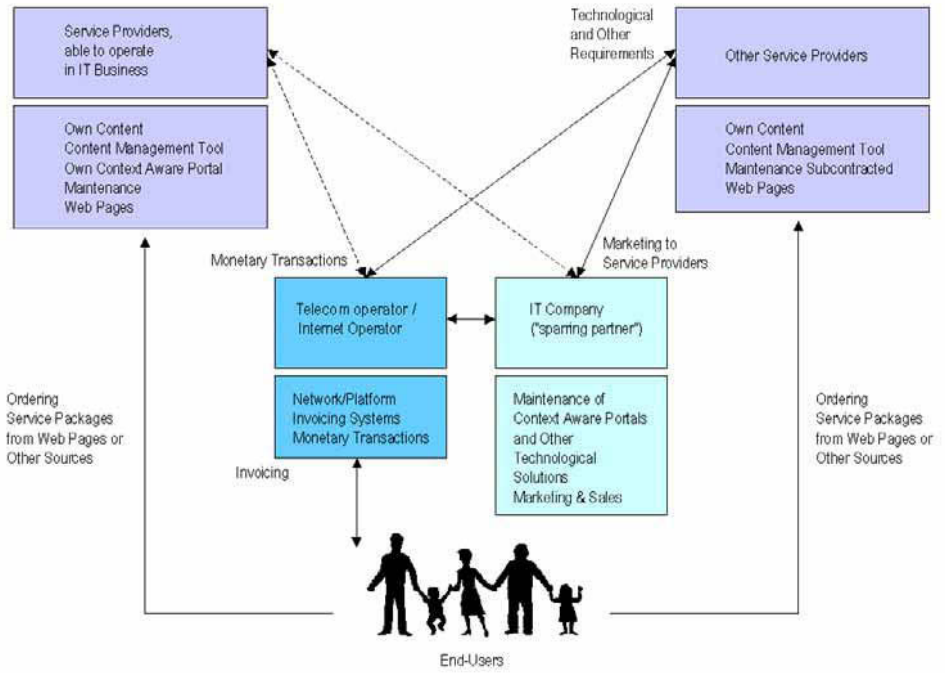

Figure 47. The proposed business field for mobile context-aware services.

Since event-related use cases offer quite alluring business possibilities for some companies, it is essential to clarify the area of context-aware services from the commercial point of view. Basically, the business field describes the co-operation between the partners that are designing and implementing subscribed or ready-made services, e.g. service packages. However, it is possible to exploit the model with other kinds of services as well.

There are two kinds of service providers: first, service providers who are able to implement and maintain their own systems and second, service providers who need help of some partner or partners with service design and implementation, since IT business is not their core business. The most interesting business potential, from the point of view of Kontti project partners, can be seen with the latter group of service providers. However, making business a group demands very deep knowledge and thorough analysis of existing service processes within the group of organisations. The first service provider group is probably capable of designing and implementing their own context-aware services by themselves. Therefore, the group do not offer highly successful business scenarios for potential partners, e.g. telecom operators and/or IT companies. However, it is possible that the first group of service providers will need the network or platform from an operator.

Consequently, we should concentrate the business field analysis on service providers who need partners in order to produce context-aware services. In this context, we can describe the telecom or Internet operators and IT companies as business partners who should work in close co-operation with each other. Although their business interests are probably quite different, they both might need each other's know-how and services in this area (see arrows between the partners). Since many service providers pointed out that they would like to co-operate with large and reliable companies – preferably with the telecom operator – it is worth noticing that the IT partner could be an affiliated company of the telecom operator as well. In addition, telecom operators already have efficient invoicing systems that could be exploited in producing new services for the end-users.

However, there are some problems related to the option in which the telecom operator is operating alone in this business field. Presumably, the telecom operator is not ready to maintain context-aware portals of service providers, who are not operating in the IT business. In addition, marketing efforts to service providers, concerning possibilities of context-aware services, are probably not a core business of the telecom operator either. However, it is evident that some quarter should spread the word about the possibilities of new services and technologies. The IT company could operate in this role and, of course, sell software products related to these new services. Furthermore, the telecom or Internet operator could offer the network or platform and invoicing system,

while the IT company could communicate with service providers by offering technological solutions to their service-related needs.

In order to clarify the arrows in Figure 47, it should be mentioned that arrows between the partners (the IT company and the telecom operator) and the other service providers are the most significant. As mentioned earlier, the co-operation and business between these companies might be profitable. The arrow between the IT company and other service providers represents marketing efforts about technological possibilities, business potential, knowledge of analysing service processes in general (consulting), and selling software products. The arrow from other service providers back to the IT company represents technological and other requirements, e.g. organisational requirements, that a service provider will have regarding the new context-aware service under construction.

Furthermore, the arrow between the telecom operator and other service providers represents the need for monetary transactions concerning the usage of the new service. The telecom operator might already have a suitable invoicing system for service providers. There is no reason why it should not be exploited in this context as service providers need stability and longevity in invoicing the end-users. However, income and monetary transactions between partners are quite troublesome issues and should be contracted with the two partners and the service provider in question.

Finally, the end-users could order service packages, e.g. Tampere Theatre Festival Package from the web pages of a service provider; the same way ring tones and logos are ordered at present. It might also be useful to consider some easier and alternative ways to order a service package. Naturally, in the business use case ordering services is not necessary since the service providers are directly co-operating with the IT company and the end-users are employees of the service providers. In addition, the end-user needs for context-aware services in everyday life demand more effort from device manufacturers. Considering the subscribed and ready-made services, an end-user could pay for the use of a new context-aware service package straight to the telecom operator since it is a familiar way of invoicing the end-user.

9. Conclusions

As a result of the two-year project we have a technical platform for testing and designing context-aware services. The developed platform was evaluated in field trials with prototypes of context-aware applications. In addition, we got a lot of feedback from different user groups and views from service providers on the business aspects of context-aware services. The results can be exploited and applied directly into new implementations and application scenarios.

9.1 Technical results

Context-aware service platform. The developed service platform demonstrates personal management and sharing of contexts, adaptation, context-aware messaging, and management of contextual content. Some groundwork of the context manager application included the development of adaptation facilities together with media bank and link editor applications.

Adaptation. The developed adaptation proxy performs content and terminal adaptation and media conversions. During the project the adaptation proxy module was integrated and evaluated with the developed context-aware service platform. The adaptation can be controlled and tuned by several parameters (conversion options). The parameters include properties of the requesting user agent, system default options, user preferences, and device class-specific parameters. The parameters can be altered to configure the system operation and to provide context-awareness.

The evaluation of the adaptation features during the project showed that most Web pages would convert. The availability of information that can be accessed through the Internet make mobile services both more familiar and more personal. Users can access the news sources and personal sites they are accustomed to.

Representation of context. The technical presentation of context took form as the specification of frame-based context ontologies. The context manager application implemented a class hierarchy of generic level contexts. The context objects handled in the user interface were of the following basic types (could be

automatically or manually activated): time, weekly, location and user-defined. In addition, there are system internal context types such as logical operations for contexts, which can be used for context hierarchies of any level. The state of the location-based contexts was determined by related positioning methods: both cellular network-based methods via LIF and WLAN-based methods were applied.

Contextual content. The developed system is able to handle several kinds of content objects (links, notes, files, directories, friends and groups, messages) which can be associated with contexts. The developed representation is flexible enough to allow the introduction of new kinds of content objects to the system. In particular, contextual content provides the means of context-aware views (in the user interface) to object repositories and messages.

Personal management and sharing of contexts. The developed system also enables the user to create and edit contexts, monitor the state of contexts, and publish contexts to be visible to other users and groups. The system included a facility to view the active contexts of friends and groups. The friend and group objects ware also used to specify targets to context-aware messages. The implemented friends and groups facility obtained positive feedback in the user evaluations.

Context-aware messaging. The system enables a user to send messages to specified target contexts of recipients. Further, it is possible to attach into a message any kinds of objects (contexts, content objects) handled by the context manager application. This forms a base to the implemented content sharing, which is one of the novel aspects of the developed system.

9.2 Overall evaluation results

The technology was evaluated in four different use cases: everyday contexts, tourist guide, event guide and professional use. In each of the evaluations we shifted the focus from personalised use to context-aware service packages, from messages to social surroundings and on to future visions. In the end, the evaluations resulted in a picture of how different aspects of context-awareness work with varied concepts.

Both the historical route and the festival guide provided a glimpse of how a vast amount of data can be displayed in a context-aware manner. The trials demonstrated how complex connections with contexts could be hidden in context-aware service packages. The appropriate data is pushed for the user to see when it is topical. As the festival visitors remarked, topicality should not mean inflexibility. New technology should be made to do what the paper cannot do, using dynamic updates and topical information. More technology-oriented users were willing to accept more untraditional features, such as location-based messages and the sharing of images.

For many users, context-awareness was worthwhile just to convey the presence information to friends. From the user requirement studies on, the awareness of social surroundings through presence information remained one of the most multifaceted and promising issues. It can describe an activity or location just well as a frame of mind. This is often what the users did: they combined physical locations with mood-based descriptions to convey a fuller picture of their present situation. Although the exact nature of presence information can be difficult to explain without references to location, one must realise that location is not the key issue. The location is not the actual user context, it is a *means to identify* the context.

In addition, the use of presence information does not mean snooping on your friends. The active party is the person who puts out the information for a certain group to see. A verbal description allows a fuzzy presence with any degree of accuracy or factual content the user desires. You may convey some aspects of your contexts even to people you might not otherwise be in contact with, as our high school users did. The technology provides the settings, the social conventions develop between the users. Adding suitable media clips to your presence information would allow even wilder creativity.

In messaging, the role of context is to open new communication channels. The need for communication among a certain group of users can exist momentarily, only to be washed away when the context itself dissolves. When the recipient is not known, the context can be used to target the message. The people sharing the context will pick it up from there and perhaps resume with one-to-one communication. The results indicated that between people who know each other, the preference is on immediate messaging without the delay caused by context-

awareness. On the other hand, the filtering of excess communication may be used in work-related contexts.

On the basis of the service providers' interviews, a proposal for the business field was presented. The proposal can be used to clarify the area of context-aware services, which can still be considered quite fragmented. The most interesting business potential seems to be with the service providers who are not operating in the IT business and who need partners' help in order to construct new services. From the technological perspective, a tool for managing the content of the context-aware portal would be essential for all service providers. It would also be beneficial to integrate the present systems of the service providers with the context-aware portal. The interviewees also stressed the importance of usability and the adoption phase of a new service.

9.3 Future visions

Considering the range of topics that context-awareness encompasses, it is clear that a lot of technological development will go into the creation of all these concepts.

Applications. New and forthcoming mobile devices have increasing amounts of memory and processing capability, which enables stand-alone applications to be downloaded and executed in the terminal. In addition to browser-type, terminal-based applications are also becoming better supported by the mobile operating systems (such as Symbian) and software platforms (such as Java MIDP). In typical cases, terminal-based applications (i.e., Symbian C++ or Java MIDP) are required to communicate with external servers and data sources. There will also be mobile servers.

Representation of context, accurate positioning. One research topic includes the representation of a context ontology that is suitable for the requirements set by context-aware services. A related topic is to upgrade the current context ontology into a more expressive language such as OWL (Web Ontology Language). The state of some contexts can be automatically determined and some others not.

The location-based contexts can be related to different positioning methods. The Kontti project demonstrated the use of cell-based and WLAN-based positioning. Separate context types were defined for both cases. In addition, device-centric technologies such as GPS to obtain the location information are becoming more commonly use as GPS-capable devices become available. However, the different positioning technologies are complementary. The accuracy of obtained location information is very relevant. This poses challenges on how to represent and easily define in the user interface the related context class. Both standard and developing interfaces and protocols are available for accessing location information. Examples of such protocols and interfaces include the OMA LIF and Java MIDP Location API.

In the near future, mobile devices will support the recognition of RFID tags, which will provide a new method for the identification of context. User-initiated positioning means that the user may set his or her mobile device onto a tag to activate or deactivate certain features, make a selection or to identify a presence in a certain space. Tags can also be used to sense the environment. This means that more and more environmental factors can be recognised: lightness, humidity, temperature.

Presence information. The presence concept in the mobile domain has a relatively wide scope (OMA/Wireless Village) and provides several new application possibilities such as instant messaging. It encompasses information such as mobile device availability, user status, location, client device capabilities and searchable personal status (mood, hobbies etc).

The sharing of the user's contextual information requires access to the device itself. The profile settings of the phone can be used more globally to recognise the user's context, or the context can be recognised to change the profile settings.

Adaptation of content to the user's terminal, taking account the different kinds of user preferences, device profile, context of use, network and other properties, remains one major research issue of mobile world. For example, in the Semantic Web one key challenge is the adaptation of web content according to diverse parameters. There are requirements to configure the adaptation easily and in a

flexible way. Also, application personalization issues are closely related to adaptation. XHTML MP is based on the modularization of XHTML and is to be supported by most browsers.

The presentation of multimedia content such as images, animation, audio and video in a mobile device is very challenging. In addition to the properties of the client device and browser, the used transmission path has a significant effect on the form in which the content can be presented in the device. For instance, SMIL (Synchronized Multimedia Integration Language) is an XML-based language that offers a solution for presenting multimedia components in browser environments, and it also fits well to the modularization scope of XHTML.

Integrated messaging. The current mobile devices include solutions for sending and receiving different kinds of messages such as MMS, e-mail, SMS and WAP Push. Also, instant messaging type of services will emerge. One of the key issues is how to handle different types of messages in a common and more integrated way within an application. The Kontti project already partially demonstrates this. However, research issues include the representation of target contexts and other additional information within standard message types. A terminal application can be used to send messages. A server-side application manages incoming messages and transforms them into a suitable format. The sharing of content between users and groups of the system may be implemented via messaging facilities.

Content management and seamless storage. The Kontti project provides a solution for an external repository of the user's context-aware data. However, the memory capacity of mobile devices increases very fast and in the future more and more data can be stored locally. More and more devices will be able to collect media such as images and video clips. Much of the material needs to be stored away if the device memory becomes full or if there is a need to share it. The seamless transition between storage points is critical for an improved user experience. The data synchronisation between the local and external repositories or databases becomes an issue.

The challenge for interface design is to integrate these technologies in a manner that is automatic and transparent for the user. Tools have to be designed for the

content provider to combine the contexts and the content into simple-to-use packages. As a result, mobile content will no longer be detached from its surroundings. The mobile Internet, the device and context will become intertwined for the benefit of the mobile user.

References

ABO97 Abowd, G.D., Atkeson, C.G., Hong, J., Long, S., Kooper, R. and Pinkerton, M. Cyberguide: A mobile context-aware tour guide. *Wireless Network 3 (1997)* 421–433.

ABO00 Abowd, G.D., Mynatt, E.D. Charting Past, Present, and Future Research in Ubiquitous Computing. ACM Transactions on Computer-Human Interaction, Vol. 7, No. 1, March 2000, 29–58.

AIMS Toivonen, S., Kolari, J. and Laakko T. Facilitating Mobile Users with Contextualized Content. *Artificial Intelligence in Mobile Systems 2003* (AIMS 2003), October 2003.

BAR Barkhuus, L. and Dey, A. Is Context-Aware Computing Taking Control Away from the User? Three Levels of Interactivity Examined. Proc UbiComp 2003, 150–156, Springer.

BUR Burrell J. and Gay G.K. E-graffiti: evaluating a real-world use of context-aware system. Interacting with Computers 14 (2002), pp. 301–312.

COL Colbert, M. A Diary Study of Rendezvousing: Implications for Position-Aware Computing and Communications for the General Public. *Proc. International ACM SIGGROUP Conference on Supporting Group Work* - Volume 2001.

CHE00 Cheverst, K., Davies, N., Mitchell, K., Friday, A. and Efstratiou, C. Developing a context-aware electronic tourist guide: some issues and experiences. *Proc. CHI'00*, pages 17–24, 2000.

CHE01 Cheverst, K.; Davies, N.; Mittchell, K.; Efstratiou, C. (2001). Using Context as a Crystal Ball: Rewards and Pitfalls. In Personal and Ubiquitous Computing Vol. 5, Issue 1.

CHE02 Cheverst, K., Mitchell, K. and Davies, N. The Role of Adaptive Hypermedia in a Context-aware Tourist Guide. *Communications of the ACM*, May 2002/Vol. 45 No. 5, pp. 47–51.

DEY Dey, Ak (2001) Understanding and using context. Personal

and Ubiquotous Computing 5: 20–24.

ESP Espinoza, F., Persson, P., Sandin, A., Nyström, H., Cacciatore. E. & Bylund, M. (2001) GeoNotes: Social and Navigational Aspects of Location-Based Information Systems, in Abowd, Brumitt & Shafer (eds.) Ubicomp 2001: Ubiquitous Computing, International Conference Atlanta, Georgia, September 30 - October 2, Berlin: Springer, pp. 2–17.

FRE Fredman, M. et. Al (2003) VTT Raportti – Wireless Workshop 2. Internal project report in KÄYKSE project.

FIT Fithian, R., Iachello, G., Moghazy, J., Pousman, Z. and Stasko, J. The Design and Evaluation of a Mobile Location-Aware Handheld Event Planner. *Proc. Mobile HCI 2003*, LNCS 2795, pp. 400–404, 2003.

GRO Gross, T.; Koch, T. (2001) : Ubiquitous Computing: New Challenges for the Design of User Interfaces of Mobile Devices in Applied informatics / Hamza, M.H.. URL http://www.fit.fraunhofer.de/publications/2004931764.pdf (Accessed 13.11.2001).

HTML HTML 4.01 Specification. W3C Recommendation 24 December 1999. http://www.w3.org/TR/html4/

ISO ISO 13407 (1999) Human-Centred Design Processes for Interactive Systems. International Standard. The International Organization for Standardization.

JSP1.1 JavaServer Pages Specification. Version 1.1. http://java.sun.com/products/jsp/

KAA02 Kaasinen, E. (Ed.) (2002) Products and Services for Personal Navigation – Usability Design. Part II, Related research. http://www.vtt.fi/virtual/navi/cd/ken_d3_ii_22.pdf

KAA03 Kaasinen, E. (2003) User needs for location-aware mobile services. *Personal and Ubiquitous Computing 7/1, 2003*, pp. 70–79.

KOL Kolari, J., Laakko, T., Kaasinen, E., Aaltonen, M., Hiltunen, T., Kasesniemi, E-L., Kulju, M., Suihkonen, R. (2002) Net in

Pocket? Personal mobile access to web services. VTT Publications 464.

NAK — Nakanishi, Y., Kumazawa, S., Tsuji, T. and Hakozaki, K. ICAMS2: Developing a Mobile Communication Tool Using Location Information and Schedule Information with J2ME. In *Proceedings of Mobile HCI 2003*, LNCS 2795, pp. 400–404, 2003.

NOR — Norros, L., Kaasinen, E., Plomp, J., Rämä, P. Human-Technology Interaction Research and Design, VTT Roadmap. VTT Research Notes 2220. Espoo 2003.

OMA-IMPS — http://www.openmobilealliance.org/wirelessvillage/

OMA-LIF — http://www.openmobilealliance.org/lif/

OMA-PUSH — WAP Push Architectural Overview. Version 03-July-2001. Available at http://www.openmobilealliance.org/

OMA-SI — Wireless Application Protocol. Service Indication. Version 31-July-2001. Available at http://www.openmobilealliance.org/

RFC2068 — Fielding, R., et al., Hypertext Transfer Protocol - HTTP/1.1. January 1997. ftp://ftp.isi.edu/in-notes/rfc2068.txt

ROD — Rodden, T., Chervest, K., Davies, N. (1998) Exploiting Context in HCI Design for Mobile Systems. First Workshop on Human Computer Interaction for Mobile Devices. GIST Technical Report G98-1.

ROW — Rowling, J.K. (2000) Harry Potter and the Goblet of Fire. Bloomsbury Publishing Plc.

SAL — Salber, D., Dey, K.D., Abowd, G.D. The Context Toolkit: Aiding the Development of Context-Enabled Applications. In Proc. ACM Conference on Human Factors in Computing Systems (CHI'99, Pittsburgh, PA, May), ACM Press, New York, NY, 434–441.

SCH — Schmidt, A., Beigl, M., Gellersen, H. W. (1998) There is more to context than location. In Proc. of the Intl. Workshop on Interactive Applications of Mobile Computing (IMC98),

Rostock, Germany, November 1998.

SERVLET2.2 Java Servlet API v. 2.2 Specification. http://java.sun.com/products/servlet/index.html

TAM Tamminen, S., Oulasvirta, A., Toiskallio, K., & Kankainen, A. (2003). Understanding mobile contexts. Proceedings of Mobile HCI 2003, Udine, Italy, 18–35.

TTF Tampere Theatre Festival (2003) http://www.tampere.fi/festival/theatre/ 26.8.2003

UAPROF WAG UAProf. Wireless Application Group. User Agent Profile Specification. 20-October-2001. Available at http://www.openmobilealliance.org/

UED Ueda, H., Tsukamoto, M., Nishio, S. (2000) W-MAIL: An Electronic Mail System for Wearable Computing Environments. Proc. 6th Annual International Conference on Mobile Computing and Networking. (MOBICOM)

VAL Välkkynen, P., Korhonen, I., Plomp, J., Tuomisto, T., Cluitmans L., Ailisto, H. & Seppä, H.: A user interaction paradigm for physical browsing and near-object control based on tags. Mobile HCI 2003, Udine, Italy. Proc Physical Interaction Workshop on Real World User Interfaces. Pp. 31–34.

W3C Web Content Accessibility Guidelines 1.0. W3C Recommendation 5-May-1999. http://www.w3.org/TR/WCAG10/

WML Wireless Application Protocol. Wireless Markup Language Specification, Version 1.3, 19-February-2000. Available at http://www.openmobilealliance.org/

WTAI WAP Wireless Telephony Application Interface. Version 08-Sep-2001. Available at http://www.openmobilealliance.org/

XHTML XHTML™ 1.0: The Extensible HyperText Markup Language. A Reformulation of HTML 4 in XML 1.0. W3C Recommendation 26 January 2000 http://www.w3.org/TR/2000/REC-xhtml1-20000126

XHTMLB XHTML™ Basic.W3C Recommendation December 2000. http://www.w3.org/TR/xhtml-basic/

XHTMLM Modularization of XHTML™. W3C Recommendation 10 April 2001. [online, cited 27 November 2001] http://www.w3.org/TR/xhtml-modularization/

XHTMLMP XHTML Mobile Profile. Version 29-October-2001. http://www.openmobilealliance.org/

Appendix A: Pilot trial users

Gender		
	n	%
Male	7	54 %
Female	6	46 %
All	13	100 %

Age				
Years	Male	Female	n	%
14–19	2	3	5	38,5 %
20–34	3	2	5	38,5 %
35–59	2	1	3	23 %
All	7	6	13	100 %

WAP experience		
	n	%
Very experienced	0	0 %
Experienced	0	0 %
Somewhat experienced	1	8 %
Somewhat inexperienced	0	0 %
Inexperienced	1	8 %
Very inexperienced	11	84 %
All	13	100 %

Mobile experience		
	n	%
Very versatile	1	8 %
Versatile	1	8 %
Somewhat versatile	6	46 %
Somewhat limited	4	31 %
Limited	1	8 %
Very limited	0	0 %
All	13	~100%

Computer experience		
	n	%
Very versatile	0	0 %
Versatile	0	0 %
Somewhat versatile	3	23 %
Somewhat limited	6	46 %
Limited	4	31 %
Very limited	0	0 %
All	13	100 %

WWW experience		
	n	%
Very versatile	1	8 %
Versatile	2	15 %
Somewhat versatile	4	31 %
Somewhat limited	5	38 %
Limited	1	8 %
Very limited	0	0 %
All	13	100 %

Computer use hours / week/ free time		
	n	%
> 20	0	0 %
10–20	0	0 %
7–10	1	8 %
4–7	3	23 %
1–4	6	46 %
0–1	3	23 %
All	13	100 %

Computer use hours / week/ work or studies		
	n	%
> 20	1	8 %
10–20	1	8 %
7–10	2	15 %
4–7	2	15 %
1–4	5	38 %
0–1	2	15 %
All	13	~100%

www use hours / week/ free time		
	n	%
> 20	0	0 %
10–20	0	0 %
7–10	1	8 %
4–7	3	23 %
1–4	6	46 %
0–1	3	23 %
All	13	100 %

www use hours / week/ work or studies		
	n	%
> 20	0	0 %
10–20	0	0 %
7–10	1	8 %
4–7	1	8 %
1–4	10	77 %
0–1	1	8 %
All	13	~100%

Appendix B: Festival Guide Users

Gender		
	n	%
Male	5	42 %
Female	7	58 %
All	12	100 %

Age				
Years	Male	Female	n	%
18–24	0	6	6	50 %
25–30	5	1	6	50 %
All	5	7	12	100 %

WAP experience		
	n	%
Very experienced	0	0 %
Experienced	1	10 %
Somewhat experienced	1	10 %
Somewhat inexperienced	0	0 %
Inexperienced	0	0 %
Very inexperienced	8	80 %
All	10	100 %

Mobile experience		
	n	%
Very versatile	0	0 %
Versatile	3	30 %
Somewhat versatile	2	20 %
Somewhat limited	3	30 %
Limited	2	20 %
Very limited	0	0 %
All	10	100 %

Computer experience		
	n	%
Very versatile	0	0 %
Versatile	3	30 %
Somewhat versatile	1	10 %
Somewhat limited	2	20 %
Limited	2	20 %
Very limited	2	20 %
All	10	100 %

WWW experience		
	n	%
Very versatile	2	20 %
Versatile	1	10 %
Somewhat versatile	2	20 %
Somewhat limited	3	30 %
Limited	1	10 %
Very limited	1	10 %
All	10	100 %

Computer use hours / week/ free time		
	n	%
> 20	1	10 %
10–20	1	10 %
7–10	1	10 %
4–7	1	10 %
1–4	1	10 %
0 – 1	5	50 %
All	10	100 %

Computer use hours / week/ work or studies		
	n	%
> 20	2	20 %
10–20	4	40 %
7–10	1	10 %
4–7	0	0 %
1–4	1	10 %
0–1	2	20 %
All	10	100%

www use hours / week/ free time		
	n	%
> 20	1	10 %
10–20	0	0 %
7–10	2	20 %
4–7	1	10 %
1–4	0	0 %
0–1	6	60 %
All	10	100 %

www use hours / week/ work or studies		
	n	%
> 20	2	20 %
10–20	2	20 %
7–10	0	0 %
4–7	2	20 %
1–4	1	10 %
0–1	3	30 %
All	10	100%

PDA experience	n	%
Has not used:	7	70 %
Has used:	3	30 %
All	10	100 %

Appendix C: High School Trial Users

Gender	n	%
Male	8	57 %
Female	6	43 %
All	14	100 %

Age				
Years	Male	Female	n	%
17–18	7	6	13	93 %
57	1	0	1	7 %
All	8	6	14	100 %

WAP experience	n	%
Very experienced	0	0 %
Experienced	1	7 %
Somewhat experienced	0	0 %
Somewhat inexperienced	1	7 %
Inexperienced	3	22 %
Very inexperienced	9	64 %
All	14	100 %

Mobile experience	n	%
Very versatile	0	0 %
Versatile	1	7 %
Somewhat versatile	5	35,5 %
Somewhat limited	5	35,5 %
Limited	3	22 %
Very limited	0	0 %
All	14	100 %

Computer experience	n	%
Very versatile	0	0 %
Versatile	1	7 %
Somewhat versatile	5	36 %
Somewhat limited	6	43 %
Limited	2	14 %
Very limited	0	0 %
All	14	100 %

WWW experience	n	%
Very versatile	1	7 %
Versatile	4	29 %
Somewhat versatile	5	36 %
Somewhat limited	2	14 %
Limited	2	14 %
Very limited	0	0 %
All	14	100 %

Computer use hours / week/ free time	n	%
> 20	1	7 %
10–20	3	22 %
7–10	1	7 %
4–7	2	14 %
1–4	7	50 %
0–1	0	0 %
All	14	100 %

Computer use hours / week/ work or studies	n	%
> 20	0	0 %
10–20	0	0 %
7–10	1	7 %
4–7	1	7 %
1–4	7	50 %
0–1	5	36 %
All	14	100 %

www use hours / week/ free time	n	%
> 20	0	0 %
10–20	2	14 %
7–10	1	7 %
4–7	2	14 %
1–4	7	50 %
0–1	2	14 %
All	14	~100 %

www use hours / week/ work or studies	n	%
> 20	0	0 %
10–20	0	0 %
7–10	0	0 %
4–7	2	14 %
1–4	5	36 %
0–1	7	50 %
All	14	100 %

PDA experience	n	%
Has not used:	10	71 %
Has used:	4	29 %
All	14	100 %

Published by

Series title, number and report code of publication

VTT Publications 539
VTT–PUBS–539

Author(s)
Kolari, Juha, Laakko, Timo, Hiltunen, Tapio, Ikonen, Veikko, Kulju, Minna, Suihkonen, Raisa, Toivonen, Santtu & Virtanen, Tytti

Title

Context-Aware Services for Mobile Users
Technology and User Experiences

Abstract

Mobile services and applications are used in varying contexts and surroundings. When the services are made context-aware, they can offer contextually relevant information to the user. This facilitates the finding of data and creates new purposes of use.

The Kontti (Context-aware services for mobile users) project (January 2002 – December 2003) designed and implemented a context-aware service platform and services. The platform enables management and sharing of contexts, presence information and contextual content, and it provides context adaptation and context-aware messaging. Also, personalisation and context tools were implemented.

A human-centred design approach was adopted throughout the project: the acceptance of users and service providers guided the design process from the very beginning. The developed applications were evaluated in field trials. The results provided outlines for meeting the usability challenges in context-aware services and for adapting content from one context of use to another.

The results of the Kontti project indicate that the most promising applications for context-aware services are event guides and professional use. Also, conveying context information proved to be very interesting for the users. Further, contexts can be used for opening new communication channels for messaging. Context can be used as a mediator where any recipient can pick up a public message.

The commercial viability of the Kontti concept was also evaluated with a round of interviews with service providers.

Keywords
Context-awareness, mobile applications, mobile Internet, context adaptation, user evaluation, user-centred design, service providers

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ISBN			Project number
951–38–6396–4 (soft back ed.) 951–38–6397–2 (URL:http://www.vtt.fi/inf/pdf/)			T2SU00030
Date June 2004	Language English	Pages 167 p. + app. 3 p.	Price D
Name of project Kontti		Commissioned by National Technology Agency of Finland Tekes, Nokia, Radiolinja, Teamware	
Series title and ISSN VTT Publications 1235–0621 (soft back ed.) 1455–0849 (URL: http://www.vtt.fi/inf/pdf/)		Sold by VTT Information Service P.O.Box 2000, FIN–02044 VTT, Finland Phone internat. +358 9 456 4404 Fax +358 9 456 4374	

Mobile Internet services are used in varying contexts and surroundings. By identifying the user's context, the mobile service can anticipate the information that is needed. This facilitates the finding of relevant data and creates opportunities for new cultures of use. Mobile content becomes a part of our environment.

This publication presents the results of the development and evaluation of a context-aware service platform and applications. The software enables storing and sharing of contextual information and messages among users. During the two years of development, 98 interviewees took part in the user evaluations and the subsequent field trials. The service platform was evaluated with four kinds of applications: everyday contexts, tourist guide, event guide and professional use. As the result, promising concepts for context-aware services were identified. The results can be exploited and applied directly into new implementations.

Tätä julkaisua myy	Denna publikation säljs av	This publication is available from
VTT TIETOPALVELU PL 2000 02044 VTT Puh. (09) 456 4404 Faksi (09) 456 4374	VTT INFORMATIONSTJÄNST PB 2000 02044 VTT Tel. (09) 456 4404 Fax (09) 456 4374	VTT INFORMATION SERVICE P.O.Box 2000 FIN–02044 VTT, Finland Phone internat. +358 9 456 4404 Fax +358 9 456 4374

ISBN 951–38–6396–4 (soft back ed.)
ISSN 1235–0621 (soft back ed.)

ISBN 951–38–6397–2 (URL: http://www.vtt.fi/inf/pdf/)
ISSN 1455–0849 (URL: http://www.vtt.fi/inf/pdf/)