SmartRotuaari – Context-aware Mobile Multimedia Services

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Abstract

This paper presents the SmartRotuaari service system, which motivated by business and customer surveys provides a diverse set of consumer applications ranging from rapid and highly personalized mobile direct marketing to information, communication and payment services. We present results from the first field trial to show that SmartRotuaari provides a functional framework for large-scale field trials for the purpose of empirical evaluation of technology, new services, customer behavior and business models in real end user environment. Our work is based on a seamless cooperation between the various players in the R&D and business networks. To stimulate this cooperation we also extend our work to management research of value creating networks.

1 Introduction

Technological advances and improving financial viability of wireless broadband networks, middleware components and powerful versatile mobile devices are bringing a new dimension of mobile multimedia into the application domain. Whereas the conventional applications mostly assume stationary or fixed users, more and more emphasis is placed on mobility, the need for people to stay connected while moving around. One application domain, which is expected to greatly benefit from mobile multimedia, is mobile commerce or m-commerce for short.

In this paper we present the SmartRotuaari service system, which is operational at the city center of Oulu, the well-known "silicon valley" in Northern Finland (Rotuaari is the name of the walking area at downtown, hence the name of the service system). SmartRotuaari comprises of a wireless multiaccess network, a middleware for service provisioning, a web portal with content provider interface (CPI) and a collection of functional context-aware mobile multimedia services: service directory, map-based guidance, mobile ads, personal communication and presence, personalized news, mobile payment and Time Machine Oulu, a dynamic interactive 3D model of historical Oulu. The design of the business driven services is based on our own extensive survey of Oulu-based companies, while the design of the user driven services is motivated by existing surveys of location-based services.

The novel contribution of this work is a range of functional context-aware mobile multimedia services available in real end-user environment and their evaluation with a large number of test users. To our best knowledge we are unaware of another service environment, neither commercial nor academic, which would provide equally comprehensive set of consumer applications for businesses and mobile users. The most similar efforts include the eStreet project in Luleå, Sweden, and the Elisa mobilemall in Helsinki, Finland, which are briefly introduced below. For brevity we omit discussion on less similar installations, which for example provide location-based mobile multimedia information services, e.g. Lancaster GUIDE [8], Genoa Aquarium [1], and San Francisco Exploratorium [14].

Although not documented in the academic community, the eStreet project was one of the most successful pioneers of context-aware m-commerce services [12]. The eStreet project started off with simple SMS-based personalized direct marketing, which then evolved into more advanced services including cell id -based positioning, as well. The project had up to 2500 registered test users. One of the service providers in the project was the local McDonald's, which became the most successful store of the chain in Sweden, after 25% of the test users responded to their advertisement. The eStreet contributed to the foundation of a larger pilot framework known as Testplats Botnia [21].

The Elisa mobilemall located at the Arabia shopping center in Helsinki was introduced in September 2002 [11]. It includes WLAN coverage throughout the three-story shopping center, dynamic positioning of the user, map-based guidance to stores and products, a pool of PDA's test users are welcome to borrow and multimedia content provided in form of web pages.

This paper is organized as follows. Section 2 discusses the three-folded motivation of our work: SmartRotuaari service system, the evaluation of technology, consumer behaviour and services in large-scale field trials, and the underlying value creating R&D and business networks. Section 3 describes the SmartRotuaari service system in detail. Selected results from the first field trial are presented in Section 4. The early results of modelling the formation of the SmartRotuaari R&D network are discussed in Section 5. Section 6 concludes the paper.

2 Motivation

The inability of the mobile service providers to offer consumers sufficient added value has been among the main reasons for the slow adoption of mobile data services and m-commerce. To figure out what consumers really consider as added value with respect to mobile services is a challenging problem. As suggested by Woodruff [27], consumers' values are inherent and cannot be fully determined by the seller or producer. What is considered valuable also changes from one individual to another. This point is also stressed by Parasumaran [20], who states that values should be studied in different segments separately.

What adds to the difficulty of finding out what the really valuable mobile services and offerings are in different consumer groups is the fact that for the majority of consumers mobile Internet services are new and hence they do not really know their needs. As noted by Bagozzi and Dholakia [3], consumers' values are related to their goals, objectives and decision-making and thereby the evaluation of new services and offerings is difficult.

The theoretical base of the questionnaire used in the empirical study is in the two most widely applied theories which have been used to explain the adoption of ICT technologies, technology acceptance model (TAM) proposed by Davis [6] and the theory of planned behavior (TPB) by Ajzen [2]. Technology acceptance model predicts and explains the likelihood of technology use by stating that perceived usefulness and perceived ease of use are the primary determinants in technology acceptance behavior. It is a general level model which is capable of explaining user behavior across a broad range of end-user computing technologies and user populations. The key feature of TAM is to provide a basis for tracing the impact of external factors on internal beliefs, attitudes and intentions [7].

In the TPB, behavior is determined as a function of compatible intentions the perceived behavioral control. When studying consumer behavior with respect to new technologies such as mobile devices, the assumption that an individual is not in complete control over his/her behavior is very realistic, and therefore any possible effects of impaired control should be taken under study. In TPB the perceived behavioral control is expected to moderate the effect of intention on behavior. The intention is further determined by attitudes and subjective norms. Attitude toward a certain behavior is the degree to which performance of the behavior is positively or negatively valued, and it is determined by behavioral beliefs. Subjective norm is the perceived social pressure from e.g. friends or family members to engage or not to engage in a behavior.

We further make the use of the model of internet consumer satisfaction proposed by Matthew K. O. Lee in [24]. It provides an extensive framework for studying consumers' behavior in web environment. One of the main implications of Lee's model is that customer retention (which in the case under study could be interpreted as continuing usage of the mobile device) is determined by customer satisfaction. Customer satisfaction is in turn determined by logistic support, i.e. the manner in which the shipments of the purchased goods are handled, customer support, pricing of the goods, trust in the online vendor and different web shop related properties. These properties include different privacy and security related issues such as transaction safety, the quality of information, and the operational and navigational properties of the store such as speed of operation, system reliability and the ease of use. Although the model is developed primarily to explain consumer behavior in web environment, several features such as navigational properties, the relevance and the timeliness of the content and the offerings and trust in the service provider, can also be assumed as significant variables in explaining behavior in mobile environment.

SmartRotuaari is motivated by both the needs of companies (i.e. mobile service providers, technology providers, retailers etc) and consumers as end users of mobile services. The former have been identified via a tight collaboration with the local business actors at downtown Oulu. The motivation is straightforward: the companies have the most comprehensive knowledge about their business, in other words the "market pull". However, some of the companies, especially smaller retailers, are not necessarily aware of the possibilities offered by the new technology, in other words the fabled "technology push".

To strive for fruitful encounter of the above mentioned technology push and market pull, the project extends from technology research to management research. The interests of the business community are a vital issue in the commercial success of the innovative mobile services. To identify and satisfy these needs we work towards understanding and developing underlying value creating networks. By value creating networks we refer to both R&D networks that produce innovations and the business networks that commercialize the innovation, i.e. produce and market the innovation to end users (both consumers and other companies). In this scope we focus both on R&D activities in networks (e.g. [22]) and strategic business networks (e.g. [18]).

Our goal is three-fold: to model the dynamics of value creating networks (i.e. different stages of the process), to distinguish the

factors affecting the dynamics of value creating networks, and to model how the different factors influence the stages of the network development. The goal will be pursued via a qualitative, follow-up study, which will follow the developments of both the R&D network and the business network. Based on this real life data, the study combines theoretical knowledge into a description of the dynamics of value creating networks. Previous research has mostly concentrated in studying existing networks (see e.g. [9][16]) and thus this research fills the gap in studying networks longitudinally, producing real-time data.

The management research component has been initiated in form of a survey of business needs, joint workshops and one-to-one discussions. The survey was conducted at downtown Oulu in fall 2002. One of the objectives of the survey was to quantify the local firms' capabilities and skills in using computers, the Internet and the WWW. Further, we wanted to identify the tasks that the businesses found relevant in their daily customer service.

The questionnaire was sent to 209 companies in three business segments, namely retailers, restaurants and cafes, and other service providers. We received completed questionnaires from 57 companies resulting in a response rate of 27%. 80% of the firms were small ones, having a maximum of 15 employees. Additional statistics of the respondents: 80% uses computers daily, 75% have an Internet access, 65% uses Internet daily, 60% does not regard themselves as skilful computer users, 80% advertises their products or services, 80% of those who advertise use at least sometimes external help in implementing the advertising. From the survey, we can conclude that even though most of the respondents use computers daily, they do not regard themselves as computer wizards. This underlines the fact that any content provider tools offered to the businesses have to be as simple and easy to use as possible.

For the purpose of quantifying the end users' needs, SmartRotuaari and its services are exposed to test users in field trials. The SmartRotuaari service system provides a functional framework for large-scale field trials, which have several goals: evaluation of technology and services in real end-user environment with real users, evaluation of service usability and end-user experience, in-depth analysis of customer behavior in electronic service environment, and evaluation of candidate business models underlying this type of service system.

Data on user experience is collected in different forms, including questionnaires, interviews, monitoring and logging. The SmartRotuaari service system automatically logs data upon usage, for example locations and routes of the test users, service events and CPI interactions. Approval of the logging of data is one of the conditions test users and service providers have to comply with. All information is time stamped and stored into a database for further analysis. Having this data available, we can by means of data mining, for example, search for behavioral patterns such as typical walking routes at the downtown and how receiving a mobile ad may affect them. Having identified these kinds of routines we can then utilize them in service provisioning.

3 SmartRotuaari service system

SmartRotuaari comprises of a wireless multiaccess network, SmartWare architecture for service provisioning, a web portal with content provider interface and SmartServices, a collection of functional context-aware mobile multimedia services.

3.1 Multiaccess wireless connectivity

Wireless connectivity is currently provided in form of the Rotuaari WLAN (IEEE 802.11b) and the Octopus GPRS network. We are ourselves building the Rotuaari WLAN, which at the time of conducting the first field trial comprised of the 11 access points illustrated in Fig. 1. By November 2003 the Rotuaari WLAN had expanded to 20 access points covering the downtown and the market area. The Octopus GPRS is the network component of Octopus, the open innovation, development and testing environment for mobile applications in Oulu [18]. Up to 3000 mobile devices can be simultaneously connected to the Octopus platform. During year 2003 the Octopus environment has been upgraded to provide EDGE coverage at selected locations. Third network component will be provided by Bluetooth beacons at selected locations.

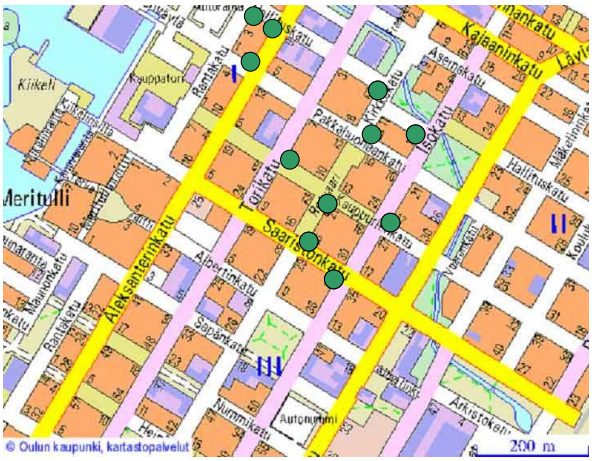


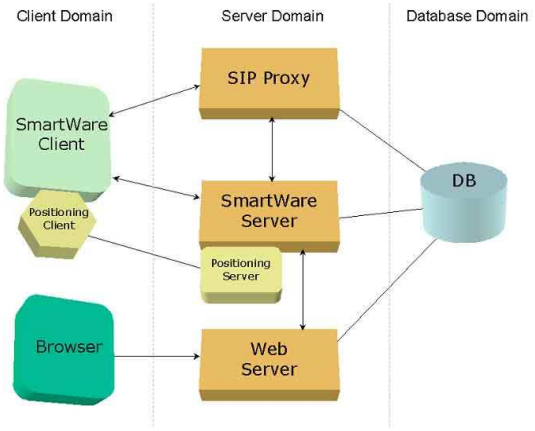
Figure 1. Locations of the 11 access points in the Rotuaari WLAN.

3.2 SmartWare architecture

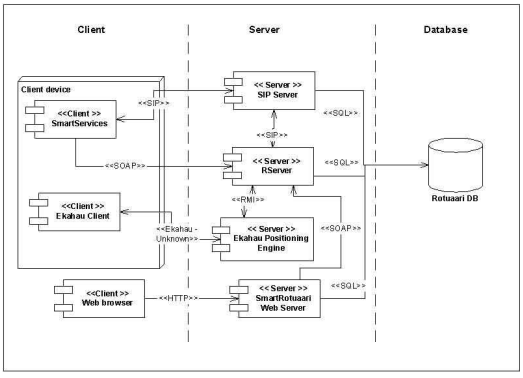
The services are provisioned with the SmartWare architecture illustrated in Fig. 2. The main components are:

- **SmartServices Client**; PersonalJava 1.2 compliant Java Application. The client is modular and extendible so that the existing services are abstracted from each other to make addition of new services as straightforward as possible. The client is designed to be used with a pen or a similar pointing device in a PDA, instead of the conventional mouse driven desktop approaches. Client communicates with the Rotuaari Server using SOAP over HTTP over TCP, and with the SIP Server using SIP over TCP.

- **SmartWare Server**; Offers SOAP interface to the clients for accessing the multimedia content of the services. It also controls the IP Gateway, so that registered users can access web content from the public Internet. The server includes SIP Server with SIP Registrar, SIP Proxy and SIP Presence server components, which form the infrastructure for instant messaging and real-time presence management. Presence notifications are used to convey all context information related to users and services. For example, when a new mobile ad is triggered, those users, which shall receive the ad, have their profile changed. This event triggers a presence notification, which is delivered to every interested party.



(a)



(b)

Figure 2. SmartWare architecture: (a) main components; (b) communication protocols.

- **Positioning Server**; Ekahau Positioning Engine [10], which conducts real-time WLAN-positioning based on a "location fingerprint" recorded beforehand and WLAN signal strength measurements obtained from the Positioning Client. The accuracy is 5-10 meters, when signals from three or more access points are available.
- **Database**; Relational database (MySQL) for storing all system data such as user information, ads, places and logs of users' and content providers' actions.
- **Web Server (http://www.rotuaari.net)**; Facilitates web based access and control of the service system. It provides interface for the general public to sign up as test users and manage their personal profile, CPI for service providers and administrative tools for managing user and service provider accounts.

One of the design principles has been to use open standards, which include:

- **HTTP** (Hyper-Text Transfer Protocol) for communicating with the Web Server.
- **SIP** (Session Initiation Protocol) for instant messaging and distribution of presence information.
- **SOAP** (Simple Object Access Protocol) for client-server communication.
- **SQL** (Structured Query Language) for database access.
- **XML** (Extensible Markup Language) for storing information such as user data, places and mobile ads.
- **WGS 84** (World Geodetic System 1984) coordinate system for describing locations of users, places, etc.

The SmartWare architecture facilitates utilization of following context information in service provisioning:

- **Time.** Time range, which indicates when the service is active.
- **Location**. Absolute and relative locations of the user and/or a service provider. For example, a service can be triggered if the user is within a specific distance of a service provider. Location of the user can be provided by GPS, WLAN-positioning or manual entry.
- **Weather**. Real-time weather observation is obtained from a local weather station, which is accessible via Internet. Two attributes of the observation can be currently used, temperature and wind speed. They are categorized to a set of non-overlapping labelled ranges, six for temperature (freezing → heat) and seven for wind speed (still → hurricane).
- **User profile and presence status**. Various detailed user information (age, marital status, education, occupation, income) is entered upon registration, together with any of the 23 different personal interest categories selected by the user. Also, the user's presence status, availability, can be utilized. Further, the user can also set his/her mood to any of the seven predefined values (hungry and/or thirsty, partying, looking for company, etc.) when logged into the system.

3.3 SmartServices prototype services

The service system includes a collection of functional prototype services: service directory, map-based guidance, mobile ads, personal communications, Time Machine Oulu, personalized news and mobile payment. The services are provided via a Java-based client software, which has been developed for the Pocket PC environment. Samples of the graphical user interfaces of the various services are illustrated in Fig. 3. The SmartServices "desktop" shown in Fig. 3(a) provides access to individual services.

Service directory provides access to a database of places, which can refer to a shop, public office, bus stop etc. The user can search places via free form text queries or pre-defined categories, as illustrated in Fig. 3(b). Once a particular place has been found, the user can ask for map-based guidance, for example. The user can also add the place to his "MyPlaces" collection of important places, which can later be accessed quickly. New places can be easily added to the database via the CPI.

Map-based guidance provides visualization of the location of a place, also relative to the user's location. A place can refer to any entry in the service directory, a 'buddy', or a location of personal interest specified earlier by the user. The service system contains maps of the whole area of city of Oulu in four different resolutions. Currently, the maps are stored and presented as bitmaps, which have been clipped beforehand. The user can scroll the map on the screen in all four principal directions with the pointer. Fig. 3(c) illustrates map-based guidance, showing the locations of the user (red dot) and a shop.

Mobile ads is a specially designed service for personalized customer service and customer relationship management, which were identified by the Oulu downtown businesses as the most important aspects of their customer service. A mobile ad is a SMIL 2.0 compliant multimedia message, which is authored and activated by a service provider and received by a customer, assuming that the conditions set for the mobile ad to appear (trigger) are met. The various conditions that can be used for triggering an ad are described in Section 3.2. Mobile ads as the one illustrated in Fig. 3(d) are created with the easy-to-use CPI, which facilitates authoring and activation of a new ad in a couple of minutes. Effectively, from a service provider's point of view mobile ads provide means for conducting rapidly highly personalized, low-cost direct marketing.

Personal communications is supported in form of peer-to-peer and group chat, which in the current version are implemented as simple text-based chat as illustrated in Fig. 3(e). The user can maintain a list of 'buddies' and invite them to a chat. Further, the user can set his presence status ('mood') to any of the predefined alternatives. The user can choose whether his location and/or presence status are shown to his 'buddies' and other users.

Time Machine Oulu [21] provides opportunity to travel both in time and spatial space simultaneously. The service builds dynamically from a database an interactive 3-D VRML2 virtual model of historical Oulu at the user's current location in the designated year as illustrated in Fig. 3(f). The database contains exact scientifically validated data of buildings in historical Oulu. The current database covers years 1822-1882 and is being extended towards the 21st century. The application allows for moving around in the virtual model using different viewpoints and accessing the buildings for additional information, e.g. the owner of a particular building at a given time. The service is realized using Cortona's browser, which supports VRML2.

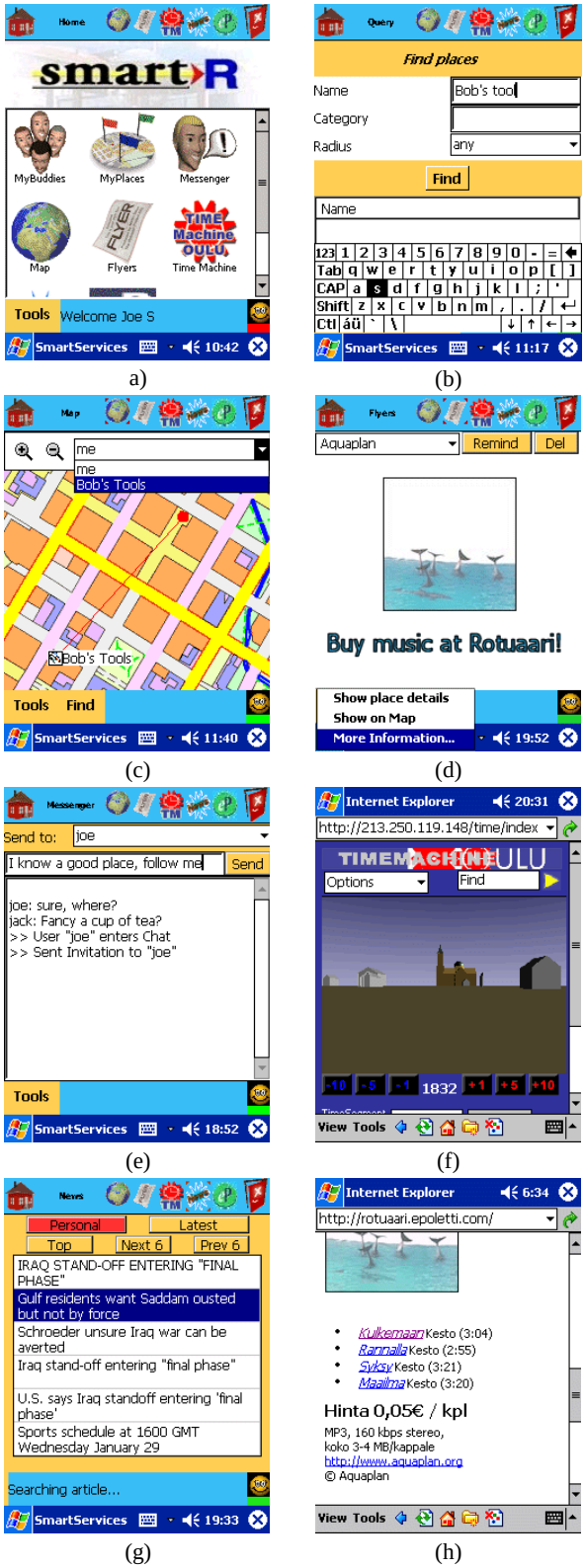


Figure 3. Samples of the graphical user interfaces of the prototype services: (a) "desktop"; (b) textual query into the service directory; (c) map-based guidance; (d) mobile ad; (e) personal communication; (f) Time Machine Oulu; (g) personalized news; (h) mobile payment.

Personalized news provides personalized access to a news feed as illustrated in Fig. 3(g). By using the '+' and '-' buttons the user can designate whether he finds the current article interesting or not. Personalization is carried out with the Leiki Targeting personalization engine [17], which based on the user's feedback updates the user's profile and ranks the incoming news so that those matching the user's profile are provided first.

Mobile payment facilitates micropayment for on-line content with real money. This is an important detail, for any service pilots providing chargeable services for artificial money are bound to produce unreliable results on customer behavior. The mobile payment is realized with the ePOLETTI service, which monitors the HTTP traffic and upon recognizing a link to a chargeable content redirects the traffic to the payment server [12].

4 Empirical evalution: Field trial #1

In this section we present the setup and results of the first field trial, which was conducted between 29 August and 30 September 2003. We have previously conducted smaller scale user evaluations of the SmartLibrary, the location-aware library service realized on top of the SmartWare architecture [1], and the TimeMachine Oulu service [21].

4.1 Setup

The field trial comprised of three major functions: deployment and maintenance of the service system, establishment of an office to coordinate the field trial, and collaboration with companies to obtain real-life up-to-date content in form of mobile ads.

Deployment of the service system was initiated by choosing the services to be evaluated: service directory, map-based guidance, mobile ads and TimeMachine Oulu. The mobile ad service was configured to allow the service provider to use following optional context conditions in triggering and delivering a particular ad (we call the set of conditions defined by the service provider the ad profile): activity range, time, age (seven ranges: custom (m-n), children (0-12), teenagers (13-15), youth (16-19), adults (20-39), middle-aged (40-64), seniors (65-119)), mood (seven categories), personal interests (23 categories), temperature (six ranges) and wind speed (seven ranges).

The ranges and categories were mutually non-exclusive, i.e. the service provider was able to designate any combination of them. If all conditions set in the ad profile were fulfilled, together with the receiving range set by the user (i.e. the user was within the designated distance from the service provider sending the ad) and the user allowed the reception of ads, the ad was delivered to the user's device.

The various conditions in the ad profile facilitate precise definition of the target group. However, the larger number of conditions is set in the ad profile, the sparser becomes the parameter space, when the numbers of ads and users are fixed. Since we had a limited number of active ads available in the service system, we removed personal interest categories from the ad profile at the halfway point of the trial, to guarantee that each test user received ads during his/her test period.

We allocated a pool of HP iPAQ's with expansion packs and WLAN cards to be loaned to the test users. We configured the iPAQ's shortcut buttons to directly open SmartServices client and an Internet browser. We also attached small label stickers to the buttons to increase accessibility. The maximum loan period was set to two hours, though longer periods were granted upon request.

(a)

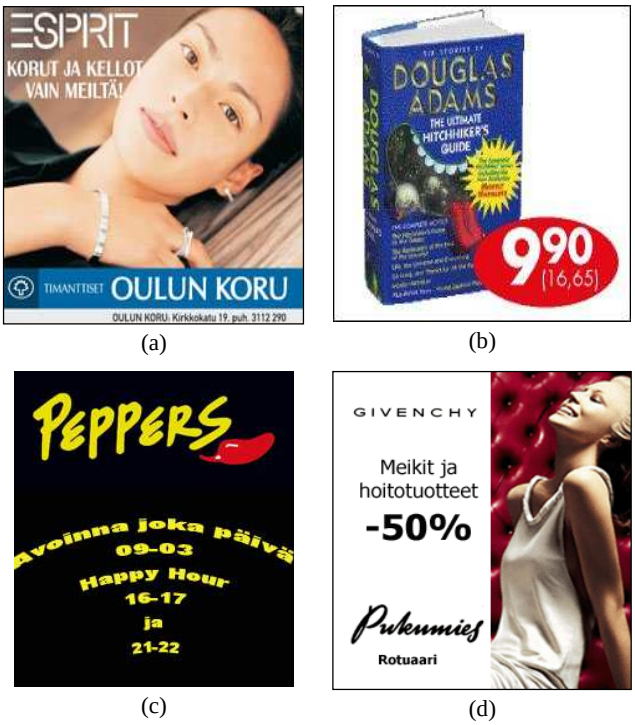
(b)

Figure 4. (a) Field trial office at the Rotuaari pedestrian street; b) a test user is signing up.

The field trial was coordinated from an office established in a small hut placed at the very heart of the pedestrian street Rotuaari (Fig. 4). The office was open for six hours daily from Monday to Saturday. The office was staffed with at least two researchers, who persuaded passers-by to sign up as test users, helped test users in creating a user profile and in using the iPAQ and services, and collected feedback via a questionnaire and occasional interviews. Each test

user was awarded with a voucher to a nearby café after the test session.

We recruited 18 local companies to serve as content providers, to produce for free mobile ads promoting their products and services. It was an encouraging experience that none of the companies we approached rejected the invitation. The companies were presented with the possibility to either produce the ads themselves using the CPI at the web portal or order the ads with a paper form from the 'advertising agency' offered by the project. To support the companies in their content creation we offered them few ad templates, which were produced by a professional advertising agency, one of the partners of the project.



(a) (b) (c) (d)

Figure 5. Sample mobile ads: (a) jewelry store advertising a jewelry brand; (b) discount offer from a bookstore; (c) bar advertising its happy hour; (d) cosmetics discount ad.

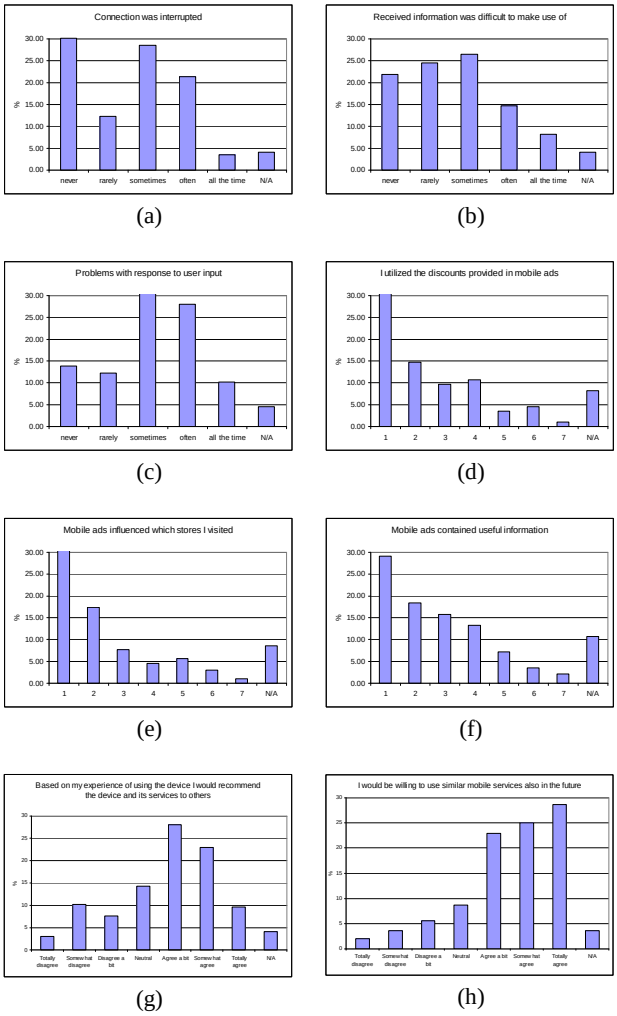
The final outcome was that five companies produced the ads themselves, seven companies relied on our 'advertising agency' and six companies did not produce any ads during the field trial after all. Their inactivity was compensated by few companies, which had several places of businesses for which they produced ads. Fig. 5 illustrates some of the mobile ads created by the companies.

The main restriction of the field trial was the limited coverage of the Rotuaari WLAN (see Fig. 1) and lack of indoor coverage. This resulted in test users losing the network connection upon leaving the coverage or entering stores, which in turn spelled usability problems.

4.2 Results based on questionnaires

We first extract some statistics of the questionnaires returned by the test users. It should be noted that not all test users filled in the questionnaire after returning the device. The questionnaire was very extensive, totalling 219 individual questions grouped into 31 categories. The questions provide comprehensive data both in terms of the background of the user and the experience of the mobile device and services evaluated in the field trial. The questionnaire was probably too extensive, as several test users complained about it being too long and requiring too much time.

There were 196 respondents in total, of which 66% were male and 34% female. The age distribution of the respondents was: under 18 3.1%, 18-24 38%, 25-34 41%, 35-49 14%, 50-65 3.1% and over 65 1.0%. 43% of the respondents were students, 17% executives and 16% workers. 86% of the respondents lived in the Oulu region, 11% elsewhere in Finland and 2.1% abroad. The reason for their visit to downtown was: running errands 33%, shopping 30%, work 10%, leisure 9.4%, tourism 2.6%, other 15%.



(a) (b) (c) (d) (e) (f) (g) (h)

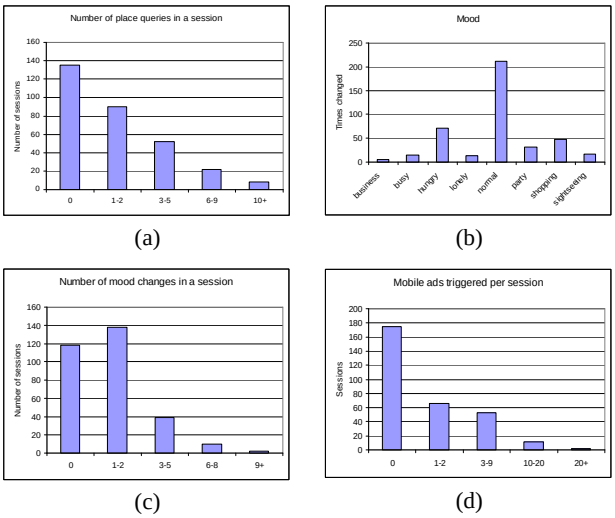
Figure 6. Some statistics compiled from the questionnaires.

The charts in Fig. 6 illustrate few selected statistics compiled from the questionnaires (presenting all interesting charts would require dozens of pages). Charts in Fig. 6(a-c) address the technical functionality of the device and the services with respect to connection stability, information usefulness and response. Charts in Fig. 6(d-e) reflect the test users' experience of mobile ads, when asked to provide their feedback on scale 1 (totally disagree) – 7 (totally agree).

The graphs support our own observation of the limited added value provided by the bulk of the mobile ads, which were content to just provide the name and street address of a store, for example. This emphasizes the importance of training the companies to use this type of a new marketing tool in a manner, which provides some benefit to the recipient. Despite the occasional technical problems and limited informative value of mobile ads the overall user acceptance of the device and services is encouraging, as illustrated in Fig. 6(g-h).

4.3 Results based on log data

Charts in Fig. 7(a-c) illustrate sample statistics compiled from the log data automatically recorded by the service system. In total there were 307 sessions, which was defined to be constituted if a user login was followed by at least one service event (location change, place query, triggered mobile ad, etc.) within 20 minutes of the login.

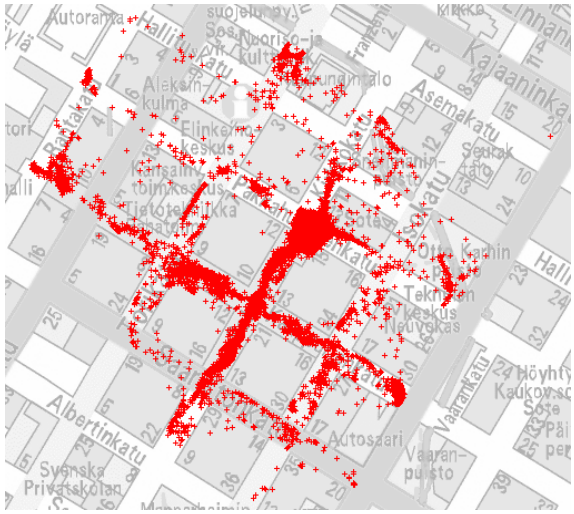


(a) (b)

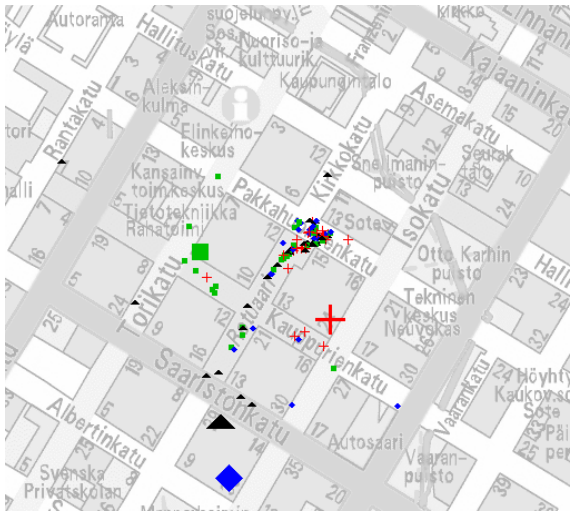
(c) (d)

Figure 7. Some statistics compiled from the log data.

Fig. 7(a) reveals that almost half of the sessions did not include a single place query, while the other half of the sessions accumulated 589 place queries in total. Fig. 7(b) shows how many times a particular mood was selected: predictably normal mood was the most common among the 413 mood changes. Fig. 7(c) illustrates that over 60% of the sessions had at least one mood change. Fig. 7(d) shows that over half of the sessions did not include the reception of a single mobile ad.



(a)



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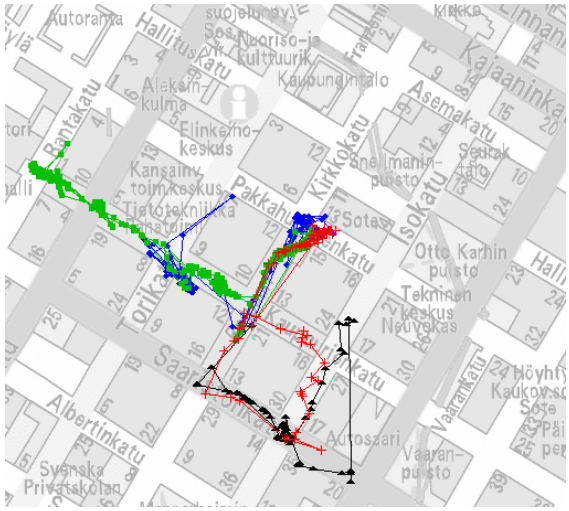

(c)

Figure 8. Illustrations of location recordings in the log data and location-based service events.

Fig. 8(a) shows all location recordings found in the log data, which correspond to the limited coverage of the Rotuaari WLAN, excluding few erroneous location estimates produced by the Positioning Server. Fig. 8(b) shows the locations where four different mobile ads were received. The shape and color of the tiny markers designate the company sending the ad which in turn are marked with large triangle, square, circle and cross symbols. As expected, most ads are received in the neighborhood of the field office, where test users started their session. Fig. 8(c) displays the routes of four different test users. The long "leaps" on a route may be due to a lost connection or the user turning the PDA on and off.

5 R&D network of SmartRotuaari

In this section we will very briefly describe the first results of the research, which focus on modelling the first stage of the R&D network of SmartRotuaari, i.e. its formation (for a detailed description, see [15]). In [15], a process refers to a sequence of events or activities, which describe the development over time [24]. In addition, a process is considered through a teleological perspective (see [24], [25]), which applied in the focal case, views the network as a purposeful and adaptive entity, having a jointly preferred end state towards which it reaches. A process consists of a multiple streams of activities and may be limited by the network's recourses and environment. Moreover, the actions of the actors may also change the goal and thus the outcome of the process cannot be known in advance.

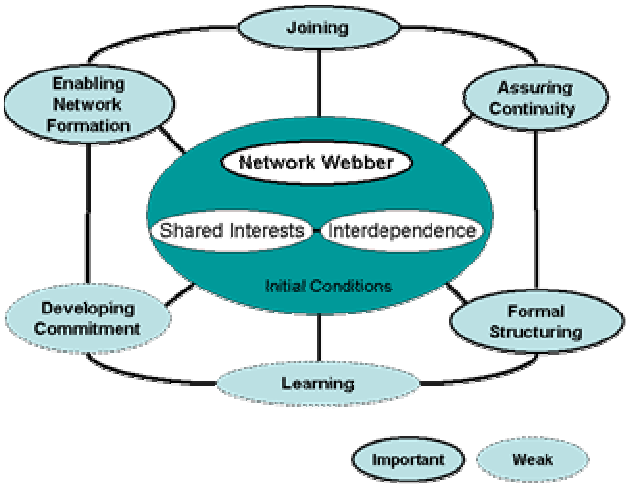

Figure 9. The process model of the engineered R&D network formation of SmartRotuaari [15].

As illustrated in Fig. 9, the process model of engineered R&D network formation of SmartRotuaari depicts two main elements; the initial conditions and the cycle of sub-processes. Third important element is part of the initial conditions, i.e. the role of the network webber. The initial conditions influence each other as well as the network formation. The cycle of sub-processes contains six intertwined series of activities, which together form the network formation process. Initial conditions influence each sub-process and each sub-process may also influence other sub-processes. The intensity of a certain sub-process as a part the network formation process can vary from low to high. The higher the intensity, the more important the sub-process is.

Based on the empirical data collected during the formation of the R&D network of SmartRotuaari, we are able to show that the sub-processes may take place simultaneously during a longer time period. Moreover, sometimes the formation process may even return to previous sub-process forming loops within the process. This view is very different from the existing research, which treats formation process as stages, following each other like steps in a ladder.

6 Discussion

This paper presented the current status of the SmartRotuaari service system, together with results from the first field trial. The results show that SmartRotuaari provides a functional research framework for prototyping and empirical evaluation of context-aware mobile multimedia services, customer behaviour and business models in real end user environment.

The main technical drawback in the current implementation of the SmartRotuaari service system is the monolithic Java client, which limits the selection of applicable mobile devices to those equipped with the required Java functionality (JVM), effectively laptops and high end PDA's. Addition of new services also requires modifications to the client software. Therefore, we are currently redesigning and implementing the client side according to the 'web services' paradigm so that services are provided via a web browser. This allows using the services also with the new smartphones, which are equipped with XHTML browsers and TCP/IP stacks. More importantly, the new architecture will facilitate seamless expansion of the service system with independent third party services. Further, we will employ services developed by our industrial partners.

In the scope of empirical evaluation, in the upcoming field trials a particular exercise we look forward carrying out is correlating the qualitative data obtained from the test users with the quantitative log data recorded automatically by the service system. The motivation is to see to which extent the test users' reporting ("I used the news service most") corresponds to the log data ("Downloading of music videos was the most often used service").

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