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INTEGRATION OF END-USER RESEARCH TO MOBILE SERVICE DEVELOPMENT

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Technology

Espoo, November 24th, 2008

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HELSINKI UNIVERSITY OF TECHNOLOGY

Abstract of the Master's Thesis

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Emerging data collection methods and end-user research processes can contribute to mobile service development. Controlled research platforms in which end-users, multidisciplinary research teams, and companies meet are suitable in experimenting with new business models, studying service adoption and measuring actual usage. Aggregated usage and survey data provide multiple data points than can be integrated to service development.

This thesis constructs a framework of integrating end-user research to mobile service development. A living laboratory research platform provides a testing environment for prototype services and business models behind them. New services that are brought to the platform are used by end-users. Objective handset- and server-based usage data can be collected with various technologies. The aggregated analysis data, together with subjective information from surveys, can be looped back to the developers. With more comprehensive feedback data more user-friendly services can be developed.

According to several experiments conducted in this thesis, challenges such as setting up and maintaining the research platform in an economically feasible way and collaboration of research teams driven by partly conflicting research objectives are the main difficulties.

The framework is tested in a real living laboratory environment – Otasizzle in Espoo, Finland. Processes, such as bringing new services and end-users to Otasizzle, conducting surveys, collecting and analyzing usage and survey data are designed and tested.

The results indicate that a further development of the framework in a more stable and longer-term form is needed. The results show that the data collection processes and research approaches work well, and can be utilized in service development. Critical points are: setting up and maintaining the infrastructure of the platform, initiating collaboration among researchers, and screening and pre-evaluation of the services. Well designed processes in which research resources are used most efficiently bring the most value to service providers, researchers, and end-users.

Keywords: End-user research, living laboratory, data collection, mobile service development

TEKNILLINEN KORKEAKOULU

Diplomityön tiivistelmä

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Uudet tiedonkeräysmenetelmät mahdollistavat uusia tapoja kehittää matkapuhelinpalveluita. Käyttäjäkeskeiset tutkimusympäristöt, jossa tutkimus, käyttäjäyhteisöt ja yritykset kohtaavat ovat sopivia uusien liiketoimintamallien kokeilun, palveluiden adoption tutkimisen, ja todellisen käytön mittaamisen kannalta. Yhteen kerätyt tiedot loppukäyttäjien seuratusta toiminnasta, sekä heiltä kyselemällä saadut tiedot muodostavat monien tietolähteiden kautta lähtökohdat tutkimukselle.

Tässä diplomityössä rakennetaan viitekehys loppukäyttäjien tutkimiseen matkapuhelinpalveluiden kehittämistyössä. Niin sanottu elävä laboratorio toimii testiympäristönä prototyyppipalveluille ja niiden takana vaikuttaville liiketoimintamalleille. Oikeat loppukäyttäjät käyttävät tähän ympäristöön tuotuja palveluita. Puhelimista sekä palvelimista saadaan objektiivista käyttötietoa. Tämä yhteen sovitettu tieto, yhdessä subjektiivisen kyselytiedon kanssa, voidaan välittää takaisin palveluiden tuottajille. Aidon loppukäyttäjäpalautteen pohjalta on näin ollen mahdollista kehittää käyttäjäystävällisempiä ja tarpeeseen osuvampia palveluita.

Tätä diplomityötä varten suoritettujen kokeiden perusteella tutkimusympäristön rakentaminen ja ylläpitäminen taloudellisesti järkevällä tavalla, sekä osittain ristiriitaisten tutkimuskysymysten huomioiminen ja tutkijoiden yhteistyö ovat pääkohtia työn tulosten kannalta.

Viitekehys testataan oikeassa elävässä laboratoriossa Otasizzle projektin puitteissa, Suomen Espoossa. Uusien palveluiden ja uusien käyttäjien tuominen ympäristöön, kyselyiden tekeminen, käyttäjien tekninen ja käytännön rajapinta, käyttötiedon ja kyselytiedon kerääminen ja analysointi ovat muun muassa testattavia prosessin osia.

Viitekehyksen jatkokehitys vakaammassa ja pitkäaikaisemmassa systeemissä on tuloksien perusteella tarpeen. Tulosten perusteella tiedonkeräysmenetelmät ja prosessit toimivat hyvin. Kriittisiä kohtia ovat tutkimusympäristön rakentaminen ja ylläpito, tutkimuksen yhteistoiminta, ja uusien palveluiden esiarviointi niiden soveltuvuuden varmistamiseksi. Hyvin suunnitellut prosessit, joissa tutkimusresurssit käytetään parhaiten, tuovat eniten lisäarvoa sekä palveluntuottajille, tutkijoille, että loppukäyttäjille.

Avainsanat: loppukäyttäjätutkimus, elävä laboratorio, tiedon keräys, matkapuhelinpalveluiden kehittäminen

Preface

This Master's Thesis has been written as a partial fulfilment for the Master of Science degree in Helsinki University of Technology. The work has been conducted as a deliverable for the Otasizzle project in the Department of Communications and Networking.

I wish to express my gratitude to the people that have supported me in this work. First of all, I would like to thank Professor Heikki Hämmäinen for the opportunity to write this thesis in his team and for his guidance and insights throughout the research process. I am grateful to Hannu Verkasalo for his extensive assistance and support during the course of the work.

I wish also to thank researchers at the Otasizzle project for their support in the experimental part of the thesis, especially Martti Mäntylä, Petri Martikainen and Olli Pitkänen. I wish to thank all the other members of Netbizz team, you all have contributed to one way or other to this work: Timo Smura, Antero Kivi, Mikko Heikkinen, Annukka Kiiski, Turo Brunou, Matti Uronen, Zhao Hanbo, Borja Salmeron, Tapio Levä, Kalevi Kilkki, Juuso Karikoski and Antti Riikonen. Other co-workers, I thank you for the pleasant work environment.

Without my family, fellow students and friends it would have been much harder to get here. Special thanks to Jori Stjerna, Joonas Ojala, Sampo Hämäläinen, Miikka Tölö, and Mika Lehto for your support during my studies at TKK. To my dearest, Mari, thank you for the strength and wisdom you gave me during the course of my work.

Finally, I want to thank my parents, Nena and Juha for excellent upbringing and support during my studies.

Espoo, November 2008

Niklas Tirkkonen

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Abbreviations

2G	Second Generation
3G	Third Generation
ABPU	Average Bill Per User
CDMA	Code Division Multiple Access
CDR	Charging Data Record
Comnet	Communications and Networking
CSE	Computer Science and Engineering
EDGE	Enhanced Data Rates for GSM Evolution
EV-DO	Evolution-Data Optimised
FAQ	Frequently Asked Question
FVT	Function Verification Test
GIT	Georgia Institute of Technology
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GUI	Graphical User Interface
HIIT	Helsinki Institute of Information Technology
IAP	Internet Access Point
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
IRC	Internet Relay Chat
ISO	International Organisation for Standardisation
LTU	Luleå Tekniska Universitet
MMS	Multimedia Messaging Service
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NRC	Nokia Research Center
OEM	Original Equipment Manufacturer

OS	Operating System
OSS	Open Source Software
PDA	Personal Digital Assistant
PVT	Performance Verification Test
R&D	Research and Development
RIM	Research In Motion
SMS	Short Message Service
SQL	Structured Query Language
STOF	Service Technology Organisation Finance
SVT	System Verification Test
TCP	Transmission Control Protocol
TKK	Teknillinen korkeakoulu
TU/e	Technische Universiteit Eindhoven
UI	User Interface
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access
WEB	WWW – World Wide Web
XP	Extreme Programming

1 Introduction

1.1 Motivation

Emerging data collection methods can contribute to mobile service development. These methods include handset-based usage data collection and interactive web-based surveys. This master's thesis is to build a framework for the utilization of new technologies in supporting service development processes – particularly building interaction between the users of prototype products and application/software development teams. In addition to building a framework, the model is to be applied in a real life living lab concept during 2008.

The introduction of 3G and along with it the bundling of mobile handsets have prompted the diffusion of so called smartphones (combination of PDA devices, digital cameras and mobile phones) and new mobile services such as imaging, mobile browsing and 3rd party applications (Tallberg et al., 2007; Verkasalo and Hämmäinen, 2007). The telecommunications industry has not yet fully exploited new possibilities as many of the earlier introduced services having been rather unsuccessful (Bouwman et al. 2008), for example WAP (Vesa 2005). The latest truly successful application to mobile handsets has been SMS (Vesa 2005). Smartphones are capable of providing much richer services to consumers than the current popular services designed originally for less sophisticated mobile phones.

This thesis addresses the issue of providing more lucrative services to potential customers. It would be beneficial to build feedback loops between mobile software developers and end-users. This can be done with new data collection methods that enable a feedback loop between the two entities, thus making the software development process more efficient, addressing how end-users really experience new services. In this thesis an end-user centric software development framework is being constructed and prototyped in real life living lab environment.

Handset-based data collection methods have been used previously in consumer research (see Verkasalo and Hämmäinen, 2007). Now this measurement platform is applied in the prototyping phase of mobile software development. The accurate information of mobile service usage alongside with comprehensive end-user surveys constitutes a novel way to boost development processes.

This research is part of bigger entity, namely the OtaSizzle project. Objective of the Otasizzle project is to provide experimental facilities for developing and studying innovative mobile social media applications in the Otaniemi (Espoo, Finland) area. Project stakeholders are primarily Helsinki Institute of Information Technology (HIIT), Computer Science and Engineering (CSE) and Communications and Networking (Comnet) departments of Helsinki University of Technology.

1.2 Research question and objectives

The measurement platform developed some years ago (Verkasalo and Hämmäinen 2007) has not been applied to mobile software development processes before. The thesis aims to gain insight into how the measurement platform can be integrated into mobile software development processes. The research problem is to build a framework of utilizing consumer feedback in mobile software development by leveraging usage measurements and surveys. The research problem is narrowed down to a specific research question which is then divided into four sub-questions:

- *In what ways could new data collection methods be used in mobile software development processes?*
    - *How can usage logs and handset/web-based survey data be collected and meaningful information fed back to software developers?*
    - *How can the data collection and end-user research methods be integrated to software development processes in living lab concepts in practice?*
    - *What advantages and disadvantages does the integration of new data collection methods possess?*

- *How to measure the contribution of the new research processes to agile software development, and how the integrated end-user research actually benefits software development?*

The research question will be answered by achieving the corresponding objectives of the research. The objectives of the research are:

- Construct a framework for agile mobile software development with new data collection methods in a living lab environment.
- Construct a set of reports based on hand-set based measurements and surveys for mobile software engineers that help them identify points of improvement in tested applications
- Identify and prototype the processes in such a test environment, that can be copied elsewhere.
- Analyze the contribution of the developed research processes.

1.3 Scope

The scope of the research is narrowed down with various constraints. The applications that are tested are built for mobile devices. Population is limited to 100-2000 end-users, who sign up for the research project. The framework is tested with a slightly biased set of end-users only, the end-users being mainly university freshmen of computer science discipline. The empirical findings are conducted during 2008, during the first year of the Otasizzle project. The building of a complete feedback cycle to software developers cannot be implemented in the project time-frame. The integration of tools and methods such as the end-user monitoring platform to the software development process is tested and evaluated.

1.4 Research methods

A **literature survey** is conducted to form an understanding of the underlying concepts. More specifically, the survey is conducted on mobile business and services, empirical data collection methods, software development processes and living lab concepts.

A number of expert **interviews** help to explain the concepts and provide insights into how these concepts are seen in practice.

A **living labs implementation of the new research methods** is part of the thesis where the process framework is being experimentally implemented.

Handset based usage measurement and **handset and web-based surveys** are used to construct the process framework.

1.5 Structure

The following chapter 2 introduces the key areas of academic study related to the topic. First, mobile business and services are studied in order to better see the big picture. After that, mobile application development processes are introduced. Followed by the living labs concept and studies of data collection methods, we have a sound understanding of the main concepts.

In chapter 3 the constructed process framework is presented, including a comparison to other living labs. In chapter 4 the framework is prototyped with three experiments and the results are documented and analysed. Chapter 5 summarizes the thesis.

2 Background

In this chapter a background for this thesis is presented. First, mobile business is discussed briefly, concentrating on the factors affecting and motivating the thesis. Mobile services are discussed in the next chapter, introducing the reader to current trends in the field for further motivation for the thesis. In chapter 2.2 the software development process is presented, highlighting the testing stages and end-user perspectives. Trends such as open source software are discussed from a mobile industry perspective. In chapter 2.3 living labs concept is discussed. In chapter 2.4 different data collection methods are discussed, so that the methods used in this thesis would become familiar to the reader.

2.1 Mobile industry

2.1.1 Business landscape

On a global level, wireless telecommunication is substituting wireline telecommunication. There are economical factors in some countries, and technological factors in other countries that explain the dramatic and rapid spread of mobile telephony (Banerjee and Ros, 2004). Also, a few major disruptions in network technologies can be identified: The introduction of GSM networks in 1991, and the introduction of WCDMA networks in 2001. At the same time, the development of handsets has proceeded fast and new emerging services are launched constantly (Verkasalo and Hämmäinen, 2007).

Due to the worldwide deregulation of telecommunication industry that begun in United States in the 1980's, the industry nowadays comprises a competitive, dynamic and uncertain environment (Lal et al., 2001). The market penetration of mobile subscriptions is above 100% in many European countries and operators are fighting the market share often leading to falling prices as happened in Finland few years ago (Aina, 2006; Ficora, 2008). The idea of generating new revenue based on content and other types of mobile services (Vesa 2005), has not yet realized into cash.

As new technologies are pushed to the newly deregulated markets where competition is fierce, it is not clear anymore who will achieve the dominant position of the value network. Is it the incumbents, handset manufacturers, MVNOs, or 3rd party application developers? Maitland et al. (2002) present a 3G value chain (Figure 1). On the other hand telecommunications value chains are evolving into value networks as presented in Li and Whalley (2002) Figure 2. The business models vary from region to region; see Vesa (2005) for comparison between Japan, United Kingdom (UK) and Finland.

Camponovo and Pigneur (2003) argue that successful business models will be those that best address the economic peculiarities underlying the industry like mobility, network effect and natural monopolies. Garfinkel (2008) claim that some companies operate *vertically integrated telecommunication ecologies* of stores, resellers, content providers and network services. Those companies' business model is based on charging consumers to access software built into their own handsets. The customer base are being kept captive with for example multi-user contracts, exclusive hardware offerings, and free in-network calling (calls are free within the same operator network). An alternate business model is based on providing information to customers with only the network access fee, as is the case in Finland for example. Yoshida (2008) provides an another "ecosystem" viewpoint believing that dominant handset vendors and operating system vendors build their own application and service ecosystem through their own developers' community. Also Vesa (2005) point out that the success of mobile data services in the future calls for a clear operator control and guidance in order to offer rich user experience. By contrast, both Garfinkel (2008) and Yoshida (2008) see open source software platforms promising a level playing field for handset OEMs by offering alternatives – at the same time disrupting the vertically integrated mobile telecommunication industry. More information about vertically integrated mobile industry can be found in Vesa (2005), for example.

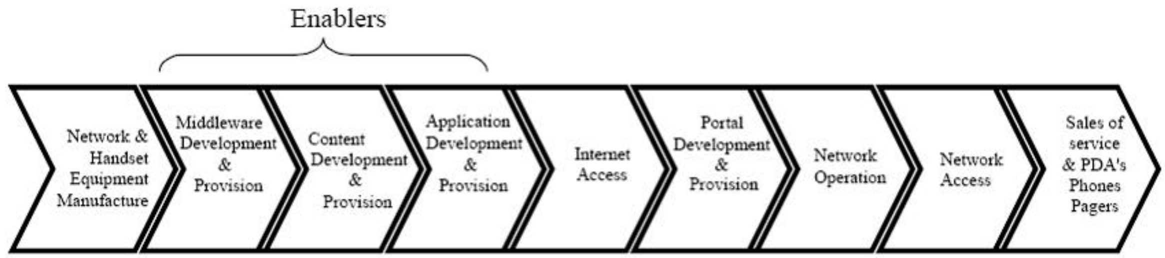


Figure 1 The 3G value chain (adapted from Maitland et al., 2002)

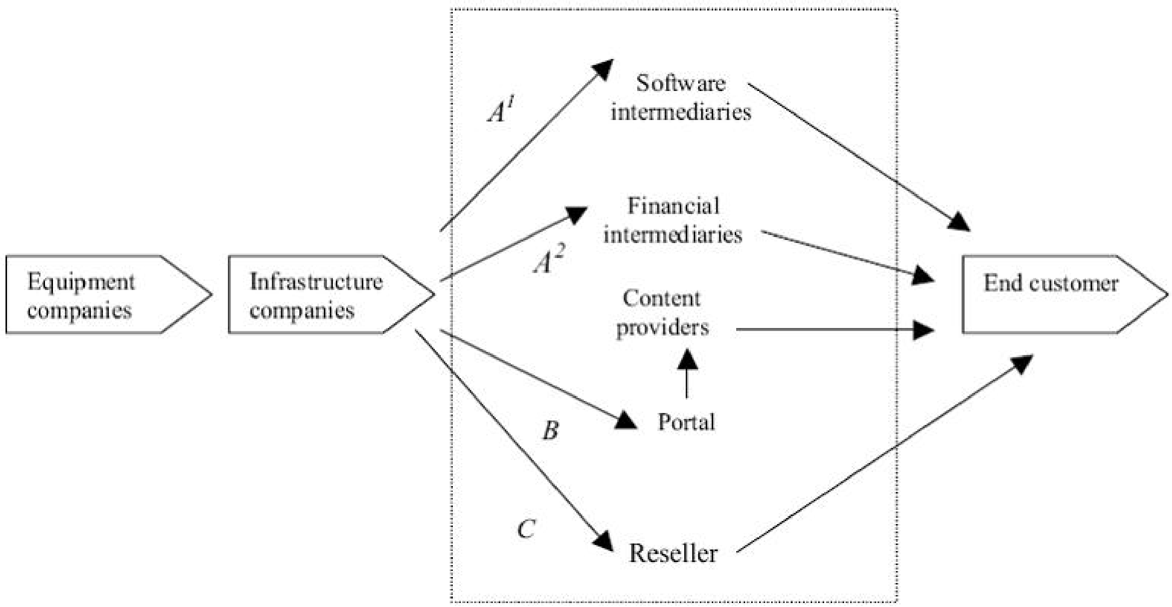


Figure 2 Deconstruction of the telecommunications industry (adapted from Li and Whalley, 2002)

Besides the value chain transformation, the industry has experienced a technological convergence in which stand-alone personal computers, the Internet and mobile handsets have converged into one single device that can run complex applications, have access to the Internet and make calls through circuit switched networks. Earlier, the convergence of telecommunications and computing triggered an argument that as a result of horizontal integration of all media (voice, audio, video, animation, and data) in a common network and terminal infrastructure, telecommunications and networked-computing applications were no longer distinguishable (Messerschmitt, 1996). The convergence of fixed/wireless and voice/data networks is fundamental to the success of the industry (Vesa 2005).

This evolution of the telecommunications industry is leading to a situation where the service providers as well as handset manufacturers must invent new ways to make money. According to handset based measurements in Finland (Verkasalo, 2008, see Figure 3), voice and SMS still dominate in terms of usage, but the business paradigm of mobile industry is shifting from the voice centric to the multimedia centric view of services (Vesa 2005). Also, as Tietoviikko (2008) points out, the mobile phone markets are becoming saturated and services will provide the income in the future. Vainio et al. (2005) provide an information system viewpoint, claiming the information system (IS) approaches for mobile products fail to incorporate market elements into the development process. Whatever the ways are to develop new ways to stay competitive, services such as SMS that has succeeded and WAP that has not succeeded as intended have probably suggested the operators that natural customer pull-effect beats the technical-push in the mobile service diffusion (Vesa 2005). In the next chapter a closer look to the mobile services is provided.

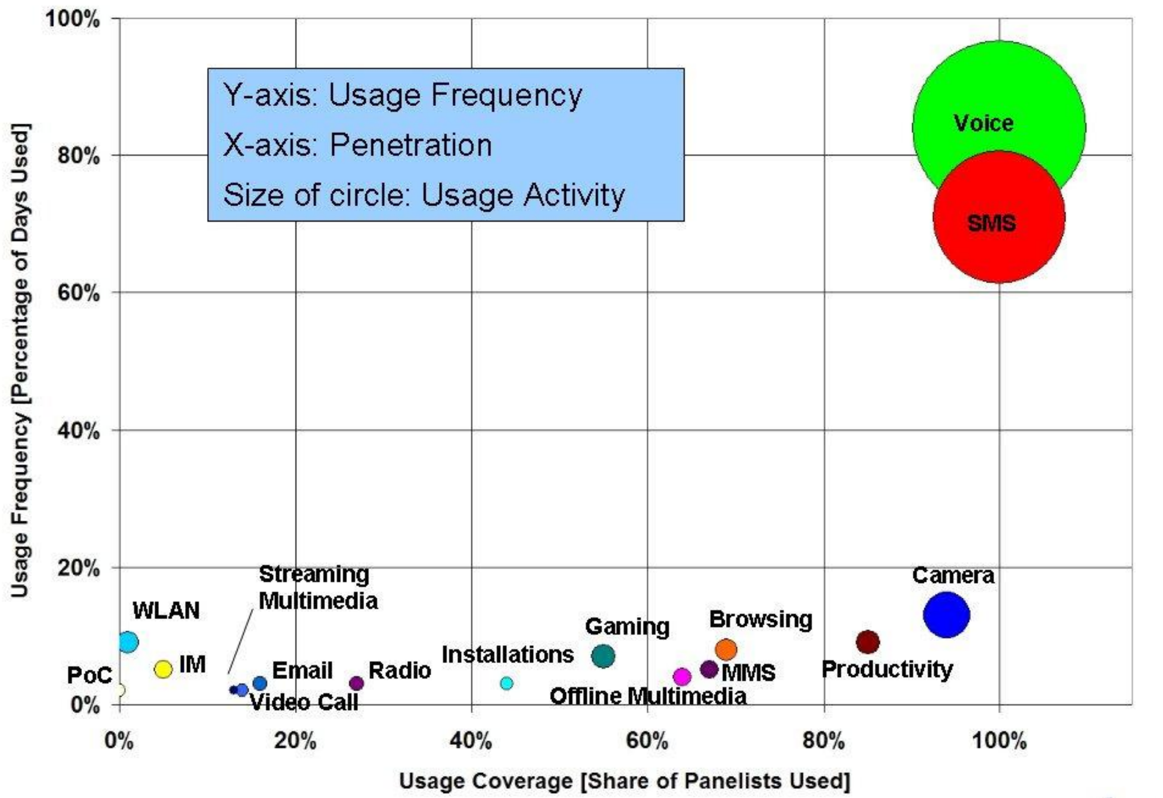


Figure 3 Mobile service usage (adapted from Verkasalo, 2008a)

2.1.2 Emerging services

For clarity, it is useful to present here the topology of mobile services. Probably the most accessible to the general audience is the topology used by Vesa (2005) in Figure 4 which is a modified version of the categorization used by Ministry of Transport and Communication of Finland. A summary of different classifications is presented also in Smura et al. (2008). Heinonen and Pura (2006) present a more conceptual classification for mobile services.

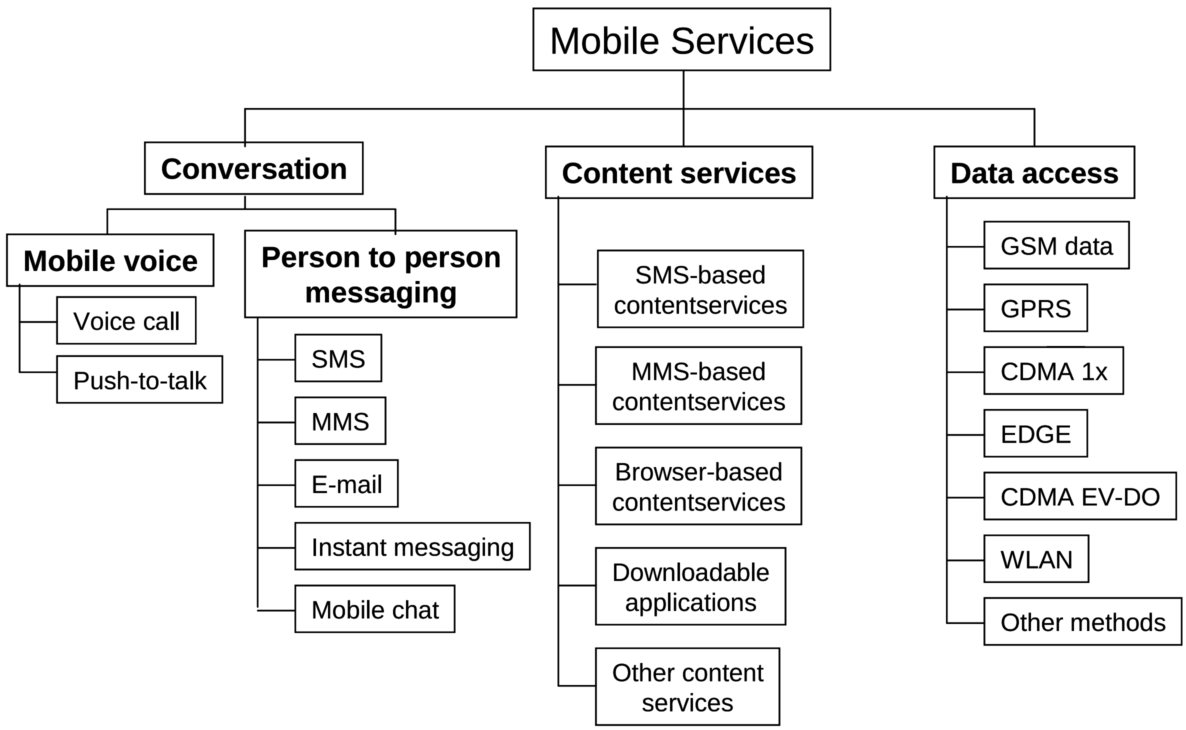


Figure 4 Mobile service classification (adapted from Vesa 2005)

As asserted in Verkasalo (2008a) mobile service usage is still dominated by voice and SMS, generating also the largest share of revenue to the operators. The evolution of services towards richer content is made possible by the evolution of wireless networks such as WCDMA and handsets that are becoming smartphones. Smartphones are a combination of PDA devices, digital cameras and mobile phones facilitating for example imaging, mobile browsing and 3rd party applications (Iftode et al., 2004). However, as has been seen in the past, neither the technology nor the marketing efforts does not give birth to successful applications, but it is rather the customers need to – in the context of telecommunications – communicate with peers. Vesa (2005) rightly calls for more intuitive products and services. Also Gerstheimer and Lupp (2004) claim that the development of third generation services and application is shaped too much by fascination with technical feasibility, but useful applications and profitable business models can only be designed by focusing on the users' needs. These needs are mostly driven by hedonic benefits, which are the strongest factor driving user intentions to use a service (Verkasalo, 2008b).

New end-user research methods can facilitate the building of user friendly applications and useful services. In these methods data is collected from actual service usage, by actual end-users in their natural environment. Combined with the survey data these methods provide accurate feedback to the service developers in improving the next releases of the services/applications. Mobile phones have been closed environments until recent years, but open platform technologies such as Symbian operating system and Java-technologies have brought change and opened up a significant business opportunity for anyone to develop application software such as games for the mobile terminals (Abrahamsson, 2005). Figure 5 illustrates smartphone penetration figures and operating system market share. A conclusion can be drawn that the market potential for new services is increasing as customers have more capable handsets. On the other hand the development efforts can be aimed at Symbian platform as it is the market leader.

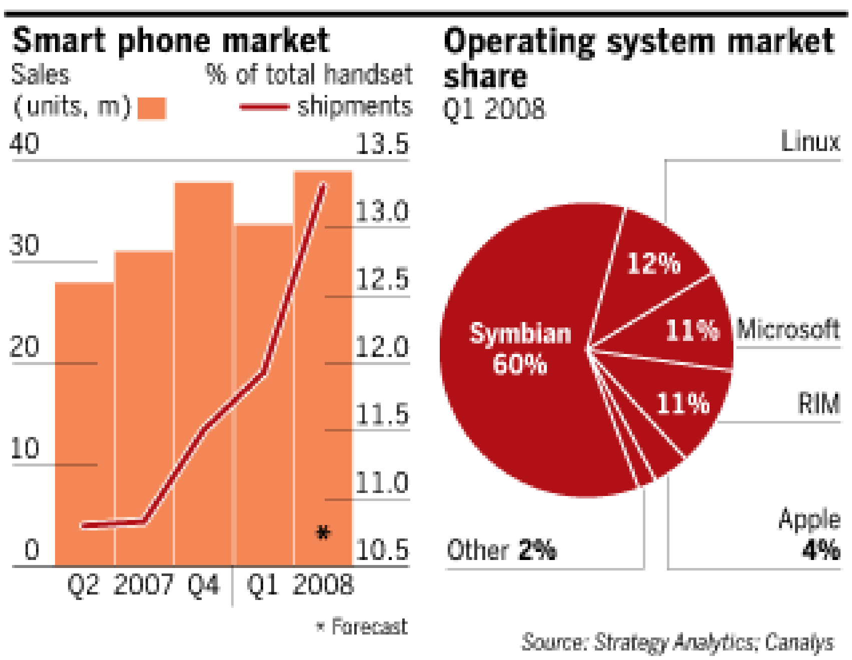


Figure 5 Smart phone market and operating system market (adapted from Ibison, 2008)

Several conclusions can be drawn of course from the success of Japanese iMode –service. In that case the key to success has been in business model, and also partly in the cultural context. The latter explains why the success of iMode has not been repeated in Europe for instance. The services offered through iMode concept include for example games, ringing tones, mobile content and other add-on java applications. These types of services could succeed elsewhere also (Vesa 2005), if the services were user-friendly, priced fairly and compatible for multiple platforms.

Add-on mobile services and applications are increasingly developed in communities, following the open-source model of the computing industry. As Vesa (2005) and Garfinkel (2008) note about business ecosystems in solving some of the challenges, they might be on a right track, if development communities are included into the ecosystems. Nokia Forum and Google Android environments are good examples of these kinds of ecosystems, where development of applications itself is dispersed around the globe, but supported centrally by providing tools, testing support, marketing and sales support. In ecosystems like these several factors such as community spirit and competition among peers, conjoined with expert individual developers lay a foundation for quality applications/services. More of Nokia Forum and Google Android please see chapter 2.2.3.

What is interesting in emerging mobile business models is that in those the customers play more active role in the service innovation process than in existing business models. End-users co-create, provide feedback with regard to existing services, suggesting alternatives, or even develop their own services or content. More importantly, service innovation is directly related to business models that support these services. Bouwman et al. (2008) present a theoretically grounded, yet practical approach to designing viable business models – i.e. the *STOF model*. Bouwman et al. (2008) provide a holistic view on business models with four interrelated perspectives: Service, Technology, Organisation and Finance. Figure 6 illustrates the STOF model.

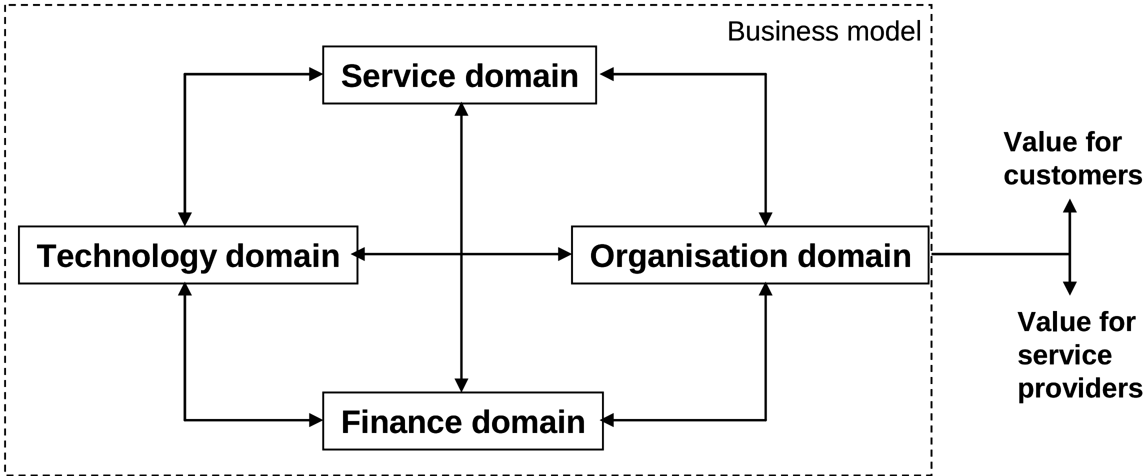


Figure 6 STOF business model domains (adapted from Bouwman et al. 2008)

STOF model is further elaborated into STOF method in Bouwman et al (2008). Designing business models with STOF method consists of four subsequent steps. In step 1 the new service idea is quickly scanned in relation to Service, Technology, Organisation, and Finance domains. In step 2 the business model outline is evaluated based on critical success factors. In step 3 the critical design issues of the evaluated business model is specified, leading to business model design. In the final step 4 internal and external issues are considered in robustness check with the goal of creating a viable and feasible business model design.

STOF model is presented here, because these living lab environments facilitate not only service development but whole new business model development. STOF model provide guidance to researchers and service developers alike in studying and testing new services and business models behind the services in living labs.

2.2 Software development

2.2.1 Software engineering

Software engineering is a layered product development system, encompassing a process, methods and tools, encircled with a quality focus. The foundation for software engineering is the process layer, which glues the technology layers together. The process also defines a framework that must be established for effective delivery of technology. "The software process forms the basis for management control of software projects and establishes the context in which technical methods are applied, work products are produces, milestones are established, quality is ensured, and change is properly managed." (Pressman, 2005)

A process framework is the foundation for a complete software process. Software framework defines a set of framework activities that are applicable to all software projects. The five generic framework activities are: communication (project initiation, requirements gathering); planning (estimating, scheduling, tracking); modelling (analysis, design); construction (code, test) and deployment (delivery, support, feedback). In addition to this, process framework encompasses a set of umbrella activities, which are typically: software project tracking and control, risk management, software quality assurance, formal technical reviews, measurement, software configuration management, reusability management, work product preparation and production. (Pressman, 2005)

The Capability Maturity Model Integration (CMMI) is a process meta-model that describes the specific goals, practices, and capabilities that should be present in software process. It is intended for organizations to help improve software processes. It defines a set of system and software engineering capabilities that should be present as organizations reach different levels of process capability and maturity. ISO/IEC 15504 and other standards define the requirements for conducting an assessment of processes. ISO/IEC 15504 standard in particular presents a reference model for international reference. ISO 9001: 2000 examines quality management within a process. (Pressman, 2005; SEI, 2008a; SEI, 2008b)

There are a wide variety of process models that define a distinct set of activities, actions, tasks, milestones, and work products. The oldest paradigm for software engineering, the waterfall model, suggests a systematic, sequential approach to software development. It contains all the five generic framework activities: communication, planning, modelling, construction and deployment. As being criticized for its sequential approach that is often inconsistent with modern realities in the software world, the waterfall model has laid the foundation for the incremental model, which produces software as a series of incremental releases. Further on, evolutionary process models recognize the iterative nature of most software projects and are designed to accommodate change. Models such as prototyping and the spiral model, produce incremental working versions of the software quickly. (Pressman, 2005) Common to all models is that they should be carefully selected according to the context of use.

2.2.2 Trends

Agile Development

Process models that emphasize project agility and less informal approach to software development process have been proposed. These so called agile process models emphasize manoeuvrability and adaptability. This kind of approach is useful in many types of project, especially when Web applications are developed. Four key issues are stressed in the philosophy behind agile software engineering: self-organizing teams; communication and collaboration between team members and other stakeholders; change is recognized as an opportunity; and emphasis is on rapid delivery of customer satisfying software. (Pressman, 2005) Agile manifesto, that crystallizes the principles of agile development, was written in 2001 by Agile Alliance (Agile manifesto, 2001).

WEB 2.0

Web 2.0 is by definition "the business revolution in the computer industry caused by the move to the Internet as platform, and an attempt to understand the rules for success on that new platform. Chief among those rules is this: Build applications that harness network effects to get better the more people use them." (O'Reilly, 2006) Web 2.0 applications can be defined as those that make use of the most intrinsic advantages of that platform. They deliver software as a continually-updated service that gets better the more people use it, consuming and remixing data from multiple sources, including individual users. At the same time Web 2.0 applications provide their own data and services in a form that allows remixing by others. This architecture creates network effects through architecture of participation. All in all the separation is between Web 1.0 and Web 2.0, the latter going beyond page metaphor of the former to deliver rich user experience. (O'Reilly, 2007)

Open Source Model

Open source software model has created much attention as an alternative way to develop and distribute software. Traditional software being proprietary, open source is to let anyone have access to the source code, so that they can modify it. Often, open source projects are referred as bazaars, i.e. marketplaces where people enter and leave, sell, buy and exchange goods. Open source can be seen as a movement, where highly skilled individuals form a community developing software. Often the quality is higher than in commercial proprietary software. Partly this is due to two facts: The individuals are highly skilled, and the reused components are best of breed, causing good code to accumulate. Loosely coupled communities keep in touch with virtual networking on the Internet. Individuals share common core values related to so-called hacker culture, including anti-capitalism values. Work in these communities is distributed and delegated. (Ljungberg, 2000; Spinellis and Szyperski, 2004)

With the context of user innovation communities, that open source communities are, von Hippel (2001) explains how the open source phenomenon is evidence that software development is shifting from companies to users. As a whole, user development communities have certain properties that support innovations that manufacturer-driven development does not necessarily support. Mockel et al. (2000) explain that in the context of Apache open source development, the developers are experienced users of the software they write. They are intimately familiar with the features they need, and what the correct and desirable behaviour is. This indicates that in open source communities the developers are also so called lead-users, linking open source model to lead-user theory (see chapter 2.3.3) and to living labs environments. The processes still do not actively utilize consumer feedback and ideas, or if they utilize, not in an integrated and continuous fashion.

2.2.3 Ecosystems

Linux

Linux ecosystem is probably the most known and widely spread open source software ecosystem. The development of Linux, or more specifically Linux kernel which is the core of Linux operating system began in 1991 by Linus Torvalds when he made the development project source code available for other developers for modifications and feedback. Today Torvalds is still coordinating the development of Linux kernel. The development community consists of about 1000 contributors from over 100 organisations, making it one of the largest co-operative software projects ever attempted. (Kroah-Hartman et al., 2008)

Motivational aspects behinds the developers of Linux have been studied and can be summarized as (i) intrinsic motivation (“fun to program”) (which was Torvalds’ main personal motive in the first place (Torvalds and Diamond, 2001)) and personal challenges to improve existing software for own needs, and (ii) social comparison motives such as competition in the ecosystem (Hertel et al., 2003). In a study of Hertel et al. (2003) developers’ engagement to the ecosystem was determined by their identification of Linux developer, by pragmatic motives to improve own software, and by tolerance of time investments. Also, it was identified that some of the development is organized in teams. Activities in teams were determined by participants’ evaluation of the team goals and by their perceived indispensability and self-efficacy. The organization of the ecosystem is mainly controlled by mailing lists such as Linux kernel. The mailing lists act as a central place to discuss about the technical and organizational aspects of kernel development. Joining and leaving the project is made easy. Even though part of the development work in not anymore done on a voluntarily basis (i.e. somebody pays) the core idea of sharing the source code publicly within the ecosystem lives strong.

Forum Nokia

Forum Nokia is Nokia’s global developer program giving access to tools, technical information, support, and distribution channel that the developers in the ecosystem can use to build and market applications for mobile devices. A professional developer can use Java technology, C++ on S60 with Symbian C++, Standard C/C++ on S60 with Open C/C++, Linux C for the Maemo platform, Flash Lite form Adobe or Python development technologies. Bringing Web sites and Web services to Nokia devices are supported with various tools like WidSets widgets. In a similar fashion, content developing to Nokia devices is supported. Forum Nokia services include: Technical support with Forum Nokia experts, Forum Nokia Launch pad for businesses working on Nokia platforms, Forum Nokia PRO for highest level of technical and business assistance, and Forum Nokia Champion that honours the top mobile developer. Forum Nokia Champion supports the fact in these kinds of ecosystems that the developers seek for appreciation among their peers. The champion of the month for example creates a sort of competitive atmosphere in the community. The services also include Forum Nokia Wiki for wealth of information, Discussion boards, and blogs. As of today, Forum Nokia has over three million registered members in the community. (eFinland, 2006; Nokia, 2008)

Google Android community

Google Android is an open and comprehensive platform for mobile devices, involving an international alliance of more than 30 handset makers and communication companies. With the new strategy, Google tries to respond quickly to the fast paced mobile services market, hoping that the collaborative Open Handset Alliance will lower the cost of developing and distributing mobile devices and services. The Android platform is an integrated mobile software stack that consists of an operating system, middleware, user-friendly interface and applications. There are plans to make Android platform available under open source license. Some analysts say Google's success in drawing a wide group of mobile industry players to its technology marks a sharp contrast to Microsoft, which tries to win support for a mobile Windows OS. (Google, 2007; Waters and Taylor, 2007)

A recent evidence of the spread of open source –like ecosystems came after Nokia announced in June 24, 2008 that it buys the rest of Symbian shares (the rest 52 percent that it did not already own) and make it a mobile open source development foundation. The move from Nokia's side is directed towards Google Android open source development community, some analysts' say, others pointing out that the creation of Symbian Foundation is evidence that *Linux* has become a threat to Symbian. (Ibison, 2008; Albanesius, 2008)

2.2.4 Testing

Any testing that is to be done to a software product, at any phase of the process, must incorporate test planning, test case design, test execution, and resultant data collection and evaluation. A number of software testing strategies have the following generic characteristics: (Pressman, 2005)

- To perform effective testing, formal technical reviews should be conducted to eliminate much of the errors before actual testing begins.

- Testing begins at the component level and expanses towards the integration of the system level software product
- Different testing techniques are appropriate at different points in time
- Testing is conducted by the developer of the software and for large projects a independent test group
- Although testing and debugging are different activities, debugging must be accommodated in any testing strategy. Figure 7 illustrates the debugging process.

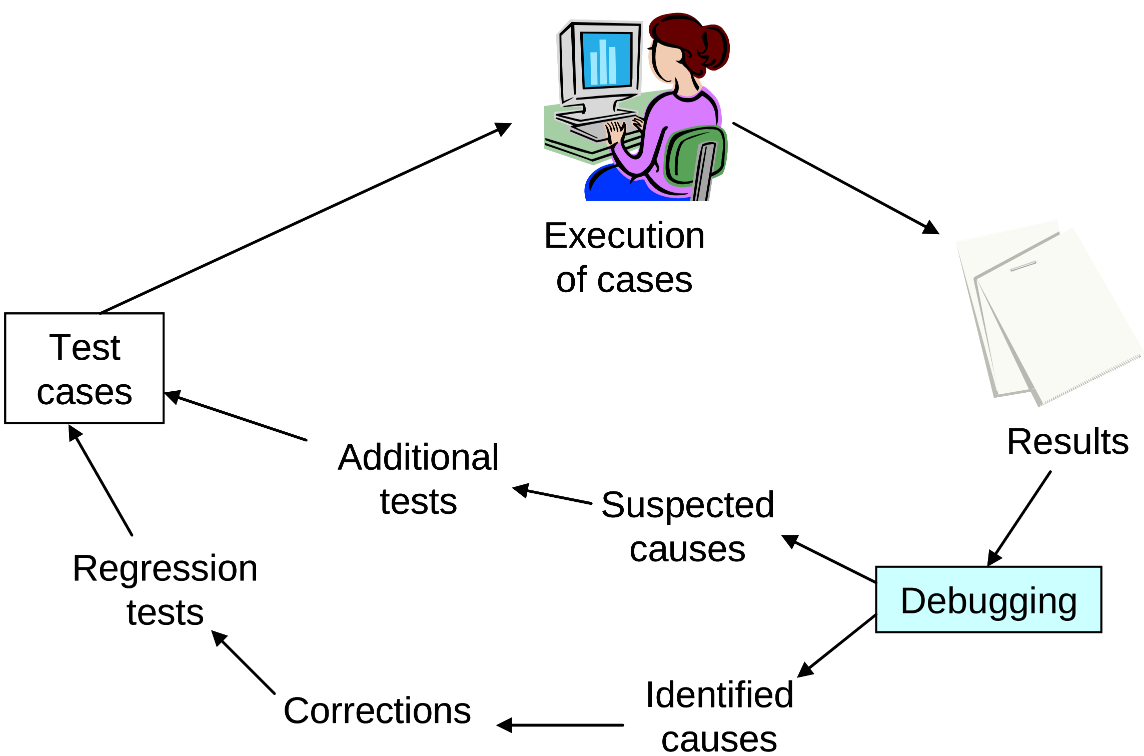


Figure 7 The debugging process (adapted from Pressman, 2005)

Testing begins in the construction phase of software development when a piece of software has been coded. In the first phase unit testing is conducted, focusing on the smallest unit of software design – the software component or module. This is usually done by the developer him/herself in a single native system. Unit testing includes considerations such as interface, local data structures, boundary conditions, independent paths and error handling paths. Unit testing targets the extraction of obvious coding errors. As the unit or component is not a stand-alone program, driver and/or stub program must be developed for each unit test. This on the other hand requires some effort. As in all testing, when there are tight schedules and tight resources, one should focus only on the most critical modules and those with high cyclomatic complexity, and test those. (Loveland, 2004; Pressman, 2005)

Integration or Function Verification Test (FVT) follows after unit testing. FVT considers the integration of modules. It is a "systematic technique for constructing the software architecture while at the same time conducting tests to uncover errors associated with interfacing". This phase focuses on validating the features of entire function or component. FVT is usually done by a separate testing team, having an objective view of the software. The tester should prefer incremental integration over combining all components in advance and then test. Is possible, FVT could be conducted in virtual environments to have cases with multiple users tested, but as this test phase takes also some resources, one should balance between cost – benefit axel and use wisely different tools to improve efficiency. (Loveland, 2004; Pressman, 2005)

System Verification Test (SVT) takes all the software components and tests them in a single software unit for the first time – the code is now being viewed as an entire product. At this phase simultaneous users are introduced to get realistic usage loads. The software is exposed to heavy load and stress by thousands of simultaneous clients and requests. The software is pushed to its limits to ensure the interoperability of new and old functions. SVT views the software from the viewpoint of a customer seeing the software for the first time. For example product migration from version to another and multiple version coexistence across loosely coupled or clustered system is tested.

The next phase, Performance Verification Test (PVT) must be included in to the testing process, to focus on how fast the program runs. Coupled either to the design phase of software, or identified by customer executing the program, PVT concentrates on performance sensitive areas of software. Performance is measured, documented and analyzed, followed by improvements in an iterative fashion until satisfaction is attained. Interestingly PVT teams do not try to break the software as the SVT team tried to do. PVT requires a smooth operating of the software to be able to measure it.

Integration test is next in testing process presented in Loveland (2004) (also known as acceptance test). Here the software is tested in simulated customer environment, being integrated into the foreign environment. Integration test takes the big picture approach where the new software is just one of many elements in customer site. Not all programs face this test phase, as it is not important for example in stand alone applications. Also, this test is often done in parallel with beta test, which is the same as early customer test. Sometimes this test can continue even after general availability of the product. The goal can be stated as being a one step ahead of the customer, improving usability among others. (Loveland, 2004)

Alpha and Beta testing is conducted because it is virtually impossible for a software developer to foresee how the customer or end-user will actually use the program. For example instructions for use may be misinterpreted, unusual combinations of input or strange combinations of data may be regularly used, or output that may have seemed clear to tester may be unintelligible to the end-user. Alpha and beta testing are considered when software is developed as a product to be used by many customers – a case in which it is impractical to perform formal acceptance tests with each customer. Here the responsibility of uncovering errors is given to the user.

Alpha test are different from beta tests so that alpha test is conducted at the developer's site by end-users, and beta test is conducted at end-user site by end-users. Alpha tests are done in a controlled environment and the developer is "looking over the shoulder" and recording errors and problems in usage. Unlike in alpha testing, the developer is not present in beta testing. Ideally the end-user records all problems in beta testing and reports them to the developer. As a result of problems reported during beta test, the modifications are made to the software. Beta test can also be the first customer shipments or an early support program. (Loveland, 2004; Pressman, 2005) Kangas and Kinnunen (2005) present a case study in which a 3^{rd} party mobile application development company used beta tests in various iterations for their smartphone application. The testing bore excellent results to improve usability and user interface of the product. This case demonstrates that especially in 3^{rd} party mobile applications, where the customer is different from the end-user, beta testing or field testing is an effective way to improve the product.

Testing in fast feedback environments

Ultimately, in every software project, the success of the product will be determined by the business value generated by the product. Time-to-market is an important metric for new software. Traditional software development models such as the waterfall-model are not enough because of slowness to the market and dependency between test phases. In classic waterfall-model, the entire pool of code is delivered before the test phases begin. This is usually challenging. A modification of waterfall-model with some common elements is waterwheel-model. Keeping the same upfront activities of waterfall-model, waterwheel-model have staged development and testing phases. The waterwheel-model is claimed to foster continuous feedback between the development and test teams. (Loveland, 2004)

Iterative software development models have been introduced in chapter 2.2.2 (agile methods). This has an implication to testing processes as well. In an agile method such as XP, feedback is an important element to create the design of the product, whereas in traditional models feedback is used to fix errors. The philosophy is different. XP also makes use of the test-driven development feature. In a test-driven model the developer is constantly considering the tests the code must pass. Those tests that the developer does not consider, XP addresses through customer/end-user feedback mechanism. Suitable from small to medium-sized projects, iterative methods are quite effective for addressing time-to-market challenges. (Loveland, 2004)

Open Source Software (OSS) ecosystems possess interesting traits in terms of testing and getting feedback. One of the most renowned open source projects has been the development of Apache web server. In a case study by Mockus et al. (2000) the characteristics of Apache development process is studied. In the development process of Apache, each developer iterates through a common series of actions while working on the software source. These actions include problem discovery, determining a volunteer to work on the problem, identifying a solution, developing and testing the code within a local copy, presenting the code changes to the Apache Group for review, and committing the code and documentation to the repository. In identifying a solution -stage, the (possibly) alternative solutions are posted to the developer mailing list in order to get feedback from rest of the developer community. The code is often reviewed by many people outside the core development community, resulting in useful feedback before the formal released package. Mockus et al.

also make the hypothesis that OSS developments exhibit very rapid responses to customer problems. Indeed it can be stated that OSS development enable fast feedback cycles between developers and end-users.

2.2.5 Challenges

In turbulent and dynamic mobile market new services have to be developed quickly (Blazevic et al., 2003), and the responses to rapidly changing needs and demands have to be almost instantaneous (Bouwman et al., 2008). Useful applications and profitable business models can only be designed by focusing on users' needs (Gerstheimer and Lupp, 2004). When considering mobile applications built to smartphones it can be difficult to trace customer requirements to the software, because it most likely will be something novel and innovative. Thus, it is virtually impossible to know what user will want because such a thing does not exist. This depicts another challenge in terms of quality and design of the product. Certain types of applications such as mobile games possess qualities such as "fun", that are very difficult to test a priori (Abrahamsson, 2005). Also, as the customer of the product is not always the actual end-user, which is the case in 3rd party mobile application, end-users and customers may have contradicting expectations and needs towards the product. In reality, some mobile software projects are carried on with such a fast pace, that there is no time to conduct user needs study (Kangas and Kinnunen, 2005). Taking these challenges into consideration, the actions for *verification* (set of activities in testing processes that ensure that software correctly implements a specific function) could be done to some extent, but *validation* (a set of activities that ensure the software that has been built is traceable to customer requirements) is more difficult. Thus, user-centric design and field tests (alpha, beta) in possibly living lab like environments could provide solutions to 3rd party mobile application success.

2.3 Living labs

The Living Lab concept originates from MIT, Boston, Professor William Mitchell, MediaLab and School of Architecture and city planning. According to his definition, "*Living labs represent a user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts*."

(Eriksson et al., 2005) On the other hand Ballon et al. (2005a) defines living lab as "*An experimentation environment in which technology is given shape in real life contexts and in which (end) users are considered 'co-producers'*." In Figure 8, Nuria de Lama, a consultant from Atos Origin illustrates Living labs in relation to other test platforms. De Lama sees Living labs as the answer to industry's service innovation efforts.

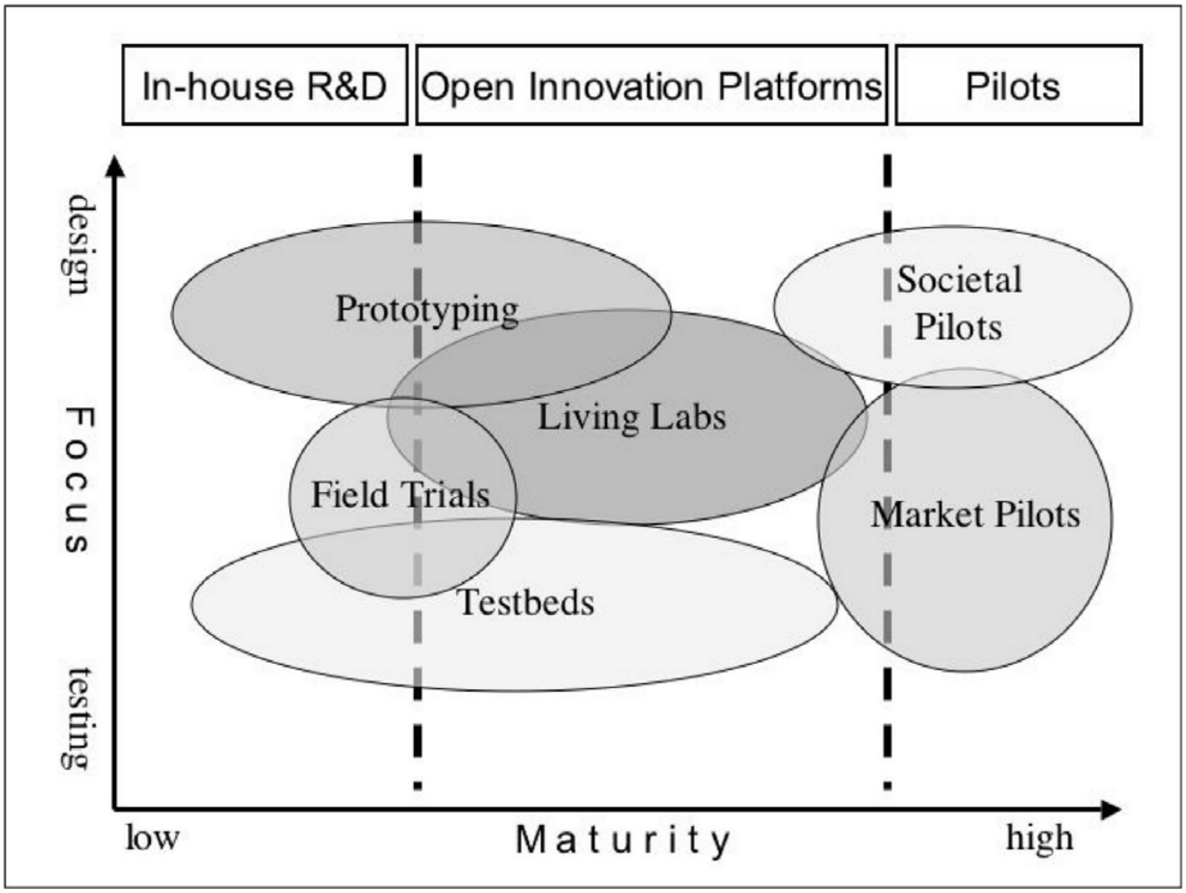


Figure 8 Living labs in relation to other test platforms (adapted from de Lama, 2006)

Ballon et al. (2005a) define the concept of testbed as "a standardized laboratory environment used for testing new technologies, products and services and protected from the hazards of testing in a live or production environment." Clearly, the definitions are congruent with the positioning of testbeds and living labs in Figure 8.

Oulasvirta (2008) sees a living lab as a research platform, not merely as a research method. On top of the platform many different methods can be used. When stripped down to pieces, five common factors can be found to the research done within living labs:

1. **Scale** – The magnitude of factors in the research domain is larger than has been possible with the conventional methods.
2. **Naturalistic nature** – The research is done in natural conditions, at least outside the laboratory.
3. **Technology centricity** – The information produced in research is primarily concerned of some technological prototype.
4. **Partiality of the control** – The events in research (process) are only partially under control.
5. **Constructivism** – The objective of the research is to create constructive understanding, which is useful in planning and decision making.

Ståhlbröst (2006) discusses the nuances and differences between testbeds and living labs. Testbeds are environments in which tests are performed in a closed and controlled environment, whereas in living labs technology is tested in real life contexts and end-users are in an important role. On the other hand, the terms testbed and living lab are rather new and thus evolving, along with other terms presented in Figure 8. Given this, the terms are not set in stone and are used in different contexts quite vaguely.

Especially consultants and marketing people seem to have adopted the term living lab for their use in many contexts. The wide use of the term living labs in many contexts, whether in designing, or in testing, or practically almost any endeavour in which technology and its users meet, is causing an inflation of the term (refer to Figure 8). (Mäntylä, 2008)

The challenge of living labs methodology lies in its design. Different stakeholders must be drawn together, including local partners from user groups, public or civic sector participation parallel with private sector technology and service providers. It requires a wide understanding of innovation processes, especially in the context of fundamentally changing society. (Eriksson et al., 2005)

The motives to bring services to living labs may vary from provider to another. Applying the STOF model presented in Bouwman et al. (2008) to living lab environments, four different kinds of motives can be distinguished. Bringing services to living labs environments can be done for the sake of *marketing*. In this case the major driver is to introduce the product to potential customers, to get market attention, publicity, and in this way be more prepared for the actual market introduction later on. The second major driver can be *debugging* the service. Technical solutions that have not been tested with end-users are seldom ready for the market and it is useful for them to go through an end-user testing. This is traditionally the focus in testing environments, to ensure the enhancement of the technical aspect of the product. The third driver, *innovation* is included, because in living labs end-users can innovate by suggesting new features and functionalities to the service. This is different from debugging, it goes beyond it. Actually innovation is unpredictable, but desirable. Finally, in living labs there is ideally a wide sample of end-users. When the service is brought to living lab and used for a while, *user profiles* can be distinguished. It is valuable for the service provider to know what kinds of users use their product. Once the product has a better identified target segment it has clear implications to the marketing efforts of the product.

2.3.1 Categorisation

Future Computing Environment Group

The Future Computing Environments research group from Georgia Tech studies ubiquitous computing with the help of living laboratories. The study relates to human-computer-interaction. Living labs are critical to their research as it is possible to extensively experiment with prototype environments. In living labs or laboratories they can experience, analyze and improve the technologies they invent. They have studied futuristic computing applications in everyday-life, such as in the classroom, office and home. The projects include: Classroom 2000, the Wearable Computing Project, the Aware Home and the Augmented Office. Next these projects are discussed.

Classroom 2000 is an attempt to study the impact of ubiquitous computing on education. A prototype classroom environment captures rich interactions that occur on a typical university lecture. The streams of interaction are integrated together to an easily accessible interface. This way the need for verbatim note-taking is reduced, and students are allowed to hopefully better engage in and understand the classroom discussion. During four years of Classroom 2000 research effort over 100 classes have been taught.

In Wearable Computing project, Dr. Starner has worn a custom wearable computer since 1993. Living with these technologies have enabled the researchers to uncover new issues and opportunities in areas of augmented memory, augmented reality, intellectual collectives, and wearable sensing.

Aware home is devoted to multidisciplinary exploration of emerging technologies and services for the home. Research areas are Chronic Care Management in the Home, Future Tools for the Home and Digital Entertainment and Media. The produced environment is capable of knowing information about itself and the whereabouts and activities of its inhabitants. (Georgia Tech, 2007)

Augmented Offices seeks to study additive visual peripheral displays in human-computer interfaces. The displays are seen as natural extensions to present-day office computer screens. For this research a system, Kimura, has been developed. Using peripheral displays, this system assists users to manage multiple working contexts. Background activities are visualized as montages, to remind the user of past actions. Principally this perceived activity information could be applied effectively to support office workers. (Georgia Tech, 2008; Abowd et al., 2000)

LivingLab – A major research initiative of the Eindhoven University of Technology

Markopoulos and Rauterberg (2000) explain LivingLab, a research initiative at the University of Eindhoven. In this concept LivingLab was planned to be a building providing temporary residence to experiment subjects. During their stay, the inhabitants would experience a range of novel technologies in situations as life-like as possible.

Observation of inhabitants of LivingLab is supported with audio and visual recording devices, high-bandwidth telecommunication infrastructure and supporting services. Issues, such as privacy are addressed, and the inhabitants are aware, or even remain control of being observed. This requires designing observation equipment in liaison with the inhabitant. Whatever the conditions are, they allow the realism of daily life. The monitoring conditions affect as little as possible to the natural activities of LivingLab inhabitants.

The paper presents the concept and outlines the research agenda. Enriched by LivingLab “use-cases”, or scenarios of futuristic home-related utilitarian and hedonistic technologies and services, the paper is a good plan. [At the time when the paper was published (2000), the project was planned to last approximately ten years. However, at the time of writing this thesis, no information of the project was available. Thus, the conclusion is that we can not say anything about the results, achievements, or added value to the industry of that project.]

European Network of living labs

European network of living labs comprises of 50 different living labs across Europe. On a high level, these living labs focus on innovation lifecycle, stakeholder co-creation and user-centred development. Typically stakeholders in these projects are municipalities, small to medium sized companies, universities and research centres. Mobile and broadband technologies are strongly represented. For many projects, the first obvious tangible phase has been a building of fast broadband, mobile (GSM, 3G), or free wireless LAN network. (Enoll, 2008)

Testbed Botnia

Also a member of European Network of Living Labs, Botnia Living Lab proposes an interesting environment. Also called as Testbed Botnia, it provides an end-user test environment particularly for mobile services. The project is based in Sweden, Luleå University of Technology, in the Centre for Distance spanning Technology. The original idea for the project dates back to 1999, when two projects started and later developed into Testbed Botnia.

Testbed Botnia has over 6000 private end-users registered to a web-based virtual meeting place where they take part in new tests. The web-portal is actively promoted to public with a goal of having 10000 end-users in it. Testbed Botnia offers support in any phase of the service development, and usually ideas are taken to Testbed Botnia for the length of the whole development process, to get continuous feedback. Ideas as well as prototypes can be evaluated with different methods such as surveys, and supported by the technical platform and research methods developed together with scientific partners.

Testbed Botnia operates within three main areas; technical platform, consultation/evaluation of the innovations, and end-users. The technical platform is a service network with service nodes and access interface. The service nodes are accessed by the applications over an interface. Application providers can either connect their application servers to the local network, or have an access to the testbed over the Internet. Application providers receive consultation and related services from the testbed experts. The ideas are studied with the help of end-users in an interactive manner to get fast and accurate feedback. (Ståhlbröst, 2006; Testplats Botnia, 2008)

2.3.2 Lead-users and early adopters

Von Hippel (1986) defines lead-users as “users, whose present strong needs will generalize to the mass market months or years in the future. Since lead-users are familiar with conditions which lie in the future for most others, they can act as a need-forecasting laboratory for marketing research. Moreover, since lead-users often attempt to fill the need they experience, they can provide new product concepts and design data as well“.

There is evidence that lead-users have co-developed successful products (von Hippel, 2005). Von Hippel defines the lead-user concept of the 21st century, by introducing horizontal innovation networks (von Hippel, 2007). In these networks end-users are user/self-manufacturers. One of the most recent perceived embodiments of these kinds of networks are open source software development communities.

Rogers (2003) have laid the foundation of innovation diffusion research. The author classifies adopters of innovations in five groups, depending on how long time has been passed when the group adopts the innovation. The two most important groups for this paper are presented: *Innovators* are those that typically adopt the innovation first. Being an innovator has several prerequisites, one being the ability to cope with the uncertainty about an innovation at the time he or she adopts. *Early adopters* are those, who mainly serve as role models to many other members of a social system. Early adopters help trigger the critical mass, since they are respected by their peers, decreasing the uncertainty about a new idea.

Whether the terms lead-users, innovators, or early adopters are used, there exists direct implication that those user groups are the ones that could act as main end-users in living labs. These kinds of leaders – brave, unprejudiced, even risky individuals are of valuable sources of information, constituting the core user groups to be studied in living labs.

2.3.3 Innovation management

Often, innovation management is considered in a purely organisational context (Trott, 2008). However, individuals are an important element of an innovation process. Innovation processes has not been studied in the context of living labs, but the expectations are high that living labs will shape as successful innovation systems (Living Labs Europe, 2008; OpenLivingLabs, 2008).

Ballon et al. (2005b) discuss widely test and experimental platforms, of which living labs is a category. These platforms are facilities and environments for joint innovation including testing, prototyping and confronting technology with usage situations. Also, these environments are open and innovation-oriented platforms that involve various technology and service providers as well as users in different stages of technology design, development and testing.

Innovation is a process of seeking and obtaining competitive advantage – requiring risk. It is claimed that test and experimental platforms are relevant in three major ways: by enabling industrial research, pre-competitive development and other innovation activities; by introducing innovations in a specific competitive milieu; and by spreading and mitigating the cost and risk associated with innovation activities. (Ballon et al., 2005b)

Living labs are based on the notion of users as co-producers of ICT, characterised by openness and confronting users with technology early on in the innovation process. The approach has three main advantages especially in terms of lowering risk associated with innovation. First, living labs help in developing more context-specific insights on development and acceptance process and especially the interaction between both. Second, these experiments inform us about the possible conditions for simulating the societal and economic embedding of technology. Third, embedding technology in real life situations reflects the potential societal impact of innovation. (Ballon et al., 2005b)

2.4 Data collection

On a general level, data collection methods can be grouped according to whether they use secondary or primary sources of data (Aaker et al., 2007). *Secondary data* is the type of data that is already available, because it is collected for some other purpose than solving the present problem. *Primary data* is the kind of data that is collected especially to address a specific research problem. Because different methods serve different purposes, a researcher often uses several in sequence, so the results from one method can be used by another. Or, as some studies to be presented in the following chapters show, the results of different methods can be used crosswise, with statistical regression methods for example.

In this chapter the data collection methods used in previous research on mobile services usage is presented to introduce the reader to relevant issues for this thesis.

2.4.1 Handset-based methods

Mobile handset-based data collection can in principle be used to detect what user does, when, or where user uses mobile phone. In Verkasalo (2005) and Verkasalo and Hämmäinen (2007) the authors present a novel data collection method that can be used in Symbian smartphones, in specialized panel studies. The platform is based on a developed Symbian 60 smartphone client that observes all kinds of actions taking place in the handset. Usage log information on any application, network or user interface level action in the handset is collected with time stamps to centralized server. Users in these panels are volunteering. This platform is effectively used in conjunction with surveys, when datasets from actual usage is compared to survey results and used crosswise (Verkasalo, 2008b). In Figure 9 the principal process of capturing and utilizing subscriber data is presented. Descriptive statistics are used for the datasets. Accurate results are presented for communication usage, application usage (usage frequency and intensity) and packet data service usage (Verkasalo and Hämmäinen, 2007).

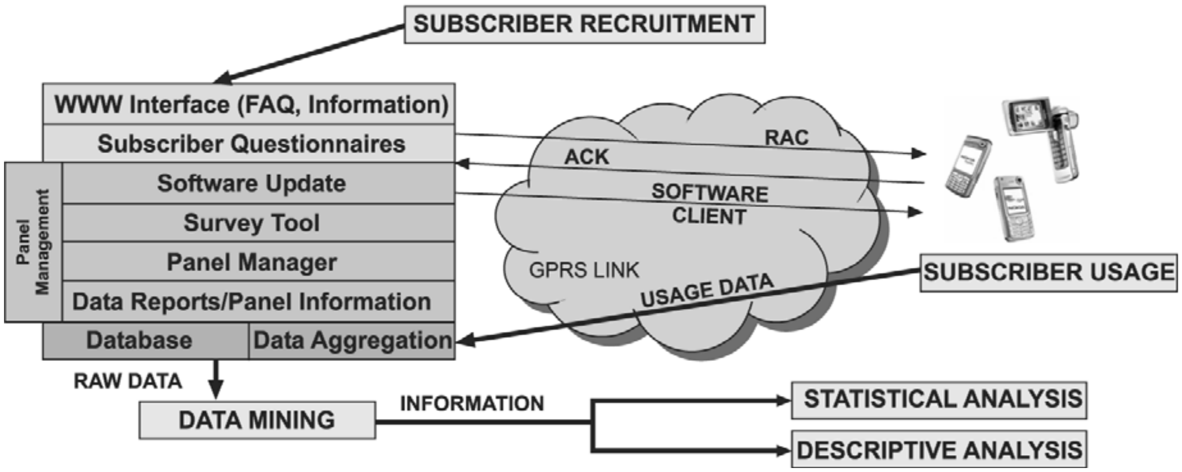


Figure 9 Handset based measurement (adapted from Verkasalo and Hämmäinen, 2007)

Another embodiment of the handset-based measurement platform is developed with an approach to help developers more easily create applications that integrate into both existing technologies and users' everyday lives (Raento et al., 2005). The platform called ContextPhone, unlike not being a proprietary system as the one used in Verkasalo and Hämmäinen (2007), is well documented. The ContextPhone platform contains four modules:

- *Sensors* acquire context data from different sources, such as location (Cell ID and GPS) or phone use.
- *Communications* connect to external services via standard Internet protocol using GPRS, Bluetooth, SMS, and MMS
- *Customizable application*s – such as ContextLogger, ContextContacts, and ContextMedia – can seamlessly augment or replace built-in applications such as Contacts and Recent Calls lists.
- *System services* automatically launch background services, error logging and recovery, and the status display.

Both Laasonen et al. (2004) and Eagle and Pentland (2005) use handset based measurement in their studies of adaptive on-device location recognition and complex social systems respectively. Laasonen et al. (2004) present a novel adaptive framework for recognizing personally important locations in cellular networks, implemented in mobile devices. They construct a conceptual framework for the tasks of learning important locations (of end-users) and predicting the next location. Eagle and Pentland (2005) study social systems with data collected from dozens of mobile phones. They are able to use standard Bluetooth-enabled handsets to measure information access and use in different contexts. With the help of proximity log of the Bluetooth-devices, they figure out and model complex social systems. The mobile access network cell-ID tags and Bluetooth connection tags among others are collected with software that runs continuously on mobile phones. Salmeron (2008) further utilizes the method of collecting mobile network cell-IDs in order to detect end-user contexts, such as home, office, on-the-move, and abroad. These and other presented studies imply that the applications to utilize handset-based measurement data are numerous (Greene, 2008; Kivi, 2006) for example in marketing research, social sciences and pervasive computing.

2.4.2 Network-based technologies

In Kivi (2006) network elements based data collection has been divided to reporting system based data collection, and packet data traffic measurements. In this chapter an overview to these methods is presented alongside to server side measurement.

Data collection with operator reporting system

Mobile operators' charging oriented reporting systems provide a source of general level service usage information. Charging Data Record (CDR) databases and billing systems are two separate reporting systems that can be used for the whole subscriber base.

CDRs provide so called ticket information that is time-stamped. CDRs register the mobile subscriber by IMSI code, the used mobile terminal by IMEI code, and the used service, which can be for example voice call, SMS or packet data traffic. The billing system then combines aggregated CDR data with tariff information, i.e. merging CDRs to billing system. Subscriber specific data such as demographic factors can also be linked to usage data, depending on the implementation of the reporting capabilities of operator's information systems. In principle, an unrestricted access to CDR databases or customer registers would enable to uncover usage patterns by using sophisticated data mining techniques. This type of information does not however refer to the actual end-user but to the payer of the bill. Also, as the accounting systems refer only to the SIM card, it can be attached to any device, not the actual end-user device. (Kivi, 2006; Kivi, 2009)

Packet Data Traffic based measurements

Packet Data Traffic measurements such as TCP/IP traffic measurements are a common research approach in technologically oriented studies, thus there exists standard tools for collecting TCP/IP traffic traces. Mobile device originated packet data traffic can be measured at various places in the network. In TCP/IP measurements the network architecture plays an important role, as points of convergence of mobile data traffic should be identified in the network for comprehensive and representative measurements. In GSM/UMTS networks there are centralized points for measurements, since the traffic to and from mobile terminals are routed to external networks via just a few places.

Some mobile terminals have WLAN network interface, thus the data traffic can go through WLAN when on suitable coverage area. The measurements are a bit more problematic than in 2G/3G networks, due to the small number of individual WLAN hotspots and lack of centralized routing in large city wide implementations. Traffic should be captured at the backhaul connection near the router connecting several WLAN access points to wired network. Kivi (2006) treats the issue thoroughly.

With network based data traffic measurements it is also possible to detect what kind of mobile device the user uses, by identifying the end-user device operating system software. By avoiding the use of application layer data, a method called TCP OS fingerprinting can be used. Once the OS of the device is detected, for example laptops can be distinguished form mobile phones. (Kivi, 2009)

Server Side Measurements

Mobile service usage data can, in addition to handset-based measurements and network elements based measurements, be collected from the log files at various servers. These servers include for example portals and individual WEB/WAP servers, search engines and proxy servers. Background data on the registered users of a service might also be available. The limitation of this method is that the data is naturally limited to the users of the service in question. (Kivi, 2009)

Usage data can be obtained from numerous sources as we can see from Figure 10. The most straightforward method is survey studies (discussed in next chapter) made for actual end-users (Kivi, 2009). This subjective source of information combined with objective data points recording actual usage provides versatile information for many research domains.

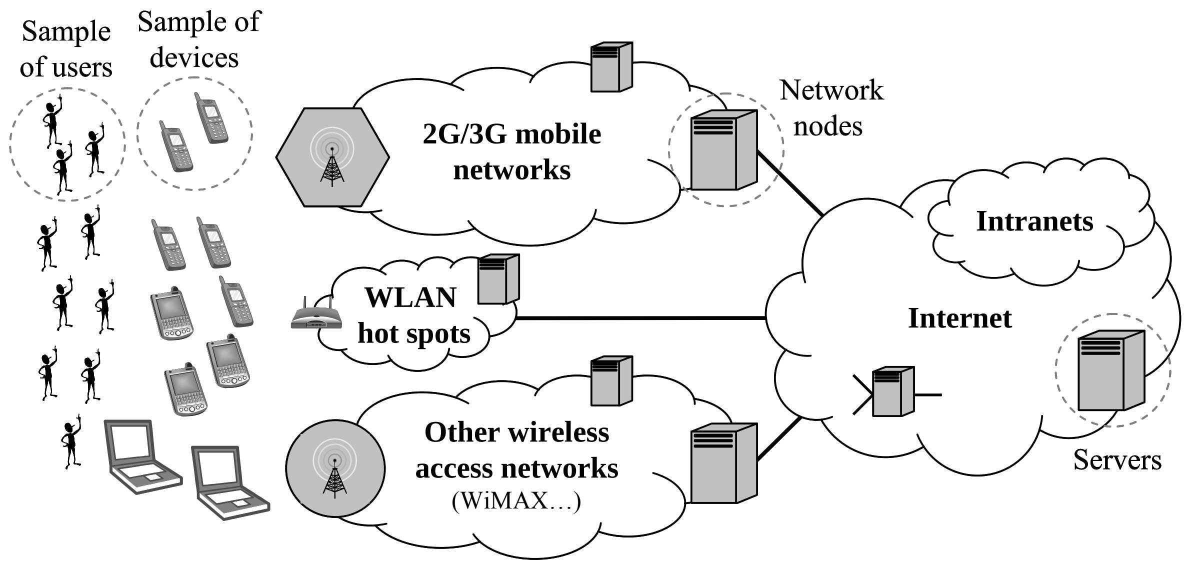


Figure 10 Sources of data (adapted from Kivi, 2009)

2.4.3 Survey studies

Surveys gather subjective information, whereas handset-based and other technical solutions are able to measure objectively handset usage. On the other hand surveys provide access to qualitative information about service usage. End-user satisfaction and opinion levels can easily be measured with surveys, thus making it an essential tool in the context of prototype application/service testing framework.

In marketing research surveys are used to capture a wide variety of information. Information on attitudes is obtained in the form of consumers' awareness, knowledge, or perceptions about the product, its features, availability, and pricing. Surveys can also capture respondents' overall assessment whether the object is rated as favourable or unfavourable. A wide range of information can be collected with surveys, such as respondents' attitudes, values, beliefs, and past behaviour. Measuring behaviour usually involves four related concepts: what the respondents does or does not do; where the action takes place; the timing, including past present, and future, and the frequency of behaviour. Social contact and interaction are often the focus of survey research – family setting, memberships, social contacts, reference groups and communication of respondents being measured. Demographic factors such as age, sex, marital status, education, employment, and income can be obtained through surveys. Personality, motivation and knowledge are also measured using surveys. Then again, survey responses depend always on the respondents' motivation, honesty, memory and ability to respond. While pursuing to have a random sample of the population selected for the survey, the actual respondents are usually self-selected, leading to a situation where the characteristics of the whole population cannot be obtained from the sub-set of the population. Moreover, respondents and researchers may have different interpretations of the survey questions and answers, thus attention should be paid to question formulation. (Rossi et al., 1983; Aaker et al., 2007; Kivi, 2009)

Surveys have been used recently in conjunction with handset-based data for example in Verkasalo and Hämmäinen (2007) and in Tirkkonen et al. (2008). Valuable crosswise information is obtained for example of intention to use the service, which is obtained through a survey, and of actual usage of the service, which is obtained through a handset-based measurement (see Figure 11).

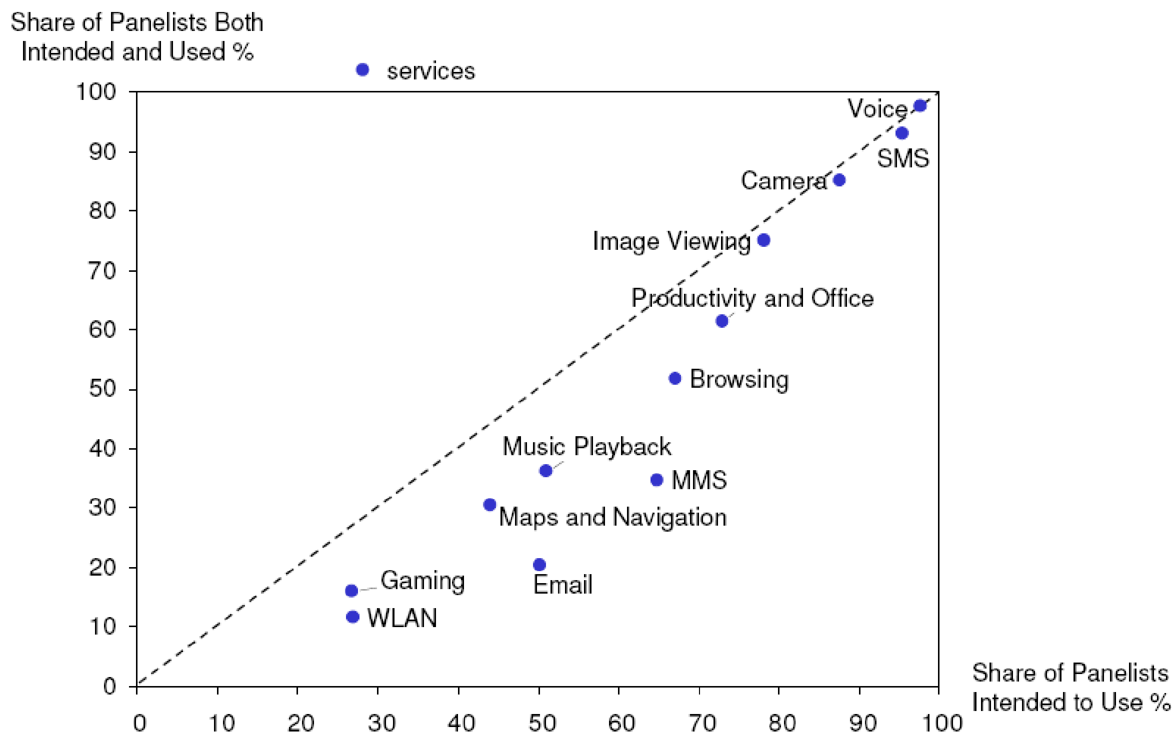


Figure 11 Mobile service intention vs. usage (adapted from Tirkkonen et al., 2008)

Mobile surveys are a novel way to collect information from respondents. As a part of the newly developed handset-based measurement platform, mobile surveys are triggered in the client itself, and answered through mobile phone interface. For example the client can be triggered to ask a mobile question regarding a specified service right after the usage session of the service has ended. In this way instant information about the usage experience can be collected from the respondents. (Kivi, 2009) The method has been used in several studies made with handset-based measurement platform. (Verkasalo, 2007a; Verkasalo, 2007b)

Already in the 1980's, end-user satisfaction on computer programs were researched. Doll and Torkzadeh (1988) used personal interviews in their research, but the similar questions can be asked with survey forms, as was done by Gelderman (1998). Gelderman used surveys sent by mail to the respondents. The purpose was to measure end-user satisfaction to used information system. Ståhlbröst (2006) also uses surveys in her study of mobile service evaluations. In that research, surveys are a part of toolkit, used in parallel with other measurement methods. Other studies (Verkasalo, 2008b; Kivi, 2009) have also highlighted the need to use both objective and subjective methods such as surveys in end-user studies.

Especially Kivi (2007) points out the possibilities of handset based data measurements in parallel with mobile surveys.

2.4.4 Interviews

Interviews can be considered parallel by surveys, as they collect subjective information from respondents. Four types of interviews can be chosen depending of the goals of the evaluation; unstructured, structured, semi-structured, and group interviews. Interviews can be done either face-to-face, or by phone. Focus group interviews on the other hand involve several people discussing the matter, which, along with open ended questions and follow-up questions, are flexible methods to gather information, but require special skills from the interviewer. (Ståhlbröst, 2006; Preece et al., 2002) On the whole, interviews are an expensive and time consuming method for both respondents and researchers.

2.4.5 Laboratory studies

In usability engineering, evaluation of a product can take place in a laboratory. As usually end-users are involved, the method can be compared with the alpha-testing used in software engineering. In alpha-testing the testing of a product is conducted in a controlled environment, usually in the developers' premises or test environment. Sometimes called as usability laboratories, these laboratories are typically rooms equipped with observation tools, such as one-way mirrors to another room where the experimenters are, recording devices such as a video-camera (sometimes several cameras) or at least a microphone. Ideally, the user should be able to perform the task with the product in total isolation and peace, but compromises must be done because information must be gathered about user's performance.

Laboratory studies are intelligibly an expensive method. Apart from the premises and equipment, capable experimenters are required. Also the end-users must be compensated somehow for the effort. Portable usability laboratories have emerged with stripped down equipment to allow more flexible studies. (Nielsen 1993, Faulkner 2000) One could argue that the method could be applied to the very first prototypes of a novel product.

3 Project framework

3.1 Otasizzle – a living lab

Otasizzle is a living lab project with an objective to create experimental facilities for developing and studying innovative mobile and social media applications in the Otaniemi area, Espoo, Finland (HIIT, 2008). Otaniemi is a district including a technical university and related research institutes and companies. The aim is especially to reach larger user communities for test periods longer than typically possible in regular projects. The project requires a scalable experimental platform instrumented for collecting experimental data for multidisciplinary research of mobile service innovations. Field tests planned in the project are sufficiently large and extensive, coupled with quantitative measurements of actual service use, in order to study service features contributing to service adoption, diffusion and use. Following themes are stressed (HIIT, 2008):

- “The impact of social networks for service diffusion and use and on user experience and social impact of services in general
- The role of user innovations and emergent everyday practices in adapting services for novel and unforeseen uses
- Incentives of various stakeholders in service provision and in general the digital service economy and local service ecosystems
- Privacy and trust of mobile social media services and security issues in general
- Scalability issues of the technical service platform, especially emergent bottlenecks”

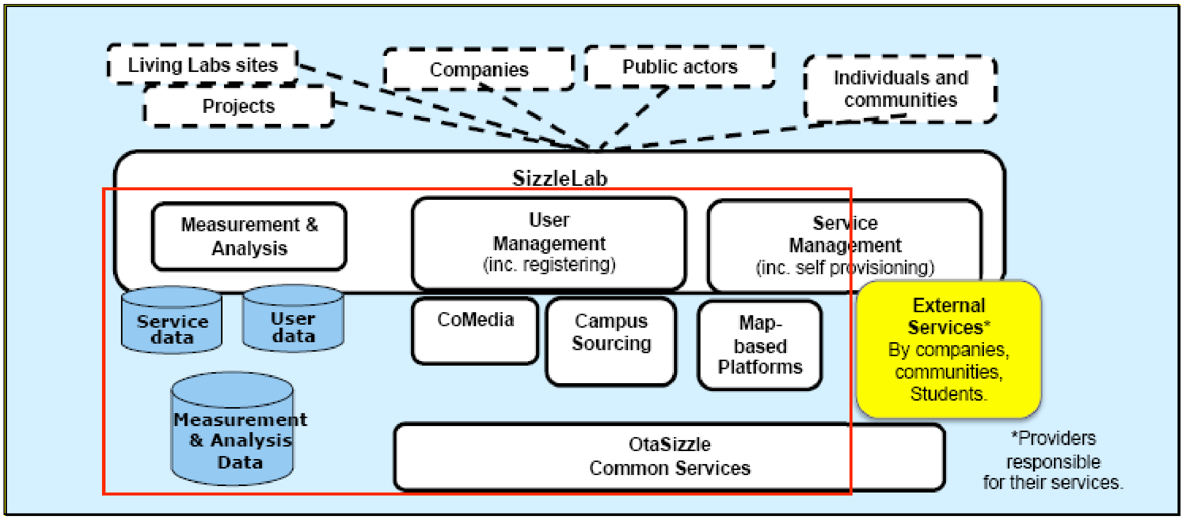


Figure 12 Otasizzle service architecture (adapted from Hämäläinen, 2008)

Figure 12 reveals the architecture of the Otasizzle concept. In the Otasizzle concept the element called *SizzleLab* conceptualizes the idea of living lab research in Otasizzle. SizzleLab is the framework via which 3rd party services are brought to Otasizzle. The measurement platform that enables end-user research is at the core of Otasizzle. The measurement platform links the user feedback in terms of subjective survey data and analyses of objective log data to software development teams, forming a feedback loop between developers and end-users. This method of measurements from several data points in a living lab context is a novel approach. It tackles issues in the alpha/beta testing of software, promising faster development cycles and more user-friendly software products.

SizzleLab provides an interface for linking new partners and acting as a launch pad for new satellite projects. Satellite projects are projects that come off from the original project in terms of its specific agenda, for example. Otasizzle research and environment can be used also in other related projects, including studies of new services, user populations, domains and geographies – thus Otasizzle is a scalable environment.

SizzleLab in Otasizzle provides an environment for testing new mobile and ubiquitous services. In the first phase user population consists of campus population that is students and university staff. In following phases the population is larger. SizzleLab provides measurement and analysis methods and tools for studying use over time. In SizzleLab a handset-based research platform along with surveys is in a central role. Research collaboration modes include experimenting with a specific service/application and a set of development tools. As the project environment matures, it extends to open source based projects where the end-users become innovators.

At pragmatic and technical levels, the core of SizzleLab is SizzleLab Portal in which information sharing between stakeholders is ensured, information publishing is enabled, and tools for collaboration, experimentation and 3rd party functions reside physically. In the early phase of the project, development work begins with a couple of pioneering software products. The approach here is bottom-up: building of a few lucrative services in order to get the first end-user masses to the continuous panels. Little by little the subscriber bases of these services are brought to the general Otasizzle Portal, where each end-user has a username and a password. With this identity information the end-user has access to every 3rd party service. This general Portal would then act as the core of the whole project, a virtual collaboration space of end-users, 3rd party service developers, research community and other stakeholders.

The research setting in Otasizzle is close to the one in neighbouring country Sweden – the Testbed Botnia living lab (Testplats Botnia, 2008). There are a few differences though: Testbed Botnia has been up and running for years now, but Otasizzle launched the platform in September 2008. Otasizzle differs from Testbed Botnia with its focus area. Especially social media applications and service adoption and diffusion are concerned in Otasizzle, but not in Testbed Botnia. Testbed Botnia is also dispersed to the whole geographic area of Sweden, with every Swede belonging to the focus group. Otasizzle has a strong research platform focus, with a smaller population, focusing on the students of one university. Testbed Botnia is more of a pure technical and consulting test platform, whereas Otasizzle concerns also social networks and other psychological research topics.

In Figure 13 some of the existing living labs are compared with Otasizzle. The comparison is made by comparing the target services, context, current status, end-users, experiment duration and investments of the living labs. There are probably hundreds of living labs out there, but many are poorly documented and they would not add value to the comparison.

Living lab	**Otasizzle**	**Testbed Botnia**	**Living Lab**	**LivingLab**
Organizer	TKK, Finland	LTU, Sweden	GIT, U.S.	TU/e, Holland
Target services	Mobile services, social media	Mobile web services	Home, office, and classroom technologies	Novel technologies at home
Use context	Mobile	Mobile	Indoor spaces	Indoor spaces
Launch date	2008	1999	1993	2000(?)
Targeted end-users	TKK students and personnel	Swedish consumers	Invited individuals	Unknown
Number of end-users (max)	100-150 *(1000-5000)*	6000 *(10000)*	1-40, varies by experiment	Less than 10
Duration of experiments	From weeks to months *(many years)*	A couple of months	From very short periods to years	Unknown
Estimated level of investments	$ *($$$)*	$$$	$$	Unknown
Associated papers	Zero *(dozens)*	Circa 10	Circa 100	Unknown

Figure 13 Living labs comparison

3.2 Conceptualization of the process

In the context of service/application development process, Otasizzle project offers possibility to study end-users with several research methods, and collect feedback to the developers. The most typical scenario of Otasizzle is that a 3rd party brings its prototype/beta-phase service/application to the project for the end-users' testing.

Services/application is typically brought to Otasizzle for continuous use. However, experiments of shorter duration for example one to three weeks can be conducted to gather feedback and help the developers work for the next release of the same service/application. Otasizzle acts as a kind of outsourced test environment for the service developers. Apart from the usage information, the developers co-design with the Otasizzle research community the survey questions and have access to the survey results later on.

3.3 Role of data collection

Within the Otasizzle, data collection has an important role not only for software development, but to study panellists' behaviour, their social relations, etc. Besides of collecting the data, equal importance has to be put on analysing the data. Multiple research questions can be studied. Figure 14 illustrates a sketch of Otasizzle environment. It is shown here that the data collection and analysis forms an essential component of the research environment.

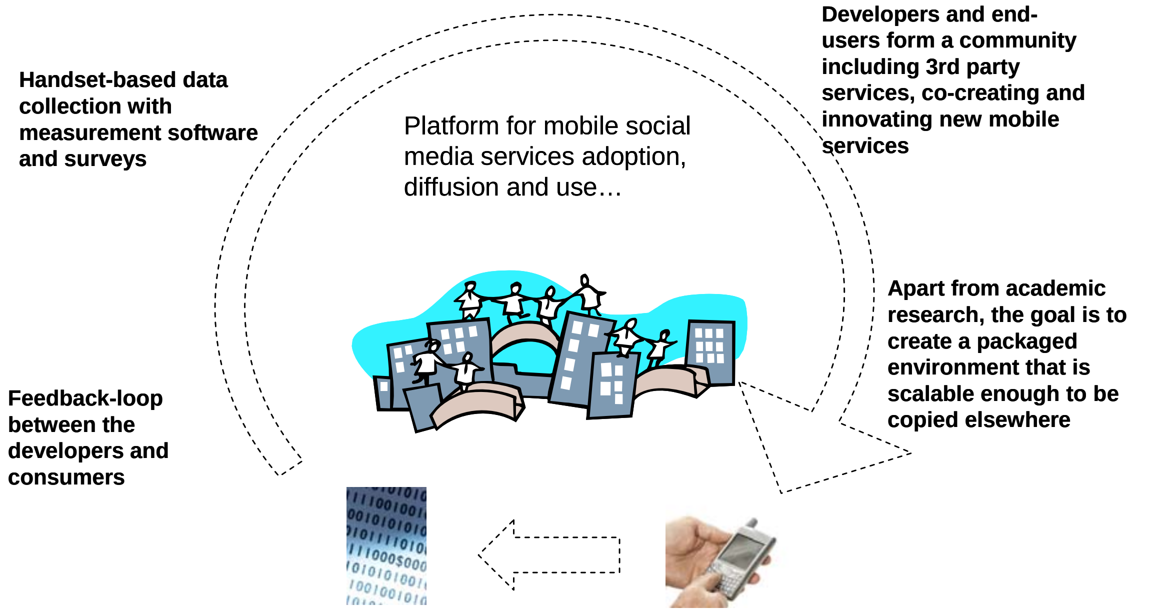


Figure 14 Otasizzle environment

In the Otasizzle environment, the service/application is brought to the platform for the users to download it to their smartphones and use it. The same users have measurement software running in the background of smartphones, recording the usage. The usage information collected from several end-users regardless of how much and which application the users have used. The usage log information is sent every two or three days to a server. Based on the log information of a fixed time period, converging reports can be made which are of help to the development teams of the services. Figure 15 illustrates this feedback cycle.

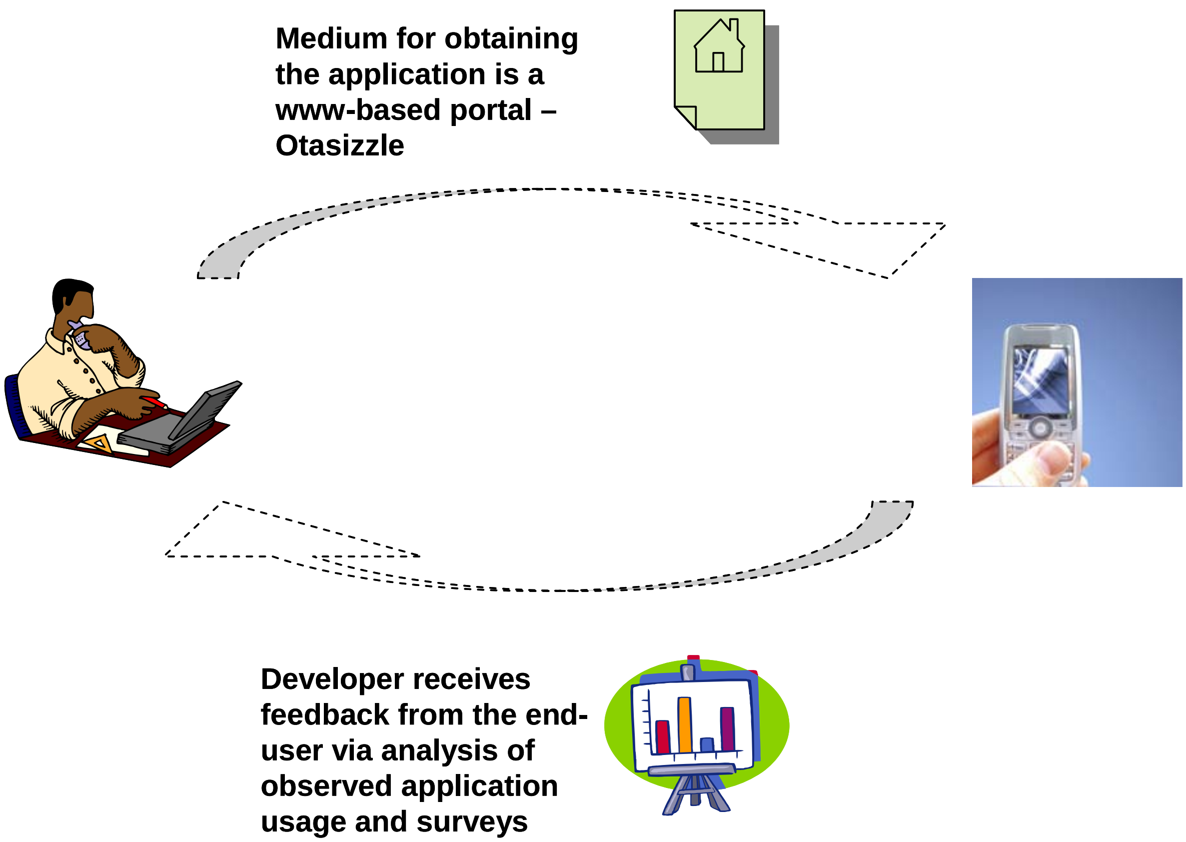


Figure 15 Otasizzle feedback cycle

Bouwman et al. (2008) suggest that the STOF method is of use in user trial experiments of prototype products. Otasizzle is particularly an environment for user trials. The typical use of STOF in user trials is evaluation of value aspects and design choices. These actions are refinement steps in the service and technology domains of STOF domains.

Innovative ways to use the STOF method in projects such as Otasizzle are provided through surveys. Alongside the typical evaluation of the service and technology domains the finance and organisation domains can also be evaluated. In the finance domain evaluation, opinions of various aspects of pricing and the perceived utility of the service to the user can be asked from the end-users. A typical scenario here could be that the users have had the service in use via Otasizzle for a couple of weeks and then they are asked how much they are willing to pay for the service, what kind of tariff structure they would prefer, would the pricing be flat fee, per session, et cetera. Pricing is an important element of service success and a tool to control the demand of the service (Courcoubetis and Weber, 2003). Pricing and other aspects of the finance domain can and should be evaluated in Otasizzle as the finance domain is as important aspect of the whole business model as the technology and service domains.

Whereas the finance domain is related to the surveys, the organisation domain is related to the whole Otasizzle environment. When a service developer brings the service to Otasizzle, it tests the whole business model, not just the technology domain. The critical design issues such as partner selection, network openness, network governance and network complexity of the organisation domain are evaluated. Figure 16 illustrates how STOF domains are related to Otasizzle environment.

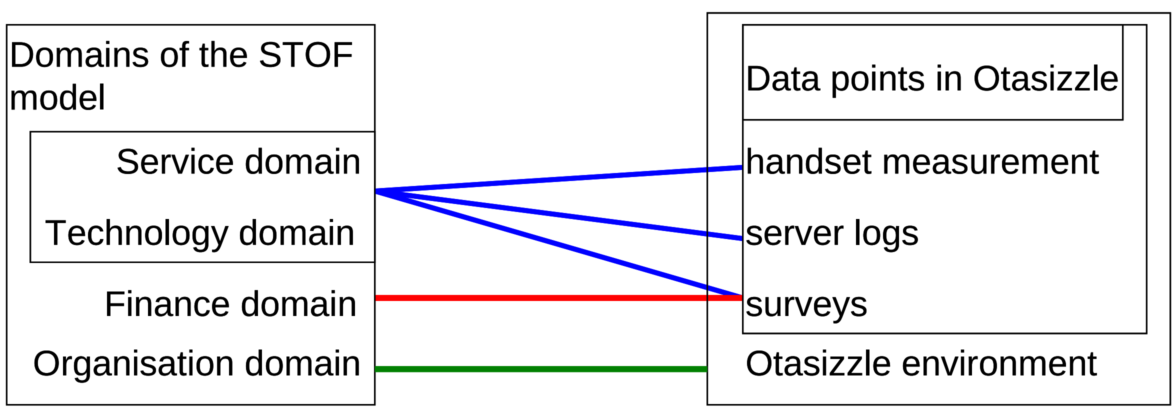


Figure 16 STOF model applied to Otasizzle

The STOF model is designed for business model designing, but is now applied to mobile service evaluation in a living lab environment. Novel measurement tools like handset based measurement facilitate this appliance.

3.4 Data collection technologies

Data collection and analysis process is implemented automatically to the greater Otasizzle-portal. Each end-user that comes to Otasizzle installs a monitoring software client to their handsets that gathers usage log information. This way, as new applications are installed to the handset and used, the usage events are recorded. Also, as client-server –based applications are used with the handset, the usage log is recorded to the server-side. This opens up a possibility to use the server side measurements together with handset-based measurements. The limitation of this method is the server data corresponding of one single application, whereas in handset based data usage of many applications is measured from one single data point. This results in a situation where the data to be retrieved from servers must be as standardised as possible, so that different server data sets are comparable.

The measurement software observes how the mobile device is used. This observation is automatic, so the user can use the mobile phone as he/she normally would. The software creates a data log that is automatically encrypted and transferred over a secure connection to study servers on a regular basis. To enable this, the user needs Internet/WAP settings to be installed on his/her phone. The software collects information anonymously on: how many people the user communicates with, and when; what applications the user installs, when and for how long the user uses the applications and how much data traffic they generate; how many contacts the user has saved in his/her phone and what data fields the user uses; domain names of the websites the user visit; technical patterns such as signal strength, battery level, charging patterns, moving from one cell-id to another, profile use and power on/off patterns.

The measurement software contains a number of observer modules and a server in the phone itself. The observer modules send information to the server that uses connection interface to send aggregated logs to study server. With GUI the user may see the state of the software and control the critical IAPs that the software uses to send data logs.

The technology has been used in many scientific projects recently; see e.g. Salmeron (2008) for location patterns, and Verkasalo (2005 and 2007b) and Verkasalo and Hämmäinen (2007). The research of Verkasalo has been unique, because he utilizes both handset based data and survey results in the analyses. The data is gathered in parallel from both data sources. Usually the process includes an initial survey in the beginning of the panel, when the handset monitoring also begins. Handset data is gathered during one to two months. Other surveys can be carried out during that period. In the analysis the data sets are combined with a common factor such as mobile phone number or e-mail address.

Figure 17 illustrates the data collection process in Otasizzle. Three data points are used, handset-based data, survey data and server side data. At the location where data is exported, privacy of the end-users is ensured by separating the data handling roles for two individuals. A person associates the raw data to individual level with common keywords and another person analyses the datasets that are cleared of personal identification information.

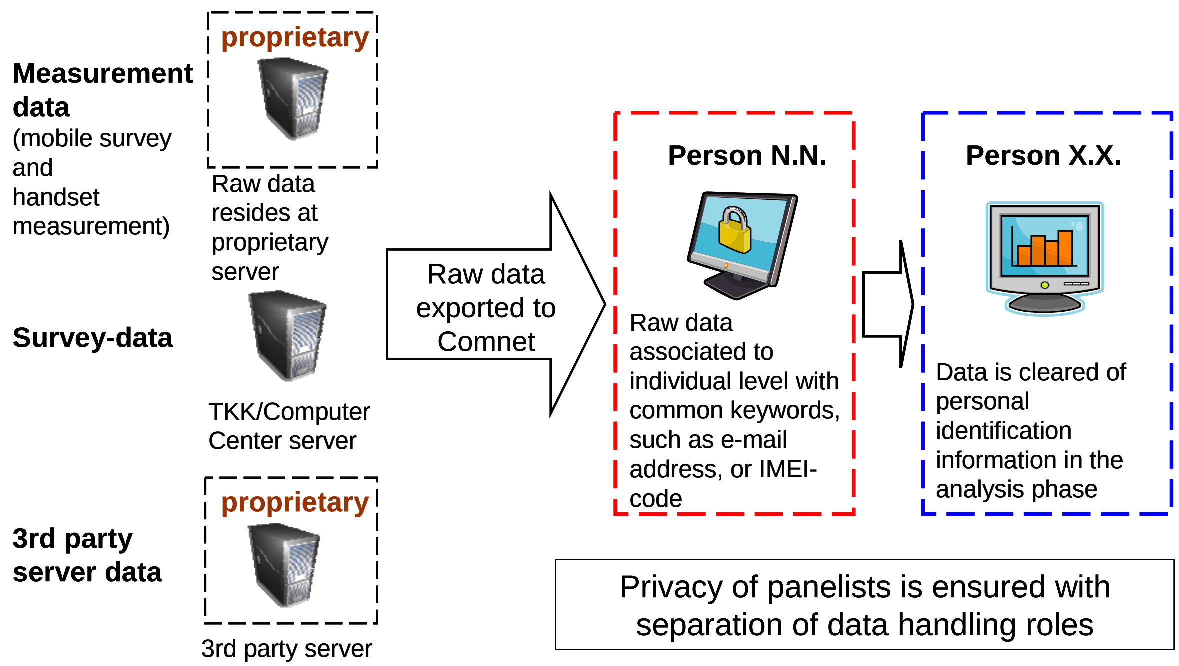
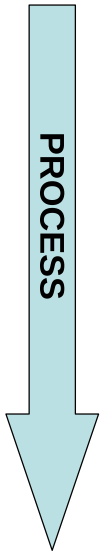


Figure 17 Otasizzle data collection process

The back-end of the data collection process is now presented. Front end, which is the process by which the end-user become as part of the Otasizzle research, follows. Figure 18 summarizes the steps how new panellists subscribe to Otasizzle, by following instructions in Otasizzle Portal, filling in the background survey, and downloading the handset measurement client to their mobile phones.



Step	Activity
1	Student learns about Otasizzle measurements portal from publicity or through targeted email postings. Only email addresses with tkk.fi accepted initially.
2	Student navigates to Otasizzle measurements portal (http://survey.comnet.tkk.fi).
3	Student starts the sign-up process and becomes a panelist (filling in personal data).
4	Panelist fills in the background survey.
5	At the end of the registering process, the panelist is directed to another server, where user can download the (measurement) software in .sid –file (https://www.puhelintutkimus.com/)
6	The following information is given to the panelist: How does the study application work? What does the study application observe? How is panelist's privacy ensured?
7	In this location, the panelist has to agree with the terms related to the software.
8	Panelist provides the information needed (IMEI, phone number, e-mail address). Panelist accepts the User agreement in which data processing and legal principles are explained.
9	A SMS is sent to the panelist. The SMS contains a link that the panelist navigates to with the mobile phone. The software downloads automatically to panelist's mobile phone, when clicked the link in SMS. Now the software is up and running.
10	The panelist becomes an active data producer!

Figure 18 Otasizzle measurements portal use case

The efficiency of the service/application testing process in Otasizzle is ultimately measured by (i) time-to-market improvement and (ii) software quality improvement in comparison to traditional methods of controlled testing. In the ready Otasizzle framework, it is possible to bring relatively fast new 3rd party applications into the testing process. The applications go through a certain process in which they are screened for suitability, legitimacy and quality for Otasizzle. This routine, when designed, tested and standardised, should not take more than two to three days.

Once the application has gone through the screening, it is available at the portal. In the meantime, the development team co-operates with the Otasizzle researchers for the survey questions and data sets retrievable from the handsets and servers. A pre-requisite of the application to be taken into Otasizzle, is the access of Otasizzle researches to the application server information. The surveys after initial survey contain two modules: questions that are designed by Otasizzle researchers and are same for all of the applications, and questions that each development team can design for their application – application specific questions. Further, as researchers have access to surveys conducted in Otasizzle, they can learn from the questions that the development teams have created, thus improving the standard application questions. This process of designing the application specific questions takes a day approximately.

New applications are advertised to the end-users automatically via the portal to get maximum amount of users for the applications. Now, it is the development team to decide how long they want the test period to last, during which surveys are made to end-users. Surveys can also be made in several steps, first after few weeks to capture the end-user's first impression of the application, and the following surveys after certain maturity have been achieved. After minimum of one month of usage, the application survey data and usage data is ripe to be collected and analysed. The analysis takes from one to two days.

Now, the time spent for the whole process from start to finish can only be approximated. The process will evolve over time, and become better. Certain metrics that can be followed are for example the number of end-users using a 3^{rd} party application and the rate of adoption of the application (interesting reports can be produced when comparing the rate of adoption between applications).

Otasizzle environment is mainly a research environment. However, the application developers pay for the access to OtaSizzle, to cover the operating costs. Otasizzle as a business model itself is a specific research topic. Naturally, business factors drive the design of Otasizzle. In order to be scalable and duplicable elsewhere, the processes and components must be first designed for research, but second designed for business purposes. In all of this, the data collection and analysis process is in a central role.

3.5 Report types

In this section, examples of different report types of handset-based data, survey data and 3^{rd} party server data is presented. The examples are to give a conception of how versatile the data collection platform is, enabling virtually unlimited variations of report types when cross-referencing data sets from different data points. Graphical illustrations of the various reports can be found in chapter 4.1. List of reports:

- Number of users in the panel
- Software platform, device type, GPS functionality, WLAN

- Total phone usage activity
- Usage distribution to service categories and applications, relative usage time distribution
- Usage distribution time series and usage per time of day
- Voice calls, phonebook contacts
- Application activations, installations and removals
- Application session durations
- Photos and videos taken
- Phone metrics such as battery levels, cell IDs, phone on/off, system crashes, memory status, profile actions
- Packet data traffic generated, total, and per application, per used technology
- Context of usage

With surveys and cross-referencing between surveys and usage data the following report are generated:

- Background metrics, such as gender, age, employment, smartphone usage history
- Data plan, subscription types, ABPU levels
- Service intention vs. actual service usage
- User segmentation based on usage and background variables
- Adoption of new services
- Pricing preferences of existing of future services
- Importance of services
- Context of usage
- Evaluation of experiment-specific matters
- Open ended feedback for example to service developers

3.6 Efficiency of the process

There are two basic metrics for measuring the efficiency of any process: time and cost involved. These two are also the easiest to measure. Other metrics may include quality aspects such as customer satisfaction. On a higher level metrics are profitability, market share growth and other financial measures. One may also take into consideration the utilization rate of time consumed for a certain step in the process. (Trimble, 2001; Khan, 2004)

There are operational costs involved in managing the Otasizzle platform. Work packages that create costs are: screening of the new service for suitability for Otasizzle, co-developing part of the survey questions with new service providers, making a contract with service provider, launching the new service at Otasizzle portal, marketing of the new service, managing the data gathering process (surveys, handset-based and server-based), analyzing the results, creating documentation of the results, and communicating with the service provider during the process. These costs Otasizzle staff recovers from its *client,* the mobile service provider.

What the client expects, is to gain maximum benefit within as short time span as possible. There is some distinguishable lag time involved in some of the work steps. Time periods that seem lag time to client are: time from contract to living lab introduction and time from ending the data gathering to presenting the results. The less time the steps in the process take the less the overall costs are. On the other hand, quality of the work has to be balanced with the time consumed. The service developer expects to get added value to its business from bringing the new service to Otasizzle. The research on the other hand depends on the new services introductions. Otasizzle is mainly a research platform. There are thus synergy effects that profit both the research and commercial activities. In this situation the approximate monetary value of the benefits to research have to be subtracted from the costs incurred by operational activities in Otasizzle process before invoicing the client.

4 Prototyping the process

Total of three experiments were designed for data collection and analysis. The first occurred during spring 2008 and the second and third in parallel during fall 2008. The experiment work group mainly coordinated the work involved with the experiments.

4.1 Experiment – CallTheWeb

4.1.1 Design

The planning of spring 2008 experiment started in January 2008. The experiment was realised in April-May 2008. The working group that conducted the experiment consisted of representatives from all research groups within Otasizzle – Comnet, CSE and HIIT. Also a 3rd party research instance was invited to the working group. The early meetings were brainstorming session about the design of upcoming experiment. The overall infrastructure of Otasizzle and various research questions set guidelines and restrictions for the experiment. Soon the idea evolved: to videotape various student events during a big student festival using a mobile phone. The idea was to have live coverage at the same time from different angles and from different locations. Users would also be able to watch the live video stream with mobile phones. A service close to this idea was searched for and soon it found from the 3rd party research instance. The name of the application was CallTheWeb.

By the end of March 2008, the experiment software was being tested first in the working group. Soon, it was found out that a lot of development had to be done before the end of April, mainly because the software was initially designed for slightly different purpose than the experiment. The development took major steps ahead prior to the experiment, but still the software was quite unstable when the experiment realised. The experiment was to be carried out nevertheless.

The final design of the experiment was: 10-20 recruited students videotaped various student events with the CallTheWeb-application. The videos that were shot were available in a web-based portal, either as live coverage or as saved files. The videos could not be viewed with mobile phones due to technical problems. CallTheWeb was pre-installed in Nokia N95 8GB smartphones along with the survey software. It was ensured that the software collected data properly well before the event. This was done via a web-based management UI. The phones were distributed to the users a few days before the event and instructions how to use the application were given. Information about the nature of survey software and the terms of use was also given. Same terms applied to the use of survey software in this controlled experiment as applies in a normal use case. The CallTheWeb web portal was advertised to students of TKK via e-mail lists of the student union.

The design of the experiment was quite different, than is the design of the ideal Otasizzle environment. The end-users in the experiment were recruited specifically for the experiment and they were given handsets to use the application. The experiment lasted only for a couple of weeks. In Otasizzle the end-users are students recruited on a voluntary basis by offering them incentives to join Otasizzle. It is expected that the panellist stay within Otasizzle services for a long period of time and use new introduced services alongside with their normal mobile phone usage. In this experiment the new application and survey software were pre-installed to the phones, whereas in Otasizzle the users should themselves acquire the measurement software, and the applications from Otasizzle portal. In this case the portal did not exist yet.

Design of the survey questions was also quite different from ideal case. In the experiment, two kinds of question sets were designed, one for those users who used the client with mobile phones, and one for those users that used the web portal with computer. The latter usage was not measurable with end-user device based measurement. The questions were designed in a team of Otasizzle researchers. There was not an initial survey made to the end-users. The initial survey measures basic demographics, normal mobile phone usage activity, and ideally allusions of users' early adopter kind of behaviour. In the experiment the surveys were mostly carried on with the intention to test the data collection and analysis process in those parts that were applicable to Otasizzle.

4.1.2 Implementation

During the student events, CallTheWeb was used and log information was produced to the web-server of the survey software. After the events, two surveys were made, one for

CallTheWeb client users, and one for the users of web-portal. E-mail addresses of the client users were gathered manually prior to the event for the purpose of sending them invitation to fill in the survey form. E-mail addresses of the web-portal users were given to the researchers by the development team of CallTheWeb. These addresses were collected from the users when they had signed up for the service and created a user profile.

Approximately a week's time was given to fill in the surveys. The survey server was operated by Otasizzle research team. After the period, the results were downloaded from the server as cvs-files, aggregated and analysed.

An aggregated sample of handset usage data was retrieved from the survey software server, and analysed. This was done approximately one week after the main event, to see how the usage activity had normalised after the event. Two different persons inside the research unit handled the data, so that the privacy of the users was secured. Another person handled the raw data, and cleared it from identification information, and another person made the analysis based on the data. Also, small amount of CallTheWeb-server data was given to researchers and this was also analysed.

In this experiment, no cross-reference between survey results and usage data was done. The reason for this was that the design of survey questions was made in a hurry, and this issue was not considered in design phase. Other issues, like the fact that this was a short controlled experiment with no real end-user usage, favoured the exclusion of data cross-reference. The mobile surveys were not realized either. The reason for this was technical. The technology of mobile surveys was not stable enough.

Due to the hurry in last minute development efforts, there was no time to co-develop any of the survey questions with the CallTheWeb development team. This emphasises the need for proper processes in the experiment preparation phase, but more importantly it emphasises the need for feasible and proper services, that are ready for Otasizzle experiments, and do not require last minute development efforts.

4.1.3 Documentation

In the first instance, in Figure 19, phone usage activity during the experiment/panel is illustrated. The left y-axe tells the amount of daily phone usage per user during the panel. In the right y-axe the amount of users in the panel is illustrated. With this type of graph it is facile to communicate the general status of the panel to different parties involved. For example once it is known how many users there currently are in the panel, it is possible to make reactive actions like additional recruitment of users to the panel.

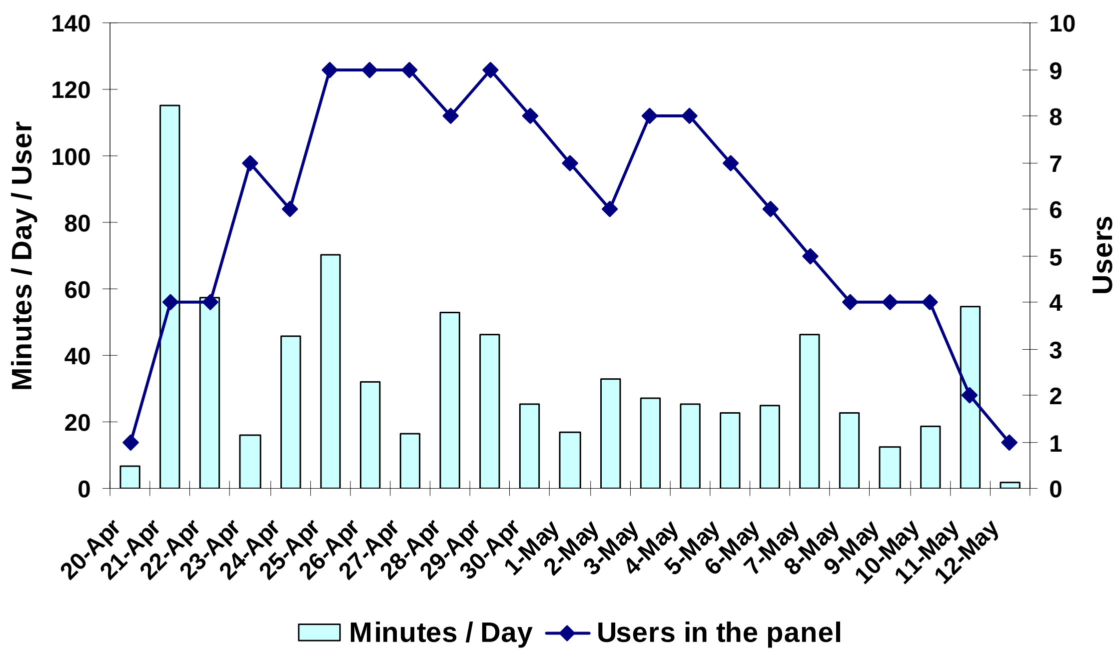


Figure 19 Phone usage activity during the panel

The Figure 20 illustrates the application usage per hour of day. Five different applications are taken into account here. This graph is good for studying how 3rd party applications such as CallTheWeb are used in relation to built-in applications in daily usage. Various report types can be used in reporting application usage statistics, for example the share of total usage time, average session durations, launches per day and usage time per week.

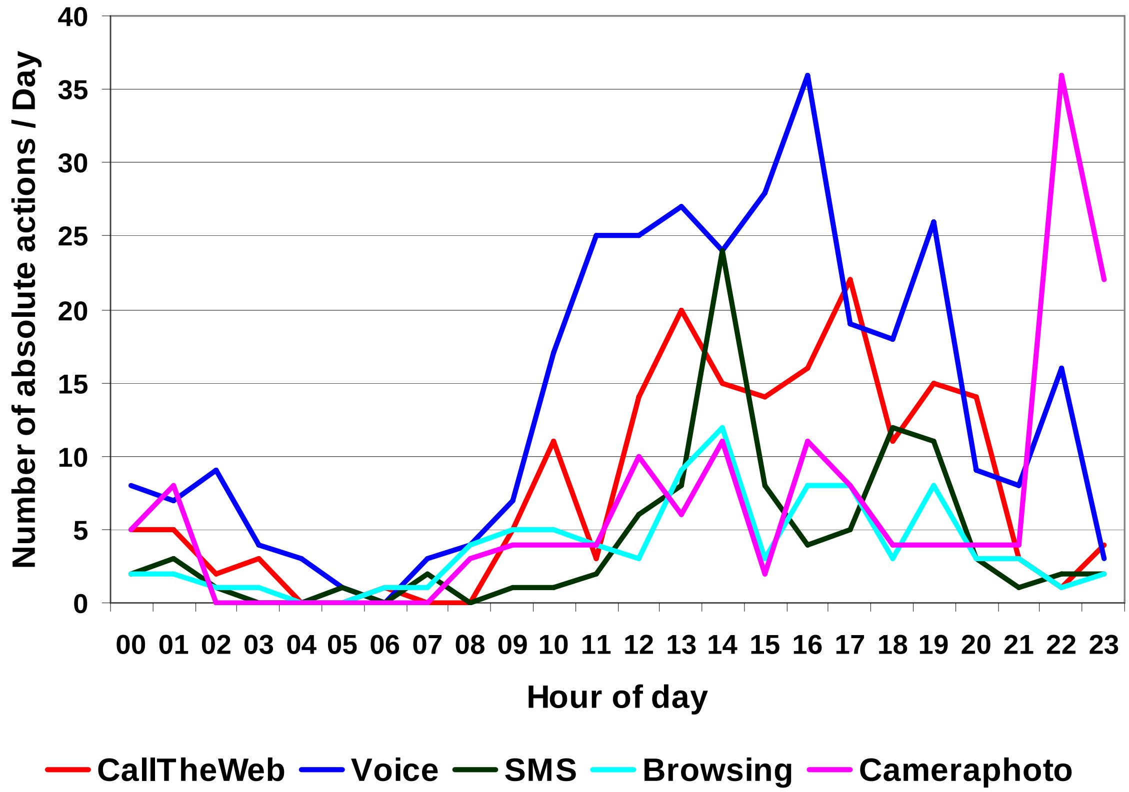


Figure 20 Application usage per hour of day

Surveys make possible all kinds of subjective information to be retrieved from the respondents. Satisfaction and other subjective ratings measured during the panel about specific application are of value to the development teams in gaining insight into how users perceive the application. In the following example (Figure 21) the users were asked to rate CallTheWeb's usability, robustness and overall satisfaction level. Similar ratings and more detailed questions can be made. These type of questions are valuable especially when there are more than one 3rd party application in use in the same period of time, in which case the ratings can be compared with each other.

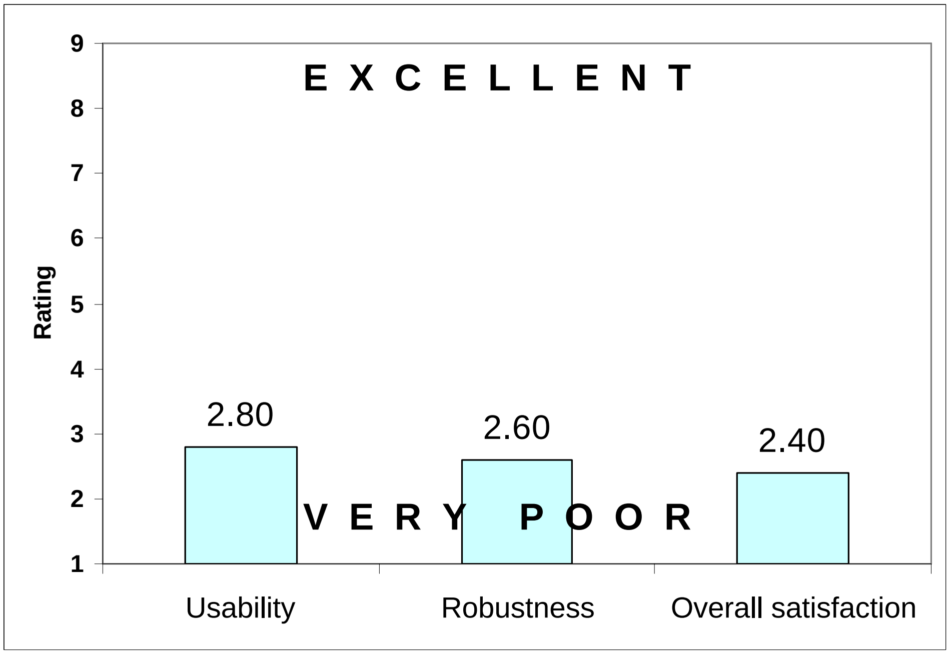


Figure 21 Rating levels of the service

Third important data points are application specific servers. In Figure 22 a sample of SQL database is taken. Here the experiment period is shown. It illustrates the level of application specific data, and the alteration of it during the panel. This example also illustrates the challenge with server data. In this case it was not specified before the experiment what kind of data is needed for the study. In fact in this example the data from Otasizzle experiment is merged with the data from other simultaneous experiments. This emphasises the need to standardise the type of data that is required for research purposes. The standardisation means that same kind of data is collected from different application servers, in order to be able to compare the application usage.

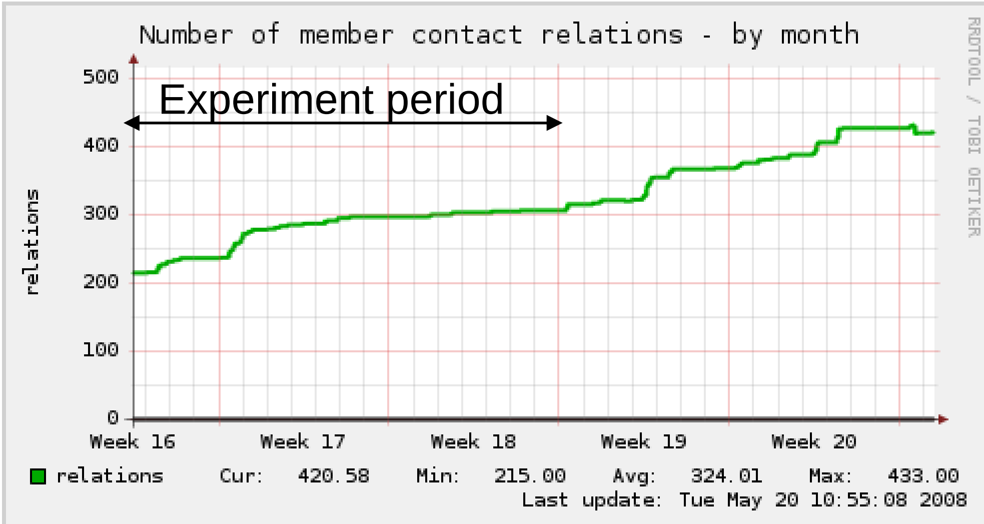


Figure 22 Application server data

These examples illustrate the gathered data from the experiment. These reports were mediated to the CallTheWeb development team, and other project partners. Unfortunately, the development team had no time to co-develop the survey questions. On the other, the experiment was a valuable testing opportunity for them. Prior to the actual end-user usage, the application was being redeveloped to match the requirements of the experiment, taking the development major steps ahead.

4.1.4 Findings

There were approximately ten end-users in this controlled experiment. The results are strongly biased, because the users were explicitly instructed to use the 3rd party service.

It is noted here, that although the experiment was a controlled one, it demonstrates the data collection from handsets and application specific server, conjoined with surveys. Moreover this experiment was important to demonstrate the capabilities of data collection and analysis to other parties in the Otasizzle research community.

The dataset acquired from the experiment does not reflect real handset usage. In this controlled experiment, the users were instructed to use a specific application – CallTheWeb. If this application had been installed to the users' principal handsets, the results would have been somewhat different.

In the process itself, important factors that are included in the ideal Otasizzle process, were not tested. These are: registration of users to Otasizzle, filling in an initial survey, downloading survey software to end-users principal mobile handsets, receiving the 3rd party service through Otasizzle portal and using the service alongside their normal handset usage. On the other hand, what was able to test, was: the technical functionality of the survey software, bringing a new service to Otasizzle, data collection methods, using aggregated raw data for analysis, conducting application specific surveys to a restricted user population, analysing of the survey data and combining it to usage data in documentation phase and mediating the documentation of the experiment to the service developers.

In the process the research team was able to report findings based on actual handset data and surveys back to service developers. While the goal was to test the process, and some major issues were not tested, the draft of the framework was tested successfully. Based on the report mediated to service developers, they are in theory able to make adjustments to the service, and make it more user-friendly.

4.2 Experiment – Ossi

4.2.1 Design

Ossi is a service designed and developed in HIIT. It comes from "inside" the Otasizzle research community, thus it is not a third party service like CallTheWeb. Ossi is a browser-based social networking service enabling media rich communication between users on mobile and web platforms. The mobile version of Ossi is accessible via the handset's browser. In the first phase, there is not client software for Ossi available. The basic functionality of Ossi includes:

- Communication channels, messages can contain text and pictures
  - Private, public, and location-based channels
- Status and location updates
- Social networking functionality
- Sizzle channel, aggregates the activity of the user's friends
  - New messages, new friends, status and location updates

The target group of Ossi are the freshman students of Computer Science and Engineering department of TKK. Content in Ossi is made for the freshmen in particular. Ossi, being also a social networking service, is designed to foster the interaction of students, making it yet appealing in the small unified end-user population. Once Ossi has gained a stable and plausible end-user base it is easier to market both Otasizzle and Ossi among a wider student population. Another positive factor is that Ossi is a social networking service, meaning that the more people use it, the more valuable it is to all users. This positive network effect, once exploited, would mean that the service diffuses even more likely to a wide user population. One research question of Otasizzle is to study service diffusion. In the expansion phase both planned and unplanned word-of-mouth marketing happens. All this is part of the holistic Otasizzle research agenda.

At the same time with this experiment, Otasizzle as a project became public. News releases about Otasizzle and Ossi were given, and a video about Otasizzle was made and put to the Internet. This was all made to raise awareness about the project. The students heard first time about the project in August 2008, when they received a letter about Otasizzle. In the letter it was emphasized that Otasizzle is a research environment, and that the students are welcome to co-develop it. It was acknowledged that Otasizzle and Ossi are under development so that students would not expect too much from the service.

An initial survey was designed to be filled by the students. Different research themes were behind the survey questions. Topics such as social networking and communication were considered, alongside the usual demographics and intention questions. See Appendix 1 for the survey form.

The survey software would be brought to the experiment with the same setting as in the CallTheWeb-experiment. The survey software client would be retrievable by signing up for a web server, after which the user received a text message with a link to download and install the software. In this experiment, the end-users would do this by themselves. This procedure would be integrated to filling up a web-based survey. The survey would be filled first, and the end-users would be directed to retrieve the survey software client. The process was designed to be as smooth as in the ideal case: end-user learns about Otasizzle, navigates to the portal, fills in an initial survey and gets the survey software to the handset.

The students were offered mobile data subscriptions, to compensate the costs involved in using Otasizzle service via mobile phone. In the first phase a deal of 200 mobile subscriptions were made with the local MNO. The operator would cover the costs, as a part of participation to Otasizzle project. Getting the free mobile subscription would require the student to be signed up for Otasizzle portal, and to the survey software, meaning that the student had the survey software client working in his/her handset.

The Otasizzle panel is meant to be continuous. It is planned that once the end-user registers to Otasizzle, their handset usage would be monitored for months, maybe for years. No exact timeline is planned. The idea is to get a sustainable user base to Otasizzle, and then conduct various end-user studies with the users. This kind of continuous panel would be new of a kind; it would enable different and more thorough research than had been possible with the short term panels.

4.2.2 Implementation

The implementation was different than the design. First of all, the students filled the initial survey in paper form. On the other hand, with this measure the number of respondents climbed up to near 100 percent of the freshmen. Students were gathered in a lecture hall for their normal sessions for becoming acquainted with the university. During this session the Otasizzle researchers took the floor and told them about Otasizzle, about Ossi and helped them to get started with using Ossi. This session was a natural occasion to conduct the initial survey as well.

Now, nearly 100 percent of the end-user population filled the initial survey. Not every one of them had a smartphone let alone a S60 model that was required for the experiment. The required handset models were: Nokia 3250, Nokia 6110 Navigator, Nokia E50, Nokia E60, Nokia E90, Nokia N73 , Nokia N76, Nokia N80, Nokia N81 and N81 8GB, Nokia N95 and N95 8GB. This configuration obviously left out many potential panellists.

The users began to use both mobile and web versions of Ossi. Approximately one month after the users had filled up the initial survey, the survey software signing-up was opened for them. An e-mail was sent to the users, with a link to the survey software website. It was emphasised that especially those who have the free subsidised mobile data subscription, should register for survey software.

4.2.3 Documentation

Of Ossi-experiment survey respondents, **39** percent have a Nokia S60 smartphone. **14** percent of the respondents have a handset required for survey software. Based on this analysis, theoretically 14 percent of handsets were able to show any usage of Ossi. Based on the actual Ossi-server logs, the usage had been minimalistic, due to lack of functionality of the service. This resulted in a situation in which there were only 14 percent of potential Ossi-users that had the handset suitable for the measurement, and on the other hand there was the service that nobody used. Added to this, the registration to survey software opened one month after the introduction of Ossi, and a few weeks before this analysis. The result was that no actual usage data from the handsets was collected.

Survey results show that there were 73 end-users in this experiment. 19 of those live in the campus area, which is a noteworthy issue, when designing mobile location services in Otasizzle. 30 end-users (that are all freshmen) live with their parents / a parent. Everyone has a mobile phone and over half does not pay the bill themselves. Most popular communication methods are (over 60 percent use these daily) e-mail using computer, phone calls with mobile phone and IRC, following SMS and instant messaging.

35 percent intends to try or use WLAN with mobile phone in the near future. Intention to try or use other features was 36 percent for maps and navigation, 39 percent for e-mail (with a mobile phone), 44 percent for camera (photos and videos), and 66 percent for calendar. MMS on the other hand is not popular, with 57 percent saying they will not use it.

4.2.4 Findings

The most important findings were the smartphone and survey eligible smartphone penetration percentages, which were 39 and 14 percent respectively. The results indicate that the share of smartphones among students is not enough to study for example social networks.

There were two major reasons for the problems in the implementation phase. The service, Ossi, was lacking functionality, so that many of the research topics intended to study in Otasizzle/Ossi framework had to be postponed. The other problem was the delay in launching the survey software.

This experiment shows how important it is to have appealing, working, feature rich, and somehow novel services in Otasizzle. On the other hand, it shows how important it is to put the different pieces of the puzzle together and test the configuration within the research team, before the experiment is launched to end-users. This experiment shows how important the screening of incoming services is. All the services should be handled the same way independent of the origin of the service (in-house built vs. 3rd party). The case here is though that Ossi is an early incarnation of Otasizzle itself, and it had major research questions driving its design, and thus justifying its (maybe too) early launch to public.

Not to blame Ossi team for everything, things did not go too well with the survey software. The integration of survey platform to handset measurement platform was troublesome and time-consuming, partly due to shortage of resources. This caused the postponement of survey software relative to launch of Ossi. It was designed that these two had been launched in parallel.

4.3 Experiment – TKK panel

4.3.1 Design

The planning of TKK panel began in summer 2008. Initially TKK panel was meant to be integrated to Otasizzle and Ossi experiment from the launch of Ossi. Hovever, the user population of Ossi seemed too small for the research questions that drove TKK panel. Also the signs were that Ossi would not be an appealing service right form its launch, which would mean that Ossi itself was not a strong incentive to join the panel. Another panel, partly separate from other Otasizzle efforts, had to be made.

TKK panel was designed to be a long lasting panel. Starting at September 2008, and lasting possibly years, it would grow little by little through aimed marketing efforts and through word-of-mouth marketing. The panel would include two components, the survey platform and survey software platform, integrated together so that the ideal user case would be the same as depicted in Figure 17, chapter 3.4. After a sufficient user population had been achieved, and normal handset usage had been monitored, a 3rd party service would be brought to the panel. The adoption of the service would have been studied in a controlled environment, including a dedicated 3rd party service specific survey.

The users would be encouraged to join the panel by offering compensation for it. Users that stayed in the panel for long enough, had access to a report based on the study, and participated in a lottery of new Nokia smartphones. The users were also said that it would be possible to try out some new innovative mobile services for free during the panel, which was thought to be appealing for technically oriented students.

4.3.2 Implementation

The recruiting of panellists went as planned. First there was an invitation letter sent via e-mail to the members of the Guild of Electrical Engineering in HUT. The guild has approximately 2000 members, all students, of which 1700-1800 have subscribed to the two mailing lists of the guild. There is a list for freshmen (200 members) and another list for the second year and above students. On 13.10.2008 the invitation e-mail was send to all the freshmen of the guild and on 15.10.2008 to other 1500 members of the guild. In the third wave of campaign, there was advertisement put to electronic media that the students and staff of Faculty of Electronics, Communication and Automation use. This advertisement was launched on 21.10.2008.

A 3rd party service was brought to the experiment. This service was Nokia Sports Tracker, developed by the Nokia Beta Labs. The software is available free of charge to public. The configuration of the experiment was light for the researchers. The research staff did not provide any end-user support for example. The service included a downloadable client, and a server. The end-users received an e-mail invitation to download the client to their mobile phones. The invitation was sent only to those end-users that had a GPS-receiver in their handsets, because the service requires GPS functionality. The number of those end-users in the panel was 28. A short survey was designed within the research team. Unfortunately, the development team of Sports Tracker did not participate in designing the survey. An invitation to fill in the survey was sent one week after the invitation to start to use the service had been sent. It was unsure if there had been any real usage of the introduced service. The main goal with the experiment was to test the process of bringing a new service to the panel and market it to the end-users, finally conducting a dedicated service specific survey to them.

In this experiment the configuration was the same as in Ossi-experiment, in terms of acceptable handsets. The handset models were: Nokia 3250, Nokia 6110 Navigator, Nokia E50, Nokia E60, Nokia E90, Nokia N73 , Nokia N76, Nokia N80, Nokia N81 and N81 8GB, Nokia N95 and N95 8GB.

4.3.3 Documentation

The following Figure 23 shows how the panel developed during the fall. Waves of recruiting on 13th, 15th, and 21st of October are visible, resulting in more users in the panel.

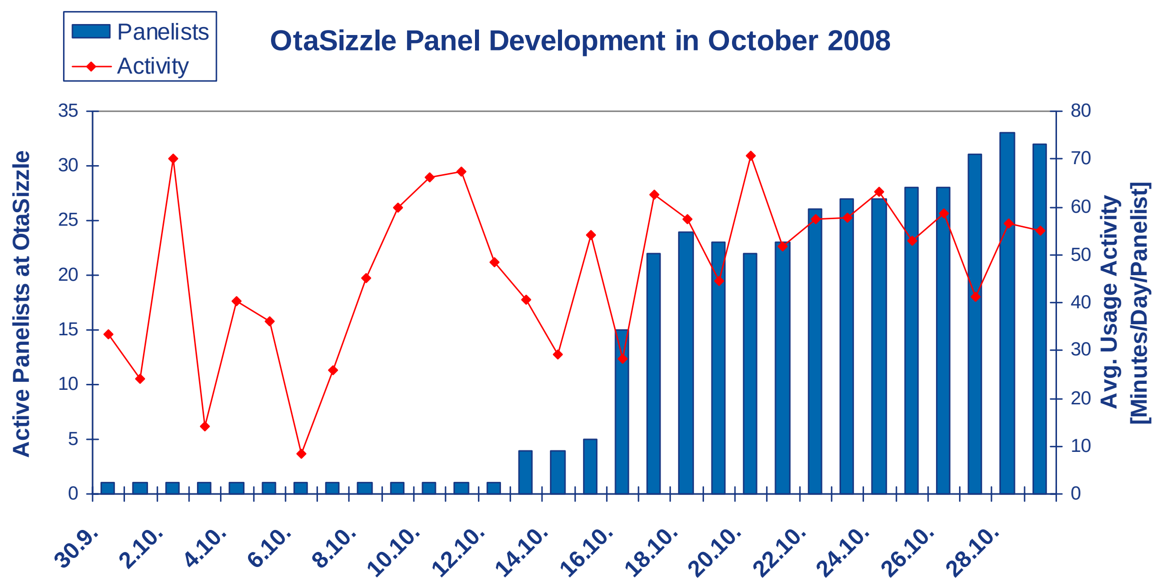


Figure 23 Campus panel development

40% of the panel's handset models had GPS-navigation. 64% of the handsets had WLAN access. The most common models were Nokia N95, Nokia N73 and Nokia E90.

The next Figure 24 illustrates the application usage in the panel. The graph is to show that the data collection method is essential in measuring accurately the application usage in handsets, especially when there is a need to compare different application with each other. The Figure shows that voice, messaging, PIM (personal information management) and web browser dominate application rankings. Average Usage Frequency tells how many days of the panel the user has used certain application. Frequency = Number of days used / all days. Penetration axis tells the percentage of users that have used an application. The penetration is independent measure in relation to the frequency. The Frequency tells the amount of usage among those that use the application.

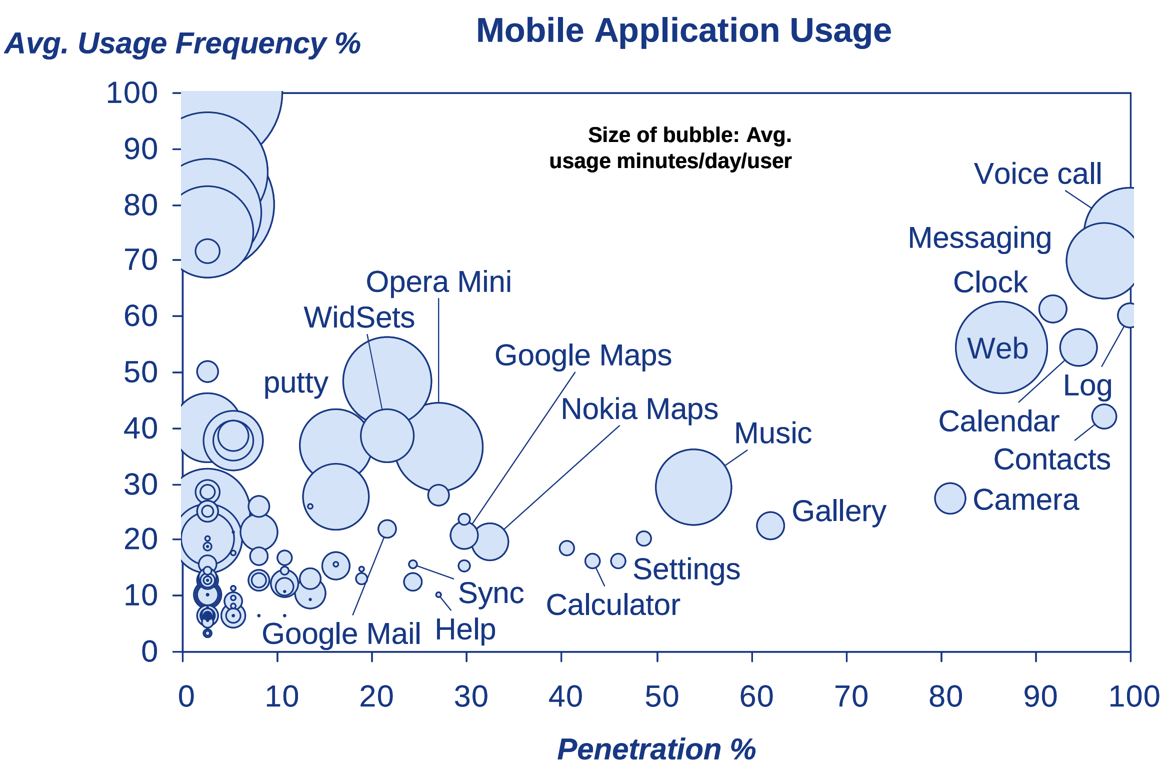


Figure 24 Mobile application usage

The following Figure 25 continues with comparing the applications. In the graph the penetration levels of different applications is shown. Penetration axis tells the percentage of users that have used an application. For example, everybody in the panel has used voice calls (100 percent), but only 30 percent have used Google Maps. Certain services have been highlighted because their usage is surprisingly high.

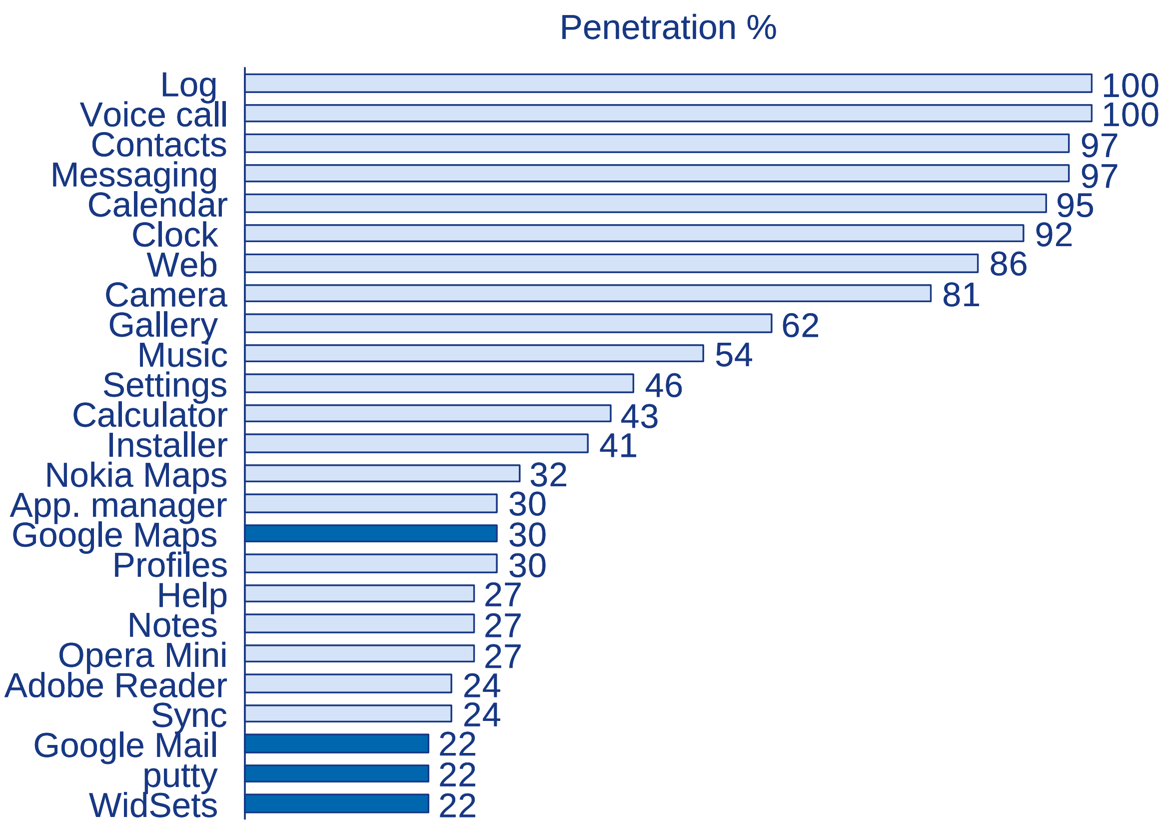


Figure 25 Penetration comparison

In this experiment, the monitored handset data was separated from survey data, and no cross-referencing was done between the datasets. This way there is no suspicion about how sensitive identification information was handled, because such information was not handled at all. This information is normally used in forming the liaison between the usage data logs and survey data. The following graphs show some of the results from the initial survey.

The following documentation concerns the results from the initial survey. Figure 26 illustrates the average bill per user. This is the estimated value from the survey respondents themselves. The graph shows that 35% spend only 10 to 20 euro per month to their mobile subscription. It has to be noted here, that the user population is a biased one, consisting of students whose income level is generally lower than general population's income level.

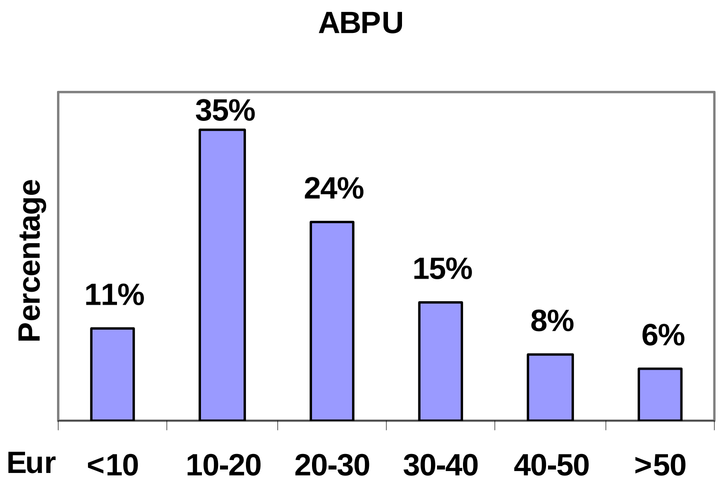


Figure 26 Average bill per user

The following graph (Figure 27) illustrates the analysis of mobile internet capability versus mobile internet usage. The end-users were asked how long they have used a mobile phone that has internet access. Using the same time-scale, they were asked how long they have used internet with their mobile phones. A gap of nearly 30% is observed between the capability to use internet and the actual usage of internet with mobile phones. Similar analogy would work in almost any functionality item.

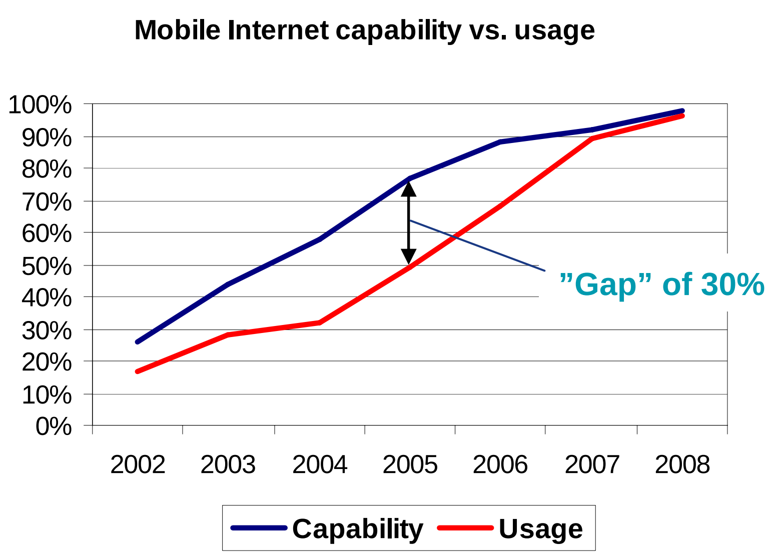


Figure 27 Mobile internet capability vs. usage

The results of the Sports Tracker survey show that the response rate was 54 percent. Only 27 percent of the survey respondents had used the service within the test period of a week. When asked to rate the service in terms of *technical functionality* in scale four to ten, ten being the highest, the service got an average rating of **8,29**. In *usability*, the service got a grade **8**, and in *usefulness* for the end-user the service got a grade **7,14**. The open feedback concerned mostly the high battery consumption when using the GPS-receiver with the service. In general the service got positive feedback for its many features.

Analysis on the handset usage data shows that **17** percent of total users had tried Sports Tracker since the start of the panel. The usage in general had been minimalistic in terms of minutes per day and sessions per day. No usage patterns were observed due to insignificant usage. There were 28 end-users with a Sports Tracker capable handset. Thus, **36** percent of the end-users capable to use Sports Tracker used it.

4.3.4 Findings

In total 80 users answered to the initial survey. 60 of them installed the survey software to their handsets and produced usage data. The participation was restricted to the students and staff of TKK.

Survey results and handset based data was collected and analysed in the experiment. The analysis was made to demonstrate that the data collection methods work and the analysis process works. Any 3rd party software can be analysed the same way existing services are analysed, and any 3rd party service specific surveys can be implemented and analysed the same way as the initial survey and the service specific survey in this experiment.

The experiment reveals some of the problems there is in the process. a) Once the end-user fills in the survey form, he/she needs to go to survey software website to retrieve the client. Based on the analysis of the number of user that had filled in the initial survey versus the number of users that had registered to the survey software server, it is seen that not everybody finished the process. This could have been caused by many reasons. First, the survey form was in Finnish. On the contrary, the survey software website was in English, apart from the parts that had to be in Finnish for the research to be legitimate. These documents were User Agreement and Software Agreement, and the Frequently Asked

Questions section. The change of language in the middle of the process seemingly caused partly the loss of users in the panel. Another reason for the loss could have been natural: the user had second thoughts about joining the panel and had cancelled the process on purpose.

b) The installation of survey client to the handsets is not 100% fail-safe. For example one source of defect is that the end-user might put his/her mobile phone number in wrong format to the system. In this case the end-user does not receive the SMS that contains a link to install the survey client. Even if the user receives the link, there can be other issues, namely plain inexperience of installing software to handsets.

The process of bringing a 3rd party service to the panel and conduct a survey related to that was the best effort to test the framework constructed in this thesis. It was shown that it is possible to bring a beta-phase service to Otasizzle, encourage the end-users to use it, ask them to fill in a service specific survey, and analyse the results.

Majority of the problems is tackled when the user population is technically oriented, which was the case in this experiment.

5 Conclusion

5.1 Results

New data collection and end-user research methods that can be used in controlled experiments, can benefit service developers by providing valuable feedback. Usage logs and web-based survey data can be automatically aggregated, cross-referenced, and analysed in finding out how people really use services. The end-user research process can be provided to service developers as a service.

In the developed framework service developers bring a new service to the living lab, and after a testing period the developer receives a report based on empirical findings. The framework facilitates quick and scalable debugging, more efficient time-to-market, and an improved process of getting consumer feedback of the product functionalities. Also, the way how end-users actually use the service and new innovative ways of using the service are observed. The framework may also be a relatively cheap way to assess the success or failure of the service.

The framework was tested in three different experiments. These experiments were rather cumbersome to set up and manage. The experiments were carried out in ad-hoc configurations, due to the premature status of the research platform.

In the Ossi –experiment, 39 percent of the 72 Computer Science and Engineering freshmen had a Nokia S60 smartphone. 14 percent had an eligible phone for the study software. In TKK panel, a total of 60 end-users were recruited to the research panel. 28 of them were invited to try a 3rd party target service. The response rate to the service specific survey (N=28) was 54 percent. Out of those end-users 27 percent had used the service during the test period. The survey results reveal possibly valuable feedback to service developers.

The methods used in the framework are integrated in a novel context (Otasizzle living lab), and for a novel purpose (mobile service end-user testing). Overall the results are promising from the perspective of integrating data collection and analysis tools to the end-user research. Three somewhat different experiments show, that 3rd party application/service usage can be effectively measured in controlled panels, conjoined with surveys and other relevant data points. These data sets can be cross-referenced in the analysis phase. The process from bringing the service to the platform to receiving the report based on analysis may produce value to the service developers. What has been created here is a roadmap to the future, a framework of integrating end-users to service development using various tools. This framework has weaknesses and strengths.

- Strengths
  - Amount and accuracy of data points.
  - End-user research combination with service testing
  - Scalable environment in terms of researchers, end-users and services
  - Longitudinal analysis
  - Real adoption analysis (from the point of first touch).
- Weaknesses
  - Setting up the research infrastructure is cumbersome
  - The survey software is proprietary and the log information is collected to a proprietary server
  - The cycle time of the process is still too slow from the service developer point of view. The process must be economically feasible for all parties.
  - Still inefficient collaboration between different stakeholders
  - Privacy of the end-users
  - Biased datasets (early adopters)

5.2 Limitations

The research partially met its objectives set in chapter 1. What is a setback in this stage is that it was not possible to test the complete feedback-loop from new service provider to the end-user and back. A set of exemplary reports were created in the experiments, but as the experiments lacked a suitable new service, or the service developers did not partake in experiments, the value of these reports is unknown. The processes were identified and prototyped in a test environment, but the environment was ad-hoc. It was not possible to analyze the contribution of the developed research process in the project frame; this could be done by interviewing the service developers after an Otasizzle experiment.

There are three main points for consideration in the framework:

- *Setting up and maintaining of the infrastructure of the panel*. Before anything can be researched, the technical infrastructure has to be there. The building of this platform is a cumbersome endeavour that requires resources. The platform can be driven by the services point of view, or by more holistically the research platform point of view. Also, maintenance of the platform is needed, which is possibly a full time job of one to two professionals.
- *Collaboration among the researchers*, of which a good incarnation is the design of surveys. Collaboration and synchronization of activities is important for the end-user experience to be smooth. For instance, in designing surveys to end-users, there is an abundance of questions that different research groups want to pose to the end-users. Only the most essential questions per survey must be taken into account, so that the surveys are not exhaustive to the users.
- *Screening and pre-evaluation of the services*. In one of the three done experiments, the target service was not usable for the end-users. It is important to have suitable, working solutions, which do not need special attention from Otasizzle maintenance point of view. The customer support has to come from the service provider directly. There must be clear requirements set for the service.

5.3 Exploitation

The key takeaway of this research is the potential value of research platforms like Otasizzle. In controlled systems, with innovative tools, and processes, that are economically feasible, lays a repertoire of opportunities for researchers, end-users and service providers. Of course, the building of this system is cumbersome, requiring investments. The work done so far is a good start, and the researchers working on the research platform are motivated.

The framework developed in this thesis can be effective especially in testing the market potential of a service, that is *market testing*. The framework may also be good at tracing the usability issues of the service/application, that is *usability testing*. The framework is principally meant for *acceptance testing* of a service/application in an actual end-user environment done by the end-user – that is *beta testing*. The framework is not suitable to test the service/application at test levels, when the testing is appropriate to conduct with software tools and by expert professionals, not by end-users. Unit testing, integration testing and system testing and the test types associated with them fall into this category.

The framework created here can be used in future research around Otasizzle. The research process data can be used in performing "richer" and longer experiments, in order to also get better results.

In the future, Otasizzle may facilitate occurrence of some of the end-user "phenomenon": Lead-users might arise; start leading the service development inside the community. Hopefully some of the services will be open source to maximize the power of end-user co-development. New research methods may arise, focused evaluations with interviewing the end-users might be reasonable at some point.

5.4 Future research

In the future Otasizzle as a research platform facilitates diverse research. Both TKK-based services, 3rd party services and end-user created services must be researched. The research must be directed to facilitating the development of better services. The source of the innovation – the innovation processes must be included in the research agenda.

The low smartphone penetration among the university students indicates that without a significant increase in the penetration, social networking studies are impossible to conduct in Otasizzle. One way to increase the penetration is to offer subsidised handsets to students. Even now the low smartphone penetration enables to continue research on closing the feedback-loop between service developers and end-users.

The methods used in the thesis will be refined. It is important for the sake of reliability and credibility of the research that all the end-user information is handled with care inside the research community. The usage of end-user information itself is a research topic by definition.

The technical architecture of end-user platform could be one research topic. End-users and researchers point of views are equally important. Visibility to public, to other stakeholders such as companies and municipalities could be studied.

The economies of the framework created here could be studied in detail. How value is created, what are the key components? What are the costs of bringing a service to Otasizzle or other research platform? What is the economic return on that? What about the return on Otasizzle project? A five year long project, with millions of euro invested capital. In what forms, when, where, and to whom the project creates the biggest return? Will it generate value to the industry, research community or society at large? Longer and more profound research on these topics is important.

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7 Appendices

7.1 Appendix – Otasizzle initial survey

Background Information

In this section we collect some background information of the participants of the study. The data will be used in analysis and for describing the research material. The answers will be handled with full confidentiality and it will not be possible to recognize any individual participants from the results.

1. **E-mail address** (preferably username@cc.hut.fi) ___________________________

2. **Phone number** (e.g. +358-44-0797799) ___________________________________

3. **Year of birth** (in the form yyyy) ___________

4. **Gender**
   - □ Male
   - □ Female
   - □ I do not want to answer

5. **Nationality** ______________________________

6. **Year of enrollment to TKK** ______________

7. **Faculty at TKK**
   - □ Faculty of Electronics, Communications and Automation
   - □ Faculty of Information and Natural Sciences
   - □ Faculty of Engineering and Architecture
   - □ Faculty of Chemistry and Materials Sciences
   - □ I do not study at TKK

8. **Department within TKK** ____

9. **Where (from which town) do you <u>most</u> feel that you come from?**

   ____

10. **Have you moved or do you know that you will be moving during the year 2008?**

□ Yes, inside the capital area
□ Yes, from elsewhere to the capital area
□ Yes, to elsewhere than the capital area
□ No

11. **What is the postal code of your current residence** (e.g. 02150)? ___________
12. **If you live currently in Espoo, do you live in Teekkarikylä?**
    □ Yes
    □ No
    □ I do not live in Espoo

13. **When have you moved to the town where you live currently?** Estimate in case you do not remember the exact date. (Answer in the form mm/yyyy) __________

14. **Choose the option describing best your current situation in personal life.**
    □ I am single
    □ I am in a relationship
    □ I do not want to answer

15. **Choose the option describing best your current housing situation.**
    □ I live alone
    □ I live in a share student apartment
    □ I live with one or more friends/siblings
    □ I live with a parent/parents
    □ I live with a partner
    □ Other, please describe: ____

16. **Do you live with your own or your partner's children in your household?**
    □ Yes
    □ No

17. **Did you know people from one or more of the groups below before the beginning of the term?** Estimate roughly the number of people you knew from each group.

	I knew well	I knew by name/nick (that is a nick name used in Internet) and/or by face
Your freshman group		
The freshmen of your own guild		
Members of your own guild		
Students at TKK		
People living in the capital area		

Background in technology usage

This section consists of questions concerning your background in technology usage. The section begins with a set of questions on mobile phones and concludes with questions covering the usage of various devices and social media services.

18. Do you have a mobile phone?
□ Yes, please complete which brand and model:______________________________
□ No

If you answered ”No” to the previous question (18), please proceed directly to question 26.

19. Who normally pays your mobile phone bill?
□ I pay it myself
□ Somebody else (for example parents, employer) pay it for me
□ I do not know

20. Estimate your average monthly cost of calling, messaging, using data and other mobile services in euros. ______________ EUR/month

21. Do you have a pre-paid mobile subscription?
□ Yes
□ No
□ I do not know

22. Is the phone included in your mobile subscription?
□ Yes
□ No, the phone was purchased separately
□ I do not know

23. On what basis are your voice calls charged?
□ Usage based (fixed price per minute)
□ Flat rate (unlimited amount of calls per month)
□ I have a contract with monthly voice call limit of ______ minutes
□ I do not use my phone for voice calls
□ I do not know

24. On what basis are your text messages (SMS) charged?
□ Usage based (fixed price per message)
□ Flat rate (unlimited amount of messages per month)
□ I have a contract with monthly message limit of ______messages
□ I do not use my phone for text messaging
□ I do not know

25. On what basis is your mobile data traffic (GPRS/3G) usage charged?
□ Usage based (fixed price per MB or hour)
□ Flat rate (unlimited amount of data per month)
□ I have a contract with monthly data limit of ______MB
□ I do not use my phone for mobile data traffic
□ I do not know

26. I am interested in using the following services and applications within the next 4 months with a mobile phone. Please, answer by using the scale from 1-5 where 1=Strongly disagree, 2 Disagree, 3=Neither agree nor disagree, 4=Agree 5=Strongly agree and 0=I do not want to answer.

	1	2	3	4	5	0
Phone calls	☐	☐	☐	☐	☐	☐
Text messages (SMS)	☐	☐	☐	☐	☐	☐
Multimedia messages (MMS)	☐	☐	☐	☐	☐	☐
Calendar	☐	☐	☐	☐	☐	☐
Web browser	☐	☐	☐	☐	☐	☐
Camera (photos and videos)	☐	☐	☐	☐	☐	☐
Image/video viewing (gallery)	☐	☐	☐	☐	☐	☐
E-mail (e.g. e-mail client, webmail)	☐	☐	☐	☐	☐	☐
Instant messaging (e.g. MSN Live Messenger, Fring)	☐	☐	☐	☐	☐	☐
Games	☐	☐	☐	☐	☐	☐
Maps and navigation	☐	☐	☐	☐	☐	☐
WLAN access	☐	☐	☐	☐	☐	☐
Internet calls (e.g. Fring, Skype, SIP)	☐	☐	☐	☐	☐	☐
File sharing (e.g. Symella, SymTorrent)	☐	☐	☐	☐	☐	☐
Social networking services (e.g. MySpace, Facebook, LinkedIn)	☐	☐	☐	☐	☐	☐
Internet videos (e.g. Youtube)	☐	☐	☐	☐	☐	☐
FM radio	☐	☐	☐	☐	☐	☐
Internet radio	☐	☐	☐	☐	☐	☐
Video playback from phone memory (e.g. DivX)	☐	☐	☐	☐	☐	☐
Music playback from phone memory (e.g. MP3)	☐	☐	☐	☐	☐	☐

27. Some ways that can be used for staying in touch with friends and acquaintances are listed below. Which of them do you use and how often? Please, answer by using a scale from 1-8, where 1 = Multiple times a day, 2 = Daily, 3 = At least once a week, 4 = At least once a month, 5 = Less than once a month, 6 = Never, but I am familiar with the medium, 7 = Never, I am not familiar with the medium and 8 = I do not want to answer.

	1	2	3	4	5	6	7	8
I use e-mail with my computer	☐	☐	☐	☐	☐	☐	☐	☐
I use e-mail with my mobile phone	☐	☐	☐	☐	☐	☐	☐	☐
I make phone calls from my fixed line phone	☐	☐	☐	☐	☐	☐	☐	☐
I make phone calls from my mobile phone	☐	☐	☐	☐	☐	☐	☐	☐
I send text messages from my mobile phone	☐	☐	☐	☐	☐	☐	☐	☐
I use instant messaging (e.g. MSN Messenger, Skype-chat)	☐	☐	☐	☐	☐	☐	☐	☐
I discuss/follow discussions at IRC (Internet Relay Chat)	☐	☐	☐	☐	☐	☐	☐	☐
I make Internet calls	☐	☐	☐	☐	☐	☐	☐	☐

(e.g. Skype, MSN Messenger)
I read blogs □ □ □ □ □ □ □ □
I maintain one or more blog(s) □ □ □ □ □ □ □ □
I microblog (e.g. Jaiku, Twitter) □ □ □ □ □ □ □ □
I read discussion forums and/or write to them □ □ □ □ □ □ □ □
I play multiplayer games over the Internet □ □ □ □ □ □ □ □

28. Which of the following services do you use and how frequently? Please, answer by using a scale from 1-8, where 1 = Multiple times a day, 2 = Daily, 3 = At least once a week, 4 = At least once a month, 5 = Less than once a month, 6 = Never, but I am familiar with the service, 7 = Never, I am not familiar with the service and 8 = I do not want to answer.

	1	2	3	4	5	6	7	8
Facebook	□	□	□	□	□	□	□	□
MySpace	□	□	□	□	□	□	□	□
IRC-Galleria	□	□	□	□	□	□	□	□
LinkedIn	□	□	□	□	□	□	□	□
Habbo Hotel	□	□	□	□	□	□	□	□
Second Life	□	□	□	□	□	□	□	□

Do you use some other similar services (as the ones listed above)? What and how frequently? Please, answer using the same scale as above.

	1	2	3	4	5	6	7	8
Name of the service: ________________________	□	□	□	□	□	□	□	□
Name of the service: ________________________	□	□	□	□	□	□	□	□
Name of the service: ________________________	□	□	□	□	□	□	□	□

29. Feedback. Please, share you ideas concerning the survey or the research here.

Thank you for your participation!