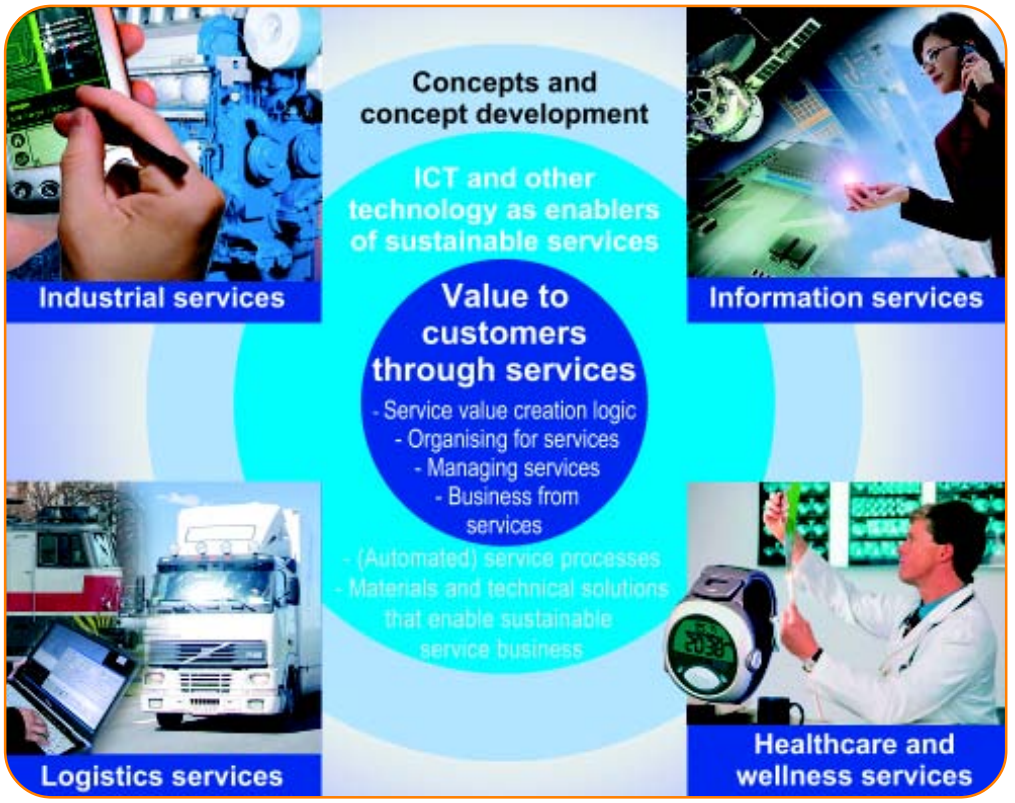

VTT Symposium on Service Science, Technology and Business

VTT SYMPOSIUM 253

Keywords: business-to-business services, business-to-customer services, industrial services, information services, service concept development, ICT based services, health services, wellness services, service delivery

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Abstract

VTT's traditional focus has been on the development and application of technology. However, over the past couple of years, our interests have extended to technology-based business and innovation research. Many research groups and teams at VTT have carried out relevant research – often without explicitly calling their work service research. In order to boost the service business, VTT launched the Service Beyond theme in August 2005 as one of the Strategic Technology Themes. The theme was strongly business oriented, and sought to track new commercial service innovations, assuming basic ICT technology (e.g. hardware devices, sensors and IP infrastructure) was already available. As a result, the main effort was focused on integrating the technology into innovative service concepts. Based on VTT's competencies and know-how as well as expected business potentials, the focus areas for the theme were defined as: 1) Services for citizens – Well-being and quality of life, 2) Industrial services – Enhanced human technology interaction for mobile workers, and 3) Services for living – Living in buildings. To demonstrate and disseminate our competence wider than the theme alone, an internal symposium was organised to take an overview of the service research at VTT and to compile representative documentation on recent and ongoing service research. The symposium papers fall into four key areas of service business: 1) Industrial services, 2) Information services and concept development, 3) ICT-based services where ICT plays a key role in delivering or providing services, and 4) Health and wellness services. These topics cover the whole service and value chain and a wide spectrum of various types of business. Service enabling technologies are included on the condition that the service business model is discussed thoroughly. Both business-to-business and business-to-customer services are covered. Our research covers all three main interdisciplinary areas of service systems: business, people in different roles in organisations, and the technology to share the information.

Preface

Services, both as a business and as a science, are a rapidly growing sector, and they have a remarkable influence on processes and operations in companies and other organisations. This change not only touches industry but also society as a whole, affecting the everyday life of citizens. Today, service business is experiencing rapid and extensive changes with impacts on existing business operations and the roles of actors. Services now represent over 70 percent of the economy in OECD countries, and over 80 percent in the U.S. ICT is developing rapidly, providing new service business opportunities. However, the elaboration and implementation of services take place at a remarkably slower pace – slower than what technology enables.

Traditionally, VTT's main focus has been on the development and application of technology, but recently technology based business and innovation research have also been part of our focus. Many research groups and teams at VTT have carried out relevant research – often without explicitly calling their work as service research. VTT has invested in developing competencies in service research – recently in the Service Beyond Technology Theme, with the purpose of recognising generic service concepts valid across business segment boundaries and which utilise state-of-the-art ICT. One of the target areas has been business cases with new commercial service innovations. Taking this path, VTT aimed to increase its front-running role, particularly as a developer of service enabling technologies and service business models. The relevance and benefits to Finnish industry and society continue to be the guiding principles in our service-oriented R&D activities.

This internal symposium was organised to take an overview of the service research at VTT and to compile representative documentation on recent and ongoing service research. The symposium's focus was on services that are treated as:

- economic activities offered by one party to another to bring about desired results for recipients themselves or in objects or other assets
- a system of interacting parts that include people, technology and business that draw on ideas from a number of existing disciplines and integrating them into a coherent whole
- co-produced activities by the customer and the provider on a customized basis where, for the exchange to be successful, the provider understands the customer's business and the customer understands the provider's capabilities.

These topics cover the whole service and value chain and a wide spectrum of various types of businesses, from service providers to value-adding offerings of "hardware" providers. Service enabling technologies are included on the condition that the service business model is discussed thoroughly. Both business-to-business and business-to-customer services are covered. The papers are grouped according to their content into: 1) Industrial services, 2) Information services and concept development, 3) ICT based services, where ICT plays a key role in delivering or changing services, and 4) Health and wellness services.

I thank all the contributors for their distinguished achievements in the field of service science. I trust that this collection, introducing some of the results of VTT's service R&D activities, will be of interest to a wide variety of readers, whether they be business managers, civil service managers, experts in technology or service development, and researchers themselves.

Pentti Vähä

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Programme Manager
Service Beyond

Animals, goods and technological innovations: The story of the noun *service*

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The noun *service* is quite productive. Above all, it tends to qualify the so-called head noun, for example, *agreement* or *manual*. In the compound *service science*, *service* qualifies the head *science*. The focus falls on the latter word. According to the *Oxford English Dictionary* (OED), these kinds of business-related compounds were not frequent in the English language until the twentieth century. Twentieth-century examples from the OED include *service industry, service occupation*, and *service sector*.

In this article, we will outline the history of the noun *service* as presented by the OED, some electronic corpora of the English language, and the Internet. A linguistic corpus is a collection of texts in electronically accessible format. The corpora which we have used for this article represent eighteenth-, nineteenth- and twentieth-century English. This is a pilot study, meaning that the corpus results are tentative.

The following is a simplified presentation of the OED main senses for the noun *service*:

I. The condition of being a servant to a master.

II. What(ever) someone does in order to serve a superior.

III. Religious devotion and/or activity.

IV. Something given or received.

V. Supply of something (mainly material, but potentially immaterial).

In addition to these five senses, the OED lists a great number of subsenses, part of which will be discussed.

The OED suggests that the medieval ‘waiting at table, supply of food’ sense of *service* is the origin of all senses suggesting the ‘supply of something’, such as the present-day English ‘provision of maintenance or repair work to ensure the efficient running of something’. Here we can see a generalisation of the sense ‘supply of food’ to ‘supply of anything that people need’.

The OED sense ‘duty of a soldier or sailor’, including the contract, the moral obligation, and the actual performance of the duty, stands out as a potential core sense in the sixteenth century. Our findings suggest that in the eighteenth century, *service* often involved instances of good will, or simple wishes to help someone, which might still very well be core components of *service* today.

In the nineteenth century, we see such modern senses of service as ‘the supply of gas, water etc. through pipes from a reservoir’, ‘provision of labour and materials for the carrying out of some work for which there is a constant public demand’, and ‘transit afforded by vehicles plying regularly on a route’. In this way, the history of the word reflects the development not only of modern society, but of modern technology. The history of *service* infolds the kinds of things and the manners in which these can be supplied in each period.

In the twentieth century, business and society merged in the concept of privatization (state services being owned by private enterpreneurs). This development is reflected, for example, in the compounds *service-learning* and *community service leaders* and the concepts behind them.

People’s associations of the noun *service* with various concepts certainly depend on their personality and background, including native language. As for historical strata of the meaning of *service*, these are likely to mix in a present-day English speaker’s mind. There seem to be two particularly relevant questions. One is if any common associations are primary and others secondary; the other related question is whether people associate *service* with something positive or negative. The relative importance or ‘weight’ of the various associations contributes to how positive or negative a matter *service* is.

Contents

Developing industrial service capability: Towards service-oriented organisation culture

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Abstract

The aim of this paper is to introduce a new emerging approach to analyse and support industrial service business development from the organisational activity point of view. Developing new profitable industrial service business is challenging regardless of the way chosen to build the business. There are several identified organisational challenges in developing industrial services, related, for example, to manufacturing traditions, different operational functions and managerial processes. The new approach is based on two main concepts: industrial service capability and industrial service culture. The paper presents preliminary results of how our approach worked in a case study: what we learned from the challenging nature of the change and the limitations of the approach. In the end, the challenges of supporting the change from a product-oriented culture to a service-oriented culture are discussed.

Introduction

Industrial services business

Manufacturing companies are increasingly investing in building industrial services. Lately, there has been an increasing interest also to study industrial service business and service innovations [e.g., 1, 2]. Some studies have been focusing on the challenges in the transition of manufacturing organisations to become more service oriented [e.g., 3, 4, 5, 6]. Typically. in manufacturing companies industrial services are developed as an extension to products, for example, to support the life cycle maintenance of products. Nowadays, it is not uncommon that companies would also invest in developing new services outside their traditional product business area. These may include services such as consulting, information services or training services. However, due to long manufacturing traditions and yet quite a small volume of service business in many companies, there seems to be lack of belief towards services as a potential growth business.

Industrial service development is a systemic change in a company. It requires and creates changes in organisations, processes, partner networks and customer relationships. The transition of the companies from product provider to service provider can be considered as a stepwise strategic development process. In Figure 1, this development path is described as development of a service provider's competencies and the intensity of customer relationship.

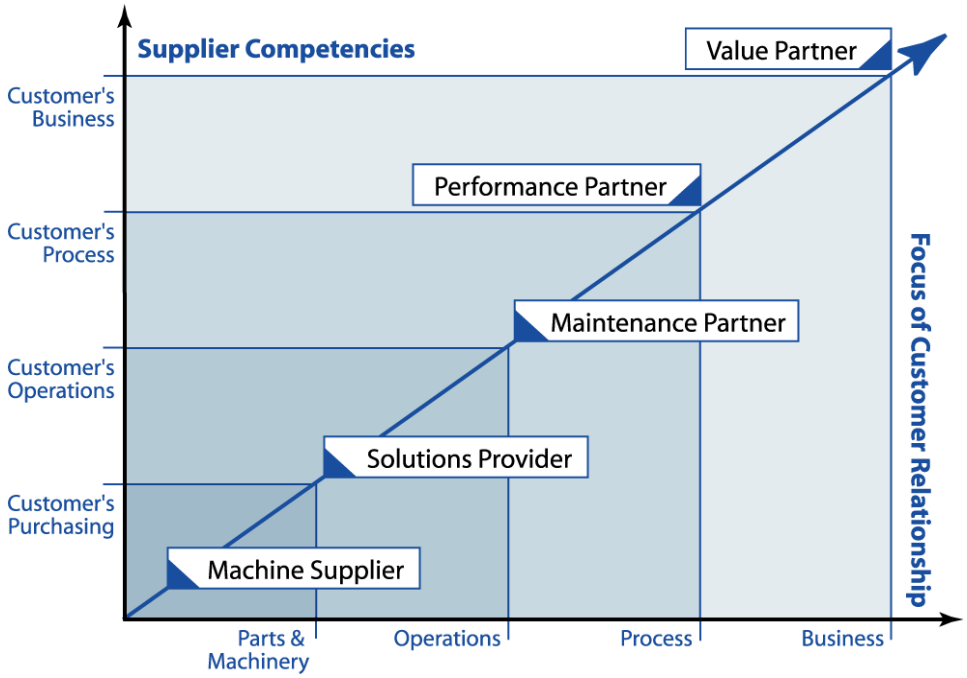

Figure 1. Service performance development steps [7].

We argue that in order to understand the opportunities and constraints of the transition process, change in industrial service business should be analysed and developed from strategic, operational and cultural perspectives simultaneously. The comprehensive approaching of service management in manufacturing companies requires an interdisciplinary theory that integrates service management, motivation and behavioural theory [4]. We have integrated management and organisation theory views to build a concept of industrial service capability that presents an organisation level approach to developing services in manufacturing companies [8]. The new concept is a key building block in an approach for analysing and supporting the change in manufacturing companies towards the industrial service business.

Organisational challenges in developing industrial services

Organisational challenges related to a manufacturing company becoming a service provider can be evaluated from many perspectives. Usually these challenges are

consequence of strong manufacturing oriented way of doing business. The major challenges from an organisational perspective seem to be related to managerial roles, employee perceptions, service development procedures and creating a service-oriented culture.

Gebauer and Friedli [9] have studied successful and unsuccessful transition processes from products to services, and identify some critical behavioural changes needed, focusing on managerial and employee perceptions. Managers need to be aware of the economic potential of the service business and be willing to *take some risks* when investing in service development. In service development, managers also need to focus simultaneously on establishing several new elements of organisational structures and processes in renewing the business. This means that *managerial role changes* from customer support to business management. *Employees service awareness* needs to change from giving customer service favours for free, to really appreciating services as value added business. Another challenge for the employees is to *understand the organisational change* needed to move from selling products to providing services.

In extending the service business in manufacturing companies, Gebauer et al. [3] emphasised the following aspects in their guidance for management: 1) Establishing a market-orientated *service development process*; 2) Focusing service offers on the *value proposition* to the customer; 3) Initiating *relationship marketing*; 4) Defining a clear service strategy; 5) Establishing a separate *service organisation*, and 6) Creating a *service culture*.

Industrial service development is a process that focuses on three levels in an organisation: strategy, business processes and operation [6]. In addition to this *multi-level nature*, also a strong *cross-functional development* approach is required because service development is very much a systemic and process-like phenomenon. Another aspect of industrial service development is that both fast and incremental changes may be needed in the process of moving towards a more service-based business. The central challenge for companies is to organise and manage the change processes, taking into account all these special characteristics. [10]

The aim and the structure of this paper

The aim of this paper is to introduce a new emerging approach to analyse and support industrial service business development from the organisational activity point of view. The key factors in the approach are the concepts of industrial service capability and service culture.

We have introduced the industrial service business concept and the background related to organisational challenges found in service business development. Next, we will

present our new approach for industrial service development and illustrate it with a case study. Later, some challenges of supporting the change from a product-oriented culture to a service-oriented culture are discussed through the case study. Finally, some benefits and challenges of the approach are discussed.

New approach for developing industrial service capability

From the perspective of work and organisational research, the central challenge is to understand different levels of organisational behaviour and the associated cultural and organisational factors, both enablers and hinderers, related to industrial service business transition manufacturing companies. Our approach for developing industrial services is strongly based on two main concepts: industrial service capability and industrial service culture. *Industrial service capability* is presented here as a concept that helps to consider both strategic and operational level challenges in the development of industrial services. Industrial service capability is built on theoretical perspectives of organisational capabilities, service quality, service management and organisational culture.

Industrial service capability in our study is seen as a particular form of organisational capability. Organisational capabilities are suitable for addressing complex organisation-wide processes, such as service management [11]. We define industrial service capability in an organisation as collective operational characteristics and qualities aiming at renewing manufacturing business towards services and providing services. Organisational level perspective here means that the capability is something possessed by the whole company. It includes the particular organisational competences needed to provide industrial services. Industrial service capability in an organisation is expressed in 1) service-oriented organisational culture, 2) managerial abilities to understand service operation, 3) managerial practices to run service operation, 4) inter-functional development procedures, and 5) development oriented customer relations.

An important factor in industrial service capability is organisational *service culture*. The service culture concept can be defined as a solution created by an organisation for the demands set by searching for the core task and the changing core task in the context of transition towards industrial service business. [12] Industrial service culture includes in particular those practices, values, norms, conceptions and underlying assumptions that are related to the service business. With the service culture concept, it is possible to describe the recognition of the current level of service business in the organisation and the experienced need for service business development. Related to service culture, one challenge in moving from being a purely product-oriented organisation to producing product service systems is that in fact there may be two simultaneous core tasks, one aiming at producing products and another aiming at providing services. This situation

may be prevailing in manufacturing companies at least in the transition period before the core task refocusing on product service systems is defined and in use.

We started to develop a new integrative approach to analyse and support the change process in industrial service [10]. The approach is based on ideas from previous frameworks of strategic enterprise network development [13, 14], organisational culture assessment [15], and analysing and assessing working and organisational practices [16, 17, 18, 19].

Based on literature and preliminary studies regarding the industrial service business, we formulated *five critical dimensions of change in developing service capability*: 1) business environment and competition situation, 2) customer demands and customer strategy, 3) strategy and practice of management and leadership, 4) company culture, and 5) internal and external cooperation and competence. These critical dimensions specified our approach, forming a basis for the service capability development agenda used as a method for structuring the development work in companies. Additionally, the pilot version of the service culture survey was created based on these five dimensions.

Case study

Case study objectives

Our approach was piloted and tested in a case study. We selected a case company in an early state of its development towards becoming a service business provider in order to challenge and test our approach profoundly. The case study started at the end of 2006 and is ongoing. The case company produces machines which are based on advanced technological competence and it is a market leader in its own branch. The practical aim of the study has been to support the development of industrial service business by analysing the current strengths and challenges of the organisation and enhancing development actions.

The data gathering and development methods in the case study have included interviews, organizational culture survey, working groups and seminars. The study started with interviews of the key personnel of the company. Then development groups were established and the data from them collected. The material produced in these sessions and the memos of discussion are a further source of data. In these development groups, the researchers offer the frame for discussion and particular development tasks and the company personnel works within this frame. In addition, a personnel survey was conducted in the company. The questionnaire was a pilot, contextualized version of the

well-documented CULTURE questionnaire [see 15]. The pilot version included a new part focusing on service culture.

The data of the interviews was first used to get familiar with the company and its current practices. The data was analysed in order to create an overview of the main challenges and strengths for service business development. This overview created the basis for organising development groups for particular issues in the case company.

The response rate in the service culture survey was 58%. The results of the survey were discussed and analysed in a workshop in the company. In the cooperative analysis, the meaning of the results from the point of view of the operational history, current state and development conditions were reflected. Several contradictions complicating the organisational change towards services were recognised on the basis of the analysis.

Results

The analysis of the data from the case company resulted in recognition of several challenges in the current culture and way of operating, which should be solved in the development of the service business. These included the following:

- How to prioritise: invest time and energy in daily duties or in developing service business operation
- How to handle risk: offering services which are based on very limited resources and pilot concepts or developing resources and offerings further without knowing if they are going to be profitable
- What to sell: product that is good by itself and needs no support services or services that can be based on a wide range of products and are questioning the very uniqueness of the product
- What kind of competence to develop: product and manufacturing competence or customer service competence
- How to commit the organization to the change: strong strategic management or gradual co-operative working.

Based on the results of the personnel survey, four dimensions of a new industrial service business core task and its development were recognised. These were the following: 1) the realistic recognition of the current level of service business, 2) the experienced need for service business development, 3) the recognition of potentials for service business in the environment, and 4) a positive attitude towards increasing cooperation and services. In the case study company, there seemed to be quite a realistic view of their early state in service business development. The experienced need for change was

on a mediate level although they did not always see potential or conditions for developing services. The attitude towards increasing cooperation was clearly positive.

The case study revealed that in developing a service business it is important to realise the extent of the changes needed in an organisation's core task. The targeted core task dramatically changes and the demands it sets on the organization and individual are hard to understand when the previously product-oriented company chooses to search for growth in service business. Another challenge is related to the result that there are (at least) two conflicting core tasks during the transition phase: one related to product and the other related to service production.

Discussion

The aim of this paper was to introduce a new emerging approach to analyze and support industrial service business development from the organisational activity point of view. We introduced the industrial service business concept and the background related to organisational challenges found in service business development. We presented our approach for industrial service development that was based on five dimensions of organisational development and illustrated it with a case study. Our case study indicates that it is important to recognise the critical contradictions in the culture and operation of organisations, contradictions which should be solved in the development of the service business. The case study also led to recognition of four dimensions in developing a new industrial service business core task. A significant organisational challenge that the case study also showed was that in the transition phase towards service operation, there are two conflicting organisational core tasks.

Organisational challenges related to developing a more service-oriented business in manufacturing companies were presented in the first chapter. The major challenges were related to market orientation in operation, needed changes in managerial roles and employee perceptions, and the overall understanding of the extent of organisational changes needed. In addition, the creation of systematic service development process and service-oriented operational culture, and adopting cross-functional development approach are found challenging. Our approach for developing organisation-level industrial service capability was built to answer these specific challenges. The five dimensions that the approach is built on consider the following aspects: business environment and customer perspectives, management practices, company culture and internal collaboration in the organisation. In addition, the employee perceptions are widely evaluated as a part of the service culture survey, which forms an important part in our approach. Based on these features, we state that our approach meets the organisational challenges of service development.

There are some further methodical challenges we identified in our approach based on the case study. Realisation of the needed change in an organisational core task is an important factor in industrial service development. A definite challenge in this is that the intended core task does not exist in the present, but in the future, and the current culture restricts the way of thinking. The stronger emphasis on anticipatory, conceptual core task modelling as a part of a service development process could be one way to overcome this methodological challenge. Another challenge is closely related to the pervious one: how to guide and support the organisation in practice to find solutions to the conflicts of the core tasks in such a way that these solutions also promote the change from a product-oriented culture to a service-oriented culture? Emphasising the cooperative definition of the targeted core task more and its reflections in the current culture during the development process can also be a solution to this challenge.

Conclusions

Developing industrial service capability by analysing and supporting the change process from a product-oriented culture to a service-oriented culture showed potential according to our study. The different contradictions of the case study argue for the need for a balanced and parallel development approach. Analysis of industrial service culture and the core task concept can be utilised for this purpose. Based on this study, we can propose three important pre-conditions for change from a product-oriented culture to a service-oriented culture. Individuals and groups in an organization should consider the service business worth of investing their energy and time in and they should have the feeling of having possibilities to get the resources and the competence needed for the development. They should also have opportunities and knowledge to reflect core task change demands and the development state of service business. Supporting the organisational change towards services is a very challenging task and further development of our approach is still needed.

Acknowledgement

The authors wish to thank the colleagues who participated in the definition of the preliminary approach and the personnel of the participating organisation for helpful cooperation and many fruitful discussions. The writing of this article was supported by ServO-project funded by Tekes, VTT and companies.

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Service business development in machinery manufacturing industry – results from the project "Future Service Concepts – Based on Diagnostics"

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Abstract

A new production paradigm consists of collaborative networks, in which, for example, service providers deliver maintenance and design. The transformation from product-centric to service-centric business calls for a new way of business thinking. For a machinery manufacturer, the transformation constitutes a major managerial challenge and is an important strategic choice. The paper describes a novel framework for industrial services addressing key areas of development in a company looking for growth in service business. The framework consists of three main areas: 1) Service business development, 2) e-Maintenance, and 3) Product development. The paper also sketches the areas for further research.

Introduction

When manufacturing companies focus on their core business, the role of external services increases. According to a survey by the Plant Maintenance Resource Center [1], the objectives to increase labour productivity, to reduce maintenance costs and the willingness to focus on the core activities are the main drivers for buying the maintenance and development services in the capital-intensive industry. Production processes and related machinery are becoming more complicated and keeping up the required skills and special know-how or resources in the in-house organisation may not be profitable. Besides logistics services, external maintenance services are the most important services to the manufacturing industry [2].

The industrial companies expect increasing significance of the services as a part of the business and it to become a source of growth [3]. Service business seems also to offer more steady and continuous turnover than capital business, which may be very sensitive to economic fluctuations. In a Finnish survey, two-thirds of the companies reported that during the last three years, the after sales market growth was 10% per year [4]. One

third of the companies reported over 20% annual growth rates. However, 60% of the Finnish companies answering the inquiry estimated that the value of the after sales services is less than 10% of their turnover.

According to Deloitte [5], the main challenges in increasing the service business are in strategy and business design, operations planning and management, and execution. There is a lack of insight into the barriers and opportunities for driving profitable growth through services. Similar conclusions have been made in a BestServ feasibility study [6], which considers the current status of research and development and consequently needs for future research. Many companies find that they still lack successful business models and the right Industrial Service mindset throughout their organisation. One reason for this may be the lack of customer-oriented industrial service development management and a lack of successful industrial service business frameworks.

Service science and business has an important role in VTT's technology strategy. The main objective of the Future Service Concepts – Based on Diagnostics project was to collect VTT's experience in measuring, monitoring, diagnostics, prognostics and ICT together with systems engineering and maintenance management in such a way that VTT can deliver the customers comprehensive knowledge in all areas of service business development, and form a development strategy.

Service business models and new product concepts

For a machinery manufacturer, the transformation from a product-centred business to a service provider constitutes a major managerial challenge and is an important strategic choice. The change in the value creation logic needs to be understood when building a business model for a service. Osterwalder et al. [7] define a business model as *"a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams"*.

Companies in the service business may not have a single model, but they rather may have to apply different models depending on the value creation logic of the service. The prevailing value creation logic of many product-centred manufacturing companies is the value chain. Value chain is a Porterian approach, in which value arises from cost-efficient transactions. Other basic approaches are value shop and value network [8] or value web [9]. In value shop, the key competitive factor is not cost-efficiency, but rather the value of the solution to the customer. In the value network – or value web – the value is derived from the number or quality of direct or indirect connections.

The changing conception of a product may also lead to new business concepts. As an example of the transition from ownership to access is the cost per performance agreement. Figure 1 presents an example of the profitability evaluation of such agreement. When the access and service (performance) replaces ownership to the product, then there will be room for new innovative business models, for instance, for new kind of knowledge-based companies [10].

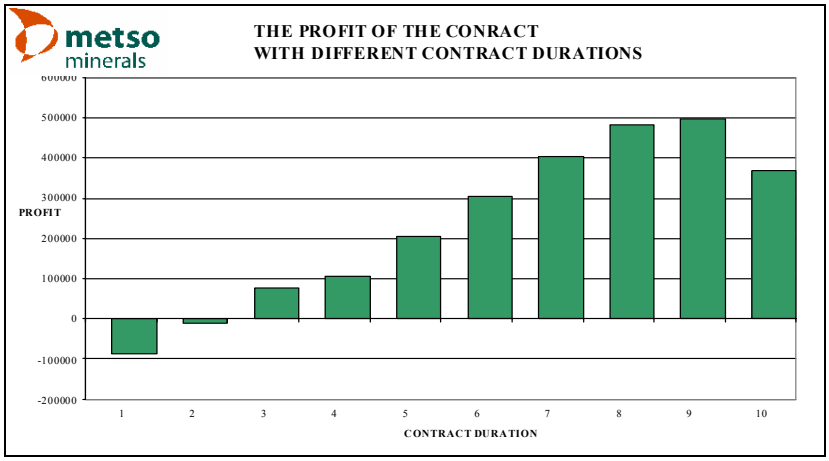

Figure 1. An example on the profitability evaluation of a cost per performance agreement [11].

The transition to the service business is considered a great challenge for the whole organization. Service processes change relations, work sharing and information flows between service providers and customers, and thus necessitates changes at the customer's end. Table 1 compares the nature of the products and the services.

Table 1. A comparison of traditionally produced products and service products [12].

Traditionally produced products	**Characteristics of services**
Goods and products have detailed specifications.	Services are described and illustrated.
Goods and products are produced in well-planned and controlled processes.	Services are performed.
The goal of producing goods is uniformity.	The goal of performing services is uniqueness.
The customer is not involved in production.	The customer is often involved in the service performance.
Internal quality control compares outputs to specifications. If improperly produced, the product can be recalled.	Customers conduct quality control by comparing expectations to experience. If improperly performed, apologies and reparation are the only means of recourse.
The morale and skill of the production workers is important.	The morale and skill of service providers is critical.

Research methods and data collection

The main objectives of the Future Service Concepts – Based on Diagnostics project was to collect VTT's experience and form a development strategy. We used a questionnaire to collect data from the knowledge centres having experience of some areas of service development. These areas included service business earning logic, profitability, enabling technologies, service architecture and implementation, and management of product characteristics. The customer references in the service development were collected together with the views on challenges and research needs.

We arranged brainstorming workshops to produce a vision, to create the framework for industrial services, and to identify the needs for further development. As attending researchers were involved in customer discussions and projects, we addressed customer needs by reviewing relevant ongoing sales activities in workshops, and by analysing the identified development needs. Customer managers attending the brainstorming sessions brought further insights. The relevance of the developed industrial service business framework (Figure 2) was tested with ongoing discussions with customers.

Industrial service business framework

When starting to create a service business framework and development strategy, the project group defined the vision as follows: *New product and service concept development as a joint effort with our customers for the optimised lifetime profitability of machinery – e-Maintenance makes the difference.*

Creating a service offering covering the entire life cycle of a product calls for major changes and extensive development work in several areas in the company's operation. In our project, a service business framework addressing the key areas of development was created (Figure 2). The framework consists of three main areas: Service business development, Product development for life cycle business and e-Maintenance. The following chapters illustrate the content of each area is in more detail.

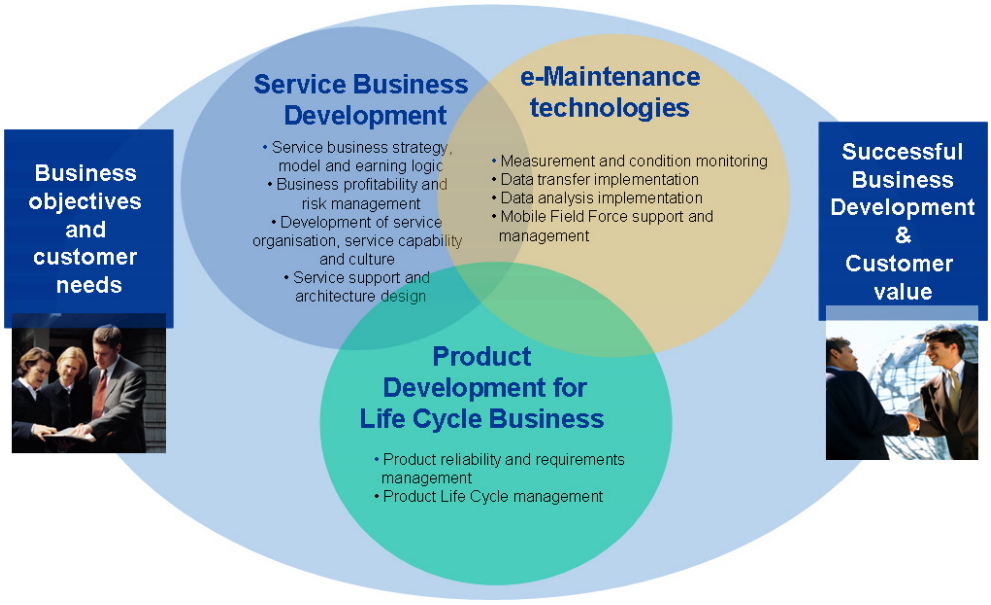

Figure 2. Industrial service business framework [13].

Service business development

Developing a service business and building multidimensional business models that cover the different value creation logics is not an absolute value. Building sustainable service business calls for careful strategy work during which the maturity of the offered product and related technology, and the markets need to be analysed [14]. Service business is on solid ground only if it is strategically sound for the provider and encounters customer's true needs. Therefore, the strategy exercise needs to be conducted also by the customer. In service development, the customer is present during the whole process.

The transition to a service business is a remarkable change for an organisation. Organisations should also notice that new risks emerge and old ones change. These risks must be carefully taken into consideration during the transition process, thus a well-organised risk management process covering endogenous and exogenous risks is needed. In the steps of the transition process one must also consider the different risks that are connected, for example, to customer relationships, contracts and responsibility.

In the area of service support and architecture, system and service engineering, design process, methods and tools are available together with competence on implementation and deployment of innovative ICT-based service systems. When a company includes services as a part of its business, the service architecture is a part of the corporate architecture. It is also recognised that the sophisticated methods of business modelling bring new information for the development of systems supporting the business.

Product development for life cycle services

Product development is a crucial phase also in relation to the life cycle services since a major part of life cycle costs is defined by the decisions taken in the early concept and design phases [15]. The management of a product's life cycle may offer the machinery manufacturer a significant competitive advantage.

Life cycle services attempt to guarantee the achievement of the agreed service level, typically the production efficiency, of the manufacturing assets over the entire life cycle. The characteristics of the product including reliability and maintainability are defined by choices: i.e. component quality, tolerances, system configuration, handling, and ease of maintenance actions. A product's downtime is a function of how easy, safe and economic it is to perform the maintenance, and how effective the maintenance organisation is in carrying out the required tasks (Figure 3).

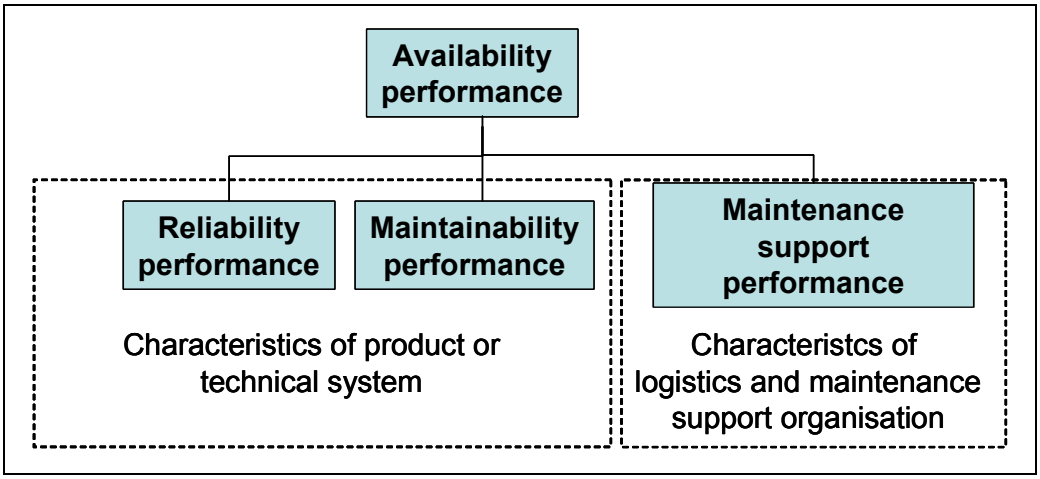

Figure 3. System availability performance, modified from the IEC 60050 [16].

Typically, tradeoffs are made in the design phase between the numerous requirements and design factors (e.g. manufacturability and maintainability). However, when the manufacturer's responsibility as a service provider is extended to cover the whole product lifecycle, the weights of these factors may need to be reconsidered. Product design phase offers the machinery manufacturer an opportunity to create life cycle services that are based on detailed knowledge of the design parameters.

Apart from having the best knowledge of the product related technology, the product manufacturer is also able to make technological enhancements to favour services. Thus, the product manufacturer can enhance the service business profitability by considering service related requirements in the product design phase as well as in enabling technology development. Implementation of enabling technologies provides the basis for e-Maintenance applications.

e-Maintenance

The e-Maintenance platform offers the technology that can support the previously described service business framework with suitable hardware and software. Iung [17] defines e-Maintenance as the ability to monitor plant floor assets, link the production and maintenance operation systems, collect feedback from remote customer sites, and integrate its upper level enterprise applications. The adaption of e-Maintenance aims at promoting a major change in the focus of condition-based maintenance, essentially taking full advantage of recent advanced information technologies related to hardware, software and semantic information modelling [18].

The main technologies facilitating the upgrade are wireless devices, such as smart tags and micro-size MEMS sensors. Adequate information processing tools should take care of the continuous data flow and suggest appropriate actions to the operators. At the intermediate level, smart hand-held devices, such as PDAs (mobile agents) will provide higher communication interfaces with sensors, intermediate processing capabilities and a smart user interface to remote web services that will compose a distributed web platform system at the higher end of the processing hierarchy. This coupled with wireless data transmission between sensor devices and information processing layers should provide adequate mobility for a distributed and collaborative system. Based on the e-Maintenance concept and data management, the final goal is to be able to manage the entire life cycle of large investments in an optimal way. This includes interoperability solutions for managing the information between various data sources.

Research and development needs

The service business framework (Figure 2) gives an overview of VTT's present offering to machinery manufacturers in the field of service development. In order to search for future research needs, we arranged two brainstorming sessions with the question: what will be the next goal for the service companies after value partnership.

The research ideas and needs generated in the brainstorming sessions were clustered and the remaining clusters were analysed in relation to technology/business intensity and maturity (closeness to the market). Figure 4 shows the resulting classification. In several areas, identified technology or knowledge is rather mature and close to the market. Few research ideas we regarded as research intensive (low maturity) and they would require an in-depth study to investigate the potential. Most of the ideas lay between these two extremes, indicating that the technology or knowledge is at least partly available, but some development needs still exist.

A major part of the technology intensive research needs in Figure 4 is not dedicated especially to industrial services. Also, traditional capital business profits from new product characteristics, e.g., *advanced diagnostic and prognostic properties*, new generation user interfaces, or from *cost-effective sensors*. However, a service business may accelerate the development as service providers look for more efficient operation models. One interesting development trend shown in the figure leads to *machines communicating* with each other, and finally to the consolidation of traditional branches – *convergence*. In this case converging branches could be machine design and ICT.

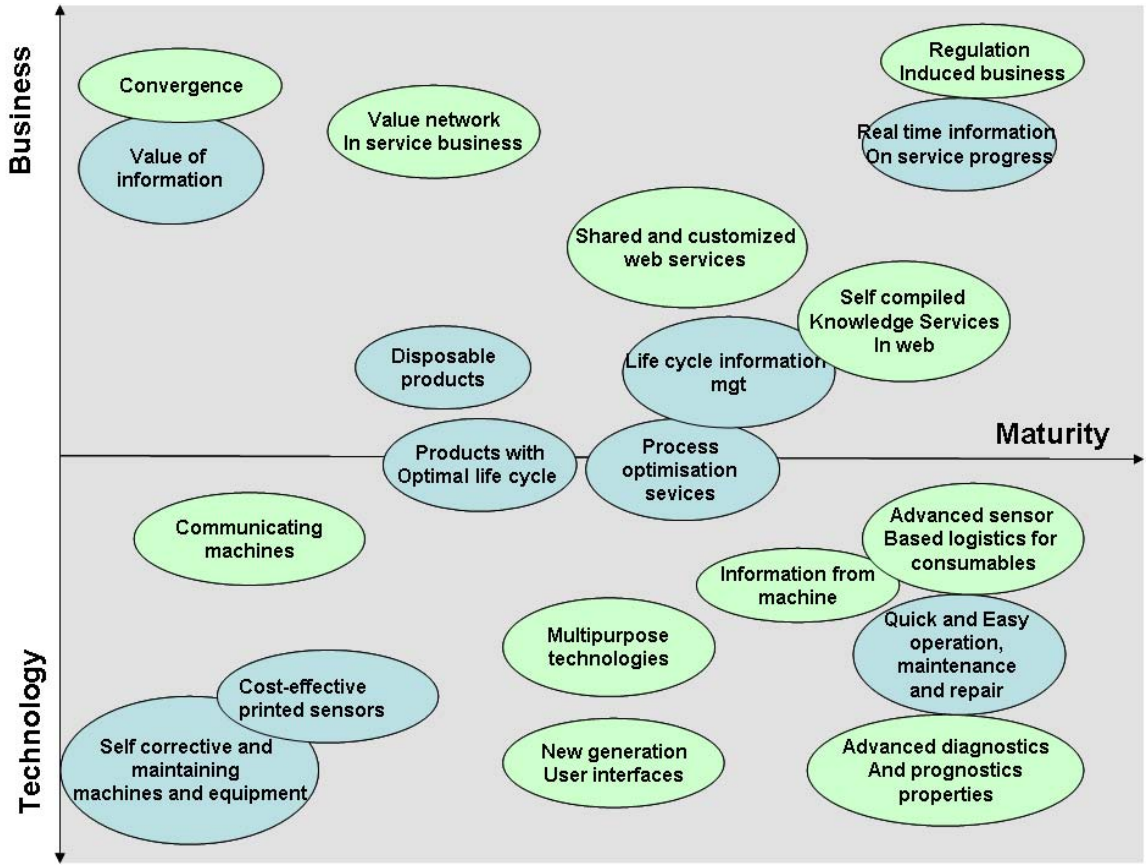

Figure 4. Identified research needs classified according to the technology/business intensity and maturity (closeness to the market).

A variety of sophisticated measurement techniques and data transfer methods are available already today. Advanced machinery manufacturers already collect *information from the machines* in the field. The development needs concentrate in the utilisation of the information. The use of the information for *process optimisation services* or *life cycle information management* are possible development trends. Novel possibilities could be derived from collaboration of service providers, e.g., establishing *shared* and *customised*, or *self-compiled knowledge services in the web*.

Further development would lead to *value networks* in services if earning logic in collaborative networks can be agreed upon. The *value of information* is crucial in knowledge intensive services. An important question is what the customer is willing to pay for a piece of information, and how this value is defined. Value creation has also the reverse side: how to share risk. New business models implicitly give rise to new types of risks, which need to be identified, taken into account and controlled. Also, new methods are required.

Growing service business may not be a lasting trend: *disposable products* exhibit another possible future. In capital-intensive industry, the life time of production machinery is traditionally designed to be long. However, shortening end-product cycles and the desire to reduce capital-intensity may lead also to new solutions in production machinery design.

Conclusion

The industrial service business framework developed in the Future Service Concepts project addresses the issues that reflect the customer needs and VTT's experience in service business related assignments. The areas include service business development, product development for life cycle services, and e-Maintenance. When identifying the future research needs in the roadmapping process, we concluded that the major part of technology intensive research needs is not dedicated especially to industrial services. However, the increasing service business may boost technology development. In our opinion, the greatest challenges are in understanding and modelling value creation and sharing, in building value networks and in the goal-oriented utilisation of information. The consolidation of traditional branches – convergence – may lead to unexpected and extensive changes, which need to be searched for.

Our findings correlate well with the technology roadmap for Intelligent Services [19] which states that the service-related technology development must not be separate from the development of the service business itself but be driven by the needs identified.

The European "Vision for 2020" report [20] calls for understanding manufacturing as a network of complex and development-oriented relations. A new production paradigm is based on collaborative, value-adding networks, in which, for example, maintenance, design and logistics are delivered by service providers. Accordingly, the technological approach has to be combined to new market conditions and business models in order to reap maximum benefit from the innovations.

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Mixed-reality techniques to support a new type of service business in industrial operation and maintenance

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Abstract

Traditionally, industrial facilities such as process plants have been maintained by the plant owner's organisation. As the plants have become more complex and the demands of production performance have become higher, the outsourcing of plant maintenance activities and combining them to performance consulting has become attractive, thus opening a new market for industrial services. This has resulted in major changes in the work and responsibilities of the maintenance engineer. The change has in turn set new demands for software products and opened new software business opportunities. VTT has international state-of-the-art expertise in industrial software architectures, Augmented Reality, video stream processing and human-technology interaction. Using this expertise, we have developed a novel concept for providing each stakeholder intuitive access to the right information in the very location on the plant floor where that information is needed. The concept involves video-stream based user interfaces, mobile devices and location-aware information services.

Introduction

The lifecycle management of a complex industrial facility, such as a process plant, involves three main groups of players: the owner/operator of the plant, system/equipment providers and engineering consultants. Traditionally, the operation and maintenance of the plants have been the plant owner's core business and therefore carried out by the plant owner's own organisation. The role of the equipment suppliers has been mainly to supply spare parts. However, as the demands set by the global business environment on plant performance have become higher and the plants have grown in complexity, the plant owners have started to outsource plant maintenance and even parts of the plant operation. This has developed new business opportunities in industrial services (Figure 1) related to plant maintenance and performance consultation. While the change creates new business opportunities, it also creates new demands for software applications and

services related to application interoperability and the usability of human-system interface.

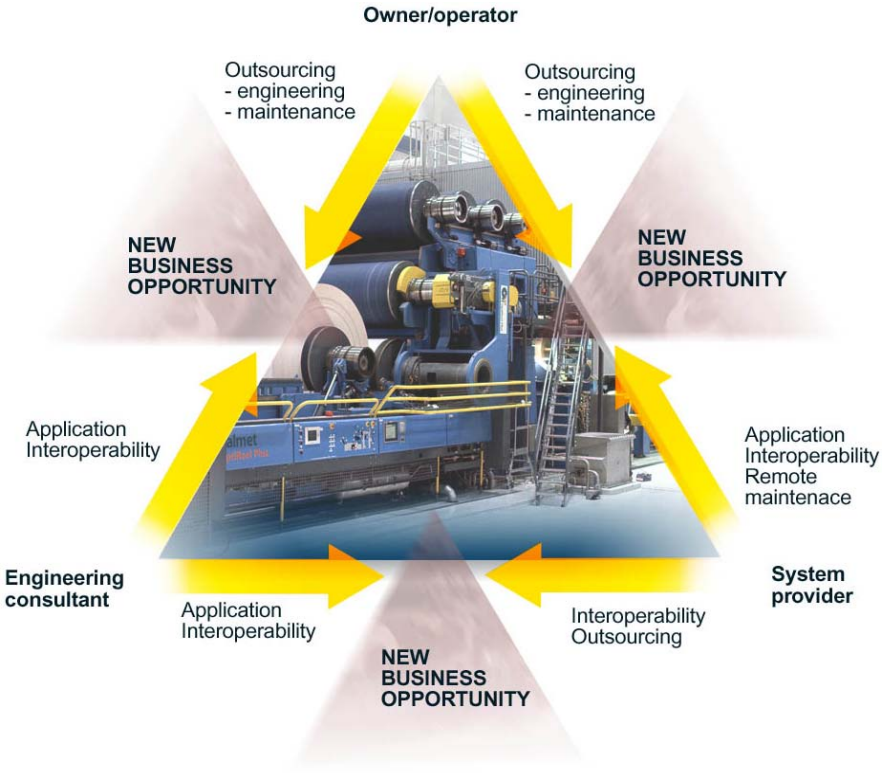

Figure 1. Change of focus in plant maintenance management, modified from Ylä-Anttila's web page [1].

From the maintenance personnel's point of view, the major change is that the workers tour around several plants without having the chance of really getting to know a specific plant. Therefore, all information about the plant that they need to have to accomplish their tasks must be made explicitely available to them. This sets requirements on the plant's documentation as well as on the plant's automation and maintenance systems. Moreover, during their working tour they have to be able to plug their software tools into various plant systems, which sets requirements for the standardisation of plant system interfaces and the semantics of the plant data.

Even though the current maintenance and automation systems enable the storage and browsing of equipment and process-related data, many of the common problems the maintenance personnel are facing are not solved, e.g.:

- how to locate the equipment needing maintenance,
- how to get intuitive and easily understandable information about the plant floor equipment and their state,

- how to combine data from several sources without accessing many different applications with various user interfaces.

The problems are expected to become more difficult in the future. Currently, there are ongoing industrial efforts (see ISO 15926 & IAI web pages [2]) that aim at standardisation of plant lifecycle information expression in different contexts. This information model, also known as the plant model, will form the basis for application interoperability in the industry.

In the Plamos (Plant Model Services for Mobile Process Maintenance Engineer) project, a new concept was introduced for accessing data from any plant application using intuitive user interfaces. The primary scope of the Plamos project is process plant maintenance. However, the results are applicable also to other business areas, for example the building sector.

Business foresight and conceptual design

To find the essentials of the maintenance work and to outline changes and future challenges in this domain, the Core-Task Analysis (CTA) method was used. CTA is a work analysis method developed to study different kinds of work taking place in complex, dynamic, and uncertain environments [3]. It aims at identifying the core task of a particular type of work – the essence of the activity which stays the same from situation to another, independent of, e.g., the work organisation and the specific tools being used.

CTA was carried out by interviewing 15 maintenance engineers from three different companies (two paper mills and one service organisation on maintenance work) and by arranging a workshop for management and strategic-level management personnel, concerning the objectives of different stakeholders in maintenance work.

Core-Task Analysis: Essentials of the maintenance work

Based on maintenance workers' interviews, a model of maintenance work [4] was developed. The model presents the key elements for the functioning of the maintenance work. According to the model, especially the tools related toinformation technology should mediate the state of the object, i.e., process equipment, in relation with the desired outcome. At the moment, appropriate tools are seldom available. For instance, history data is gathered and analysed in plants but that information is usually not available for engineers for fault anticipation.

This model was further developed based on the information gathered from workshops between managers. As a result, a hierarchical model was built, with the topmost level describing the objectives for the maintenance work.

- The central and most generally identified objective is the *appropriate utilisation rate* of the process or plant and therewith the equipment.
- *Cost efficiency* is an objective easily conflicting with other ones.
- The maintenance work also affects the *quality of the product*.
- *The safety and the development of production* are objectives within the organisation.
- Well-planned maintenance can enhance the life cycle of the process and the equipment; hence, the *optimising over the life cycle* is an objective.
- The *development of the production* is a business-oriented objective of the maintenance work.

The means to reach these objectives fall into three main categories: *fault anticipation, repairing work* and *operation management*. The means range from work culture that affects attitudes, developing skills and maintaining knowledge, to equipment calibration and procurement planning.

The tools and resources enable the use of the means. The resources can be concrete or human capital, which include general and professional skills. Such tools or resources were found as history databases, online tools for fault diagnosis, process measurements, testing, prognosis applications, insight of the domain and training and instructions. Hence, to support maintenance work efficiently, the new tool should cover as much of the tools and resources needed as possible.

Changes and future challenges of maintenance work domain

A set of challenges and change factors for maintenance work were identified using the interviews of maintenance engineers.

During the last decades, demands on engineers have increased as the working domain**,** equipment and processes have become more complex. Furthermore, the use of information technology has increased. Hence, the nature of the work has changed also because mastering this technology has become a central skill in vocational proficiency. As several of the data systems used in the maintenance domain frequently include problems in usability, the effect of these problems becomes considerable when the use of the technology becomes more common.

It is feared that outsourcing causes the skills of the maintenance engineer to deteriorate, as one cannot be an expert in all domains. This is experienced as lowered respect for the profession. On the other hand, outsourcing also means that customer satisfaction is more meaningful and becomes a motivating factor in the work of the engineer.

There are some problems in work management. Situations where it was not clear what the objective is and how the information is transferred from one shift to another were found to be problematic. Also, the push for effectiveness results in working alone**,** which is experienced as raising safety risks. If an accident occurs, there is nobody near to call for help.

Use cases

The Plamos project carried out tool development primarily for the maintenance engineer but also for other plant personnel working with the equipment. The core-task analysis was used for deriving requirements for the tool in the contexts of various use cases. The users of the tool partly differ in their needs regarding the content and the quality of the tool.

The following use scenarios were provided to cover the most elementary users of the tool. The functionalities are in accordance with the needs found by CTA (described in the previous chapter) and they all are available in a small terminal device that is easy to use and to carry along.

The scenario for the maintenance engineer is focused on repairing a failure. With the new tool, the maintenance engineer locates and identifies equipment, which is especially important for an outsourced engineer. The engineer also clarifies the nature of the defect, which requires viewing and connecting data from several sources. Further, the worker views large pictures and diagrams, sees the state of functioning of the equipment and tests the repaired equipment by viewing the process data on the plant floor.

The scenario for the operator is related to monitoring and controlling the operating process. In this scenario the operator views process data and controls the process on the plant floor.

The scenario for the designer and mechanic involves the installing of a new piece of equipment in the plant during a fast track design project. With the new tool, the designer and engineer need to perform several actions: they exchange design data on-line, locate where the installation will take place and view the planned equipment in its correct location (which can be performed with Augmented Reality).

In the scenario for a new employee, knowledge of plant processes is provided on the plant floor using spatial learning via the mobile terminal providing that information. The functionalities needed are more than covered in the use case of the failure repair.

Technical solutions

The increased use of mobile terminals is a natural next step in the plant lifecycle information exchange in the networked operation and maintenance. The user requirements specified in the use cases are met, taking into account the future challenges of the maintenance work (described in an earlier chapter).

Overall technical principles

To use the system, the user has a portable terminal including a video camera (Figure 2). The terminal is linked to the data systems of the plant by WLAN. Moreover, WLAN is used for determining the user's location. Despite some problems, especially in the configuration of the system, it was evaluated that the technique provided by Ekahau Inc is feasible in the cases in which the accuracy of a few meters (a room) is sufficient. This is enough for guiding the personnel to the equipment, but not enough, e.g., in the tracking of the Augmented-Reality applications. As evaluation was performed in an office environment, it is not known how well WLAN works in plant floor conditions with large electrical motors and metal objects. Currently, research is continued to extend this study also in actual plant environment.

The target, i.e. the piece of equipment, is identified using a video camera and an additional application using markers, designed for the purpose. The user interface uses the service interface and presents the needed information to the user by using Augmented Reality.

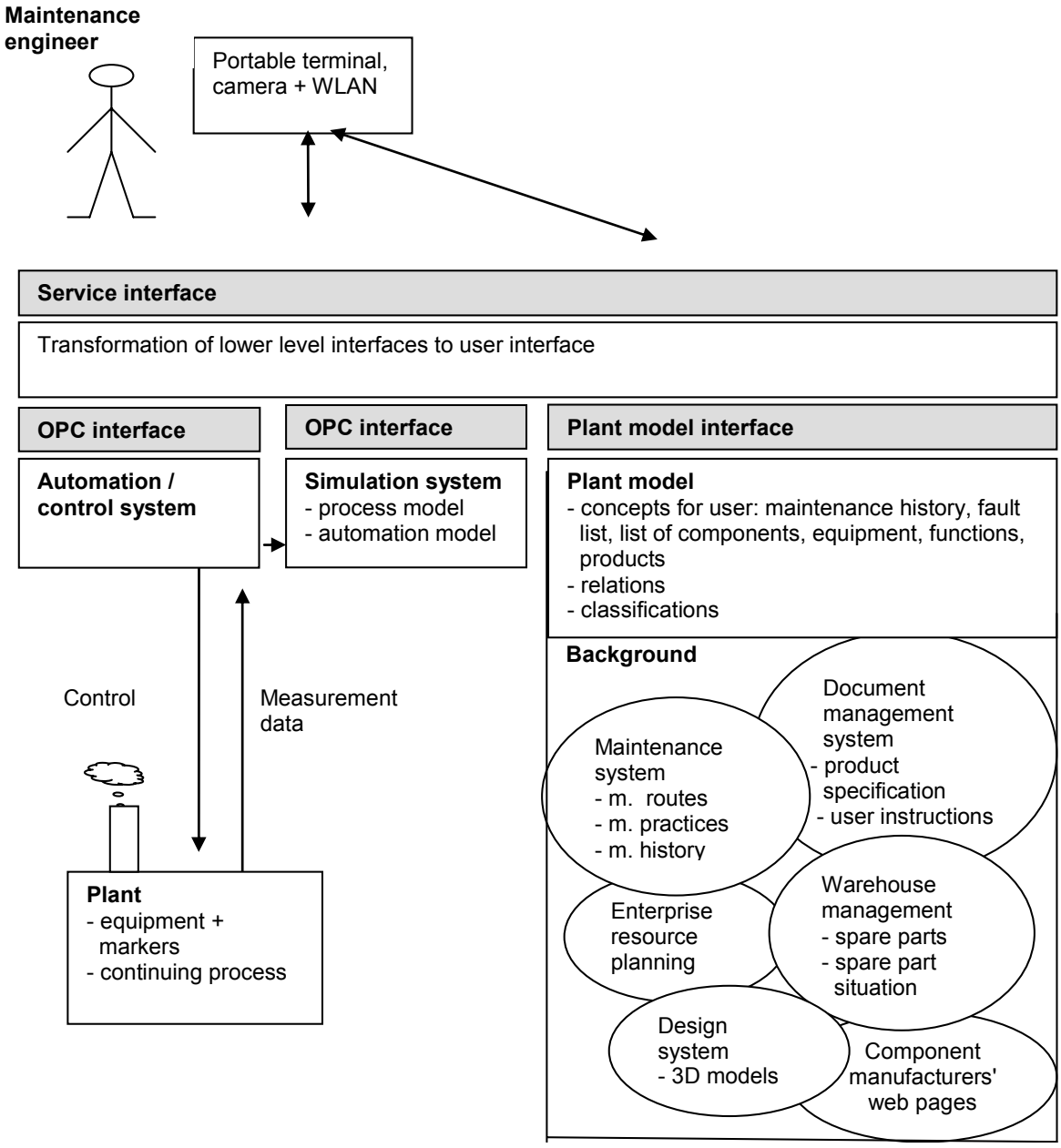

Figure 2. Technical principles of the mobile information services.

Service architecture for plant models

The aim of the service architecture is to enable the communication between the different levels of plant model services. The transfer of dynamic data within the system is based on OPC (www.opcfoundation.org), which is the state of the art in the industry.

As to expressing data content, there is not such an obvious choice. An ontology platform was developed for information management. It can be used for configuring the system for different domains by specifying the respective sets of concepts. The platform

was prototyped using the MIMOSA (www.mimosa.org) and IFC (Industry Foundation Classes) ontologies.

Structure of the user interface

A mock-up prototype of the user interface was produced with a variety of displays.

- The *Main display* presents current events of the plant.
- The *Tasks display* shows the tasks for the user and more accurate information concerning each task. The user can report the task completion in this display as well as also type a description of it.
- The *Equipment display* is the central display that shows the equipment hierarchy and information related with a single target. In this display, it is also possible to see the real and simulated states of the process, look at fault history, check spare-part availability and find instructions and equipment documentation.
- The *Guide to target display* shows the user's own location and the route to the desired target in a floor plan.
- The *Fault signal display* is used for reporting faults that the user has noticed.

Furthermore, the Equipment display can have two alternative modes. The AR (Augmented Reality) mode is the means to automatically identify the target with video camera and Augmented Reality software. In the 3D mode user sees his/her location, route to proceed and target location, all three-dimensionally.

Visual browsing and image augmenting

To develop a prototype that adds information in the video stream, i.e., to make the AR mode of the Equipment display possible, visual browsing and image augmenting techniques were studied. As a result, an augmenting prototype based on visual marker tags was produced. The method was further developed by adding adaptive thresholding, i.e., a method for the better detection of marker tags in low and high lighting conditions. In addition, the stability of the marker detection and augmenting was improved, which resulted in better stability of virtual objects in the user's view. Additionally, markerless and hybrid methods for tracking were studied. Inertia sensors with eMagin video glasses were tested for hybrid methods of tracking, but it was soon realised that the markerless image-based Lucas Kanede algorithm works better.

To make the markers easier to use, the project group developed a marker-field method, which makes the calibration of a marker system extremely easy. The method was published [5] and it is in use in other VTT projects as well.

The above methods have laid the groundwork for an in-house Augmented Reality software toolkit, named Alvar.

These results have attracted the interest of companies. Concrete actions to commercialise project results together with companies have not been taken yet. Instead, the developed AR technology is being used and further developed in subsequent VTT projects, especially in NOSE (Nomadic Use of a Plant Model). The ongoing work involves significant efforts concerning the methods for markerless tracking, and the take-up and application of marker-based tracking methods in practical applications.

Conclusions

The objective of the Plamos project was to create novel technological solutions that increase the productivity in industrial services and therewith industrial production. The project was the first phase of the development of the innovation, and whether the objective is achieved can be seen after the second development phase, i.e., subsequent projects. The prospects are good; Plamos provides a sound and versatile technological basis for development in the future.

The development of the concept was based on the research of the needs and business opportunities of the organisations involved in the service business. Special attention was paid to the new human-technology interaction concept; it was studied what actually constitutes a usable work system for a mobile worker in industrial settings. The conceptual level formulation of human-system interfaces started already in this early research phase, as the future business models and industrial services were envisioned together with the industrial partners. Additionally, user interfaces were sketched in the project in a mock-up using human-centred design principles.

An important result of the project is increased knowledge about the generic aspects of how to implement “ambient intelligence” in industrial settings. These results are delivered outside the project by scientific publications. They pertain marker-based tracking and marker field [5], modelling, simulation and 3D visualisation [6, 7], markerless tracking [8], the use of semantic plant models to mediate information [9], controlling the data access [10], the use of Augmented Reality in the visualisation process [11], and the usability and functional demands of the new tool [8, 12].

The technical result of Plamos is a service framework specification and a set of demonstrator systems for a mobile maintenance engineer and for the communication between the 3D engineering and installation. The service framework specification includes interface specifications for plant model, simulation and control system services, specification for user interface framework and a software tool set for using Augmented Reality in mobile terminals.

The plant model information was utilised in a mobile terminal where an Augmented Reality view was generated parallel with a live video image. The mobile terminal used in the project was a tablet PC equipped with a camera and WLAN connection.

In this first project phase, the results were demonstrated in pilot-scale systems together with models that simulate real applications. In the next phase, which consists of several independent projects, more prototyping can be performed in real plant environments.

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Semantic technologies in enterprise interoperability

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Abstract

Global competition, rapid development of technology, increased cost pressure, and more aggressive demand from customers have changed the business environment once and for all. Companies are merging, they buy and sell other companies and they network more than ever before. Companies must have readiness for enterprise interoperability that requires both technical and information integration. Most of the enterprises have solved the problem of technical integration but at the moment they are still struggling with information integration. This paper discusses how semantic technology can be used to ease the information integration process. In order to really benefit from semantic technologies in integration, there is a need for a process that provides methods and instructions for building such solutions in practice. This paper presents a process which supports the development of semantic-based solutions for information integration. The process is tested in one industrial case study that is described in this paper.

Introduction

Today, business processes must be managed and modified more effectively than ever before. Processes need to adapt to consolidation, mergers and acquisitions, joint ventures, divestitures, regulatory compliance issues, shifts in business models, changing customer expectations, industry standardisation and business process outsourcing [1]. Successful management of a company requires overall management of all processes and information connected to them and therefore all changes in business processes have influence on several information systems. Seamless communication and integration of data and information as well as synchronisation of inter-organisational business processes are complex problems that are still lacking efficient and cost-effective solutions [2]. There is a need for Enterprise Interoperability (EI) that describes the process by which enterprises, for example by means of ICT technology, interoperate with other enterprises, organizations, or with other business units of the same enterprise

in order to conduct their business, enabling them to, for instance, deliver new products and services and to be more cost efficient [3].

Interoperability is comprised of both technical integration and information integration. The main technical challenge in EI is the lack of interoperability of different systems and data sources, thus most of the current solutions are focused only on technical integration to link disparate software systems to become part of a larger system. According to [4], there are two strategies for migrate system integration problem with the enterprise. First, the development of an enterprise *message model* as a reference point for flexible and economic integration and, second, the use of a *semantic broker* so that each application would not have to understand the semantics of every other application. The message model is used as a technical integration solution for today's companies, although between large companies the architecture still has many unsolved problems, such as easy configuration, and interpreting the meaning of information in a similar way between designers. Most of the integration is still done manually using point-to-point integration, although the transportation layer is common for all the integration solutions (e.g., IBM WebSphere, Microsoft Messaging Queuing or BEA ESB). Point solutions do not provide long-term results because they do not adapt to changes and are hard to maintain and update [1]. Change in one system will break downstream systems that are connected to the upper system. In addition, the enterprise may not know all the processes that are depending on that particular system, database or interface, because those processes or systems may not be under the control of the people who manage certain application [4].

Information integration is focused on preserving the meaning of information while transforming the context. Meaning is about using metadata, business rules, and user supplied application contexts to facilitate a robust information transformation. In a practical sense, software is given the information about the environment, domain, and metadata that a programmatic algorithm can use to manipulate information from one system so another can fully understand it [5]. Information integration is enabled by semantic interoperability that emphasises the importance of information inside enterprises and focuses on enabling content, data, and information to interoperate with software systems outside their origin [6]. Yet any moderately complex integration work requires both technical and information integration.

This paper proposes the use of semantic technologies to solve the interoperability problem in enterprise collaboration. The paper focuses on researching the usability of semantic technologies as a tool in integrating information in an enterprise's information systems. 85% of business information has been estimated to be unstructured, and therefore a majority of data is not interpretable by software [7]. This paper describes a development process that includes methods and tasks for running a semantic

interoperability project. The research work is conducted in Semantic Business Interoperability project (SEBI) led by VTT Technical Research Centre of Finland. SEBI focuses on developing solutions for information integration in industrial environment by using semantic-based technologies. The major aim of the SEBI project is to develop a faster-cheaper-easier process for technical and information integration.

This paper is organised as follows. The following chapter introduces the underlying principles of semantic technology used in information integration. Chapter three describes the development process of information integration by giving a detailed description of the required phases. The case study according to the presented process model is presented in detail in chapter four and chapter five concludes the paper.

Semantic-based technologies in information integration

Enhancing information integration with semantics and semantic technologies enables more effective information interoperability. Meaning of information is separated from content, and the information is understandable to both humans and machines. Semantic interoperability is information integration at the concept level, rather than the instance level. Ontologies form a basis for building such semantic-based solutions. Ontology captures consensual knowledge in a generic way to be reused and shared across software applications and by groups of people [8, 9]. According to Zimmermann [10], ontologies provide a way to define semantics, provide support for handling disparate data sources and provide a mechanism to define complex knowledge models. For developing and using ontologies, there is a need for ontology tools that create, manage, and link conceptual models, taxonomy, and canonical models to actual enterprise data, process and business rules schemas. The information infrastructure is created using different ontology architectures and languages.

In this research we have used Ontoprise's tools. By comparing the characteristics of available ontology environments, Ontoprise's tools were most suitable for the purposes of the SEBI project, as they support combination of mapping patterns and have already been used in many industrial cases [6]. Ontology creation process involves several knowledge representation formats that vary in their formality and precision [6]. The most efficient languages, Resource Description Framework (RDF) [11] and OWL [12], provide semantic and inference support, whereas knowledge presentation formats, like XML, only provide information modelling. Furthermore we used F-logic (Frame logic), which combines both object-oriented and deductive approaches to represent knowledge and ontologies [13].

Ontology mapping approaches have been developed to fulfil different needs [14]. One-to-one mapping uses only local ontologies, single-shared ontology uses global ontology without local ontology, and a mix of single-shared and one-to-one mappings uses global ontology with local ontologies [15]. Information integration, when using semantic interoperability, can be represented in four conceptual layers: data sources, data source ontologies, business ontology and view. The layers are represented in Figure 1.

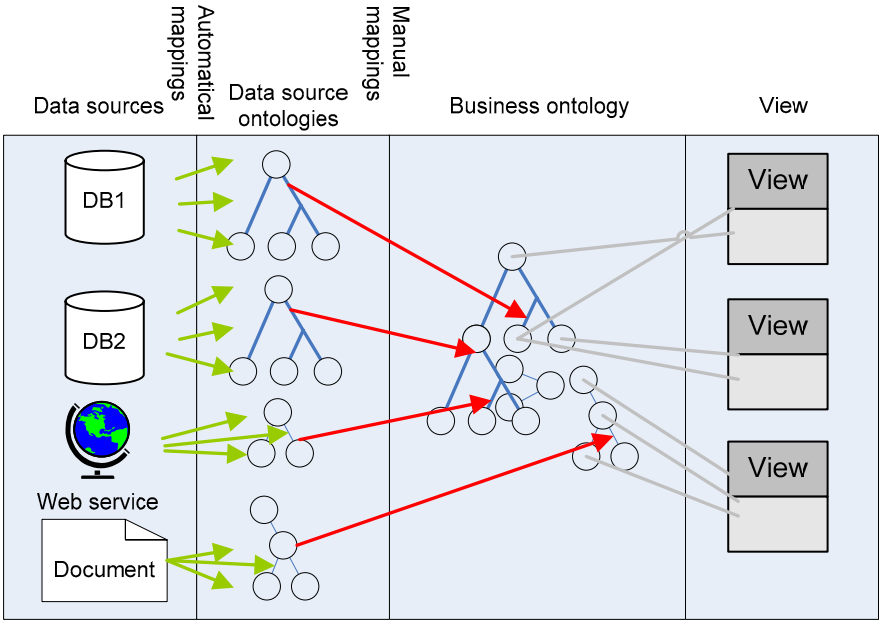

Figure 1. Conceptual layering of ontologies [16].

Development process of semantic solutions

Research on developing processes for semantic interoperability projects has been conducted previously. In "Information integration with ontologies: Experiences from an industrial showcase" [17], Alexiev describes an EU-funded COG (Corporate Ontology Grid) project that has been built using the same SIM architecture. For the sake of comparison, this study is recommended. In "Towards the semantic web: Ontology-driven knowledge management", Davies et al. [18] provide several valuable case studies on the subject. These studies focus on the upper abstraction level, and deeper definition for the tasks and deliverables of the process were discovered to be significant. The primary objective of this research was to build a semantic interoperability process chart, represented in Figure 2, and to define and describe its phases, tasks and deliverables. The deliverables of the semantic interoperability process include, for example, documents, data, records, forms, personnel lists and ontologies.

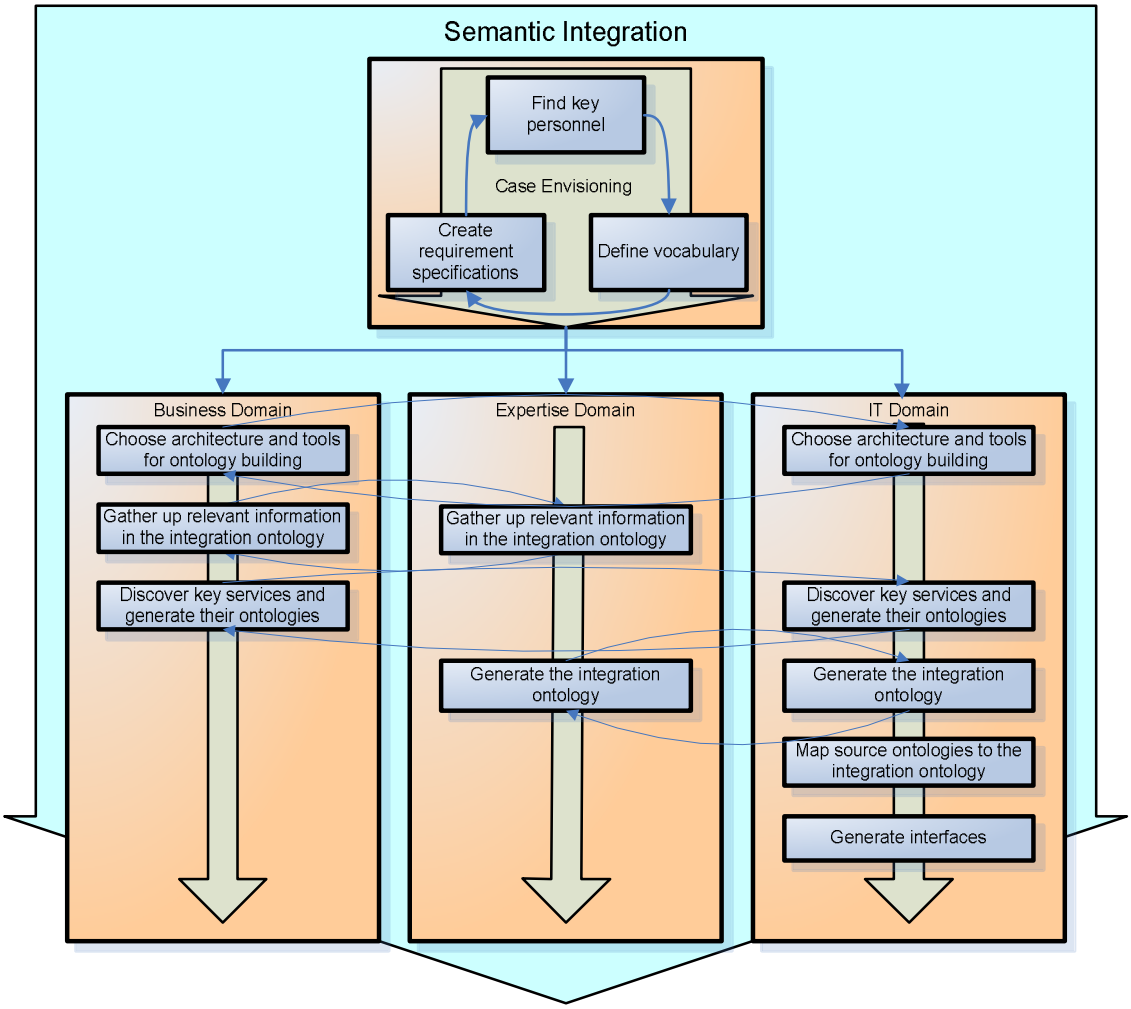

Figure 2. Semantic interoperability developing process.

The literature review, described in the previous chapter, provided the basis for building the process flow chart. The process was constructed iteratively, and several stakeholders in the SEBI project have reviewed the flow chart in regular intervals. Some tasks, and the order they should be executed, were needed to be field-tested until their correct positions in the chart and work products were found. Others were built on the requirements that were set in the theoretical research.

The semantic interoperability process is divided into four sub-processes where case envisioning is a prerequisite process for the other three, and is not necessarily completed long before the completion of the project. Business, expertise and IT domains contain domain specific tasks that are executed either alone or in co-operation with other domains. The case envisioning sub-process includes the most important tasks: key personnel identification and acquiring, domain vocabulary definition and requirement specification creating. The deliverables made during these tasks are used in the later tasks and, for example, the key personnel acquired at the corresponding phase must be

selected from several hierarchical levels and they must have disparate levels of knowledge. They must also be committed to the project to ensure its successful completion.

The main challenges in realising a successful IT project are finding a common vocabulary between business and IT people (bridging the business-IT gap), and to make correct choices when selecting a technology platform from the constantly growing amount of options in IT solutions. Solution Envisioning with Capability Cases provides tools that help to solve these challenges: the Solution Envisioning process helps people to picture the needs and possibilities of the business. Capability Cases support the envisioning process by aiding the understanding and evaluation of capabilities [19].

The case envisioning sub-process does not have a definite termination point, but the process may be adjusted during the other sub-processes. This provides flexibility and quick response to changes. The tasks in other sub-processes have triggers to adjust case envisioning tasks further, if it is required.

Development process in practical case study

Expectations set on maintenance have grown as the machinery has become more complex, which occurs as an increased need for computerized maintenance information systems. Maintenance information systems are usually one of the most expensive single instruments that enterprises invest in. As the systems are not omnipotent, various software developers have developed several systems, which may not have compatible interfaces with each other. As the integration process is incomplete, the applications are used separately and the information integration is made at the user level.

The proof of concept case solution consists of integrating two disparate data sources in order to list the most frequent failures, and providing additional data regarding the machines that cannot be retrieved from the failure database. As we were implementing semantic technologies to the case environment for the first time, the fundamentals of ontology building were required to be learnt first, and other properties were allocated to a later phase. The scenario of choice provides a solid foundation for the future projects and it is possible to be extended further when needed. Architecture of the case solution is represented in Figure 3.

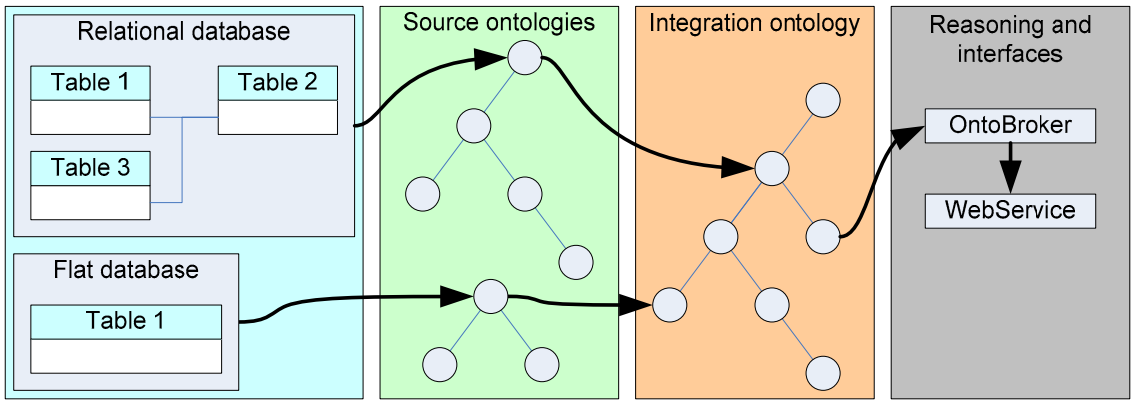

Figure 3. Simplified architecture of the case solution.

The failure management system operates in a customer environment, where software houses have developed several software modules. This case study utilises product information and failure event management systems. Maintenance information is going to be utilised by a maintenance information application that is being developed. Integrating event management application data to the new maintenance information application is challenging, as the data structures are different.

The case study is developed to verify the feasibility of the semantic integration process by implementing a working solution that integrates disparate data sources to one view. The case solution is possible to be utilised in researching the benefits that semantic interoperability provides, and in identifying and solving challenges that are faced during the process.

Conclusions

Enterprise Interoperability is a financial challenge for companies as the integration is the most pressing and expensive IT problem that enterprises are facing today. In fact, many IT organizations spend up to 80% of their budgets maintaining the legacy systems, leaving only limited funds to support new business opportunities or to satisfy new regulatory requirements [19]. Integration projects are often the most complex and most risky type of projects, and together with high integration cost, they compose an important obstacle to the implementation of EI solutions.

The aim of this work was to develop a process for semantic-based solutions for information integration and to test it in real life case study. By developing semantic-based integration solutions, companies are able to conduct integration work more efficiently and cost-effectively. However, in order to achieve these benefits they need a

process that guides the use of semantic technologies in practice. During this work in the case solution, some benefits were verified as they were stated in theory. Using semantic interoperability proved to be flexible, while adding, removing and modifying information, and even integrated data sources, were straightforward tasks. The integration ontology had some major changes at the beginning of the building process, changes which did not endanger the project and were successfully performed. OntoBroker's WebService interface has proven a flexible way to utilise the integration ontology in various application environments. The case solution project was developed by using PHP scripting language, but more sophisticated programming languages can easily be used instead.

Benefits of using semantic interoperability as an integration tool were discovered during the case project. Beforehand, the concurrent access to both source databases prior the case project was very difficult and required human interaction, while the current solution retrieves data from both sources and delivers responses that integrates data from both disparate data sources. The SEBI solution proved to be flexible: adding, removing and modifying information and applications have been controlled and changes in one source ontology has not affected the other source ontologies. Furthermore, all the changes made to source data may be made invisible to levels higher than the integration ontology. The research work is still in the early phases and there are some problems that need to be solved. The queries, rules and mappings must be improved further as the performance is significantly lower in comparison to SQL querying. The developing process is not finished yet, as it does not provide explicit step-by-step instructions to managing semantic interoperability projects.

In future, the development process needs to be further defined and tested with several practical case studies. The instructions of the development process should ease the continuous integration work companies are doing everyday. It should also give guidance for companies where semantic-based solutions are best and most beneficial. For fulfilling these future objectives we need to make several tests and improve the technical solution along the process.

Acknowledgement

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Operational and maintenance services for work machines

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Abstract

Industrial services are business processes where service employees, technology, information and fixed assets interact in a value-generating way. Companies are seeking ways to increase service revenues. One way to increase organisational efficiency is through the implementation of more disciplined and well-defined service processes that easily adapt to changes in business needs and uses capabilities of the current state-of-the-art technology and a company's existing technologies. In every way, an optimised service system requires a deeper understanding of the service-related enablers, constraints, value creation and also tools and methods supporting service engineering. This paper presents the Framework for Value Creation Method based on the Enterprise Architecture approach in order to understand service system as an essential R&D object. This paper also gives an overview to service process modelling and tools supporting Business Process Management and Enterprise Architecture approaches.

Introduction

Today we are living in a service economy. Companies are shifting the current product focus more and more towards a service-oriented approach. Very few companies have developed structured methods for developing services and there are very few companies that have an R&D unit for services [1]. Industrial services are not yet seen as R&D objects in the way that pure products are. A service engineering culture at companies is not very mature and there exists a lack of tools, methods and guides supporting the service system development and analysis to find an optimal system, from the companies' point of view, in terms of human resources, price, process, technology and business [2, 3].

In most markets today and in most cases it is not possible to maintain a competitive advantage through product differentiation and price alone. Increasing competitive pressures are forcing companies to increase efficiency and to seek new ways of profit creation via new product-related services. In fact, in many manufacturing companies

there would be little or no profitability without the service business [4]. The industrial services market still offers considerable growth and profit opportunities. Service margins could be as high as 15–20% (in the power equipment and the metallurgy equipment industries), exceeding the average margins in the product business by a factor of 4 to 5 [5].

Because of the complex nature and quite long life cycle of industrial services, it is difficult to pay attention to different aspects and elements of the service and related systems without having approaches like Service Engineering. Service Engineering began to attract greater attention in the mid-1990s. Since the developing art of Service Engineering is quite new, an established body of principles and techniques takes time to mature before adopted in companies [6].

The main challenges foreseen and tackled are interrelated with understanding the service system as a R&D object, tools and methods supporting service system development and life cycle management and how to get an overall view to the service-related business processes, constraints and enablers via modelling.

In this paper:

- We briefly introduce the operational and maintenance services related to work machines, discussing their importance and problem areas.
- We represent the basic idea of the Framework for Value Creation Method based on the Enterprise Architecture approach. This framework helps to understand value creation and service systems as R&D objects.
- We describe features of tools supporting Business Process Management and Enterprise Architecture approaches. We also show how to utilise these tools as part of the Value Creation Method.
- We shortly describe the role of process modelling as part of the Value Creation Method, Business Process Management and Enterprise Architecture approaches.

Operational and maintenance services for work machines

The focus area of our research was the important operational and maintenance services related to work machines. The common industrial service types are: spare parts, repair, performance upgrade, reconditioning, inspections, maintenance, training, consulting and remote monitoring [5, 7]. Across the manufacturing companies, services revenues today represent an average of more than 25 percent of the total business. Even more importantly, the average profitability of the service businesses is more than 75 percent

higher than overall business unit profitability, and accounts for an estimated 46 percent of total profits generated today [4]. For mid-market companies, it is extremely important to look at existing human resources in terms of business and IT, and their skill sets. Since mid-market companies face more resource constraints than their larger competitors do, they need also to take better advantage of technologies. Everything what is done as a service is a process that is performed by the people and technology based systems that make up a part of company. Without sufficient technology support it will be increasingly difficult, if not impossible, to manage and optimise the service business as customer requirements increase or change and the service business grows more complex [4].

At the first phase, we interviewed four Finnish mobile work machine manufacturers to strengthen our service business related knowledge in the area of industrial services. Our interviews showed that these companies already have some set of industrial services in their service portfolio and they are also developing new services and service enabling technologies. The Finnish mobile work machine manufacturers are more and more interested in moving towards the service business. In fact, these companies see that the service business will represent the main share of their annual turnover in the near future. Thus, they are looking for new ways to increase their turnover. These companies rely widely in service business creation, although the tools, methods and personnel specialised in creating new service business or in enhancing the existing one are not widely used or do not even exist. The ability to represent and manage all the complexity of real-world business communication, collaboration and available personnel and computing resources is a necessary first step when developing effective service systems. The overall view to the service-related business, service processes, enabling technology and personnel makes it possible to handle service systems as R&D objects, i.e., as services that are developed by using tools, methods and engineering knowledge like those used in traditional product development. Thus, service analysis, optimisation and life cycle management will be more effective.

Value Creation Method: Service system as an R&D object

After analysing the interview and literature research results, we noticed that problem areas related to the service engineering can be divided into three different levels:

1. Service business development

   Encompasses service offering development. From the service designers point of view, services will create value for both service provider and customer. These two aspects are important to take into account.

2. Service process development

   Comprises service-related process development and analysis. It is important to identify and analyse service processes in order to realise cost savings. Different types of service process models, such as service blueprints and flowcharts, can be used when exploring different enabling technology options, enhancing and optimising processes or designing the service front-end.

3. Service architecture development

   Covers enabling technology, systems and people's roles as service enablers. With the rapid and continuous evolution of both the service business and technology, it is important to anticipate movements and trends in a specific service business area, and understand how different enablers are driving or reacting to these. Competitive advantage is often dependent on the quality of the ICT architecture and infrastructure. Understanding the economic benefits of ICT investments, a long-term service and supporting architecture alignment and management becomes easier.

When the business changes, the technology should adapt to this change. To manage this change there is a technique called Enterprise Architecture [8]. An Enterprise Architecture (EA) is a blueprint that documents all the information systems within the enterprise, their relationships, and how they interact to fulfill the enterprise's mission. By adapting this philosophy in service engineering, we derived the Framework for Value Creation Method to help service system development and to assist and clarify value creation (Figure 1).

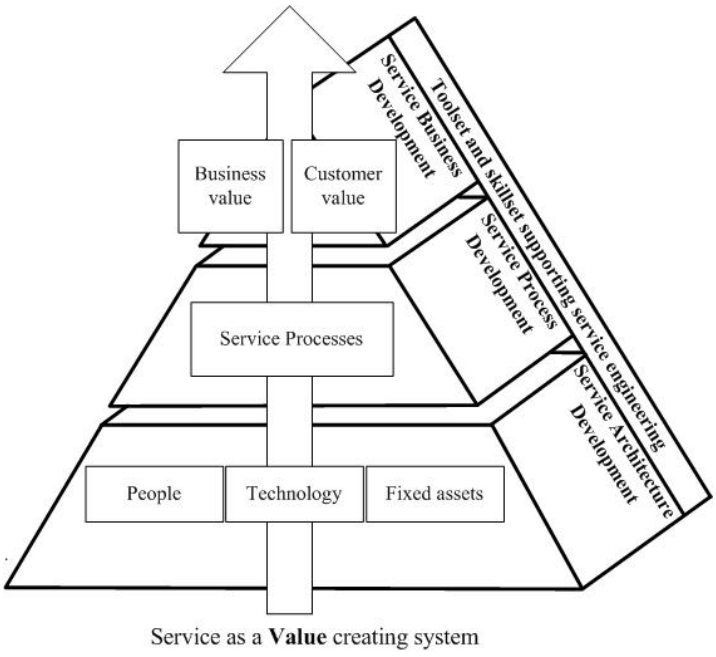

Figure 1. The Framework for Value Creation Method (derived from [9]).

The Value Creation Method constitutes a layered framework. Each of the layers may contain different type of tools and methods. Because services are vague by nature, the Framework assists in clarifying the value creation levels and components making it easier for conventional product designers to understand services as R&D object. The Framework for Value Creation Method also makes possible the following: to build up the proper personnel needed in different service engineering phases, to clarify the engineering personnel roles and the needed engineering knowledge, and to apply the appropriately modified engineering knowledge established in the field of traditional product development to the development of services.

Tools for Service Process and Architecture Modelling

When service business constitutes a bigger part of the annual turnover, service enabling architecture will deserve more emphasis and become a part of the enterprise architecture. To handle all the complexity related to the service business, processes and the technology that fulfil those processes, some supporting software tool is needed. Thus we focused our research on tools supporting Business Process Management (BPM) and Enterprise Architecture (EA) approaches. Enterprise Architecture and Business Process modelling tools are software products that are used by business managers, analysts and developers: to create models of process-based business organisations, to analyse and optimise models and to save information about models. Enterprise Architecture and Business Process modelling tool environments help organisations understand the contributions of their current architecture and how to plan and implement changes for improvement. To assess the state of the business process modeling tools market and see how the vendors stack up, we used information from Gartner, Busines Process Trends and Forrester. Gartner and Forrester has evaluated the strengths and weaknesses of top Business Process modelling tools vendors [10, 11]. Business Process Trends has made a thorough report, *The Enterprise Architecture, Process Modelling and Simulation Tools Report* [12]. Serious modelling tools, like Enterprise Architecture & Business Process modelling tools, create data entries in a database for sustained modelling and redesign efforts. You can record requirements, costs, associated business rules and you can name the software applications that support activities. In other words, a serious process modelling tool is the interface for a database that allows you to organise and save information about your business processes [12]. In general, these tools support several various process modelling languages and methodologies, such as the Integrated Definition (IDEF), the Unified Modelling Language (UML), and the Business Process Modelling Notation (BPMN) [13, 14, 15]. The Business Process Modelling Notation (BPMN) is a relativy new standard notation for developing process models. The BPMN 1.0 specification was released to the public in May, 2004 by the Business Process Management Initiative (BPMI) [15]. The primary

objective of developing Business Process Modelling Notation is to provide a notation that is readily understandable by all business users, from the analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. For modelling and developing information architectures, these tools normally uses frameworks as an interface to the database. Zachman framework offers a generic framework with no implied method – in other words, a tool to assist with your thinking [16]. The Open Group Architecture Framework (TOGAF) describes both an Enterprise Architecture (EA) framework and an accompanying methodology [17]. The two approaches can be usefully used in conjunction. Modern modelling tools also provide some form of simulation capabilities as part of the tool or as an available, separate add-on module. Some tools provide pre-defined methods for analyzing data captured during simulation – for example, activity-based costing (ABC), which allows users to approximate the actual operation of a scenario and provide predictive analysis.

Service process modelling

Process modelling is a component of the Enterprise Architecture approach. Service process models describe how a business, or service, works, or more specifically, how it accomplishes missions, activities, or tasks, thus giving the insights to re-engineer the business for maximum efficiency, agility, and customer satisfaction. Business Process Management creates leeway on both the information architecture and business ends, allowing business managers to focus on the processes and ICT managers to oversee resources and deliver them where they're needed. The focus on process models as supporting decision making is prevalent, but process models can have various other purposes: Training and communication, Simulation and analysis, Costing and budgeting, Documentation, Knowledge management and quality, Enactment, System development, Organisation design and Management information [18].

We tested one Enterprise Architecture and Business Process modelling tool, called Telelogic System Architect, with the simulator add-on and we also modelled one simple work machine related maintenance process. Figure 2 shows a simplified example of that maintenance process. The swimlanes represent the different people who take part in a process. Many costing and budgeting approaches are based on the Activity Based Costing (ABC) method. The goal of ABC is to measure and then price out all the resources used for activities that generate goods and services for clients. A workflow model can be used as a basis for ABC. With the simulator you can, among other things, identify bottlenecks, weakpoints and costing information within the process.

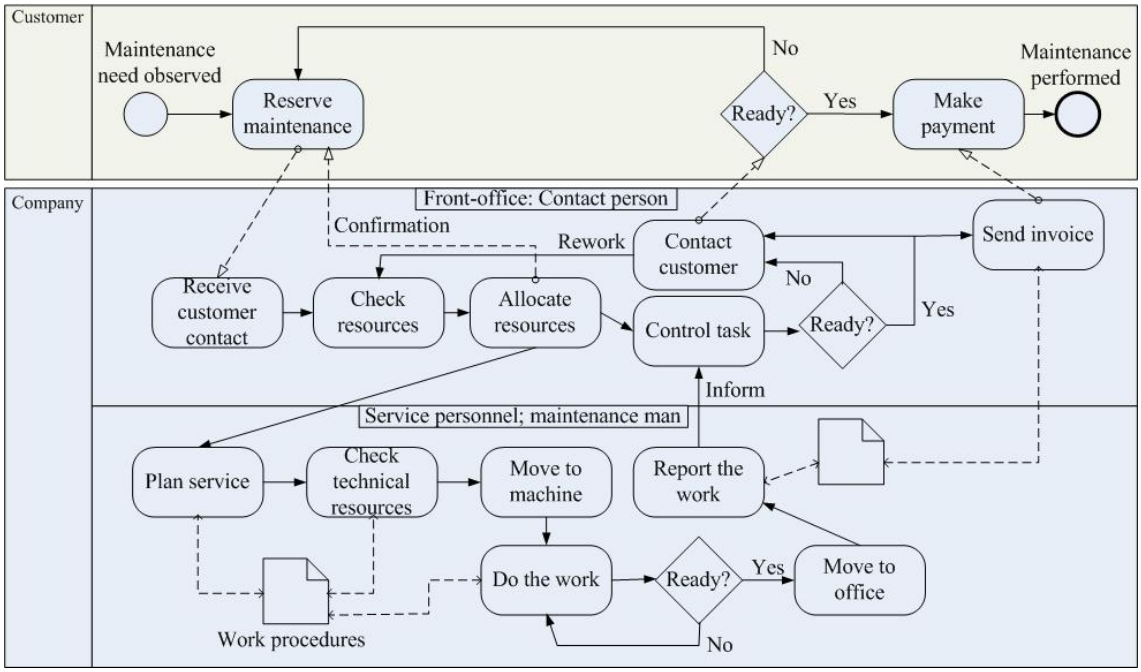

Figure 2. A simplified example of the work-machine-related maintenance process.

To make a step forward towards the service architecture, you can use Business Scenarios. Business scenarios are a part of TOGAF Architecture Development Method (ADM) [17]. The business process is the binding focal point where the creation of business scenario starts. During the business scenario creation, you can utilise a concept of process enablers and constraints. Figure 3 shows a process frame, where different enablers and constraints to be considered in process related scenario development are described.

Constraint: organisation, mission, strategy, goals and objectives		Constraint: process goals, objectives and differentiation			
A Process					
Enabler: workflow design	Enabler: information technology	Enabler: motivation, measure-ment	Enabler: human resources	Enabler: policies and rules	Enabler: facilities and other

Figure 3. The process in context with goals, constraints, and enablers [19].

An enabler is a factor that helps a process to achieve its intended results and meet performance targets within applicable constraints [19]. Business scenarios are an appropriate and useful technique to discover and document business requirements, and to articulate an architectural vision that responds to those requirements. A business scenario is essentially a complete description of a business problem, both in business and in architectural terms.

Discussion and conclusions

Suitability: Industrial services, like the work machine related, are quite long-term services. Thus, service engineering process and enabling technology development can also be long-lasting activities. The service enabling information systems can be a mixture of old and new technologies. The knowledge of how to enhance the supporting service architecture in parallel of service portfolio development is important and companies can boost their effectiveness via better technology and personnel usage.

Adaptability: It is possible to use the Value Creation Method in different branches, but it is also obvious that we should adapt the toolset and methods to the branch specific needs, i.e., more agile and speedy methods and tools.

Service Engineering Culture: It is possible to deepen the service related knowledge at companies and so to evolve the service engineering culture. The Framework for Value Creation Method makes important areas of service engineering more illustrative. By developing company specific guidelines and tools supporting the specific service offering, companies can manage the lifecycle of their service portfolio better and use traditional engineering personnel in service engineering, thus gaining economic benefits via that.

Enterprise Architecture & Business Process modelling tools are not widely known. Companies may have modelled business processes and work flows by some Business Process modelling tool, but it seems that these models are not used in aligning architecture and processes. A conclusion from the company interviews was that quite few companies have personnel specialised in service engineering. Personnel developing services may have a different type of traditional engineering background. There is a need to strengthen somehow the service engineering knowledge at companies. In future, we should identify or develop proper tools and methods related to different levels of the Framework for Value Creation Method. We should also identify branch-specific needs to adapt the Framework in different branches.

Acknowledgement

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The role of risk management in industrial service business

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Abstract

It is widely stated that there is an ongoing transformation process towards more a service-oriented business in the networked environment. From the manufacturing company's point of view, new risks can emerge and old ones can change during the transition process. There is, however, not enough research information concerning the risks and the role of risk management relating to the circumstances of extending the service business. In this paper, some considerations about the suitability of formal risk management practices in those circumstances are made.

This paper summarises some findings from four ongoing projects. The findings are analysed together with the literature viewpoints in order to outline a preliminary framework, which describes the study needs in the field of risk management in industrial service business. On the basis of the synthesis, it is concluded that the transition process itself might trigger the need for more flexible risk management process.

Introduction

This article focuses on the role of risk management, particularly in the circumstances of extending the service business in manufacturing companies. That phenomenon was chosen to be considered based on the assumption that during the transition process new risks emerge and old ones change, when risk perceptions and risk management habits might need to be refreshed.

It has been stated that extending the service business leads to a step-wise transition from products to services. In addition, many authors have recently stressed that the traditional boundaries between manufacturing and services are becoming obsolete [1, 2] and there are new forms of production for supplying physical products together with intangible services [1]. During the transition process, many companies are facing difficulties in successfully exploiting the financial potential of an extended service business [3].

Gebauer et al. [3] are suggesting increasing the service awareness, accepting the risks and believing in the economic potential of services to avoid cognitive phenomena limit the managerial motivation to extend the service business. The implementation of changes must also be carefully planned.

This paper questions whether the current risk management practices in a manufacturing company will be sufficient for the continuously changing and more service-oriented company. The main aim of this paper is to summarise findings from some ongoing projects and literature for outlining the preliminary framework, which describes the study needs in the field of risk management in the industrial service business. Suitable methods for researching the phenomenon are also discussed.

This paper is based on a literature review, including findings from four separate projects concerning risk management. The duration of joint research projects (Studies 1–3) is three years and the Risk Management centre from VTT is participating in all of them. Study 4 was a short-term preliminary review. Research methods are briefly presented alongside the study findings.

Risk management

It is a challenge for companies to consider and manage a large range of various risks related to their operation and business. Effects of these risks can be directed, for example, towards people, the environment, corporate finance and operations, and even society. Some of the risks had influence inside the company or the business network, but some of them extend their influence to the local or global business/area or even jeopardise functioning of the critical infrastructure. Awareness of different risks can help organisations in operating and making decisions with the presence of uncertainty. In order to perceive risks and manage them systematically, organisations are typically applying formal risk management practises. However, it is argued that by formal risk management practices companies are actually trying to organise an area where total manageability is impossible. In addition to formal practices, it is stated that organisations need to increase flexibility for absorbing the unexpected and be prepared for the uncertainties that cannot be assessed beforehand [4].

Research concerning risk management is related to several theoretical areas and researchers from various disciplines and specific fields are forming the understanding of risk management. For example, Rasmussen [5] has concluded that cross-disciplinary research is needed in the field of risk management. According to Power [6], various specialists' definitions and classifications exist to attempt to secure the meaning of risk. These definitions, however, reflect the specific interests of the definer. For example, in

the safety tradition, risk is equated through the probability and consequences of a hazard. Instead, for finance, risk is a matter of volatility of expected outcomes, both negative and positive [6]. As Miller [7] has stated it can be confusing that the term risk is used to refer to uncertain environmental variables that reduce performance predictability (source of risk), as well as the lack of predictability in firm outcomes itself.

Despite the multiple viewpoints and definitions, there is a certain consensus about the risk management process including identification of risk factors, risk assessment and execution of mitigating actions. [8] In the context of technological systems, the IEC-standard [9] gives the definition: *Risk management is the systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling risk.* In a wider scope, Committee of Sponsoring Organizations of the Treadway Commission [10] defines enterprise risk management (ERM) as *a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives.*

The above mentioned definitions can be criticised for taking too strong command and control approach and also ignoring both shared management of uncertainties with external parties and social implications [4]. Bannerman [11] brings out in his definition of project risk management that risk management "is also a real-time threat management capability that is developed within an organization, through learning, practice, and other mechanisms, over a long period of time." In addition to typical phases of risk management (risk identification, risk assessing and mitigation actions), he mentions contingency strategies and states that risk management is "about being able to respond quickly and effectively to realized threats as they arise." Actually, risk management can also be conceived as firm responses to deal with identified uncertainties. According to Miller [7], "financial risk management techniques reduce corporate exposures to particular risks without changing the firm's strategy." On the other hand, there are also strategic moves that can potentially mitigate risks [7].

Based on the descriptions of risk management above, it cannot be clearly stated the way how organisations are executing risk management. Our experiences from the risk management consultations, however, give us a basis to understand risk management practices in the real organisations. Based on our experiences, the systematic hazard identification and risk assessing process is usually the most documented and guided part of risk management. Risk response, learning and a real-time threat management capability is, however, less tangible and thus more difficult to study. With the following study examples, we are trying to describe not only actual findings but also the different ways to approach risk management research.

Study findings

Study 1

Study 1 is a multi-disciplinary research project started in 2007. The specific focus of the Fleet Asset Management project is on the development of a service business based on the exploitation of the available product lifecycle information. Consideration of success and risk factors related to new service development is also included in the study. Methods used in the study are literature review, qualitative expert interviews, workshops and case studies carried out in cooperation with several industrial firms. In the first round of company interviews, totally 11 experts in five industrial companies were interviewed. Additionally, all five companies studied participated in a workshop. [12]

Based on the literature review the influencing factors related to new service development can be grouped in many different ways, e.g., to internal and external factors. On the other hand, the barriers or risks can be categorised similarly, and in many cases, they can be seen as the "other side of the coin" to the success factors. Categorisation of success factors can be, for example, strategic, organisational, structural/process, technological, market and network-related factors. [12]

Based on the first expert interviews and workshop meetings the following inter-related themes were evaluated to be the ones that are most relevant for success in the industrial service business. The themes were a) customer demands for maintenance services concerning machines provided by other manufacturers; b) adequacy of skilful employees; c) adaptation to technological changes; d) safety (and security) management at the global level; and e) potential for leasing services in the future. [12]

By analysing the workshop discussion with qualitative methods, some key elements relating to success were found. The central one of them was trust. For example, unsuitable service concept or low service functioning can have a negative effect on the overall reputation of a highly appreciated manufacturing company or machine supplier. In addition, the trust of the customer can fade if the machine and service selling are bundled together too tightly or the pricing of the service is too unclear or hidden. [12]

Study 2

In Study 2, the essential focus was on the opportunity recognition and management of future uncertainties and risks in companies that are giving rise to a new business. The INNORISK project started in 2006 and the objective of the project was to develop tools and methods for companies in order to support the decision making related to new business creation. [13, 14]

An opportunity and risk management based assessment model was proposed for the management of uncertainty in the front end of radical technological innovation. The development process of such innovations is seen to be very challenging and risky because of uncertainty in many aspects of the development and commercialisation processes. The working report states that when elements and critical decision points in the front are identified, and information and criteria required for decision making at these decision points are defined, the front-end becomes controllable and actions for new business creation can be co-ordinated. [13, 14]

During the project the uncertainty management model has been applied the in a few very different conceptualisation cases in different companies and industries with good response from the companies. However, in the working paper it is stated that it will take several years to evaluate the success of the model in minimising the submission of false projects into the new product development and commercialisation stages, because the time from concept to product launch is long for radical technological innovations. [13, 14]

Study 3

Study 3 was a qualitative case study started in 2007. The four case companies of the Global Project Strategies II project were Finnish companies with a worldwide presence. The data analysed in that study consisted of two sets of open-ended interviews (six project managers and ten co-workers) and risk management documents. The project managers were asked to tell about their current project, the project-specific risk management practices used and the events that significantly affected the progress of the project. Qualitative coding was used to process recorded and transcribed data. [15]

In the analysis of the interviews, a quartet of different approaches to project risk management emerged [15]:

1. *Risk regulators* follow a normative risk management process. Risk analyses are conducted at the beginning of the project, necessary documentation is delivered during the project and risks are summarised at the end on the project.
2. *Risk modificators* use the formal risk management process actively to develop project management practices and processes to be more suitable for the project-specific needs. Other expedients are also used to share understanding of risks.
3. *Risk mergers* have integrated the risk management deeply in project manager's daily tasks, almost to an unrecognisable level. Project contracts and client relationships play an important role in their risk management.
4. *Risk adjusters* are typically very experienced project managers and active in making risk preventing decisions and actions or helping others in predicting and

overcoming risky events in projects. Cooperation, teamwork and creating of "risk atmosphere" in the project team are important for them.

In this phase of Study 3, one of the conclusions has been that the formal risk management activities cover only a small part of all the work that the project managers do to identify, analyse and prevent risks during a project.

Study 4

Study 4 was a pre-study executed during spring 2008. The purpose of the Risk Management of Intangible Assets project was to find out risks and risk management procedures related to intangible assets. Interviews were conducted in seven manufacturing and service companies in Finland. [16]

Almost all of the company representatives considered that the risks connected to the human assets were the most important risks related to intangible assets. Several issues, such as unwanted turnover of workers, losing key persons, lack of new competencies, failures in recruitment and lack of motivation and personnel engagement were mentioned as examples of the risks. It was also highlighted that human and relational assets were difficult to quantify. The researchers state that there are several ways or informal procedures for managing the risks of intangible assets. However, the company representatives said that, typically, these procedures were not considered as risk management procedures. Instead, they were included in normal everyday management practices relating to, for example, personnel training, competence transfer, communication, occupational health and safety, cooperation agreements, centralised patent management, competitive bonus schemes and corporate atmosphere. [16]

In Study 4, a preliminary map, including categories of intangible risks, was outlined. The map revealed that there were potential intangible risks in every area and function of a company. Based on the literature review it was concluded that management of intangible risks should not focus only on efficient minimisation of risks and their costs, but also on ensuring that the opportunities are utilised optimally. [16]

Discussion and conclusions

Current descriptions for risk management process typically consist of the following basic phases: risk identification, risk assessment, risk reduction and control, and monitoring. These phases constitute the base of the formal risk management activity. In addition, other activities, such as defining the risk policy, setting objectives for risk management, reporting, communicating and auditing the risk management process are

added to some of the corporate risk management frameworks, in order to unite risk management and other management activities. For example, in Studies 1, 3 and 4, it was clearly noticed that risk management was incorporated into other management activities. Studies 1 and 4, which focused on categorising risks and searching relevant fields where risk management is important, revealed that risks can be found relating to every area and function of a company. In consequence, suggestions for effective risk management need to be absorbed into other managerial guidelines. Based on these findings, the basic phases of risk management process are solely not enough to respond to the challenges concerning management activities and the extended approach of risk management is needed. To meet part of this requirement, Study 2 focused on developing risk management tools and methods for companies in order to support the normal decision-making during the innovation development process.

In addition, the literature review and some findings from the studies give an impression that the formal risk management process (even the extended one) might not be flexible enough for managing uncertainty and risks in the complex and continuously changing circumstances. The current risk management models can be criticised for taking too strong of a command and control approach and forgetting the viewpoint of human behaviour. Despite the criticism, the researchers have also had positive experiences relating, for example, to systematised methods used for formal risk identification and assessment. The formal process also opens up a possibility to self-evaluate risk management process phase by phase. However, the formal risk management process might not be enough to respond to the challenges in real life. Those real life activities and habits related to risk management are discussed more deeply in Study 3.

Despite the studies presented in this article, there is not enough research data concerning the risk management methods, activities and habits in the case of organisational changes relating to the transition process towards a service business. It can, however, be hypothesised that when risk environment and organisational functioning are changing the "old" risk perceptions and risk management habits are still dominating and affecting decision-making and operation. If this is not realised can risk management be in conflict with reformation. With the help of formal risk management procedures, it might be possible to systematically identify and assesses new risks, set new risk policy and objectives and evaluate the functioning of the risk management. Because the risk perceptions and risk management habits are, however, based on former experiences, it is not easy to change real acting. In new business world, trusting intuition can then misguide the decision maker and lead to unwanted consequences. The events mentioned above are possible, for example, in the circumstances of extending to the service business in manufacturing companies.

To understand better the meaning of risk management in the case of extending service business in manufacturing companies, more information about current risk management activities is needed. Table 1 summarises the relevant questions relating to the research topic at the issue. The case study approach and qualitative methods for collecting and analysing the data concerning risk perceptions and risk management habits are usually chosen to study risk management.

Table 1. The research needs relating to risk management in the circumstances of extending service business in manufacturing companies.

Relevant questions	**Methods for data collection and analysis**
– In which way are the risk management process and practices described and organised in companies? – What are people really doing when they manage risks? – How are the old risks changing in the new situation and what kind of new risks can emerge? – How can a company learn about the new risks before the risks have been realised? – How are risk perceptions and actions changing in the new situation? – How are organising and executing risk management changing / should be changed in the new situation?	case studies, interviews, workshop meetings, documents, qualitative analysis **Results: theoretical and managerial implications** principles, typifications, process models, frameworks, implications, suggestions and guidelines concerning risk management

To conclude research needs, it can be stated that studies focused preciously on extending service business in manufacturing/product oriented companies is needed in the field of risk management. In order to increase the understanding of risk management, collaboration and information sharing are needed between various research fields. The topic is currently relevant and previous studies have already revealed development needs concerning risk management frameworks and activities in the companies.

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Value analysis of information services: On theory and methods

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Abstract

As information services are designed and related business or other decisions must be made, there has to be a clear understanding of the benefit generating potential of the service. The potential must come from the utility, or value, that the information is meant to deliver to its users and producers. This paper shows the methods and techniques for information valuation. The value of information is explained in this paper in the light of economic theory. The value consists of several attributes. Different attributes have varying importance in different measuring and valuation points. Hence, they also are of varying value to different actors, depending on actors' position and preferences in the value chain. With the described methods and techniques, the valuation problem can be clarified and appropriate tools selected.

Introduction

When information services are designed, the business potential must come from the utility, or value, that the information is meant to generate to its users. The business community seeks the opportunities to provide such utility to its customers and to get money in return for it. Hence, the underlying assumption is that *information* provided to users who benefit from it, is a synonymous concept to *information service*.

This paper looks at the theory and methods of information valuation, and thus includes the service valuation viewpoint. The paper starts with basic concepts, disaggregates information value to its attributes and finally introduces methods and techniques to measure the value.

Information is always there. It becomes a service commodity when it is delivered to those who need and appreciate it, in the right format at the right time, and as correct and usable as possible. The service aspect turns information into a commodity that has a value. Value in turn consists of multiple attributes that have different relevance over the value chain and over actors in the chain.

Information value, impacts

Information economics (or the economics of information) is about how information affects the economy and decisions with economic impacts. This particular field of microeconomics has become highly relevant in today's information society. The impact of information on societies' and firms' functions and decisions with economic dimensions has been recognised to have a wide scope. Even macroeconomics is affected by information. What a national central banker says and means has a direct impact on the stock market and behaviour of investors. The state economies and societies' systems are affected by various sets of information and by the messages that the information contains.

Value of information can be looked at from at least two angles:

1) value of information to the decision maker, who feels to be in better or worse decision making situation with the available information to aid his/her decision making process
2) value of information realised through the impacts resulted by information.

The first angle reflects the *perceived* value and the second the *realistic* value of information [1]. Perceived value of information is very close to *normative* value, mainly because of the focus on the decision-making situation. Perceived and normative values are always speculative in cases where the decision impacts are uncertain. Hence the perceived and normative value measurement fall also under the research on decision making under uncertainty, which has multiple application areas, such as capital markets, managerial decisions and behaviour of consumers, to name a few.

Realistic value is empirical in nature and by definition. It requires the measurement of the impacts of a change in a system and can be measured only after it has taken place.

Figure 1 shows the two valuation points in a simplified information value chain. It is notable that users of the information are in facts decision makers, taking different actions and measures based on the information and their expectations on the utility achieved via their actions and decisions.

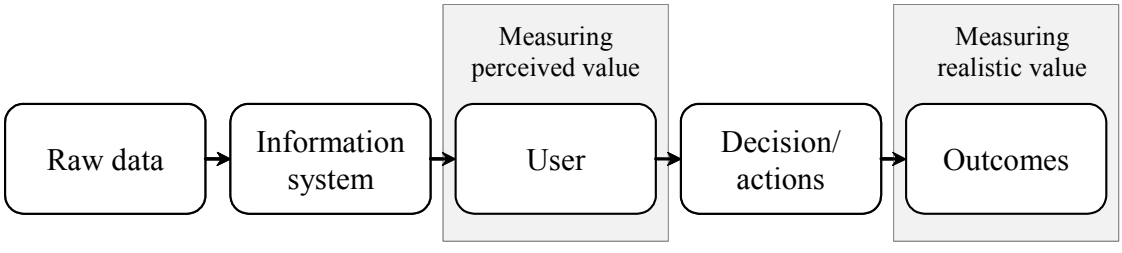

Figure 1. Perceived and realistic value of information [1].

It is of paramount importance to understand that different actors perceive and realise information value at different points in the value chain. For example, a raw data provider perceives and realises value before the actual utilisation downstream in the chain. From this, it follows that there are several subsequent perceived and realised valuation points, each specific to a particular actor.

A typical actor list is visualised in the Figure 2 value chain, which depicts more detailed role identification and complements the previous simplified view of the value chain.

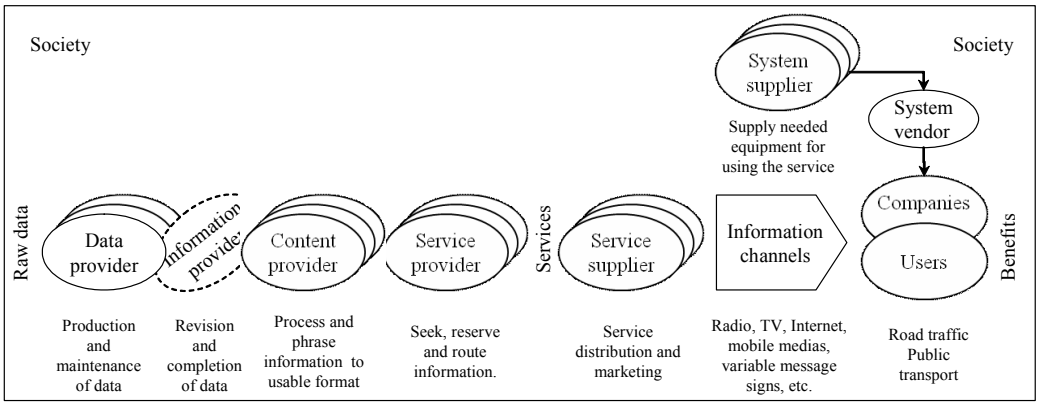

Figure 2. Actors in an information service value chain: example from transportation [2].

Figure 2 illustrates that perceived and realised *private* benefits, which represent the value perceived and realised by value chain actors, are present all along the chain, whereas the *public* benefits normally start to accrue at the downstream end of the chain. Typically, B2B transactions occur in the upstream and middlestream points and when information has been refined to meet the demands of wider public and consumer market – or a wide spectrum of corporate users – the benefits can be recognised at society level, or in other words, as socio-economic benefits. The sum of private net benefits is equal to public benefit. If, for example, end-users pay for the information service, these payments are benefits to information service providers but not benefits to the society.

The realistic value of information for the very end users – for example in the case of transportation such as drivers, public transport passengers, freight customers and operators, etc. – must include a measurable impact with increased utility for the users. On a societal scale or socio-economic scale, the impact must be measurable from the system performance, whatever we choose the system to be, be it the transportation system or something else. The measurement of an empirical change of a system's performance is usually a demanding task and feasible only in very exceptional cases. The most common approach to impact measurement at the system level is to apply sophisticated impact models and simulation of the system change. For a system model to be comprehensive at a satisfactory level, it usually must involve several models grouped as a meta-model. Transportation is again one typical specimen that requires this approach.

Most system performance measurements and impact analyses are, on one side, relying on empirical models and their combinations into meta-models and, on the other side, on perceived impacts, benefits and value, based on sophisticated application of the meta-models. This means that in most occasions the perceived value dominates the decisions taking place in individual value chains, but also the wider decisions concerning socio-economic benefit expectations at the system level.

Value attributes

Value of information is not a uniform and single, aggregated concept. It consists of multiple attributes weighed in different ways by different actors who valuate information according to their own particular preferences. Literature on information theory, economics and information economics lists a long set of value attributes which build the aggregate value. The list drawn from the literature is in Table 1. This list is not exhaustive but covers a wide range of attributes. We can also regard the value disaggregation as a *value engineering approach*, looking at the different characteristics and aspects that build the commodity value.

The attributes listed before can be grouped or combined in many ways. How one groups the attributes is not relevant *per se*, but rather the acknowledgement of pragmatic reasons to aggregate some attributes in order to keep the list manageable and meeting the needs at hands. Table 2 shows the suggested hierarchical grouping, but it has to be emphasised that this grouping is just one possibility. The grouping can vary from one application sector or organisation to another and is contingent in nature.

It is also easy to deduce from Table 2 that a single attribute may be a function of multiple components and the total value might be a function of all the attributes. The simplest and probably the most common analytical structure applying this type of thinking is to form a weighed sum of components into an attribute and assess the total value by summing (either with or without weights) the attributes into a total value.

The value accumulation is heavily dependent on the point of measurement. For example, availability and accessibility are relatively more important in the upstream part of the value chain as well as in the downstream end of the chain, because it is logical to assume that availability and accessibility are critical when data is gathered or observed. Non-observable data has little value. When the end users start to use an information service, accessibility and availability become likewise relatively more important. If users cannot access the information, it is hard to imagine any realisable value behind it. Same type of logical reasoning is applicable to all attributes and components of information value. Again, the relative value of an attribute in the information service chain is something that depends on the context, valuator and valuation method.

When designing information value chains, the value build-up of different attributes and relative importance in different sections of the chain must not be neglected. What seems to be of high value in the decision-making situation might not be in the consumer marketplace, or *vice versa*.

Table 1. Value attributes of information: summary from the literature (modified from [2]).

Value attribute	**Explanation, definition**
Accessibility	Accessibility means the ease of use and ease of access of information. It includes the information mode and media through which information is delivered (e.g., personal devices, internet; voice, displays) but also the reliability of the information system.
Accuracy	Accuracy means that information is free of error. [3] Accurate information describes the right phenomena with the right characteristics. Inaccurate information can be misleading and even harmful. [4]
Availability	Availability refers to how often information is available when it should be. [5] It can also be regarded as a sum of 1) coverage, which indicates from how wide an area the system provides data; 2) volume, which tells how much information is acquired from one measurement point; and 3) consistency, which is described later in this table. [6]
Completeness	Completeness refers to how complete the information about the subject on-hand is. Incomplete information can be useless, cause misunderstandings or have reduced value. [4]
Consistency	Consistent information is coherent and logical throughout. It describes the degree to which information satisfies a set of constraints. [3] It also demands the same quality for all information in the system. [6]
Contents	Information content can be divided into information about the physical environment and information about behaviour or way of action of other individuals. [7] Information content should be organised in a way that it is of use to users. [4]
Cost	Cost relates to the attributes of acquiring or providing the information. [1] Only information whose cost is less than its perceived value should be produced or acquired. [8]
Effectiveness	Effectiveness means the effect information has on its user. Effective information may change user's behaviour or his/her way to see the surrounding environment.
Form	Form refers to the mode and medium in which information is delivered to the users. In different contexts of use, users prefer different information modes, such as pictures versus text and different media like Internet or mobile. [1, 4]
Objectivity	Subjectivity in the data production process can cause a reduction in a source's reputation. Coded or interpreted data is of lower value to users and over time the subjective nature of data accumulates, questioning the credibility and reputation of source. [9]
Relevance	Relevance is an important characteristic when seeking information. Only relevant information is useful to the decision maker; it is expected to affect positively the measured or perceived payoffs. Relevant information has a positive value, which depends on the changes in decision maker's action. [8]
Reliability	Reliability refers to the certainty that expected phenomena are in fact occurring. For example, in transportation reliability is usually associated to possible late arrival, waiting or uncertainty. Reliability relates also to random effects like vehicle breakdowns and signal failures. [10]
Reputation	The reputation of an information source comes from the quality of information. Poor quality information leads to poor reputation. A reputation can develop from a factual or non-factual basis, but when a reputation of poor-quality goes out, the data source is considered to have little added value to the user, resulting in reduced use. [9]
Timeliness	Timeliness refers to how up to date information or useful in terms of its age the information is. [3, 4] Time is often critical for decision-making and realized action. It may affect the expected payoff and cause the loss of opportunity. [8] Out-of-date information is useless and is usually of little or no value. [4]
Uniqueness	Information is unique if it is the only one of its kind and there is nothing equivalent. [3] Unique information gives the user the possibility to benefit from a situation where he/she is the only one having certain information.
Validity	In the social sciences, validity means the extent to which a measuring instrument measures what it is intended to measure. [11] In logic, and as an information quality attribute, it rather means that with true premises one cannot end up with a false conclusion (Encyclopædia Britannica).

The concepts are relevant also in the context of revenue logic and revenue potential identification: for someone in the upstream end of the value chain, the effectiveness of information might not be that relevant (e.g., an information infrastructure provider) but for users (e.g., drivers in a transportation system or transport operations managers), the effectiveness could be everything. Apparently, the greatest earnings potential is found with those actors who regard the information attribute as important, i.e. valuable.

Table 2. Grouping the attributes into hierarchical order (modified from [2]).

Value attribute	**Component to attribute**	**Key questions to describe the component**
Accessibility	media &mode	What is the information format? How is the information distributed? Is the information accessible? Is the information accessible when needed? Is access restricted?
	traceability	Is the data source identifiable? Can original data be tracked and traced?
Contents	accuracy	Is the information free of error?
	uniqueness	Is the information the same for everyone? Is it possible to get customised information? Is it possible to benefit for being only one having certain information?
	relevance	Is the information something the user really needs? Does information help to solve the problem at hands?
	scompletenes	How complete is the information? Is there a deficit?
	form	Is the form of the information usable?
Availability	coverage	How wide an area does the information cover?
	volume	How frequently is the information updated? How much information can be accessed at the same time?
Timeliness	real time	Is the provided information real-time, or does it reflect a relevant time point?
	history	Is the provided information collected data of past events?
Validity	unambiguous	Does the information include obscurities?
	consistency	Is the information coherent and logical?
	objectivity	Can the information be considered objective?
	service reliability	Is the information available when promised? Are the mode and media according to promises?
	service reputation	Are there competitive services? What kind of reputation does the service provider have?
Effectiveness	decision impact	Can the information make a user change his/her decisions?
	behavioural impact	Can the information make a user change his/her travel mode?
	benefit impact	Does the information generate time saving, increase comfort, enhance safety, increase profits, etc.?
Cost		Is the information free of charge? Is some of the information chargeable? How much does the information cost?

Valuation methods and techniques

Whether the value is perceived, realistic or just a partial component of an attribute, the value must somehow be measured. There are multiple methods and techniques of doing this, but these methods and techniques must be applied with understanding and skill, being aware of the limitations, and especially of the fact of how well the relevant attributes of information are covered and in which part of the information value chain the measurement takes place. Last but not least, one needs to understand who is the valuator, the user of information or the information service.

It is possible to categorise the methods according to a dual distinction between perceived and realistic values, for example. Perceived value is always *ex ante* by definition, requiring methods different from strictly empirical methods. Realistic value in turn is empirical in nature and has the qualities of being observable. Even realistic values can be measured with different techniques, or methods, and the following discussion lists some of the relevant valuation techniques and methods.

Willingness-to-pay (WTP) is a very common and widely adopted method to make perceived value assessments. The method is described in detail in a number of textbooks on economics. WTP is a method where the valuators are placed in a position to make a statement how they see the value of the valuation object (e.g., the information or service). As a technique, WTP can be assessed through questionnaires or interviews, when obviously the value can be regarded as perceived. WTP can also be empirically observed, but indirectly. For example, the differences in house prices of certain areas can be explained by the willingness to pay to be recognised to be a part of a certain social status group. The same house with the same quality might have a different price depending on the housing area. The same rule applies, for example, to the use of transportation mode. People with low-income social status are more inclined to use public transportation than people with high-income social status, even if the market price of mobility is lower with public transport. High-income people are willing to pay extra money and time to be in their own comfortable cars. WTP is always an indirect method, since direct observation leads to market values. WTP may fail the market test, meaning that when services are actually delivered to the marketplace, the WTP values might not be realisable or can be substantially lower than WTP suggests.

Market value is always empirical and hence reflects the realistic value. It is always directly observable and might have reflections on the WTP how information or any other commodity is valued. It is important to understand that market values also carry an expectation load with them. In other words, while market values are empirical, they are also based on perception. This is particularly visible in the stock market. Stock prices are based on expectations of future cash flows generated by the stocks of the

company in question. Yet, this is the price used for trading and hence it is realistic. One could argue that the price is more perceived than realistic, because realistic and empirical value can only be recognised after the trading. In an obscure way, market values are realistic for those who realise the value (sellers) and perceived to those who have expectations on the value (buyers). One special case of market valuation is the *historical cost based valuation*. In simple terms, historical cost based valuation refers to past transactions recorded in the marketplace. This valuation principle is typical in accounting.

The *Cost of damage* principle refers to the cost of damage resulted in if specific actions (and consuming money, i.e. investments) were not to take place. A typical example of cost of damage is the building of a dam in order to prevent flooding. The potential damage caused by flooding could well justify the cost of the dam. In the case of information services, one could pick examples such as weather warnings, warnings of accidents and exceptional situations.

Economic approaches capture the wider economic values, not only those recorded in the transactions between buyers and sellers. The values associated with third parties are called *externalities*. In many cases, externalities are not included in traded prices, but should be taken into account by high-level decision makers, such as politicians and corporate executives. This pricing regime is called *shadow pricing*. Shadow prices deviate from market prices deliberately in situations where shadow prices reflect the true values or costs better than market values. Examples of when externalities must be considered and economic approaches adopted include the following:

- investments in transportation systems, taking into account environmental and safety costs
- investments in major industrial facilities, taking into account social values such as employment and social well-being.

Pricing or valuation techniques can be found in a number of textbooks dealing with project selection and cost-benefit analysis, e.g., in [12, 13].

Economic approaches are easier to apply when externalities can be ignored, i.e., when only financial items are considered. These items are almost always market valued. When markets fail to reflect the true values, as very often is the case, the value of externalities must be considered more widely. For information services, such considerations are only beginning to emerge. Examples these types of considerations are presented, e.g., in [14] and [15], where Leviäkangas et al. assess the economic impacts and benefits of meteorological information services in Finland and Croatia. In wide-scope economic approaches, one often has to combine different valuation techniques, such as market valuations and WTP.

Qualitative approaches assess the value or benefit but do not monetise them. It is very useful, however, when monetisation presents practical or theoretical problems that cannot be overridden. Qualitative approaches often well supplement monetised analysis. Examples of qualitative approaches are numerous, e.g., the benefits of information on freight tracking and tracing which are particularly hard to monetise because of the complexity of modern supply chains. Private benefits, i.e., the benefits for an individual supply chain actor, are fairly easy to measure in monetary terms. Qualitative approaches are seldom empirical, because strictly empirical observation is almost without exception including measurements on a defined scale. This categorisation is not waterproof, however. Typical qualitative methods are *analytical hierarchy process* and *multicriteria analysis*. A description of the first method mentioned can be found in [16]. Leviäkangas and Lähesmaa [17] applied AHP in intelligent transportation system (ITS) investment analysis.

Different approaches, methods and techniques are hard to put in a logical and comparative order, but Figure 3 attempts to do that. The illustration distinguishes between approaches (or methodologies), methods and techniques. The private sector usually adopts the economic approaches and related techniques, simply because the private sector focuses on monetary prospects. In the public sector, more complex and indirect methods become necessary as the number of variants in a decision-making situation may be quite large and heterogenic.

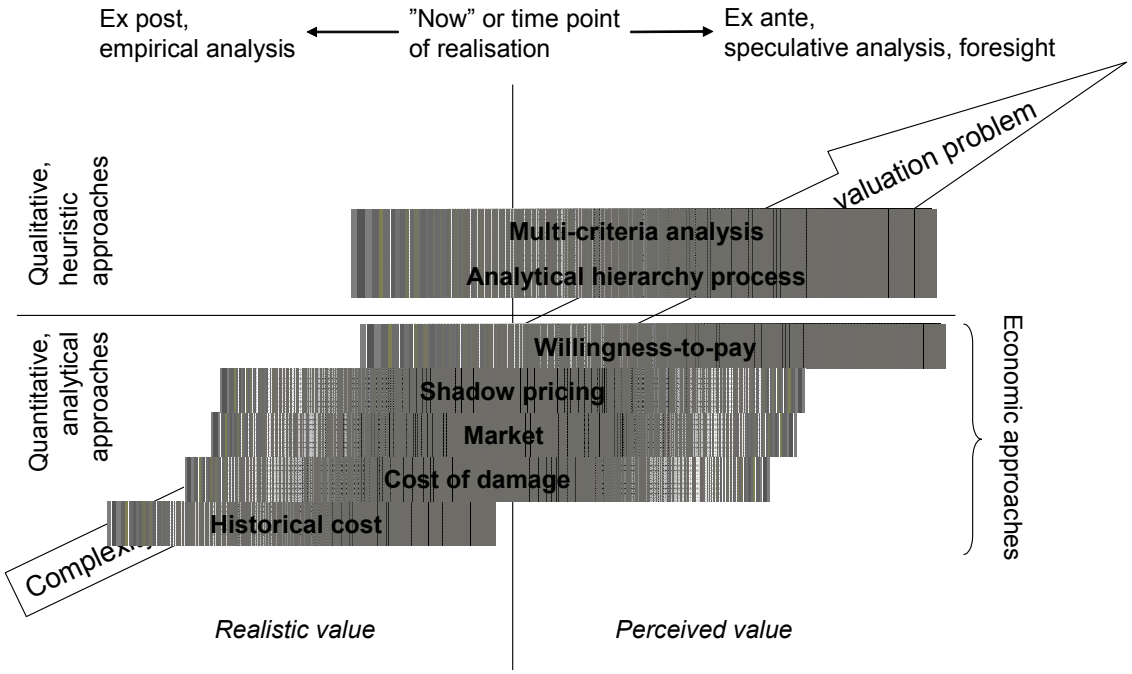

Figure 3. Approaches, methods and techniques of information valuation.

Conclusion

The value of information was explained in the light of economic theory and value engineering. The value consists of several attributes, which can be arranged in hierarchical order to be applied in contingent situations. Different attributes have varying importance in different measuring and valuation points. Hence, they are also of varying value to different actors, depending on actors' position and preferences in the value chain. The methods and techniques to measure value are numerous and apply to different situations and measurement needs.

There is no uniform methodology how to measure the value of information, but what is certain is that the valuation problems continue to exist and gain more attention as societies are, at an ever-accelerating pace, turning into information economies. With the described tools, the valuation problem can be clarified and appropriate methods selected. This is particularly useful when designing new information services and probing their business potential. Value analysis helps to understand how usable and valuable information as a commodity can be and how information delivery can be turned into a socially beneficial and/or commercially profitable service.

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Benefits and value of information services – case Finnish Meteorological Institute

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Abstract

The benefits of meteorological information services have been studied widely, but a coherent view of the impacts of the services has been ambigous. Met-information services must be first seen as a service with potential positive impacts on the societies' functions and only after that will the services be regarded for what they are in fact worth. This paper looks into the *value* of the services for the society in addition to the methodological contribution, which is also present. The Finnish Meteorological Institute's services represent the empirical case. It seems evident that the value of information will play an increasing role when societies grow more and more information intensive. The results of the empirical case were explicit. The total value of benefits, generated each year by the Institute's services, exceeded the annual budget of the Institute many times over.

Introduction and scope

The EVASERVE project (www.evaserve.fi) developed information service assessement methods and tools. The project closed in Spring 2008 and produced several evalution modules for practitioners and some case evaluations, of which the case of the Finnish Meteorological Institute (FMI) was the most extensive one. EVASERVE was launched initially in 2006, with some pre-studies taking place already earlier, because it became apparent that information services had not conquered the market space to the extent enabled by modern information and communications technologies (ICT). The prospective services seem to lack sustainable business models and clear information supply chains. This has been demonstrated, e.g., in the case of information services for logistics, where multiple actors in the supply chain make coherent information flow and services an extremely complex issue [1].

This paper introduces the results and conclusions of the FMI study [2]. We also show the methods applied to the FMI case and demonstrate the variety of methods that were needed for wide-scope analysis.

The benefits of meteorological information services have been studied widely, but a coherent view of the impacts of the services, i.e. the *value for the money* invested in the services of each national meteorological institute, has been ambigous. Some attempts have been made, however, on, for example, benefits accrued to the forestry [3], aviation and terminal operations [4] and to oil and gas production [5]. More extensive studies are few, such as [6]. Weather is acknowledged to have a drastic impact on economy and societies' functions. For example, in 1998 weather phenomena resulted in at least USD 2.5 billion (nominal terms) of damages to the Japanese economy [7]. Mostly the analyses have been very sector-specific and focused on damage consequences of weather-related phenomena.

Met-information provision must, first and foremost, be seen seen as a service, not a function in its own right. This service must have potential positive impacts on the societies' functions and only after that will the services be regarded for what they are in fact worth. This paper looks into the *value* of the services for different sectors of the society. In addition to this, the paper has a methodological contribution by demonstrating the application of information service valuation methods. The impacts of meteorological information services are analysed in this paper for transportation, energy production and distribution, construction and facilities management and agriculture.

Value analysis is usually associated with value engineering, quality engineering and cost engineering. It studies the characteristics of a product which forms its value to the user. Users could be private citizens, institutions or public administrations. Each user has a different perspective on what is regarded as value. This paper adopts the view of society and hence falls close to socio-economic cost-benefit analysis. By reducing the scope and looking at benefits and costs of met-information services to one particular entity, a single company for example, the approach would be a standard financial cost-benefit analysis.

Methods

Impact mechanisms of met-information services

Beneficial impacts (as well as negative impacts) of an information service comes through certain impact mechanisms. Often these mechanisms are very hard to assess empirically, because exclusion of other impacting variables (the noise) is not possible. Usually, impact mechanisms are a combination of empirical experience – more or less

thoroughly documented – and logical deduction. In best cases, empirical observations have been modelled so that different scenarios can be analysed, e.g., the marginal impacts of increased information.

Such empirical models are extensively found in engineering (e.g., safety impacts of road improvements), health care (e.g., impacts of smoking) and economics (e.g., impacts of tax reductions). The empirical models work well, poorly or everything in between. Usually the use of models requires expert interpretation, taking into account source data reliability and accuracy and model characteristics. We could categorise the impact mechanism modelling as shown in Table 1, for example.

The FMI case analysis incorporated all these impact mechanism model types. It is virtually impossible and definitely not reasonable to incorporate a single approach to a complex impact evaluation problem. Some impacts have more reliable source data and impact models behind them and some have to be analysed by satisfying to e.g. information gained from interviewing persons with the adequate knowledge on the impacts. Whilst this is, in most cases, the appropriate line of action, it poses the problem of having results not be uniform and poorly comparable with each other. In other words, it's the classic problem of comparing apples and oranges. Hence, the role of expert is increasing at the back-end of the impact analysis process, when sum-ups are drawn.

Table 1. Different model construct characteristics.

Construct foundation	**Source data**	**Role of expert interpretation**	**Method of gathering data**
Analytical	Analytical solution, requires known variables	Low	Does not require data unless emprically verified (except for the input data for the known variables of the model)
Empirical, tested	Empirical observation	Moderate	Statistics, recorded observations
Empirical, untested	Empirical observation	Critical	Statistics, recorded observations
Logical, descriptive	Experience and/or logical deduction/induction	Highly critical	Literature, interviews, unrecorded or recorded personal observations
Heuristic	Experience and/or logical deduction/induction	Highly critical	Literature, interviews, unrecorded or recorded personal observations

In the FMI case, the impacts on, for example, railways were based on logical-descriptive models (Figure 1), verified with some interviews and and literature. Empirical models were simply non-existing.

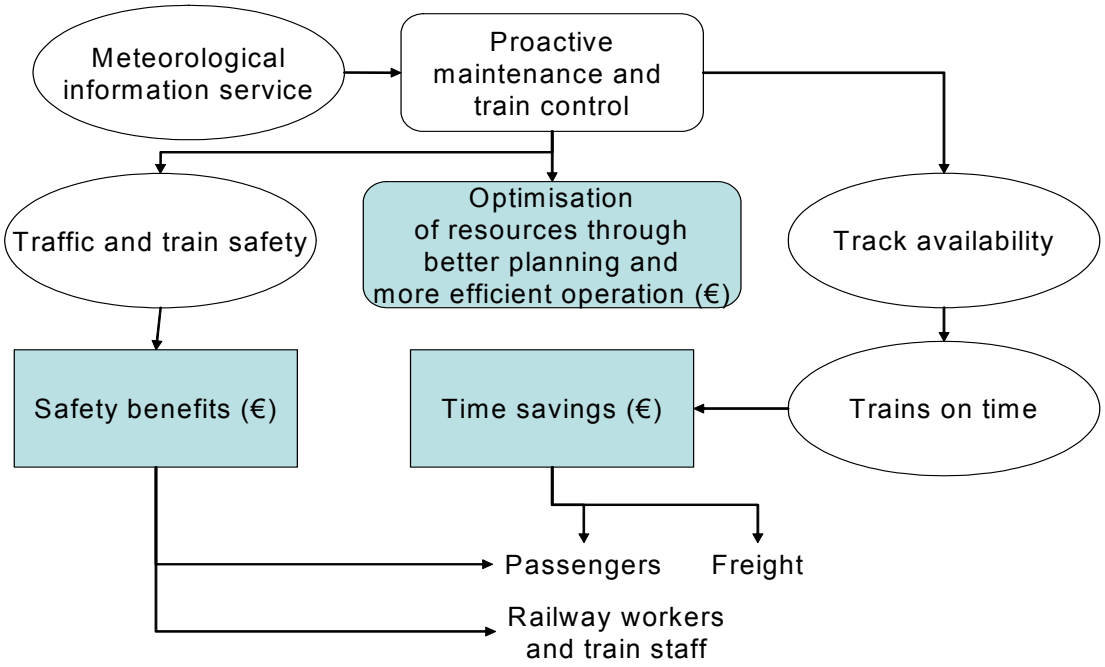

Figure 1. Impact mechanism of met-information on railway operations: an example of descriptive modelling.

In other cases, the impacts could be analysed through quantitative, analytical model specifications, as was done for safety impacts on road traffic [8]. The model assumption was that when receiving relevant weather information, drivers would lower their speed and hence the accident numbers and severity would be lower. This assumption involved in fact two models, the analytical (but empirically untested) model [9] on safety reduction numbers and severity, and the empirical model on information impacts on driver behaviour [10].

Pricing of benefits and costs

Once the impacts have been determined, there remains the challenging task of assigning a price tag for each relevant impact. The value of information and associated pricing has been more thoroughly dealt with in [11]. It suffices to list the most relevant pricing methods and techniques (Table 2) and how they apply across each other. "FMI" has been marked to those cells that were applied to the FMI case study and particular. The message of the table is, in addition to the demonstration of a wide variety of techniques used in the FMI case, the fact that not all techniques are suitable for all situations. The validity of outputs of techniques decreases from right to left and the role of the expert increases. The time scale is also roughly from right to left, historical costs representing the recorded past transaction prices and willingness-to-pay more future-oriented and speculative price setting.

Table 2. Approaches and techniques applied in the FMI case (green/shaded areas).

	Pricing techniques					
	Quantitative					*Qualitative*
Approaches to information value [12]	**Historical cost**	**Cost of avoidance (cost of damage)**	**Market prices**	**Shadow prices**	**Willingness-to-pay**	**AHP[1]; MCA[2]; Subjective scaling[3]**
Normative (decision making value)		FMI – material damages (energy, agriculture)		FMI – safety, time (road, rail, aviation, maritime, pedestrians)	FMI – safety (road, maritime, aviation)	FMI – logistics, construction, rail, aviation
Perceived (value based on expectations)						
Realistic (observed, realised value)	FMI – cost of operations (maritime, road, aviation)					
	Ex post analysis, observed prices			*Both*	*Ex ante analysis, expectations*	

[1] **Analytical Hierarchy Process**
[2] **Multicriteria Analysis**
[3] **Impacts on logistics operations were done by interviewing and applying Likert's scale; other scalings were pure expert assessments**

The evaluation process

The evaluation process follows the logic where the impact mechanisms are first envisaged or formulated, then the actual impacts are assessed or estimated, and finally, when appropriate unit prices or their estimates can be attached to the impacts, the benefits can be estimated. Figure 2 illustrates the methodological approach to evaluation and the value analysis of FMI's information services. This process was repeated for each analysed sector. Transportation was divided into sub-sectors per mode, and they were analysed as separate sectors.

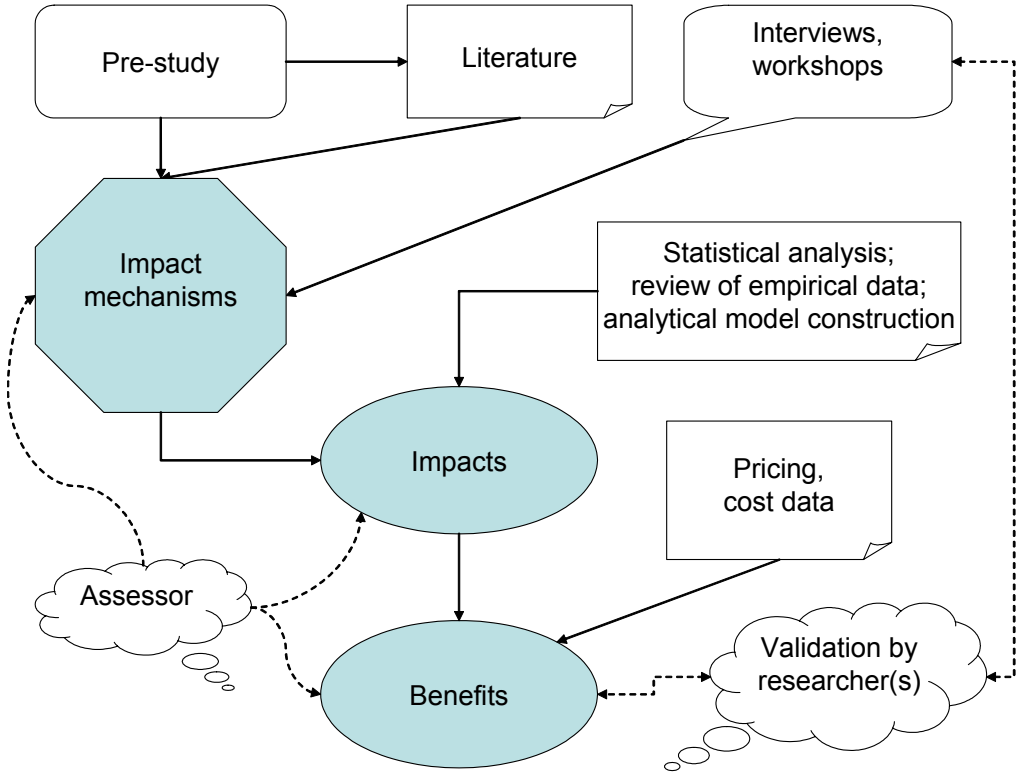

Figure 2. The overall evaluation process, repeated for each sector.

Results

The results of the FMI case concerning the benefits of its information services were explicit. The total value of benefits, generated each year, exceeded the annual budget of the Institute many times over. The benefits were calculated for current situation with existing services, and then projected to the future to assess the theoretical maximum potential. Two important concepts were applied in this part of the research:

- *value with current information*,
- *value with perfect information*.

These concepts [13] are particularly useful in normative analysis and supplement value analysis, cost-benefit analysis, etc.

The results of FMI case are summarised in Table 3. Current services generate roughly EUR 260–290 M in annual benefits for the analysed sectors and it was estimated that by enhancing the distribution systems, availability of service and improving service quality the benefits would accrue up to EUR 430–570 M per year. The annual budget of FMI being around EUR 50–60 M, the estimate for annual benefit-cost ratio for existing services is at least 5/1 and potential is up to 10/1.

Table 3. Benefits of FMI's services – summary.

Sector	Principal impacts and benefits	Value of current benefits	Value of potential benefits
Road transport (public roads)	Reduction in number of accidents, more efficient maintenance	11–20 M€ in total – accidents 9–18 M€ – maintenance 2 M€	 – accidents 9–18 M€ – maintenance, not calculated
Pedestrians & cyclists	Reduction in number of slipping accidents, more efficient maintenance	– slipping accidents 113 M€ – maintenance, not calculated	– slipping accidents 122–203 M€ – maintenance, not calculated
Waterway transport	Reduction in number of accidents and environmental damage, more efficient operations, reduction in fuel consumption	25–39 M€ in total – accidents 14–28 M€ – oil combating 10 M€ – rescue operations, fuel savings, etc. 1 M€	Not calculated
Air traffic	Reduction in number of accidents and emissions, more efficient operations, time savings for travellers	54 M€ in total – accidents 46 M€ – fuel savings 4 M€ – airport maintenance 3 M€ – environmental damage 1 M€	Around 4 M€
Rail traffic	Higher accuracy of train timetables	0.3 M€	0.2 M€
Logistics, supply chain	Higher predictability of deliveries, reduction in storage costs and risks (accidents, damage)	Not calculated	5 M€
Construction & facilities management	Prevention of mould and mildew damage, more efficient maintenance (worksites and courtyards)	15 M€ in total – construction 10 M€ – facilities management 5 M€	15 M€ in total – construction 10 M€ – facilities management 5 M€
Energy production & distribution	Energy production capacity and availability predictions, prevention of damage and production and distribution interruptions	10 M€ in total – prevention of interruptions 2 M€ – production predictions 3 M€ – peat production 5 M€	8–23 M€ in total – prevention of interruptions 3–8 M€ – production predictions 5–15 M€
Agriculture	Crop protection, pest control, harvesting	34 M€ in total – increased crops 12 M€ – crop damage 12 M€ – more efficient cultivation 8 M€ – other benefits 2 M€	3–15 M€ in total – more accurate forecasts 1–5 M€ – seasonal forecasts 2–10 M€
Total	Higher predictability, better planning, more efficient operations, reduction of damage and number of accidents	262–285 M€ in total Note! The monetary value of all benefits were not calculated	Potential additional benefits 166–283 M€ (428–568 M€ in total for the analysed sectors)

Taking into account that many sectors were excluded from the calculus, such as defence, civil protection, health care, etc., the estimates are still quite downward biased. In addition, it should be noted that the "not calculated" statement explicitly includes the

assumption of the analysts that there exists a tangible benefit, but this benefit was not calculated in monetary terms because of a lack of data, practical difficulties or confidentiality aspects. On the other hand, part of the FMI budget is covered by payments from the beneficiaries – the paying customers of FMI – and these payments should be subtracted from the benefits. However, these revenues from the customers being less than EUR 20 M per year do not change the clear pattern: FMI's services are extremely beneficial. In fact, as these revenues (including also other external cash inflows) occur "within the system" – subtracted, in other words, from the benefits but also from FMI's budget – the conclusion from the viewpoint of the society remains unchanged. Private beneficiaries (meaning the paying customers) of course have a different perspective and their "system" includes the payments for the services and benefits they either realise or perceive.

Discussion

The FMI case analysis applied the theories and methods of information economics and cost-benefit analysis. The latter has been developed by numerous economists for decades and involves quite traditional discounted cash flow analysis (except that the flows are not only financial but include many other economic items).

Judging from the FMI case, it seems evident that the value of information will play an increasing role when societies grow more and more information intensive. The value starts to play a serious role: private sector actors must consider their business development efforts and public sector their own information services and services they procure from the private sector from this particular angl: will the information be of value in financial and economic terms? The FMI case showed clearly that the value was there, and moreover, well above the initial expectations.

The value creation process is actually much longer that what it appears from the surface. Regarding the case of FMI, for instance, the data observation network, the information infrastructre and organisation have been built up for decades and the first heavy investments have not been explicitly profitable in a socio-economic sense. This problem has been identified in less developed countries, where the infrastructures and institutions are still in the erection phase. Only after the build-up do the benefits really start to accrue, and once the critical thresholds have been overcome, the next cycle of investments are easy to justify. The service layer building phase is critical: when good quality services are delivered efficiently, used widely and the services impact on system performance and behaviour, the real benefits start to accrue. This "super-cycle" of institutional and infrastructure development is illustrated by Figure 3.

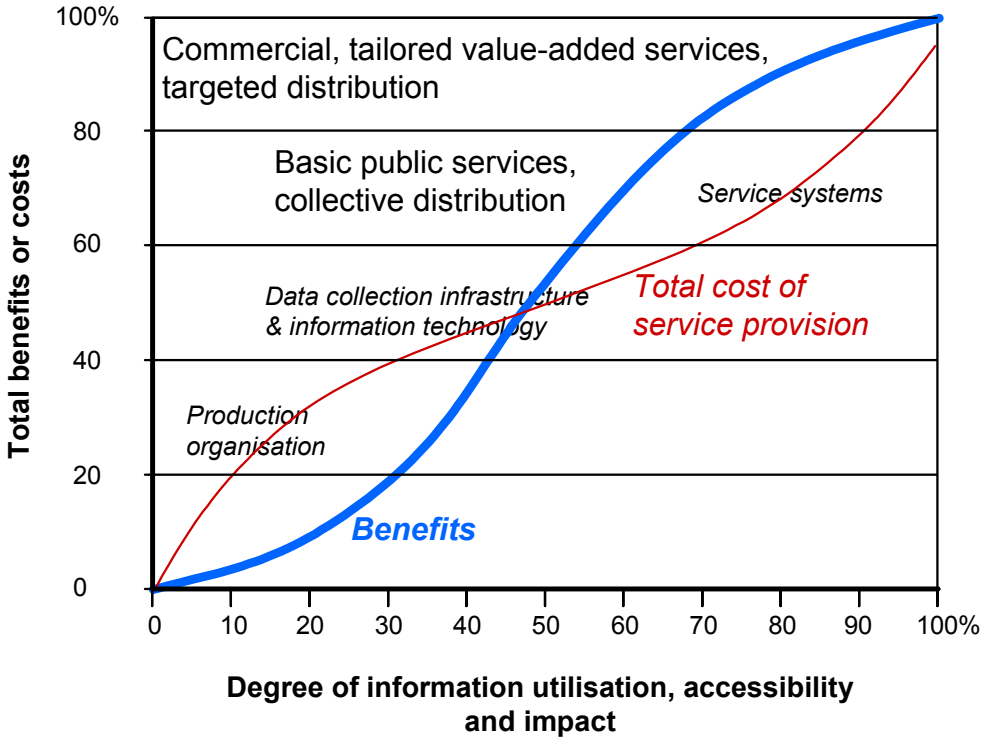

Figure 3. Super-cycle of value creation of an information service institution [2].

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Research directions for future transport service assessments

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Abstract

The new technology brought into the transport system changes the nature of schemes, strategies or measures as well as the roles of the different actors within the system. In this context a concept called "technology service" becomes a crucially important tool for understanding the dynamics between the transport system and the end-users. The paper presents a view to the transport system technology services in the future and even more importantly, to the assessment knowledge needed for their development and monitoring. The results are presented in a form of three road maps: Networking technologies, Real time information based interactive systems and Service packaging.

Keywords technology service, assessment, roadmap, transport system

Introduction

A transport system, international, national or local, is a large technological system which contains messy, complex, problem-solving components. The state of the transport system is a result of the measures and actions carried out by the producers, operators and users of the system. Basically, the ultimate purpose of the transport system is to serve the needs and expectations of the end users, who in turn shape the system by their own behaviour and actions. The system is thus both socially constructed and society shaping. For a long time, different ex ante and ex post assessments have been a standard procedure for public bodies to use when developing and planning the transport system. The range of different assessment methods is wide, including, e.g., theoretical appraisals, simulations, empirical measurements, etc. However, in all cases the question is: "How well does this scheme or strategy meet the objectives which we have set?"

Currently, new technology brought into the transport system changes the nature of schemes, strategies or measures as well as the roles of the different actors within the system. We argue that in the ubiquitous society of the future, also the functioning of the

transport system is based on different mobile, flexible and personalized ICT services. This development will have some impacts on the ways people move and work. The field of the transport policy and management will expand from macro-scale infrastructural level towards the micro-scale end-user level. In this context a concept called "technology service" will become a crucially important tool for understanding the dynamics between the transport system and the end-users. Technology service is a flexible and tailored combination of technologies and services which takes into consideration the travelling or transportation preferences, needs and expectations of the different transport system end users. The emergence of tailored technology services brings new challenges to decision makers, businesses, and other societal actors. Consequently, the roles of public and private parties in the transport system will intermingle in different ways, new business models and operational practices will arise.

Method

This paper presents a view to the transport system technology services in the future and even more importantly, to the assessment knowledge needed for their development and monitoring (see Figure 1).

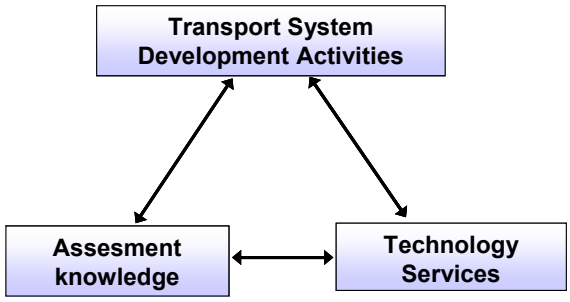

Figure 1. The three main elements of the roadmapping exercise.

The results are based on a Finnish case study [1], and are presented in the form of four roadmaps, which all take the systems perspective to the transport system development (Figure 2).

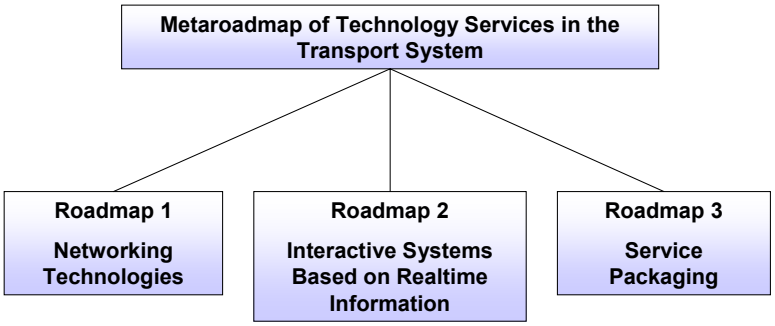

Figure 2. The roadmaps produced.

Basically roadmaps aim to provide an extended look at the future of a chosen field of inquiry, inventorying also different possibilities [2]. They also communicate visions, stimulate investigations and monitor the progress. Roadmaps are composed of the collective knowledge and imagination drivers of change in a particular field. In our case, the produced visionary socio-technical roadmaps aim for the above generic targets by 1) identifying and emphasising visions that are embedded in the roadmap structure; 2) combining different layers of society and technology [3, 4, 5, 6].

The roadmaps presented in our paper are based on two workshops and reflect the themes found important by the participants from different actors within the Finnish transport sector. The potential future developments were discussed in the workshops on five roadmap levels, namely: user needs, markets, actors, technologies, and assessment knowledge.

Results

The roadmaps, presented in the section below, provide three different, but complementary perspectives into the development of transport system technology services. Each of the perspectives is equally important in producing well balanced and acceptable technology services: Networking technologies will create settings for the service development. Real time information based interactive systems will offer the information, produced by new technologies in a custom-built form for the end users. Service packaging will help in implementing necessary, user friendly technology services.

Roadmap 1: Networking technologies

The first roadmap, Networking technologies (Figure 3), presents tools and forms of co-operation needed to make the assessment knowledge accessible to the different actors in all stages of the various innovation processes within the transport system development. The vision for the roadmap is as follows: “The information flow between public and private producers and end-users (e.g. companies, citizens) regarding transport system design, assessment as well as implementation is systematically organised. New transport policy relevant knowledge is produced within (commonly accepted) policy networks.”

In the short term (0–3 years), the user needs will focus on information exchange relating to transport system monitoring and control. The main emphasis will be on the fields of easy ac-cess to and comparability of the produced information, as well as finding descriptive indicators for the system development. The developers of the system will shape the markets by providing new uses, e.g., on the Internet. The technological base for networking technologies stems from different ICT applications, related to information exchange optimisation, Internet technologies and services as well as

positioning technologies. In the public sector, the net-working is limited to the internal information systems of different administrations or institutions. In needs of assessment knowledge, impact assessments, especially in monetary terms, are prioritised.

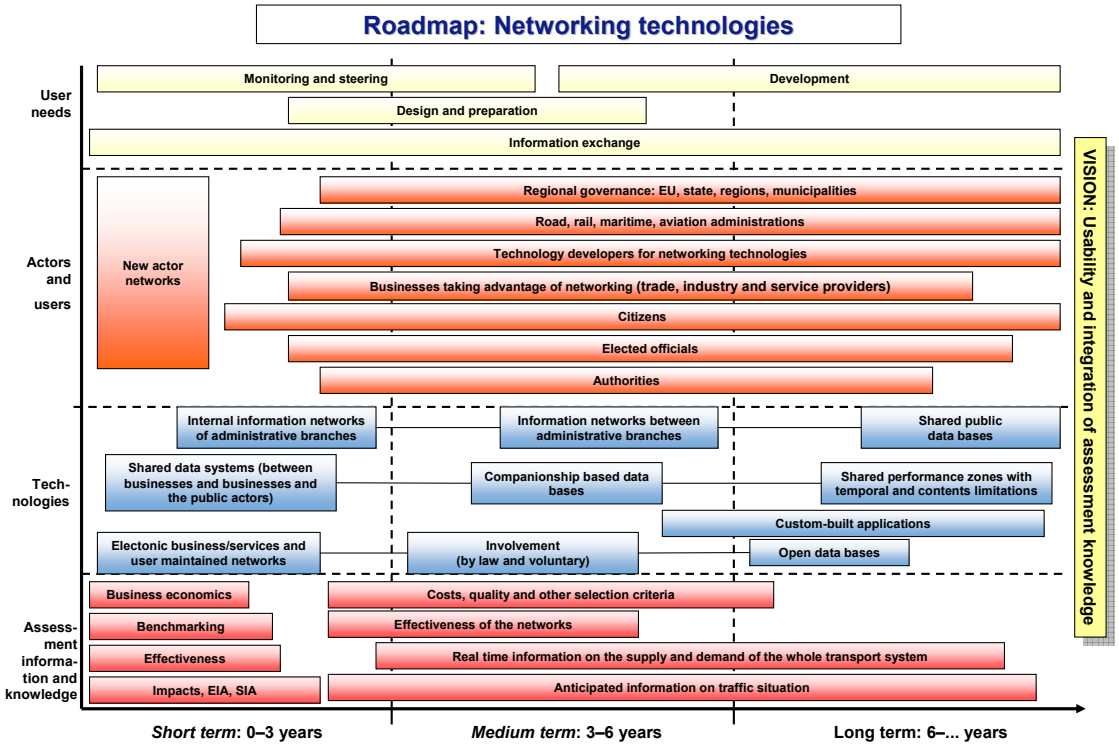

Figure 3. Roadmap 1: Networking technologies.

In the medium term (3–6 years), the internal information networks of the public administration sectors will emerge. Even inter-sectoral networks may become possible, allowing the use of information from other sectors as a basis for transport system design. On the private sector, the emerging partnership networks will serve the needs for information/knowledge of both passenger and freight transport. They may also integrate public and private actors e.g. in infrastructure design, construction and monitoring. Public participation in the design of trans-port systems will increase due to the electronic communication. In addition, the role of trans-port system users (or social networks) as designers may become one of the essential transport system or application design features in the future. The needs for assessment knowledge within the medium term will focus especially on the quality, costs and some other selection criteria for networking technologies. In addition, real-time transport information, forecasts based on real-time information, as well as assessments of the transport system demand and supply will be of high importance.

In the long term (6–… years), the objective will be focusing even more on open information and data bases. The management and legislation of data security and

privacy are, however, issues which may pose problems for the development. Integrated databases will alleviate the use of assessment and monitoring information in transport system research, design, citizen participation and implementation. There will be two different types of information within the transport system management: 1) publicly available information, which is critical from the perspectives of transport system functionality and safety; 2) restricted "non-free" information with commercial value. The line of demarcation between publicly available and commercial information will not be easy to draw, because commercial information may be produced also by tailoring, packaging, revising and personifying publicly available information. The needs concerning assessment knowledge will mostly consist of the same issues (i.e., quality, costs, and real time transport information) as in the medium term.

Roadmap 2: Interactive systems based on real-time information

The second roadmap, Interactive systems based on real-time information (Figure 4), presents technological complexes, giving the end-users of transport systems constant access (through vehicles or mobile devices) to real-time information about the travelling/transport possibilities that the system can offer. The vision of the second roadmap states: "Interactive, mobile information systems will support travelling and the transportation of goods before, in the course of and after the journey. Infrastructure, vehicles, and transport service providers will exchange information, which will enhance the fluency, safety and environmental friendliness of the transport system."

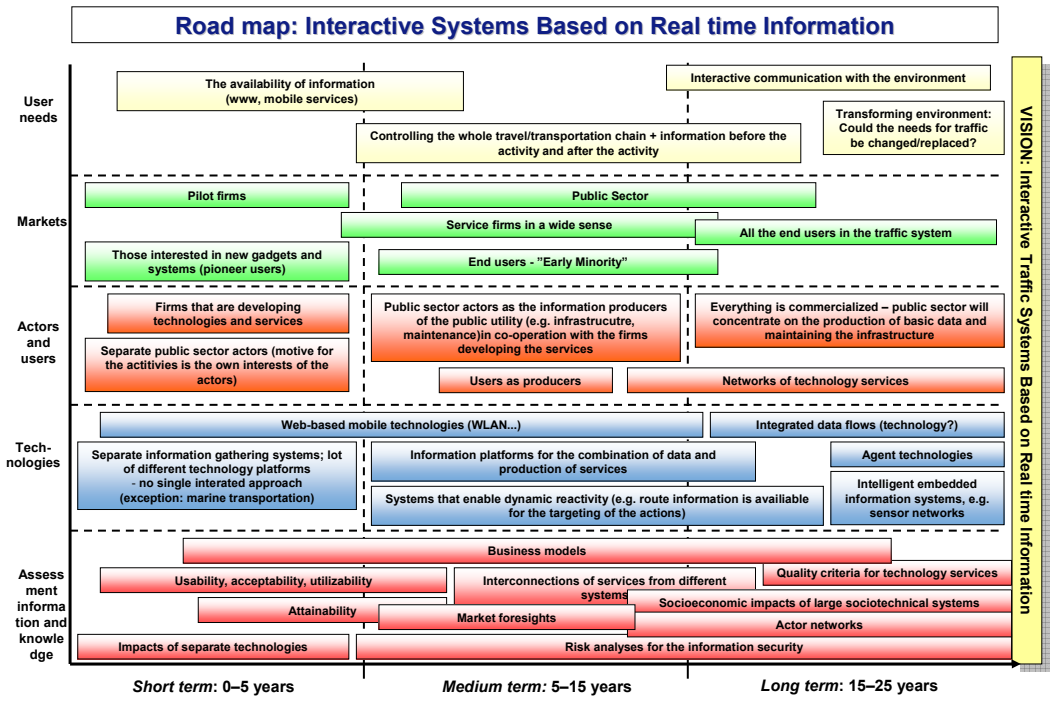

Figure 4. Roadmap 2: Interactive systems based on real time information.

In the short term (0–5 years), the needs of the transport system user will focus on the easy access to travel and transport information concerning different transport modes, equally for all user groups. The mobile interfaces will be emphasised in the information distribution. The potential market segments for the new applications will include pioneer companies in need of real-time logistic information and technology oriented individuals, or "early adopters". The information systems will be produced by different private service providers and public sector branches, each serving their own purposes. The enabling technologies will consist of many individual systems, e.g., ones for mode-specific data gathering. No common platform for the production, processing or use of (the) information throughout the transport system will be available yet. The assessment knowledge needed in developing the above services relate to the analysis of individual data systems from the perspectives of, e.g., interface design, implementation, acceptance and security. Knowledge regarding business model development and market foresight will also be essential.

In the medium term (5–15 years), the integration of the different modes and information within the transport system will increase, targeting towards one (single) transport system. The users of the system will be able to plan their trips beforehand and use the saved information during the journey dynamically, in an interactive manner. The main challenge will be finding an appropriate provider for the whole information system. Different sensors within the infrastructure and in the vehicles will continuously gather transport information for the use of both public and private sector actors. The service providers will combine transport information from different sources into new services, which will be used by a wider sector of end-users. The assessment knowledge needed will include business model development, analysis and market foresight for system wide services, provided in collaboration with private and public parties. In addition, assessments regarding the utilisation of the old smaller systems as parts of the new integrated system, which focuses on the interconnectedness and security and privacy issues, are of great importance.

In the long term (15–25 years), transport system services will become interactive real-time information based systems. There will be a need to move from services supporting mobility to new kinds of services replacing transport or making it more environmentally friendly. The service markets will develop towards the actual end-user (consumer) markets of the trans-port system. ICT will enable the communication and information flow between vehicles and infrastructures, but on the other hand, it will require the development of a common data/knowledge platform for different service providers. Many different sources, e.g., individual persons and vehicles, will be used to gather (the) information regarding the state of the transport system. The technology producers and service providers will operate in the service networks in order to increase the quality and efficiency of their services. The public sector will keep to the tasks of network building and basic knowledge production.

Roadmap 3: Service packaging

The third roadmap, Service packaging (Figure 5), answers to the daily transportation needs of individual people and firms. Service packaging helps the transport system users create a selection of individual technology services to assist in travelling or transportation, but also in other sectors of life where transport is a part of the overall service. According to the roadmap vision: "Service packaging enables the customers to define their individual selection of transport technology services. Service packages are easy to acquire and use and their costs are on a reasonable level."

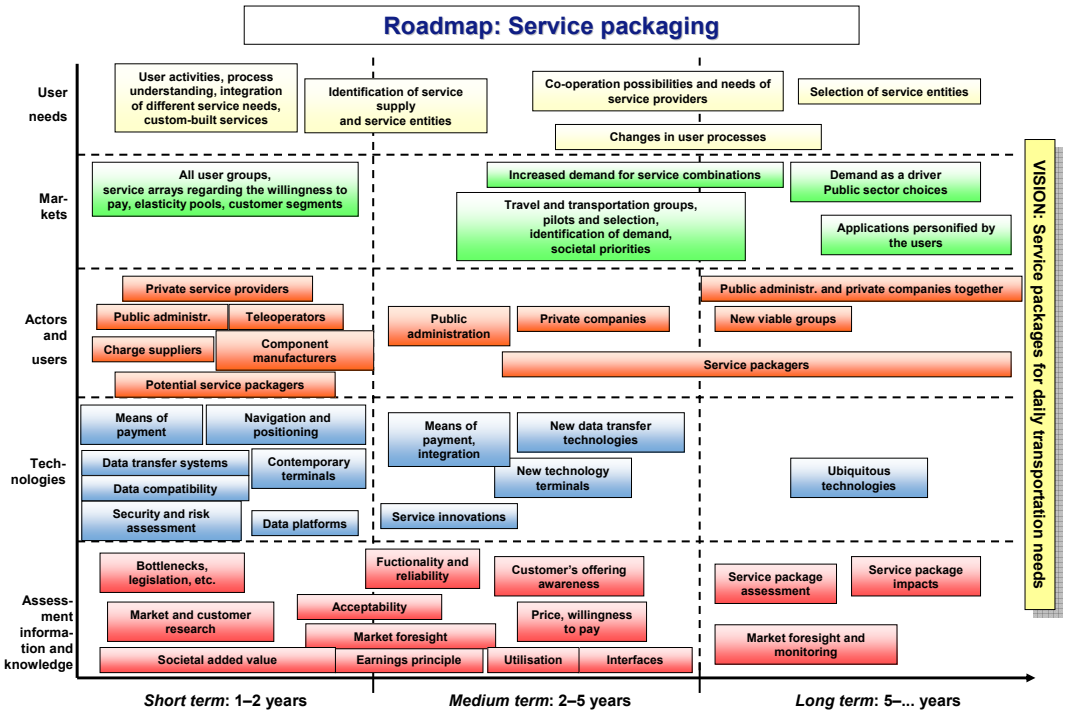

Figure 5. Roadmap 3: Service packaging.

In the short term (0–2 years), the focus will be on understanding the current actions, processes and preferences of the transport system's end-users as a basis for the package development and integration. The markets for the packages will lie among all user groups within both passenger and goods transport. The packages may assist in managing the large logistic processes of large companies as well as the small tasks in people's everyday lives. Here, finding the right target groups for the packages as well as their accurate pricing is essential and will require wide co-operation. In addition, the development of commonly accepted terminal devices and payment systems will be important. Databanks, data-transmission and processing systems will constitute the foundations of the services. Data security, data consistency and risk management may be the main challenges for service packaging in the short term. The most important assessment knowledge needs include market and customer studies, societal impact assessments of the packages and also identification of the legal bottlenecks for new service packages.

In the medium term (2–5 years), wider service areas will emerge. The co-operation possibilities, needs and preferences of different service providers as well as the roles of public and private parties within the service packaging will become clearer. The technological development will focus on the further development of data transmission, payment systems and terminal devices. The assessment knowledge needs will include the assessments of the functionality and reliability of the service packages, the service package interface design and market foresight for new services.

In the long term (5–… years), the service packages and wider service areas that best answer to the demands of the transport system's end-users will survive. The public sector may be able to steer the development through its own choices. New, viable (groups of) service package providers will dominate the markets and ubiquitous technologies will dominate the technological development. Additionally, different transport-related social (media) services are expected to emerge. Market foresight concerning the new service packages will, furthermore, be one of the key forms of assessment knowledge. Assessments regarding the functionality and impacts of wide service areas will also be important from the viewpoint of continuous business development.

The fourth, meta-roadmap, serves as a research umbrella, under which the more detailed thematic roadmaps are presented.

Discussion

As many theorists have formulated, through different terms and varying concepts (e.g., [7, 8, 9, 10, 11]), the societal development in advanced industrial countries has moved towards an information society, where the major driving forces are the development of information and communication technology, the rapidly increasing use of new devices, and the growth of the specific service sector.

Our main argument was that a move from the information society towards the knowledge society and the emerging ubiquitous society poses unique challenges to the transport system and transport policies. As the new information technologies, such as flexible mobile interfaces, sensor technologies and real-time monitoring systems, become the basis of the transport system, the views of the system itself should be re-thought. Consequently, the forms of knowledge production for transport policy and system design should change accordingly. We claim that foresight methods, like visionary socio-technical roadmapping, provide good premises and knowledge for understanding the new views.

The case study revealed that there is a need to produce assessment knowledge simultaneously from various key perspectives and throughout the transport service

innovation processes. Important continuous assessment themes include at least societal impact assessments, user centred design and different assessments regarding service demand and market foresight as well as business models. *In the short and medium term* (1–10 years), the assessment of transport system technology services needs to be focused on the following fields: market foresight, technology assessment as well as business model assessment and evaluation of integrated data systems; societal impacts and effectiveness of technology services in a production environment where the public and private parties should work in collaboration. From the point of view of the transport system end users, essential assessment knowledge covers the analysis on user's activities and acceptance of new devices and applications as well as interface design conducted together with designers and end users. In addition, it is important to identify the legal, organisational, etc. terms relating to new technology services. *In the long term* (10–25 years), the interfacing possibilities, i.e., joint implementation of different interactive systems; security and privacy related issues; business models and criteria for data transmission; societal impacts as well as actor network analysis for networking services. These are all examples of the issues to be emphasised in the assessments.

Based on the case study, we can claim that societal development leads to at least four kinds of changes in the transport system. Firstly, the actor roles and the actor networks in the system will be pluralised. The transport system will be more and more composed of public parties, private parties and contributing end-users and complex networks formed of these actors. Secondly, new kinds of business and service layers will be formed in the system because of these new dynamic inter-linkages between the actors. This emerging service layer will give possibilities to new kinds of public-private relationships and end-user perspectives. Thirdly, we propose that this service layer could be captured with the concept of "technology service". We defined technology service as a flexible and tailored combination of technologies and services that takes into consideration the travel or transportation preferences, needs and expectations of the different end-users in the transport system. Fourthly and finally, we argue that in order to grasp this emerging network dynamism in the system, a re-thinking and a re-conceptualisation of assessment and foresight knowledge is required.

To conclude, the roadmapping method tested with a Finnish case study proved to be useful in producing transport policy relevant knowledge from at least five different perspectives (roadmap levels), as well as bringing transport system actors together to discuss future trans-port visions, policies, technologies, services and their interdependencies in a collaborative manner. We find that it holds great potential as a tool for transport policy and system developments within the emerging ubiquitous mode of our societies.

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Methodologies for service concept development

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Abstract

This paper presents a methodological approach for developing innovative service concepts. The conceptual approach and interrogative research methods, which were applied in two separate case projects, are discussed. The methodology is technology-neutral and applicable to a wide range of service concepts.

Introduction

We will introduce the main findings of two distinctive research projects conducted in 2001–2005 and with a Service Scope. Both projects were initiated by VTT (Technology Integration Group), and each of them was carried out by a different project consortium. Our aim is to discuss lessons and general conclusions of the project results, using ex-post evaluation.

Methodology

Ex-post evaluation can be done after a certain period has passed since the completion of a target project, with a selected emphasis, e.g., effectiveness, sustainability or overall contribution to the state-of-the-art, and for deriving lessons and learning. Ex-post facto research resembles experimental research in the sense that causal relationships are examined, based on theory and using systematic and controlled approach [1]. However, ex-post facto research is quasi-experimental since it by definition examines events that have already happened.

State-of-the-art of innovative service concepts

The science of service innovation is multi-disciplinary and it is not yet "owned" by any single academic research discipline. As the reference framework to our ex-post facto research, we are using the recent Technology Review by Tekes, which extensively

captures the state-of-the-art of innovative service concepts [2]. The present industry transformation has made service businesses important contributors to economic and employment growth in Western societies. Service activities are essential for value creation and service-related innovation is essential for growth and competitiveness in the whole economy.

The most important shift that is currently taking place with development of commercial services is that the customer is the new reference point: *Customer Experience* is becoming the critical output of the services era.

One of the main messages in the Review [2] is that any successful service innovation in companies needs careful consideration of organisational elements and characteristics. Service innovators go beyond the traditional types of innovation and explore the W*hite Space* in their market. They look beyond the traditional competitive levers to uncover new ways to create value for their customers. Service innovation can take place in the value-network, in the delivery channel, and in the business model. The most innovative firms are skilled at (1) focusing on the white space that competitors have overlooked, (2) getting deep insight into customer needs in that white space, and (3) translating those needs into unique customer experiences.

Until now, most analyses of innovation tend to focus on products, not services. However, the Review [2] highlights the *heterogeneous nature of services.*

Case exemplars

User-centred value-networks for developing home service concepts

Scope of the case study

The aim of the HOMEDOOR Project was to develop concepts for new product innovations and systems innovations to make home deliveries in multi-storey residential buildings easier [3]. One of the Project targets was to plan and make a pilot for an unmanned delivery (box, system, etc. in connection with elevator). The final system/equipment must be cheap, secure and well managed. The key was in integrating existing and new buildings to the global e-commerce network by providing the logistics solution for multi-storey and other buildings. Linking to service provision would give growth impulses to traditional building sectors, especially in retrofitting and modernisation.

The technology driver was described in the original Project Plan in 2001 as follows [4]: “Apparently, home services are needed in future. A logistics gap at the consumer end is slowing down development of electronic commerce in Europe. On the other hand,

electronic commerce is growing rapidly in societies where consumers and citizens have easy access to ordering devices and networks like Internet, SMS messaging, WAP-phones, etc. Electronic grocery shopping (EGS) with direct delivery mode (DDM) accounts now for less than 2% of consumers' expenditure in Europe. In the US, the corresponding intensity figures are higher (10%, 1999). The evolution is towards DDM as it provides the highest supply chain savings for e-commerce deliveries."

Research methodology

We selected a group of 17 persons in 4 countries to be interviewed, face-to-face. The persons were professional "stakeholders" with a practical insight on the topic. They were working in retail and logistics firms, university research groups and municipalities.

We applied an analytical framework for designing the "questionnaire". The question lists (70 questions) were generated together with project partners in special workshops. The idea was that the interviewer could choose questions to be presented in the interviews. The list was merely a general guideline for discussion topics, for picking up questions and for categorising and analysing answers, accordingly.

Interview topics were arranged to fit in the general conceptual framework (Figure 1), generated and formatted in the project workshops. The framework included *Physical World, Virtual World* and *World of Needs*. Accordingly, there were *Technology, e-Technology* and *Markets*. *User* (i.e. customer needs) was the centre of focus.

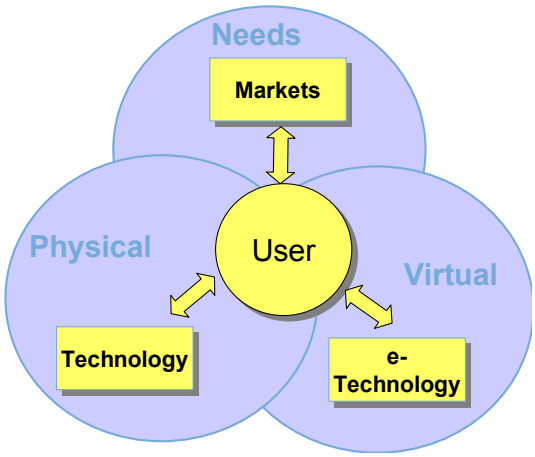

Figure 1. HOMEDOOR framework for service development, within a complex playground [4].

Related projects

At the same time, three related projects worth noting were ongoing in Finland. In the survey on "Smart Home", consumer expectations and interests were investigated by Leppänen et al. [5]. Altogether 1800 persons were interviewed, and of those

interviewed, only 6% were interested in ordering food to a "Smart Home". Instead, the most important expectations were linked to security and entertainment. The survey identified four "inhabitant tribes": Technology Oriented People, Home Centred People, Practically Oriented People, and Comfort Seeking People. By far the biggest groups in Finland were Home Centred and Practically Oriented – this is worth noting in terms of market penetration of any consumer product or service.

Punakivi [6] made an extensive study on alternative home delivery models for the e-grocery business in Finland and Yrjölä [7] studied supply chains for e-grocery shopping. It was possible to find a potential customer base for profitable e-grocery service in the 30 biggest cities in Finland.

Results

Development of any home service concept needs to be based on identified needs, potential usage and prospective markets. Potential customer segments for various home services are families, wealthy adults seeking high-quality services, the elderly and disabled people. The service should meet the needs and requirements of various users. At the same time, the service should be economically feasible for the providers. Today, much of the reasoning goes in assuming common (social) savings "somewhere in the system" and therefore financial support is sought "somewhere from the social sector" to set up the service provision businesses (public-private partnership).

Our findings [4, 8] were fully in line with the general framework of the Technology Review by Tekes on innovative service concepts [2], namely "Service innovation can take place in the value-network, in the delivery channel, and in the business model":

1. Home services with delivery require new operating models in the supply chain.
2. The cost of home delivery is heavily dependent on the service model used, market share and business size.
3. Often, the business and service models in supply chains are still not mature enough to start effectively. The challenge is to create stakeholder networks with new business concepts, which support different stakeholders' business.
4. If different stakeholder interests are not in line to support the development of common service concepts, there is an obvious risk for conflict of interests.
5. The capability of creating good, sustainable business out of a service seems to be missing. Well-defined, well-managed and open value networks with joint value-creation require a new way of thinking. In order to create service concepts for win-win-win situations, all stakeholder interests should be, at least partly, in line with the concept.

6. If a stakeholder is part of a true value network, there are both B2B and B2C issues involved and they should not stand in conflict with each other. This means adapting your own business interests to the product and service concept instead of optimising your own business only.

Business from sustainability: Towards development of new business concepts

Scope of the case study

If the perspective of an individual is considered, housing is a topic that has an effect on everybody. For most of us, the purchase of a house is by far the biggest investment during our lifetime. It is only reasonable to demand that the people making this investment be entitled to a reasonable and healthy living environment. Finnish people prefer to live in single-family houses. Traditional values such as privacy, security, closeness to nature and space are still appreciated among Finns. The aim of the EneLii Project was to seek answers to three questions [9]:

1. What issues or phenomena characterise the current low demand and supply of energy efficient single-family houses?
2. What are the drivers that may create service business potential and opportunities for energy efficient single houses?
3. How can a transition to energy efficiency be managed, and especially, what role could strategic niche management play in this transition?

In 2004–2005, we asked the following questions: Why is the market interest in energy efficient houses still low? Is it because consumers do not want to pay a higher initial investment cost? Are consumers interested or aware of energy-related issues? Are house builders unwilling to promote these products in a situation where price seems to be the only source of competitive advantage? Or, have the policy-makers failed to create a supporting environment for the successful commercialisation of such housing?

The challenge was not primarily about technology drivers: Technological possibilities to reduce a building's energy consumption have been available for a long time! The challenge was essentially between environmental drivers and consumer behaviour: Buildings, particularly in their use, have a significant environmental impact and sustainable solutions to these challenges are urgently needed. In many cases, however, environmental friendliness and sustainability are not the foremost drivers of consumer behaviour. Consumer needs and preferences concentrate more on down to earth and everyday issues such as comfort, appearance, usability and safety.

Research methodology

Earlier VTT studies on the topic were widely used. However, there was little research available on the business potential of energy efficient single-family houses. The obstacles and opportunities of energy efficient single-family houses considered and the transition process towards sustainability was conceptualised using Strategic Niche Management [10] and its Finnish application, Social Embedding [11], as theoretical frameworks. They offer one alternative for promoting the commercialisation of sustainable alternatives by providing a framework, which stresses the long-term development potential of services and products.

Qualitative focused interviews are an especially suitable research method, in a situation where it is difficult to define an exact frame for the research [12]. Focused interviews allow the research frame to be specified in the course of the research process and thus give guidance to the process. Altogether, 13 persons were interviewed [13]. The interviewees were chosen in a way that would allow the problem to be seen from different perspectives, in order to form as clear a picture as possible of the prevailing situation.

The interview situation was more or less informal and conversational in nature. This is typical of focused interviews and not only helps the interviewee to answer but also makes it easier for the interviewer to understand the answer. A drawback of focused interviews is that the gathered material may end up being ambiguous, which may make analysing and drawing conclusions difficult. To avoid this, the interviews were conducted as a team. Largely, the same question framework was used throughout the different interviews. Some adjustments were made depending on the interviewee. However, the main topics were the same in every interview. The same framework made it possible to compare answers of different people and thus come into conclusions. The main topics in the interviews were formed around the research problems.

Results

Commercialisation of energy efficient single-family houses comes close to the problems of commercialising any environmentally sustainable product. They come in conflict with the current industry structures, organisations and institutions and with the general behaviour of different, related actors. In this situation, special measures are needed to promote commercialisation. The transition to sustainability needs to be managed. We identified major trends paving the way towards business from sustainability.

1. Demand and supply of niche products and related services, i.e., energy efficient single-family houses, is growing.
2. Energy price and availability will be a strong driver, creating opportunities and new business potential.

3. Sustainable development and development of the knowledge society will affect the existing production, supply chains and delivery modes of buildings, as well as in-use services.

In 2008, three or four years from our study, the common interest and market demand of energy-efficiency has already become more evident. The basic assumption is that in future only eco-efficient solutions will be acceptable in the aftermarket. Essential drivers stem from the rising energy prices and interest rates. The question still remains how to meet the market demand.

Strategic niche management of transition to environmentally sustainable business is well in line with the concept of *White Spaces* and development of innovative service concepts [2]. The most innovative firms are skilled at (1) focusing on the white space that competitors have overlooked, (2) getting deep insight into customer needs in that white space, and (3) translating those needs into unique customer experiences (Figure 2).

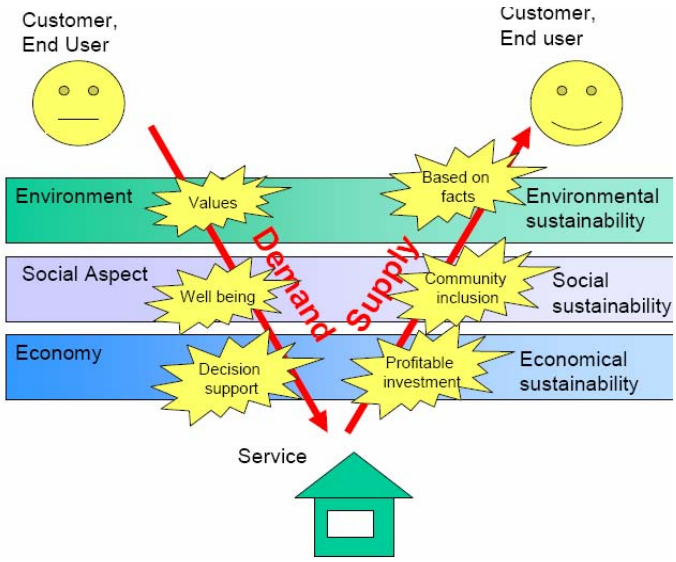

Figure 2. New opportunities for service offering in sustainable housing [9].

To achieve wider acceptance, a transition towards sustainability in the society is needed. This transition cannot be managed in the traditional manner of controlling and supervising. However, it can be managed in terms of influencing and adjusting. This means that the pace and direction of the transition can be influenced. In practice, this means creating the right climate for innovations and taking the right initiatives at the right moment. Transition management attempts to bring about the needed structural change in a stepwise manner. Structural change is needed in order to tackle the institutionalised structures that hinder the wider acceptance and development of environmentally sustainable business. Experiments with alternatives to the existing system have an important role in the transition process, as they provide the seeds for change.

Conclusions

Unlike the common technology-push approach, strategic niche management does not address the commercialisation process of an innovative service concept only in terms of its technological aspects, but also from its socio-economic context. It pays attention to the building of support networks to provide a protected space for an experiment, to help it gain wider acceptance. It pays attention to combining the interests of different essential actors involved. It raises future users as the most important stakeholder group, as they will finally decide whether an experiment becomes successful or not. The goal is to establish a common understanding of actor expectations and improve the long-term development potential of the experiment at hand.

For development of service concepts, interrogative methods have proved useful for gaining understanding of the interests of different actors and stakeholders within the total service concept to be developed. Qualitative focused interviews are an especially suitable research method in complex situations where it is difficult to define an exact frame for the research.

Ex-post facto research provides a valuable approach for validation of research results, conclusions and impacts. Ex-post analysis can only be made after a certain period has passed since the completion of a target project. In every case, ex-post facto research gives us a strong tool for learning and understanding critical phenomena.

Acknowledgement

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In the EneLii Project, different perspectives and our earlier research findings were combined with those of Helsinki School of Economics, Environmental Management. The project (2004–2005) was funded by VTT.

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Systematic support for strategic decision making in the service innovation life cycle

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Abstract

This paper describes a systematic framework to support strategic decision making in innovation development that attempts to put appropriate amounts of planning resource into the process at different stages of innovation life cycle from idea to the termination of line of business. It is constructed to make use of qualitative evaluation techniques early in the process when faster, less expensive methods are preferred to more accurate quantitative techniques. The work was triggered by the results of a large interview study about innovation management practice in 12 major Finnish organisations and an attendant research question "How should future uncertainty be managed during the entire service innovation life cycle?" The approach towards finding answers to the question was based on constructivist collective case methodology, and the process resulted in a framework model to support strategic decision making. This conceptual paper gives an overview of the model where separately developed techniques are integrated by applying generic risk management methodology to produce a more systematic, more comprehensive, but highly efficient management process for service innovations throughout the innovation life cycle.

Introduction

The importance of innovations and innovation management is recognised in companies, research institutes as well as in society as a whole. We also know that most innovations will not achieve commercial success, as a matter of fact, most innovations fail. New business creation obviously involves stepping towards an unknown future, and many kinds of uncertainties for decision making are associated. Renewal of the business, however, is the key to the long-term success of companies. Companies will not be successful in the end if they continue too long with a strategy that only fits the needs of today.

The methods currently used for the management of new innovation development are largely based on those of manafacturing enterprises [1, 2, 3]. Service innovations, however, are inherently much more multidisciplinary than innovations of manufacturing enterprises and, therefore, call for the renewal of methods and procedures used for the innovation management at different stages of innovation life cycle. To be successful, service innovation typically needs four aspects of innovation: technolological, business, social-organisational and demand innovation [4]. In the case of manufacturing enterprise innovations all four aspects are present but a breakthrough is typically needed only in one of them. Therefore, service innovation is hard for high-tech companies [4].

This work is a result of a joint study involving VTT and IBM Research. The paper gives an overview of the joint work in the field of service innovation development. In the work, we have integrated separately developed techniques to produce a more systematic, more comprehensive, but highly efficient innovation management process for new service development. The idea of the joint work is to link expertise in the area of service business and advanced technology foresight techniques at IBM and risk management of innovation development at VTT. The objective is to develop a framework model giving support to strategic decision making related to ideation, design, development, marketing and delivery of service offerings.

Methodology

We have applied a constructivist collective case methodology for the work. From the VTT side, a large interview study of innovation management practice in 12 major Finnish companies and organisations plays an important role in gaining an understanding of current practices, potential problem areas and development needs. The main results and conclusions of the study were published by Kettunen et al. [3]. In the study, 43 managers were interviewed and the interviews were analysed by 23 experts (including one author of this paper). The interview study triggered the initiation of several lines of research, including the one which this paper reports. The original study identified management of future uncertainty as one of the main challenges to corporate executives. The study also identified major challenges related to service business development and management by high technology companies. These resulted in the research question of this work: *How should future uncertainty be managed during the entire service innovation life cycle?*

The approach of the work towards finding answers to the research question was based on constructivist methodology which focuses on different viewpoints and the lived experience of organisational members. The authors at VTT have wide experience in research and development for various fields of technology and risk management. This

experience was supplemented by the experience of IBM in the fields of service science and technology foresight. At first, the joint experience allows us to assimilate different viewpoints and experiences in order to specify the research problem in a more detail, and then, to develop tools and methods in order to overcome the weak points, from the viewpoint of uncertainty management, in the new service innovation life cycle identified in the interview study.

Initially we focussed on specific phases of new innovation and business development. As we developed and tested the tools for each phase [5, 6], we found that we still lacked a systematic approach to decision making that could be applied throughout the innovation life cycle. This discovery initiated the final stage of our research: the development of a systematic innovation management framework focused on providing support for strategic decision making under conditions of high uncertainty about the future. Our framework includes techniques, originally developed for the separate phases, integrated by means of generic risk management methodology [7].

Framework for systematic decision support

We developed our framework model for systematic strategic decision support in service innovation management from the following specifications:

1. The model should be flexible in order to adapt company-specific innovation and business line management processes, which are often stage-gate processes, and it should be made of reusable process building blocks which would progressively evolve along with the use of the model, creating a reusable innovation management asset.
2. It should optimise the amounts of planning resources into the process at different stages. This can be achieved by a three-part approach: (a) fast reduction in the number of ideas and projects in the innovation development process; (b) qualitative evaluation techniques early in the process when faster, less expensive methods are preferred to more accurate quantitative techniques (work demanding more accurate quantitative studies can be valuable at later stages of the process for topics identified in qualitative studies); and (c) a simple process for approximating expert consensus without requiring face-to-face meetings of experts.
3. The foresight aspect should promote enterprise strategic preparation for the unexpected, and should be so practical that it ties important scenarios to the advancing current state of reality in a way which guides correctly timed actions at the strategic initiative level of new innovation and business development throughout the process.

4. Risk management methodology should be built into the model to make uncertainty management systematic and straightforward in identifying potential opportunities and threats where specific management actions or deeper studies could be necessary.

In the following we present the model at a conceptual level. It will be presented in more detail elsewhere as a series of publications focusing on different viewpoints or stages in the model. Note that at the conceptual level there will be no major difference between service enterprise innovations and manufacturing enterprise innovations. The differences will come up when going into lower levels of the hierarchical system.

The framework is presented in Figure 1. The framework starts with (preferably many) ideas of new business opportunities and ends with one or more lines of business with unforeseen lifetime. In the beginning, there is an ideation stage which includes phases of preparatory background information studies, idea generation and idea clustering. Idea clustering means that compatible and related ideas are collected together to be treated as one object of analysis having a common vision of future. After ideation, there is the first filtering of ideas (visions) in order to reduce the number of ideas, visions, and projects in subsequent stages. We accelerate the narrowing of the funnel depicted by increasing the bias toward stopping an idea at an early filtration step. Filtration is followed by recommendations for further actions, which may simply be 'stop', 'hold' or 'continue'.

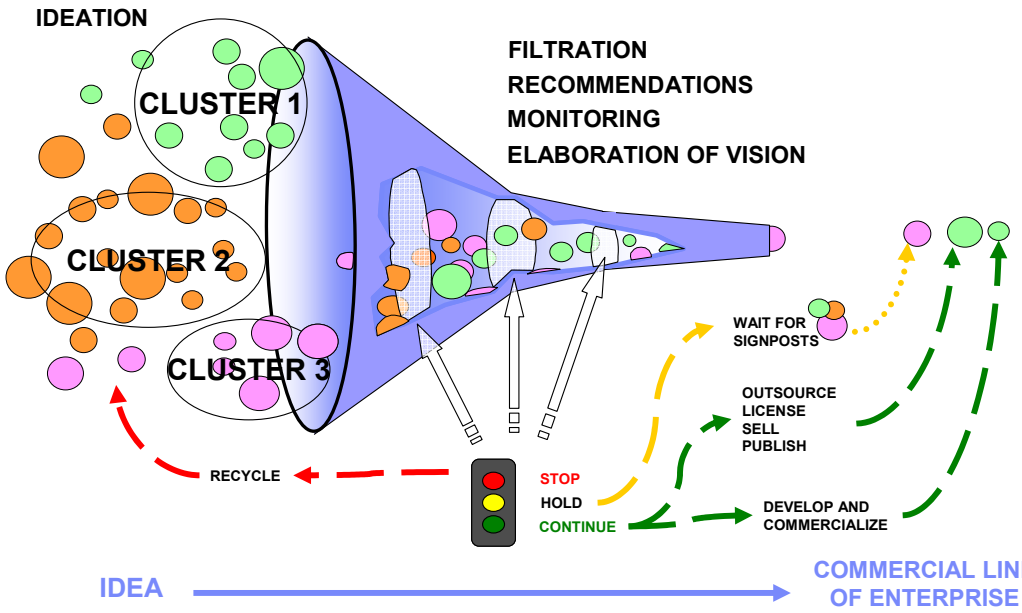

Figure 1. Framework of strategic decision making in the development of new innovations and new lines of business.

A 'stop' recommendation could mean either discarding or recycling the idea. A 'hold' recommendation could mean creating one or more signposts and actively monitoring these signposts for future conditions under which the idea would be returned to the

active innovation process. A signpost is an easily recognisable potential future event that signal changes of importance to the enterprise and call for a strategic action in the innovation development process [8, 9]. A 'continue' may include alternatives of product development, commercialisation, collaborating, outsourcing, patenting, licensing, selling, publishing. All these are strategic decisions.

Filtration, recommendations, monitoring and elaboration of vision (i.e., the actual innovation development work) form a five-phased iterative process which will be repeated at each stage of the innovation process and, depending on the company, may even be repeated inside a single stage such as product development (Figure 2). The filtration and recommendations phases are current business practices at the gates of the stage-gate process. Active monitoring of ideas or projects on hold, however, is a novel enhancement to observed innovation practices reported in Ref. [3].

Idea generation, filtration of ideas, recommendations for further actions, elaboration of ideas, and accelerated early reduction of development projects (so that, for example, out of 100 ideas, only 10 will be conceptualised and only one will be commercialised) correspond to current best innovation practices. What is novel is the linkage between the strategic initiative level and decision making by means of active monitoring of signposts. Furthermore, what is novel is the systematic way this is done throughout the innovation process from idea evaluation through conceptualisation and new product development stages to the launching decision, and after that for the running line of business until the termination of the business. The idea to terminate can be sent through the entire innovation process, with appropriate analogues for design and development phases. For example, the anticipated cost savings in terminating the line of business at the right time, can be viewed as an impact or a reward.

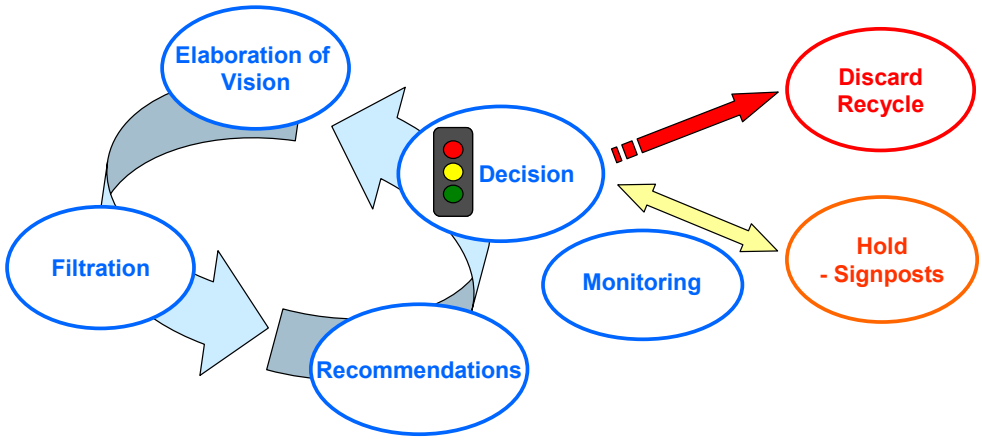

Figure 2. A five-phased iterative process of innovation development consisting of strategic decision making elements of filtration, recommendations and decision, active monitoring supporting the decision making, and the elaboration of vision, which contains the actual innovation development work.

The decision support model follows the genetic methodology of risk management, including the steps of identification of risks, analysis of risks, evaluation and selection of risk reducing measures, and implementation and follow up [7] with some refinement based on the controllability of risk factors and the realisation of the steps (Figure 3). The process starts from a taxonomy-based risk identification where checklists are used for potential risk factors. Identified risks are qualitatively analysed and evaluated by experts with the help of questionnaires. After ranking and prioritising the risks (risk profile and consequence analysis), risk reducing measures are selected. If necessary, qualitative risk analysis is supplemented by a quantitative study. The result is a complete package of support for a specific decision point. Once the decision is made, any risk reduction measures can be implemented and tracked for consideration at the next decision point.

The risk taxonomy is a hierarchical organisation of (possibly overlapping) risk factors. Relevant risk factors will depend on the stage of the life cycle. Potential risk factors at the early, design stage of new innovations (service design) may differ from those of development projects (service development) and definitely from those of the running line of business (service offering). An example of top level risk taxonomy for service innovation and life cycle management is given in Figure 4. The top level service design, service development and service offering trees include groups such as market environment, idea/value proposition, etc. Under these groups, several potential risk factors could be identified. It is helpful to bifurcate the hierarchy with a classification of risk factors that are controllable and those that are not. By controllable, we mean that the enterprise has the ability either to mitigate the risk or to compensate for the risk.

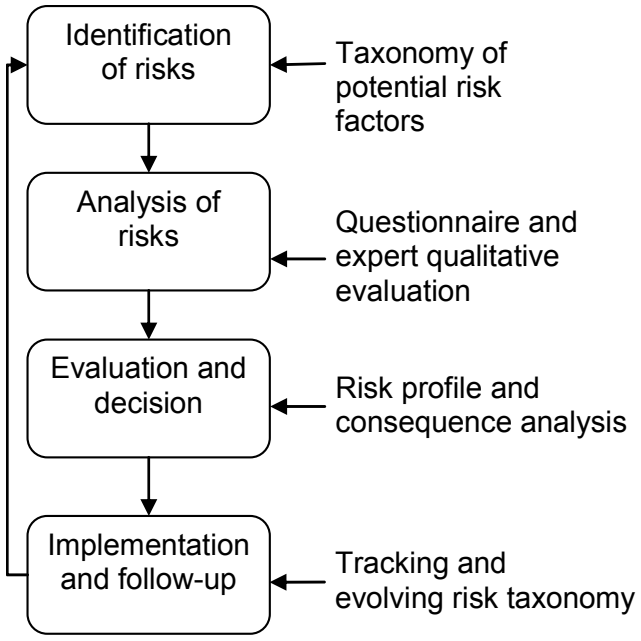

Figure 3. Framework of risk management steps for systematic innovation management (adapted from Ref. [7]).

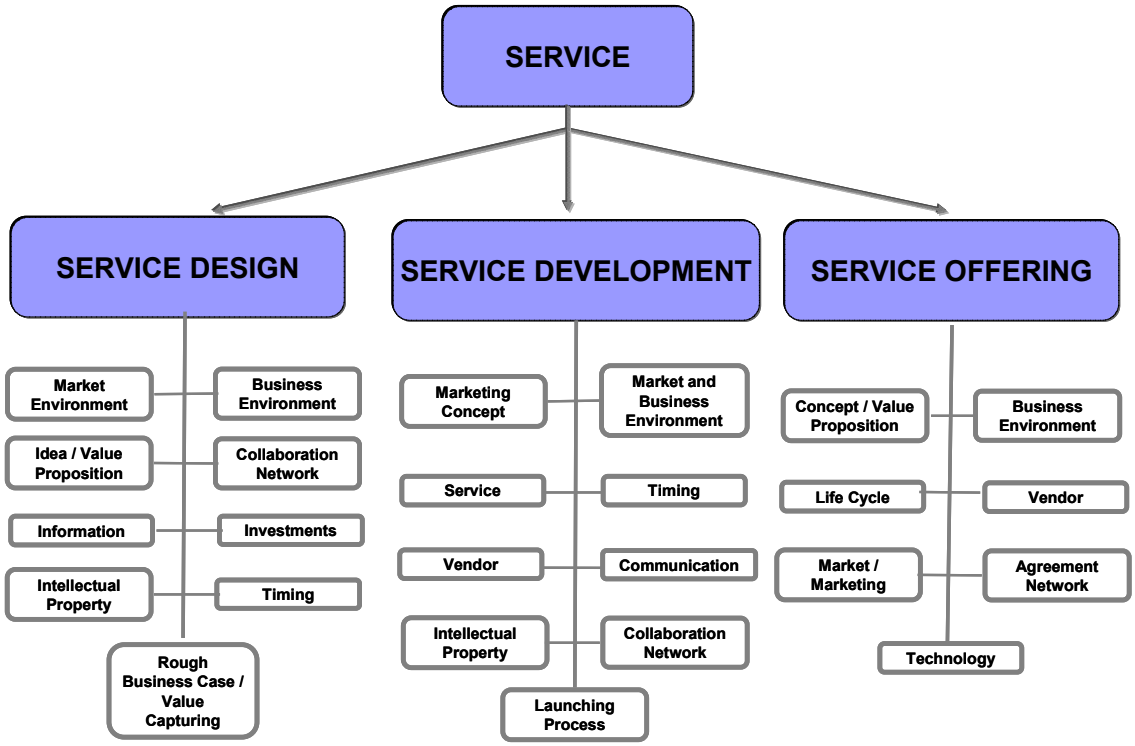

Figure 4. Top level risk taxonomy for service innovation and life cycle management.

A risk taxonomy can be used as a checklist at decision points in the innovation life cycle. Risk factors are turned into questions used for obtaining qualitative expert estimates using approximate Delphi technique (Figure 5). A question is here defined as a request for an estimate that can be answered with any rational number on a five-point scale (from 1 to 5). At this level of taxonomy, differences between service enterprise and manufacturing enterprise innovations are obvious. The results of the expert estimates are used for risk prioritising and input for strategic decision making, according to Figures 2 and 3.

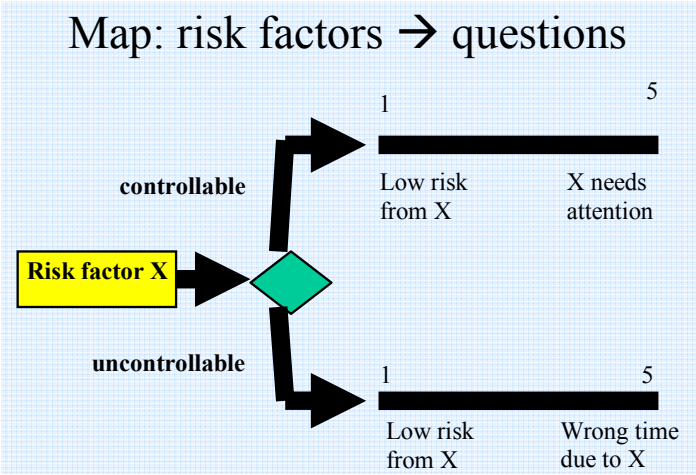

Figure 5. Map from risk factors to questions used in expert analysis of potential risks.

A risk taxonomy may be comprehensive for one enterprise but not for another. Nevertheless, we believe that good risk taxonomies are reusable resources and that the exercise of adapting a ready generic risk taxonomy is likely much faster and less expensive than developing a new risk taxonomy for each enterprise. Furthermore, the taxonomy can be evolved along with its use, itself following the constructivist methodology.

Conclusions

The framework model of systematic strategic decision support for the service innovation life cycle management is constructed to make use of qualitative evaluation techniques, based on risk management methodology and a small number of reusable process building blocks. It makes use of modern contingency planning techniques in order to reduce wasteful investment in ideas that will eventually be discarded during the innovation process. It also includes systematics in putting plans on hold and actively monitoring signposts in order to have the right timing for R&D and market launch or for terminating the line of business at the right time.

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Connecting customers and designers at Owela – Online platform for service co-design

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Abstract

The Web 2.0 and social media phenomenon have enabled customers' roles to change from passive objects to active participants. Companies are opening their innovation processes with the aim of enabling and attracting customers more, involving them in the value creation processes as co-creators.

We created Owela, an open web laboratory, to build an online community for participatory design and open innovation. Currently, Owela serves as a platform that collects user feedback, experiences and ideas from different physical and online sources and offers a place for co-design. A long time goal is to provide users with tools for creating their own products and services together with other users.

In this paper, our aim is to provide insights on utilising online research tools and conducting participatory design process at Owela. We present a project-based co-design model for creating new services with customers and end users at Owela. In addition, we report our experiences from a finished and an on-going case study in the project Täky and P2P-Next projects. Our conclusion is that tools and methods used for the offline world cannot be directly moved on to the web, thus the whole design process should be reconsidered so that it works well and logically online.

Introduction

Today's average customers are more demanding and harder to obtain than ever before. The emergence of the information age, followed by information overload, has driven companies to fight over customers' attention [1, 2]. On the other hand, along with the rise of the Web 2.0 phenomenon, customer roles have shifted from passive objects to active participants. Customers are more and more involved in business processes as co-creators and they are actively participating in the value creation processes.

In R&D processes, the getting of ideas and comments from users and customers plays a central role. On the other hand, the Internet and Web 2.0 technologies offer easy ways for customers to tell their ideas. Therefore, numerous open innovation platforms aiming

to attract customers to innovate or act as co-designers have emerged on the web. Open innovation communities may be either company maintained or maintained by information intermediaries, which are acting between companies and customers.

Customers' insights and opinions are extremely valuable in new product and service design processes. For this reason, we have launched an open web lab aiming to create an online community for user-centred and participatory design.

We start with a discussion on the issues related to users' involvement in companies' processes, concentrating especially on how to motivate users to participate actively. Then, we consider the characteristics of online tools for participatory design and present Owela's co-design process model. After that, we discuss our co-design processes in two projects, Täky and P2P-Next. We end with drawing conclusions and suggesting some further research paths.

Involving users in innovation processes

Users as co-creators

Many companies have already realised the possible benefits of integrating customers in their processes. Integrating customers into the processes means making customers "a part in activities and processes which used to be seen as the domain of the company" [3] (Wikström, 1996). Customers who take part in companies' processes are also called co-creators by von Hippel [4].

By opening their innovation processes, companies may increase their effectiveness and enhance their relationships with customers. The fact is that customers like to be heard, and by giving them this opportunity to get involved, customers' commitment to the brand and the company may be increased. Customer co-design describes a process that allows customers to express their product requirements and carry out product realisation processes by mapping the requirements into the physical domain of the product [4, 5].

Motivating users

Since the competition for customers on the web is extremely tight, attracting users to online communities is challenging, and therefore, an online community has to attract members by offering them value on every visit [6]. In order to do this, knowing users' motivations to visit [7, 8] as well as to participate in and to contribute to online communities [9, 10] is important. Lately, users' motivations to participate in online communities have been studied from many perspectives and they are dependent on the

purpose and the characteristics of the online community. In addition, different personal characteristics and roles of users affect motivation factors.

In addition to knowing the motivation factors of users, offering incentives to them may be helpful in encouraging them to participate. Rewarding methods can be divided into monetary (tangible) rewards and non-monetary (intangible) rewards (also called recognition). Monetary rewards can, for example, be money, paychecks, fees, trophies and awards. Non-monetary rewards may be the member's name in honour-roll lists or top ten lists, giving privileges and public recognition. In their study, Antikainen and Väätäjä [11] suggested that both kind of rewards should be used. In fact, the open innovation communities they studied were all offering monetary rewards and most of them offered non-monetary rewards as well.

Users want to see how their input affects the design. Therefore, designers and developers must actively participate in discussions with users in the online community. A clearly articulated design process also helps in attracting users. [12]

Tools for participatory design

In order to motivate users to participate in open innovation and participatory design processes, offering appropriate tools for users is important. Understanding the distributed innovation process and users' roles is in a central role. [13] For example, some manufacturers provide users with toolkits and configurations to customise and even design their own products.

One important aspect of tools for participatory design is that they enhance and support the creativity of users. Farooq et al. [14] suggest three design implications to support creativity within information systems: 1) Integrate support for individual, dyadic, and group brainstorming; 2) Leverage cognitive conflict by preserving and reflecting on minority dissent, and 3) Support flexibility in granularity of planning. In general, Farooq et al. stress the importance of also including the sceptical voices in the discussion. Furthermore, Farooq et al. [14] point out that social networks and their management is a crucial part of creativity.

Yet, when offering users a service including different kinds of tools for participatory design and open innovation there are some factors to be taken into account. Technology changes constantly and rapidly, which sets some requirements for the users, too. A decade ago, most Internet users were, of necessity, skilled computer programmers, or at least, they had a relatively deep understanding of network applications. Nowadays, many people have access to the Internet and the skills that are needed. However, in

avoiding misunderstandings and making it easy to participate there is a need for a clear and simple design of service and tools. People are not willing to use too much of their valuable time to learn how a questionnaire should be filled in, for example.

Furthermore, an average Internet user is often overwhelmed by the variety and vast amount of information. For this reason, people have difficulties processing and selecting the relevant information, a factor which increases the demand for clear, attractive design as well. Clearly, utilising an online environment in participatory design requires specific and carefully designed instruments that not only accommodate but also exploit the features of the electronic environment to attract respondents [15].

Finally, one thing to consider is the openness of discussion on web forums. The positive point of view is that the method remains a group discussion enabling participants to gain others' viewpoints. On the other hand, the openness of the discussion can sometimes generate some challenges as well. Firstly, openness can increase a threshold to participate for some participants. Secondly, the openness of the discussion raises a question about the IPR management, and therefore, it is important to clarify guidelines and provide information about such issues for all participants.

Owela as a co-design platform

Presenting Owela

Our open web lab, Owela (http://owela.vtt.fi), is a participatory web laboratory for designing digital media products and services. Owela aims to be a conversational online community that connects users with developers and researchers promoting open innovation. Owela offers social media tools for gathering user needs and development ideas as well as collecting feedback for scenarios and prototypes. The aim is to use Owela in different kinds of studies from research projects to smaller assignment studies made for companies. So far, Owela has been used in a couple of projects. Our lessons learnt were that the topics of discussion or research should be interesting in aim to attract members to participate. The possibility to test totally new kinds of products also motivates some people. Yet, in order to maintain users' interest they must be demonstrated, how their feedback and ideas influence the final product or service [12].

Co-design process in Owela

The Owela process consists of two parts: open ideation and scheduled projects (see Figure 1). The open ideation takes place in a tool called IdeaTube, where participants may report their experiences and problems with current solutions as well as suggest

development ideas and needs for new products and services. In IdeaTube, ideas can be rated and commented on by other users.

When new ideas emerge in the open space, some of them will be carried on as projects. The project starts with scheduling and goal setting which are articulated also to the participants. The project phases are co-design (further ideation and development of use scenarios), evaluation of the concept and scenarios, and LivingLab, where users can take part as active testers and co-developers of the prototypes. A long-term goal is to provide users not only a channel for feedback and ideas but also tools for modifying and creating their own services together with other users.

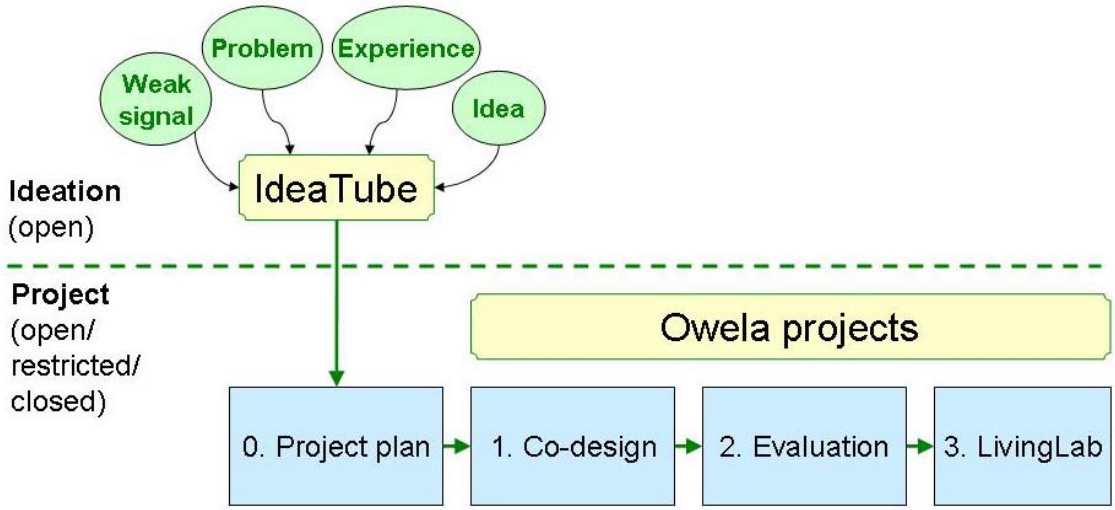

Figure 1. Owela design process consists of open ideation phase and scheduled projects.

Common experience shows that consumers typically discuss services in various online communities as well as in real life discussions. Owela will serve as a platform that collects user feedback, experiences and ideas for further development from different physical and online environments. Various mobile and web tools will be used to gather ideas and weak signals of future trends from different places.

Owela co-design process in Tilkut

Owela process was piloted in the user studies of a social bookmarking service Tilkut that was developed at VTT in a Tekes project called Täky. The study started with the ideation phase where problems and needs with existing online bookmarking services were studied with the users of the services. An online questionnaire, interviews (face-to-face or phone) and IdeaTube discussion were used to gather user needs and ideas. In the interviews, feedback was also asked for some planned functionalities of the new service.

After that, the development of the Tilkut prototype started. At the same time, more requirements for the service were collected in a user test, in which a combination of existing online services was tested. Test users were recruited from Owela, and especially the lead users of the new Internet services were selected to the testing. The inquiry methods included an online questionnaire for background information, initial and final interviews with all participants and an online test period, during which the participants discussed their experiences and ways of using the services in a blog.

After analysis and further development of the prototype, the third phase of the user study was made with the real Tilkut prototype. In this LivingLab phase, users were asked to test the new service and give feedback and ideas for further development. The research methods were interviews, individual testing periods, blog discussions and usability tests. Some of the reported problems were fixed already during the test period, and bigger changes were made afterwards based on the user experiences.

Owela co-design process in P2P-Next

Currently, Owela is being utilised in user studies of an EU project called P2P-Next. The goal of P2P-Next is to develop social television that includes many aspects related to digital content distribution, sharing and consuming (http://www.p2p-next.org/). Owela is used to establish a user community that will actively participate in various studies conducted in a four-year time span. The activities that users can conduct on Owela are currently related to our scenarios.

The study includes different overlapping phases. We start with a web survey that is based on our preliminary scenarios. The objectives of the survey are to get user evaluations as well as to get ideas of what kind of scenarios are the most relevant. Similarly, with the web survey we open some discussions on some of our preliminary scenarios in IdeaTube. After getting the results from the survey and insights on the discussions, we will open further discussions on the most relevant scenarios in IdeaTube. Furthermore, after getting some prototypes of the service, Owela is used as a living lab in testing those prototypes and getting user insights. In IdeaTube, users can comment on and rate those scenarios throughout the project as well as suggest new scenarios by themselves.

Our aim is to gain in-depth insights into users' needs and opinions related to the P2P-Next project as well as to create a dialogue between designers and users. We hope that this will help in enhancing open innovation as well as creating relevant services for users. In P2P-Next, the research process is currently focused on the first phases of the product and service innovations and development. Therefore, we stress the tools that will be the most suitable for getting open-minded discussion without too strict

guidelines. In addition to using Owela, we conduct some more traditional focus groups in our lab based in Tampere. This way we can compare the data from Owela and face-to-face focus groups, which will give us valuable information.

Conclusions

Attracting users to online communities and motivating them to participate in participatory service design and open innovation is a challenging task because of the stiff competition for customers' attention on the Internet. Therefore, an appropriate service design and tools play an essential role, and these demand knowledge of the characteristics of the web and user behaviour online. Tools and methods used in the offline world used cannot be directly moved on to the web, thus the whole design should be reconsidered so that it works well and logically online.

Utilising open innovation in scheduled projects needs planning of methods, tools, guidelines and timeschedule. This is helpful in achieving the goals set as well as in commiting the users since they know when the project ends, after which time they will get the outcomes and possible rewards. Besides designing an online research environment, strategy for the user maintenance should be done. In other words, the maintainer needs plans on how to attract users, how to activate them, and finally, how to commit them. In addition to offering appropriate service design and tools as well as motivating tasks, rewarding can influence on users' motivation. Also, rewarding strategy should be well planned in order to lead them into the planned consequences.

Triangulation of data gathering is a valued method among researchers, and we also believe that in our case combining online and offline methods with users may help us to get in-depth knowledge on the users' needs and behaviour. In fact, combining online and offline methods is also how VTT's Owela differs from other existing open innovation communities. Since Owela presents a new kind of a service model, more knowledge is naturally needed in developing and maintaining different kinds of online communities for participatory design and open innovation, and especially in mixing online and offline methods. Other areas of special interest include user motivation and collaboration and creativity in open innovation communities.

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Mobile technologies in facility services: Intensifying of operations with novel process and business opportunities

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Abstract

The aim is to describe the currently experienced benefits and obstacles for enhancing FM services with the currently available technological enablers. Mobile technology has a vide yet largely untapped potential for full mobility or micro-mobility workplaces, typical for FM services. This paper presents an integration of several studies conducted at VTT to identify the current benefits and obstacles of mobile technology as perceived by Finnish FM professionals. The main means of the study were (1) to describe the current technological enablers for the utilisation of mobile technology at FM settings and (2) to interview the FM professionals on their perceived benefits and obstacles of the utilisation of the currently available technology. Though the empirical part is limited to Finnish settings, the observations are likely valid in several other developed countries as well. The findings of the empirical part include currently feasible mobile solutions and their perceived limitations. The experienced benefits are discussed and critical success factors are nominated. The perceived benefits are mostly related to improved resource efficiency and quality control. The essential success factors and remaining obstacles are discussed. The change of practice to support the exploitation of mobile technology is emergent. The paper gives experience-based suggestions for both demand and supply sides of the service procurement to gain the feasible benefits and avoid the currently hindering obstacles, as the paper provides insight on current and future tools for the mobile aspects of FM. The findings are relevant for the service providers and operators as well.

Introduction

Facility management is, by definition, the integration of processes within an organisation to maintain and develop the agreed services to support and improve the effectiveness of its primary activities. The basic concept of FM is to provide integrated management on a strategic and tactical level to coordinate the provision of the agreed support services [1]. A recent study [2] exploring the procurement and relationship

management trends in business services, particularly in the FM settings, found that a transition towards closer relationships and bigger purchase entities is taking place in FM in the same way as in other industries. In contrast to the prevailing trends in other industries, there was increase in the size of supplier bases in FM. This might be partly due to the organisations outsourcing more of their facilities-related functions lasting recent years and partly due to the shift from using a sole supplier to using a number of specialist partners. As the lack of sourcing strategies, this also mirrors the fact that the outsourcing and procurement practices of FM services are still in the transformation phase.

The fact that FM related services are created to meet user requirements by provision of both material and human resources makes the efficacy and accuracy of communication critical to success: FM is the intersection of the demand and supply chains, and in position to optimise the process by its ability to turn information into an efficient decision tool. A factor that amplifies the importance of ICT is that the professional FM and service providers are increasingly large enough to cover wide areas and utilise international service providers often, where the value is created in different organisations and places. It is critical to gain valid and timely information on aspects to manage, including the performance of the facility (i.e., thermal conditions, energy consumption) and the people (i.e., How long have the cleaning staff worked on the meeting room? Is it clean and available for the next meeting?). Therefore, the potential for ICT technology to add value to the services is at the core of the business.

The real estate and FM businesses are typically manpowered with mobile staff and equipment, and significant material flows. The businesses have notably scant utilisation of mobile applications, in particular in relation to the potential. Mobile phones are almost entirely used for speech and text messages. These are, however, well established as support for work. Some new applications are at the trial stage, including control of safety matters at construction sites, Some quality control aspects have been piloted with mobile applications and logistics. The most frequent mobile application for real estate agents is the service request processing from reception of the request to acknowledged response and reporting. Additional applications are emerging from a combination of RFID (Radio Frequency Identification), NFC (Near Field Communication), GPS (Global Positioning System) and mobile phones.

The advances in the usability of mobile technology and simultaneous increase in market saturation with mobile devices has accelerated the diversity of benefits from access to data regardless of time and place. The use has diverged from original speech and text messages. The current applications are mostly aimed at non-professional and often entertainment content. In addition to private aspirations, some professional applications have been developed. Typical areas of operation are public services (library, health care, etc.) and business-to-customer issues, such as travel items (ticketing, hotel reservations,

and confirmations) and importantly, information delivery. Business-to-business solutions include process follow-up, tracking of transports, and various information services. Businesses-to-employee solutions include calendar, work time recording, guidance for mobile workforce and reporting. Natural settings for such solutions are sales, maintenance and service activities.

Mobile technology and FM service

Mobility has become an essential part of our life and it will continue to grow in significance. Mobility, sharing of information and knowledge, and collaboration across organisational networks are key aspects of workplace innovations. New information and communication technologies enable a diversity of future workplace scenarios. However, coping with the human and organisational aspects involved will determine their success or failure. According to Shaffers [3], there are four generic forms of mobile work: 1) Full mobility workplace, 2) Micro-mobility workplace, 3) Multi-location workplace, and 4) Dynamic workplace. Regarding FM work, the first two mentioned apply, since in a full mobility workplace the collaborative workspace is supporting full worker mobility and adaptive to any context.

For these reasons, mobility is becoming a major attraction to service industries. Increasingly, services are realised by high-quality software, offered to end users through interoperable heterogeneous networked systems. The ultimate goal is to provide information intensive services to users when, where and how the users want them. The context where and how a service is used is not fixed, but changes according to the situation and end user's preferences [4]. Service architecture provides a means of handling changing service requirements in a manageable way; it defines the rules

- how a large amount of functional capabilities, i.e., the building blocks for end-user services, are dynamically discovered from networked systems,
- how these functional pieces can and have to be recomposed, taking into account users' preferences, environmental constraints, and available resources, and how the recomposed functionality is offered as a meaningful service to an end-user.

Despite the attractive features, the development of new mobile services has been slowed down by a series of obstacles [4] such as the ignorance of the new possibilities which mobility could bring to the facility services; problems of interoperability, i.e., the immature development of systems and software architectures that link services and content to the mobile world; the question of how and to what extent will users embrace new ways of consuming content and services; and the need for new successful business and delivery

models that involve industry and research organisations restructuring through new kinds of agreements, etc. The results of the interviews confirmed these issues.

Few technological trends have a tremendous effect on using mobile devices in facility management. As the work itself is naturally very mobile, location-based services seem to be one of the trends. One of the location-based technologies is GPS-functionality which is becoming a staple feature for mobile devices. GPS and equivalent satellite technologies have the restriction that they work only outdoors. In many cases, the accuracy rate of a building is enough, but if a more exact location is needed, a way to locate the user inside is needed. The most promising candidates for this are touch-based technologies like NFC and local wireless network-based location systems.

Likely the most powerful trend in information technologies during the past decade has been port of services to the web. The web can be thought of as an environment where services are offered in a formal way and this formal way is understood by client side browsers. As browsers are able to use all web services there is no need to install locally specific software to use a specific service. This trend is increasingly coming to mobile environment. Web paradigm is a natural fit to mobile devices as distributing software to mobile devices is cumbersome and leads to difficult maintenance problems. Perhaps the most important promoter for the use of mobile technologies in FM is the need to penetrate organisational borders, as the service sector is practically totally outsourced and forms a chain of subcontractors. The needs for efficient communication and reporting are obvious for both the client and delivery sides (i.e., for timely deliveries, instant quality control, and acceptance of payable transactions).

The current uses of mobile technology in FM services

The technologies commonly utilised within services for facility management profession are [8] mobile phone (speech and text messaging), GPRS (General Packet Radio Service) and, somewhat less, the integrated camera in the cell phone. RFID reader is applied in the context of logistics and control of equipment, and quality control. Further exploitation of RFID is emerging in janitorial services, access rights controls and mobile access managements with very short-range, wireless, point-to-point interconnection technology expected to become a common technology in mobile phones. In fact, these kinds of phones already exist, offering intuitive, easy-to-use, touch-based communication and interaction between two devices with a reasonable price and low immunity to eavesdropping. The new communication and messaging systems give new possibilities and methods to manage and communicate with embedded sensor networks in buildings that have general terminal equipment through local or global information networks [4]. (See Table 1.)

Table 1. Mobility in facility services according to FM professional enquiries.

Activities and aims	Enablers	Benefits
Administration and control of work activities, reporting of request-based FM services	Mobile phone applications, GPRS (General Packet Radio Service), RFID reader, camera phone	Enhanced supervision and guidance of work, shorter lead times for service deliveries
Quality control: 1) quality control by client or service provider 2) added accuracy and details to service requests	Mobile phone applications, GPRS, RFID reader, camera phone	Better quality control and improved implementation control for the service agreement
Management of fixed assets (equipment, machinery, vehicles, etc.) including info on maintenance and locations, etc.	Mobile phone applications, GPRS, RFID reader, camera phone	Efficiency of the utilisation of the fixed assets improves; accuracy of follow-up is enhanced
Reporting, information deliveries and enquiries, data and information transmission	Mobile phone applications, GPRS, RFID reader, camera phone	Paper work lessens, the quality of information improves, communication improves, parties share real-time information
Administration, control and follow-up of the logistics of mobile services	Mobile phone applications, GPRS, RFID reader, GPS (Global Positioning System)	Productivity improvements, efficiency and quality improvements in services

Today, the connectivity of mobile phones is excellent and several models have a digital camera, Bluetooth radio, GPS or even an RFID reader integrated in the back cover, to mention some of them. By taking advantage of these accessories, it is possible to change the way in which service tasks are delivered.

The common FM-related uses of the integrated technologies in mobile phones include the management of service requests, reporting of service-related incidences and accepting the activities. The quality control from either the demand or supply side and better accuracy of the facility services is a major field of applications. Furthermore, the utilisation degree of equipment, machinery and vehicles, and the related maintenance needs and location information follow-ups are gathered with integrated mobile devices. The logistics of mobile services are controlled, monitored and optimised, and various pieces of data are transferred and reported with mobile phone applications.

The feasibility: Results of interviews

To test the feasibility of enhancing FM service procurement by the utilisation of currently available mobile technology the Finnish key players of the profession were interviewed during 2007. In particular, the benefits and obstacles of mobile technology implementation in their businesses were sought for. The number of the interviewees is very limited, only five, but they represent the major part of the professionally managed building stock in Finland. They also cover a variety of building stocks, including housing. Thus their insight is very credible, and likely valid in several other developed countries as well. In 2007, they were asked about the degree of mobile phone usage in their companies, which applications are being used, and on which technology the mobile applications are based. They asked open questions about the problems and currently experienced obstacles of mobile technology within FM settings, and about the experienced benefits.

The perceived benefits of mobile technologies for FM services

The majority of the interviewees felt that the technology exceeds the minimum requirements for implementing current mobile applications. Integration to back end systems as well as usability and clarity of the mobile application will be decisive in whether the application is exploited or not.

The perceived benefits are mostly related to improved resource efficiency and quality control. The better service instruction and guidance, and timely working instructions improve the output. The quality control issues are enhanced with visual aids of camera and other gadgets integrated to mobile phones. Paper work has been lessening, the quality of data and information has improved and become real-time for multiple parties (i.e., the facility manager, service provider and the client have access to the same information at the same time). Visual aids (integrated cameras) enhance communication. Fewer disputes occur.

The management of fixed assets is enhanced. Occupancy rates can be better adjusted according to real circumstances. Follow-up is easier and in real-time. A facility manager in another country can visually observe real-time incidences of the site. The location of an employee with confirmation of things to be done, and resulting acknowledgments of actions give real-time control of staff and resource use. Monitoring of performance and output quality can be done and recorded for, i.e., payments or documentation in case of disputes.

The perceived obstacles of mobile technologies

A major hindrance for the reaping of the benefits of technical enables has been the isolation of the FM service provider and, in particular, the mobile service personnel from the information systems of the companies. This disconnection from the company's main information system has deprived the service providers of real-time assistance possibilities that would be available with real-time connections to enterprise level background knowledge and services. The improvements in this area also enhance the benefits for clients of the services, i.e., via improved accuracy both in core substances and economic processes.

The previously observed obstacles (such as the above mentioned) have only been partially overcome. Yet the currently perceived obstacles are more in the frame of the integration of mobile services than in the maturity of mobile services.

When a market study was carried out [5] among the companies involved in services for facilities management sector either as service providers or clients, the consensus result among the companies was that the companies recognise the need for upgrading their activities (either as service providers or clients), but feel the development of mobile supporting systems to be outside of their core business and even more outside of their capabilities. Currently, the enabling mobile technology for upgrading the FM-related services is in a relatively mature stage, but the value chains lack the business intelligence for sharing even the identified benefits. Furthermore, many benefits remain unidentified.

To gain the benefits, it is essential to successfully integrate the mobile applications into the company's other information systems and company's processes. The gaps in the integration undermine the potential benefits. To gain an optimal solution, the processes need re-evaluation with the options to change or omit parts of current practice. The obstacles show up when the value chain extends outside of the company's control. If the benefits fall to other parties, there is no motivation. If the change of practices requires other companies to modify their modes of actions, it is hard to endorse for external parties.

Both the construction and FM sectors agree that the obstacles to exploitation of mobile technology are related to the lack of modes of operation with the enabling technology rather than to the capacities of the technology itself [7]. The problems occur both within companies and between them. The lack of knowledge of mobile solutions, the difficulties in the integration of systems, and the lack of routines in procurement and operation are hindrances. The technology-related problems often hinder the integration of mobile applications to existing IT systems within the company. The integration may be technically challenging and the costs may rise to make the effort unprofitable. The mobile solutions and IT background systems often have different suppliers, which is a

major hindrance to the integration and interoperability. The success in the integration is vital for the profitable exploitation of mobile applications.

When the amount of data transfer increases and the integration to a company's background system becomes more essential, the need for data protection becomes more critical. This has been recognised as something to take good care of, but not seen as an unsolvable problem.

Conclusions

Facility services include an ample amount of processes and networked tasks. One of the major attributes of facility management (FM) and service work is the mobility of both workers and services within a versatile supply chain. Enhancing possibilities for mobility makes this work more efficient, improves the quality of and access to services and thus strengthens the businesses of the involved companies, for both service providers and clients. This requires changes of work procedures, mainly by combining activities.

The majority of the interviewees felt the technology exceeding the minimum requirements for implementing current mobile applications. Integration to the back-end systems as well as usability and clarity of the mobile application will be decisive in whether the application is exploited or not. The usual processes possess several daily routine tasks like monitoring, reporting and logistics, where mobile technology could be applied as a natural part of the service process, if the back-end systems and processes are at a satisfactory level. In repetitive processes like information collection, mobile solutions are believed to increase, but they do not bring considerable strategic solutions to FM companies. Instead, benefits that are more significant could be gained from mobile solutions strengthening the operation of the whole value chain. This in fact presupposes that the whole value chain is integrated in it. Responsible providers offering these services are yet missing, and FM companies do not feel themselves to be the right operators for these kinds of tasks. Thus, new entrants are required to provide, maintain and guide the usage of mobile solutions. This will also result in the emergence of new operational models and open up novel possibilities, e.g., signing for a delivery from the supplier or a subtask performed by a subcontractor. All these performed actions will be transparent to all suppliers and subcontractors in the value chain [6].

Mega-trends – such as Internet usage, digital imaging, broadband connections, location and map information, user-created content, and open source business models – are prevailing and shaping the field and profoundly influencing the practices of daily routines. The last two, user created content and open source business models, are currently only emergent in the FM and construction sector, but the others fit well and

are already partly applied. Remarkable new potential will be found in the usage of RFID tagging, GPS, and digital cameras. Once these three usages are integrated into the mobile phone, they offer huge possibilities. At the moment, such phones exist where one or two of these characteristics can be found, but not all three in the same (though these may be available in the near future). Regarding RFID tagging, test cases in asset management and maintenance within the construction sector, especially applications involving handheld computers for use on-site, have been reported in [8].

Connectivity creates a new business model for facility managers. Networking allows the leasing of spaces to move toward service rendering by providing the ability to optimise building and tenant management by, e.g., tracking the status of work orders. It enables 24-hour availability and enhances responsiveness. It provides facility managers and tenants with a greater control over the FM operations; a tracking system for maintenance people and work progress. This shifts the business model from space to service. Our research has also indicated that the remaining substantial challenges in creating profitable business opportunities with mobile services in facility management, as well as other business sectors, are mainly in achieving the sufficient ease of use, integration to back-end systems, creating a mobile operating model for the line of business, and verifying it.

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Services in the Digital Home

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Abstract

This paper discusses the future of the Digital Home as a technical platform for end user services at home and in houses, and proposes new service concepts to serve home inhabitants. The paper was written based on the digital home-related research work we have conducted since 2001. The focus in the research work has been on the end user's home services, including welleness, energy monitoring and conservation services in the Digital Home environment. As a technical platform, we introduced the Internet, IP, UPnP, Web and mobile and wireless technologies. We conclude that the office-based IP-networking technology is suitable for home services and it reduces the amount of investments in networks to the level of CE (Consumer Electronics) products for the home. In the paper, we also identify potential service approaches, introduce a technology solution, highlight new interesting commercial trends and propose research priorities for future service challenges in the Digital Home.

Background

The home networking has undergone a significant grown up and transition and has become one of the biggest success stories in consumer technology markets in the past decade.

Earlier, home networking was mainly a hobby for enthusiasts, allthough the market area was regognised to be very lucrative for many companies in building automation sector. The big automation companies made many efforts to expand their business to home networking and home automation by modifying their current fieldbus-type automation solutions for home networking, without success.

In the late 90s, the Internet started to penetrate home environments and today tens of millions of consumers have home networks based on Internet technology in their homes. They are able to access global Internet services via their home network when the home is connected to wired or wireless broadbands. In fact, home networking has been one of the biggest success stories in the CE (Consumer Electronics) product markets.

Now home networking is entering a new phase in its evolution, driven largely by Internet-connected CE products for the home and new Web-based services. The connected CE devices will enable new classes of home services where the energy management concerns and digital homecare for elderly people may appear as drivers for launcing Internet enabled Digital Homes.

Within the Digihome Services [1] project, we have made several studies to adapt the office-based Internet, IP, UPnP, Web and mobile and wireless technologies to connecting the home appliances for a Digital Home. In the studies, we analysed and defined a technical concept to apply Internet and wireless and mobile technologies for the home environment in feasible and secure way.

Prior to the Digihome Services project, we ran an EU-project called "Future Home [2]", where we identified and analysed service and system requirements for the digital home together with European partners. Several usage scenarios were produced by the project and used to interview various user groups both in Finland in Germany. The results of interviews were taken as guidelines on focusing the Digihome Services project in its specification phase. Based on those results, we concluded the relevant home services for the Digihome pilot, identified usability issues and listed the general requirements for the digital home. In addition, the technologies surveyed by the Future Home project were adapted as a base for the technical platform of Digihome Service project. The scope of the Digihome project was additionally focused also by a recent large user study [3], where it was clearly shown that the inhabitants have an interest and need to monitor their energy and water consumption in residential buildings. Currently, they are unaware of their consumption until bills arrive.

The technical platform of Digihome Services solves several issues related to the installation and usage of the home network with connected appliances and lays the ground for creating and providing new home and house-related services. In order to facilitate the platform and to verify its feasibility and capability, a real life pilothouse was established at VTT's pilothouse area. A prototype of the Digihome home demonstrator was implemented and taken into use in the pilot house with basic home services with building automation features.

The system architecture of the Digihome demonstrator is presented in Figure 1, it integrates ordinary home appliances together with network adapters [4] to make them connected. The user uses the home system via Web browsers or dedicated user interfaces on various terminals, such as a TV set, portable game console, mobile phone, internet tablets and home PC. Two examples can be found in Figure 2. The system architecture is described in more detail in "Networking Home Appliances with Adapters and UPnP" [5].

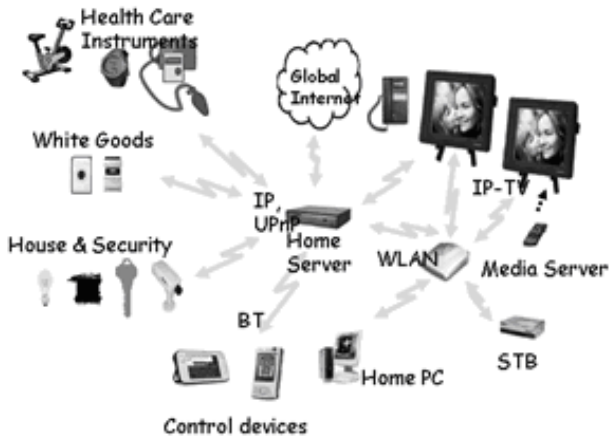

Figure 1. DHS system architecture.

Figure 2. Home terminals for DHS user interface.

The appliances connected to the piloted home network are a scale, an exercise bike, a blood pressure monitor, a ventilation unit, a surveillance camera, electrical appliance control, electricity consumption monitor, alarm sensor system and entertainment equipment.

For the commercialisation of the created concept, collaboration was established with a start up company called Mittadata Oy [6].

Services in the Digital Home

The access to the global Internet offers plenty of services over broadband connection, but there is also locally a large potential for home-related services, when we get the most home appliances and devices (white goods, survailance, house automation, etc.) connected and controlled over a home network. We can define a rich flora of services on top of the digital home platform, which make the living and staying at home more comfortable and convenient. The service potential of home networks and the digital home is still poorly used, due to a lack of connectable home appliances on the market. The possibilities for new home services in digital home environment forms a rich flora that you can see in Figure 3.

Figure 3. The flora of potential services in the digihome.

Home monitor and control

Perhaps the most basic services at home are the control and monitoring of home appliances and systems. The Service allows users to view the status of the connected home appliances and control them. The service is available locally over the home network inside the home and remotely through a broadband connection and global Internet outside the home. A built-in security system ensures that only authorised users can get access to appliances or control them. A proven approach will use a browser to access web-based services at the home server over https, using certificates and a predefined IP address.

The home monitor and control functionality allows even other authorised higher-level services to monitor and control the connected appliances at home. This function applies to authentication solutions which allow the authorised services to control the home system and a specific device. The end-user audience of high-level service should consist of home/house owners and inhabitants, maintenance personnel, safety operators.

Home wellness service

The wellness services focus on devices related to physical exercise and health monitoring and provides opportunities for added-value services by networking the devices and integrating their data storage. A demonstration system, consisting of an

ergometer (exercise bike), scale and blood pressure monitor is installed in one room of VTT's pilot house, but the same concept could be adopted also in a commercial gym.

The user interface was designed to be convenient both in the home and gym environments. The users are identified with RFID tags. For example, our scale always displays the weight and after RFID identification, it stores the measurement in a personal database and shows a weight history graph. Similarly, the blood pressure monitor and ergometer can store measurements in the personal database. The ergometer also configures itself for the preferences of a current user when she begins the exercise by showing her tag to the bike. The user interface can combine information from various devices, for instance, by showing weight trend and ergometer exercise history on the same time axis.

The demonstration system was built using an SQL database and commercial wellness devices, connected by USB and serial cables to computers, and networked by VTT's UPnP stack.

Energy monitoring

Today, inhabitants have difficulties monitoring their energy and water consumption at their homes. In Finland, the monthly bills are based on estimated consumption, i.e. the consumption of the past year, because the energy and water meters are typically read only once a year. It is important that people can monitor their energy consumption since feedback appears to be an effective strategy for reducing energy consumption and motivate energy conservation.

A service for energy consumption monitoring was developed at VTT. It gives real time feedback to occupants on their energy consumption and the cost. A goal was to be able to present the consumption and costs figures for each electrical device connected to a house's electrical power network.

The basic consumption information of all household electronic devices connected to the power network is stored in a home maintenance database. With the help of that data, it is possible to define when the washing machine or television is turned on and off by using analysis tools and comparing the collected data on energy consumption with reference information of the devices. (See Figure 4.)

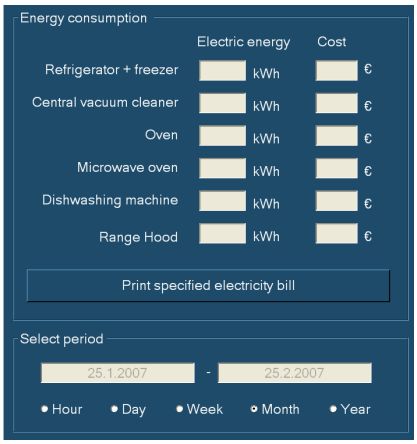

Figure 4. The consumption monitor display of household equipment.

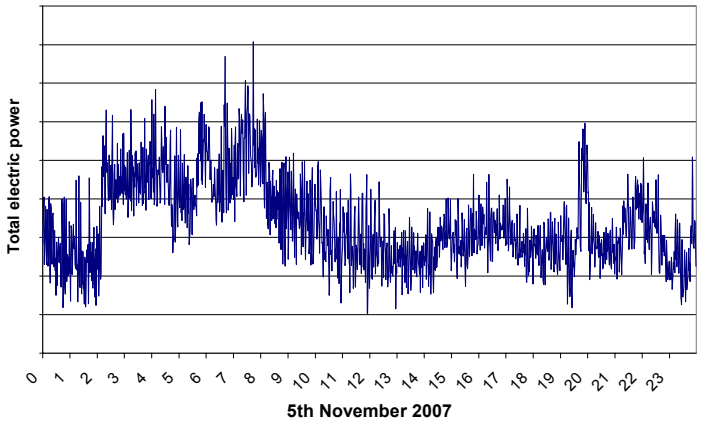

Figure 5. Total electric power consumption during a day.

In order to get accurate device-related consumption information, a trial was made to evaluate the gathered consumption data from a house power meter using a Non-Intrusive Appliance Load Monitoring (NIALM) method. The idea of NIALM is to analyse online the electric power trend (including RMS power/reactive power), so-called electrical fingerprints, and to identify the devices and how much each device consumes electricity.

A case study followed the consumption data of a single-family home for a day. It was collected when all electrical appliances (more than 100) in the house were connected and their consumption data from the three phases of electrical power network were stored and analysed. The total electric power trend in a household during a day is shown in Figure 5.

In the study, it was possible to identify several devices per measured phase; however it proved to be difficult to identify electrical finger prints of all active devices at the same time and especially when they had very similar finger prints. Therefore, the method needs to be combined with device identification and status information. When combining the identification and status information of a device with power meter data, a reliable, device level consumption data can be calculated.

Energy conservation

The Energy conservation service is defined as external service that can be implemented within a Digital Home/house environment. It is based on the house power meter data and device activity data. The gathered data are sent to service provider regularly. The service provider receives the raw data and performs analysis and comparison of data and sends a feedback report to the home server. The report describes, in detail, the

energy consumption for each day, suggests measures to save energy, and presents estimates on saving possibilities. The service provider can, for example, suggest that the customer defrost the freezer based on an increase in its energy consumption or even change the device to a new one, based on the savings in energy consumption that results in an exceptionally short repayment period.

As the price of electricity – and energy in general – keeps continuously growing, the services supporting the decreasing of energy consumption will become profitable. Potential parties for implementation of the service concept are electric companies, electric meter manufacturers, analysis software companies, and consulting firms.

Discussion and conclusions

In previous interviews, people felt that what they really would like to have was services that help them with their everyday activities and safety. These services included a camera placed at front door, or a function that, when you are on your way out or travelling, allows you to quickly glance at your home's situation, and if something has been left on, you can switch it off. In addition, the ability to get a message if there is a problem of any kind at home was found to be important. Some interviewees said that the monitoring one's home is important if you have small children, e.g., in the first grade at school.

We started our digital home research with the assumption that modern IP/Internet tehcnology, used in offices, is suitable for residential networks and can be used to create the expected residential services. Obvious advantages were seen in implementing and commercialising the connected home environment on top of the Internet. The major advantage of the digital home platform was assumed to be for senior citizens and people with handicaps, but it was considerd to be suitable for general users as well. During the work, a concept for the digital home was implemented and taken into use in a pilot house. New service concepts were specified and implemented on top of a prototype digital home environment.

The basic services in a Digital Home are the locally created service offered by the connected smart home appliances and systems, which are operating independently. The more advanced home services, where appliances and systems are communicating with each other, will need agrements on common protocols and practices to syncronise the operation in order to get more advanced services in the home and to allow external service providers to connect to home system with their services.

The service providers will play a major role in expanding the penetration of the digital home in future. New services and content will pull demand for connected devices and requirements for the home environment to supporting services. Inhabitants typically expects solutions which will make their living even more convenient, entertaining and efficient. Even the rising environmental awareness can encourage people to buy connectable appliances that help save energy by enabling online monitoring of home energy consumption and controlling the home ventilation and heating systems.

It is commonly understand that controlling home appliances through a Digital Home environment will provide a higher level of living comfort [7]. The piloted Digital Home environment gave residential consumers greater control of in-home consumption and energy usage, management and costs. We believe that rising energy costs, growing environmenmtal awareness and increasing availabilty of Digital Home solutions enables wide deployment of the consumption and energy management services.

Once the connecteble home appliances are sold as ordinary home CE products, the prices go down and a rich flora of connectable home appliaces becomes available, even ordinary consumers will turn their homes into digital homes.

Acknowledgement

The author wishes to thank the companies involved and the Digihome project team colleagues that have made the research possible. In addition, I would like to acknowledege the Service Beyond Technology Theme at VTT for its support to the project steering group.

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Improving service processes with Near Field Communication technology

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Abstract

A common objective of conducting services more efficiently is driving the introduction of new technologies to service processes. This paper presents two explanatory case studies, in which a Near Field Communication (NFC) technology is used with an aim to improve the quality of services and the effectiveness of service processes. Thus, the impact and suitability of the NFC technology to business-to-customer service processes is the main research problem addressed in this study. Theme interviews with key business stakeholders of pilots were used as the research method for analysing case studies. The results of this study indicate that the use of NFC brought both advantages and challenges to the service processes. Although demographic background of the pilot customers was very versatile, most customers experienced the touch-based user interface to be fast and easy to use and learn. In spite of these substantial advantages, pilot findings stress that there exist some challenges for the wide scale adoption of NFC in the services processes, such as the lack of NFC enabled phones. These challenges have to be overcome before NFC can provide significant benefits to business actors.

Introduction

Increasing competition in the service sector forces organisations to inspect their present business models and to find new ways to distinguish their business from their competitors. One solution to thrive in comparison to competitors is to reduce costs, which in the service sector are often highly associated with human resources. However, at the same time organisations encounter increasing demand to improve quality of provided services. Because of these occasionally conflicting demands, focus has been directed to recent technological developments, which are expected to increase the quality of provided services, and make the production of service more cost efficient. In order to fulfil expectations, Near Field Communication (NFC) is one of the most promising new technologies, which are being looked forward to as means to improve services targeted to customers. NFC is a touch-based interaction technology that has evolved from a combination of existing contactless identification and interconnection

technologies [1]. NFC offers also an opportunity to improve business processes of the actors in the service value network, which may result in cost savings and improved operational effectiveness.

The impact of NFC technology on business-to-consumer services is studied in two pilot cases. In the first pilot, elderly clients of Oulu's regional elderly care were allowed to order their daily meals using NFC-enabled phones. In the second pilot, which was realised in the restaurant environment, the target was to enhance the busy lunchtime service by providing NFC-based lunch order application to the contract customers of the restaurant. The aim of both pilots was to improve the service-process related to meal ordering, provide better service quality and improve the effectiveness of meal deliveries.

Related research

Due to the novelty of NFC technology, there are only a limited amount of experiences about touch-based user interface and results of how it can be used to improve service processes. Some recent papers indicate that touching with a mobile phone is an intuitive, natural and non-ambiguous interaction technique [2]. In the study of Välkkynen et al., they suggest that touching is also easy to learn and use [3]. Häikiö et al. have previously reported elderly clients' user experiences of NFC technology. They state that elderly people with impaired motor skills were able to use a touch-based user interface successfully in the pilot tests [4].

There are several studies of how mobile technologies can be applied to improve business processes in different industrial fields. For example, Bowden et al. describe various areas from the construction and facilities management where mobile technologies have been used to improve business processes [5]. In addition, RFID-based solutions are used to improve business processes. For example, security guards and cleaners have been using RFID-based mobile solutions in order to make their work more effective. Mobile technology has also become a part of the everyday life of the mobile workforce. Term mobile workforce refers to workers who do not have a stabile work post, e.g., travelling managers, field workers and emergency rescuers [6].

Despite the availability of various mobile technologies that can be used to improve business processes, researchers argue that the business value of mobile technology is often problematic. Heijden et al. state that in case of emerging technologies, the direct costs are quickly recognised, but the benefits are harder to see. Because of the fact that the new technology is often hard to express in isolation, business processes should be used for analysing the business benefits of mobile technology [7]. In this study, business process is defined as a specific set of linked activities across time and place, with a beginning, an end, and clearly identified inputs and outputs [8].

Research setting

In order to gain better understanding about the impact of mobile technologies on different levels of the organisation, we follow a three-level division introduced by Wang, van de Kar, Meijer and Hünteler [9]. They propose that the implementation of mobility will penetrate to three levels of organisation system, which are organisational level, process level and individual level. These levels are further divided to sublevels, which are presented in Table 1.

Table 1. Framework for analysing the impact of mobile technologies (adapted from [9]).

Level	Issue
Organisation	Workforce management: The balancing of work factors, such as the optimal level of employees, workloads and availability of resources.
	Organisation structure: The way organisations link workforces and the way to support the collaboration.
	Knowledge management: Sharing and management of the information.
Process	Process automation: Automation and improvement of the service process using mobile technologies.
	Coordination: Coordinating business activities between stakeholders.
Individual (worker)	Effectiveness: Capability of individual work to produce more outcome using mobile technology.
	Tasks: Possibility of the work force to execute tasks that are their core competence.
	Acceptance: Intention and willingness to use new technology.

The purpose of our research was to examine the impact of NFC technology in the selected pilots. The aim was to identify advantages and improvements of the NFC technology for the involved business stakeholders as well as to detect whether barriers to adoption of NFC technology exist. Our study is based on the qualitative data that was collected from two separate pilot cases. Table 2 summarises the characteristics of these pilots, which were both realised in the city of Oulu. Detailed information about the background and actual implementation of the pilots are presented in the following subsections.

The objective of the qualitative research was to find out detailed information about business actors' expectations, experiences and challenges considering the adoption of NFC in their service processes. Interviewed actors included upper and middle level managers from Oulu regional elderly care, Oulu logistics, Oulu meal service and the restaurant Pannu. The total number of interviewed persons was eight and at least one interview was conducted in each of these four organisations. In addition, the restaurant pilot included three interviews with operational level employees. All interviews were

conducted shortly after the finish of the pilots. Interviews followed a semi-structured format and lasted from one to two hours each. The interviews were recorded and transcribed for further analysis.

Table 2. Summary of the analysed pilots.

	Pilot 1: Elderly care meal service	Pilot 2: Fast Track, restaurant Pannu
User segment	9 elderly care clients with average age of 76.6 years + 5 logistics drivers	27 of the restaurant's regular customers
Time period	Autumn 2006	Autumn 2007
Duration	8 weeks	5 weeks
Actors	VTT, City of Oulu, Top-Tunniste, Oulun Ateria, Oulu logistics, Oulu regional elderly care	Restaurant Pannu, TeliaSonera, VTT, City of Oulu, Fulcrum
End device	Nokia 3220 (elderly clients), Nokia 5140i (drivers)	Nokia 6131 NFC
Goal of the pilot	Provide easy meal delivery service for elderly clients. Improve the effectiveness of meal deliveries	Provide fast ordering and payment for busy lunchtime customers.

Companies selected for the pilots were expected to benefit from the use of NFC technology in their business processes. The first section of the interview concentrated on the organisation's background information, its position in the market and its current technology usage. The second part surveyed the impact of NFC technology, which were detected during the pilots. The aim was to find out what benefits and challenges are directed to the business actors' service processes. The last part considered the pros and cons of the NFC technology in more general level.

Case study 1: Elderly care meal service

The current situation in the catering service is that elderly people, who are entitled to receive their daily meals directly to their homes, do not have any opportunity to choose the meal they would like to eat. All elderly clients that belong to the catering service program get the same meal, although allergies and medical requirements are taken into account. If the client does not want food for some particular reason (e.g., because they are travelling or a relative is preparing their food), he/she calls to regional elderly care, and asks them to cancel meal orders for a specified period of time. The main problem in the arrangement is that one elderly care worker is regularly occupied in the mornings because he/she has to receive meal cancellation from the clients.

In the meal service pilot, NFC technology was used to enable another meal alternative for clients and to make the ordering and delivery process more effective. Meal home delivery was handled by three entities: Oulu meal service, Oulu logistics and regional elderly care. All of these actors have well-defined tasks in the meal delivery, manufacturing and ordering: 1) Regional elderly care acts as a coordinator of the meal service value network. It decides which elders are entitled to have meals to their homes and invoicing of meals is directed through it. 2) The meal provider prepares meals, which are given to the logistics service provider for distribution. 3) The logistics service provider distributes the meals for the elderly clients.

In a meal ordering process, a client touches a NFC tag on a menu stand with the NFC-enabled mobile phone. The client chooses meal alternative A or B by touching the corresponding NFC tag (tag A or tag B). If the client touches tag C, the meal order for the next day will be cancelled. Touching is the only operation required by the clients in the meal ordering process; everything else is carried out automatically from the clients' viewpoint. The whole meal ordering and delivery process is depicted in Figure 1, where NFC-enabled actions are illustrated with bold red lines.

As Figure 1 points out, delivery personnel used NFC enabled mobile phones more frequently during the meal service process than actual clients. Delivery personnel touched an NFC tag when they started and ended the delivery routes, which enables automatic invoicing according to the time that is used for delivery. Additionally, delivery personnel touched NFC tags at every customer's home while delivering the meal, which enabled the real-time monitoring of meal deliveries. Hence, the monitoring of deliveries improved the trust and transparency of the service during the whole service chain.

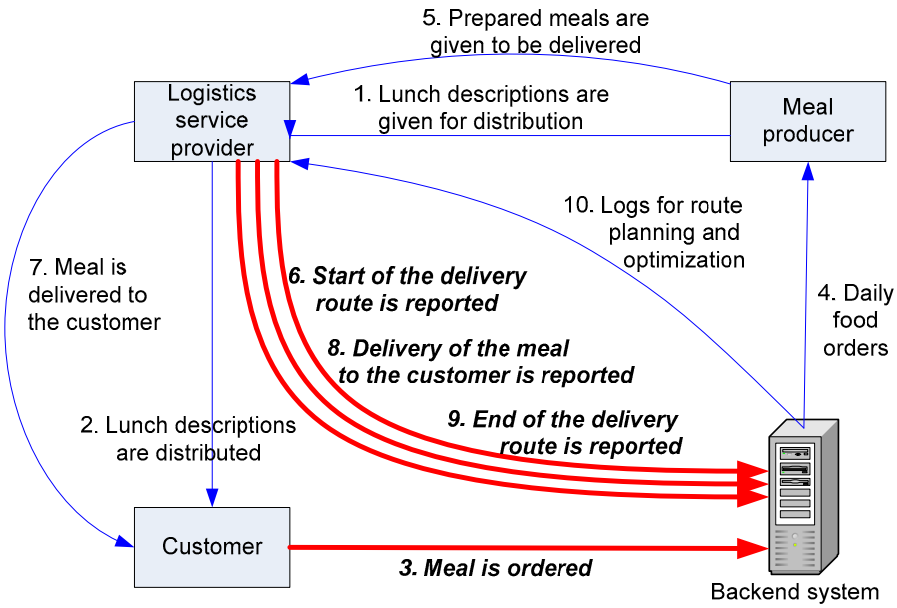

Figure 1. NFC-enabled meal ordering and delivery processes.

Case study 2: Fast track of restaurant Pannu

The problem that initiated the pilot was that busy workers want to have fast service during rush lunch hours in a restaurant. However, since many employees come to the restaurant at the same time, the traditional service process, where a waiter asks for orders, may be too slow. In order to find a solution for this problem, a new service concept, named "Fast track", was developed by the restaurant Pannu in co-operation with a mobile network operator. Fast track provided an opportunity for the busy customers to select their lunch by touching the RFID-tagged menu with their NFC-enabled mobile phones. The lunch order was directed straight to the kitchen without the intervention of a waiter. In addition to being able to place lunch order, customers could also pay for their lunch using NFC phones, and information tags provided a possibility to download information to mobile phones.

The objective of the pilot was to test the suitability of the NFC technology in the restaurant environment and to find out the impact of the new technology to rush time service processes. Restaurant Pannu invited 27 of their regular lunch customers to participate in the pilot. The customers selected for the pilot group were ones who used the restaurant frequently during lunch hours. Eleven customers used NFC-enabled phones also for the payment of the lunch. The payment transaction was conducted by tapping an NFC-enabled phone on the contactless point of sales terminal. The used terminal was a commercially available RFID-based terminal provided by a cash register provider.

Results

Results from the interviews with business stakeholders of the both pilots are summarised in Table 3. Findings are categorised on the basis of the framework introduced in Table 1.

Table 3. Business impacts of NFC enhanced service processes in two case studies.

	Issue	Meal service pilot	Restaurant pilot
Organisation	Workforce management	+ Pilot solution makes the tracking of the meal deliveries possible, thus work force and delivery cars may be more efficiently allocated to the delivery routes (Logistics service provider). + Working hours that are used for delivery can be more accurately monitored. Enables time-based billing of delivery.	+ Customer service personnel can be used more efficiently during rush hours. No reported effects on the kitchen workers.
	Organisation structure	+ Collaborative work between organisations is increased because of the more transparent information related to the delivery process.	+ The Fast Track concept may be used to reduce the number of waiters/waitresses during the lunch hours or they have more time to perform other working tasks.
	Knowledge management	+ Elderly care is able to view the status of meal orders and delivery with the help of web applications. Thus, they have instant access to this information in case of problems in the ordering or delivery.	No particular impact recognised.
Process	Process automation	+ Ordering process was automated (old phone call was replaced by touch with NFC phone).	+ One phase (waiter/waitress asking and writing down the lunch order) of the meal ordering process was replaced by the physical selection with NFC.
	Coordination	+ If a meal cannot be delivered to the client (e.g., the client is absent), delivery personnel can report it with their NFC-enabled mobile phone and other persons (from the elderly care) start investigating the problem. Delivery person can continue on the delivery route.	- Coordination of meal orders may be challenging, when some customers order with NFC and some others without it. NFC-ordered meals come more quickly and thus other people have to wait longer for their food (problem if customers belong to same group or customers who arrive later get their meals first).
Individual (worker)	Effectiveness	+ The effectiveness of meal production may increase, since the exact number of meal orders is known beforehand.	+ Customers reported that the meal waiting time was reduced during the pilot. However, the actual increase in effectiveness could not be measured because of the relatively small user group. - Lunch orders were occasionally registered incorrectly. For this reason wrong meals were served to the customers.
	Tasks	+ Elderly care personnel did not have to answer phone calls, thus they were able to concentrate on more important tasks. - Teaching and supporting the clients required some additional work form the elderly care workers and logistics drivers. This may result in increased costs, especially when the customer base expands. - Technical support for the meal ordering system has to be available.	+ There was no need for a waiter/waitress to take an order from the table. Thus, one task of their regular work was not needed.
	Acceptance	+ Learning the use and actual use of the NFC solution was very easy for the drivers. - An additional NFC-enabled mobile phone was seen as a burden (drivers had two mobile phones beforehand, one own and one work phone).	+ Waiters and waitresses easily learned the new service process and the use of contactless payment at the cash register. - Acceptance may be reduced because of the fear of reduced work amount, which may lead to fewer waiters/waitresses needed.

Discussion

The analysis in Table 3 indicates that NFC solutions have an indirect impact on many aspects of the organisation system. The use of NFC technology had a clear impact on the organisation level in the elderly care pilot, where the workflow management and coordination between stakeholders were improved. However, the most significant impacts were reported in the level of processes, where NFC was used in the automation of service processes. The impact of NFC was also notable for individual workers and customers. Accordingly, the customers reported that the most important impact of the NFC was experienced in the form of shorter waiting times and better quality of service.

Comparison to competing technologies

There are several other technological options for solving the problems introduced in our pilot cases. However, NFC has some notable advantages compared to other technologies, especially in elderly care environment. The main reason why the service was implemented using NFC technology was that, instead of many other mobile technologies, elderly clients were supposed to be able to use touch based mobile technology because of its simplicity. The same service could be easily implemented in the form of a mobile phone application, where a user could select a meal for the next day by opening the meal service application and selecting the preferred meal with a mobile phone's keypad. Although this might work for experienced mobile phone users, it is not likely that elderly clients would have been able to use that. Another option for meal delivery could be constructing a menu tag with fixed buttons for the elders. Although this solution might be very easy to use, the implementation costs of it might be significantly higher than in the case of piloted solution. In fact, the implementation costs of the NFC solution were quite low, since nothing else but a mobile phone and a few NFC tags were needed as an infrastructure at the elder's home.

Conclusions

Our case studies have shown that NFC technology can have versatile impacts on organisations. In contrast with several benefits introduced earlier, there are also several challenges that should be addressed before the implementation of NFC-enabled service on a large scale. For example, the current weakness of NFC solutions is that there are only very few NFC enabled mobile phone models on the market. In addition, the implementation issues of NFC enabled services have to be considered carefully. One of the most important things is the integration with existing information systems, which was found to be challenging in the restaurant pilot. Moreover, the design and implementation of user interfaces for elderly clients is very challenging. Although the

actual touch is easy, several other things might cause problems when the user is not familiar with the technology. For example, the information on a phone's display has to be designed in a way that it is readable for the clients with reduced eyesight.

To conclude, even though the use of NFC has been found to be easy by several entities and the cost of infrastructure needed for implementing NFC services is low, the finding of a profitable business case for NFC is much more difficult. One of the main reasons for this is the lack of NFC-enabled phones and other NFC services, which makes it very difficult to provide enough added value to the users so that they are willing to invest on the NFC phones. In addition, pointing out the actual monetary value of NFC solutions to the companies is a great challenge in a world where several other technological solutions are competing for the same IT investment funds.

Acknowledgement

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Unified presence: Carving a niche in the unified communications market

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Abstract

Communications are heading nowadays towards a real-time, always-online mode, which blurs the line between work time and private time. Consequently, people are reluctant to give out their presence information, since it can be misused. In addition, a plethora of different communication tools exists, such as phones (both fixed and mobile), e-mail, SMS, instant messaging (IM), and other non-standard (but still largely deployed) tools, like Skype. These tools work separately, and mostly do not support any form of integration, neither among them, nor with any business process tools. A Unified Communication Service (UCS) provides a way of integrating those different communication channels in such a way that users can improve the way they communicate with each other. In this paper, we discuss a Unified Presence Service, which deals with the presence issues in UCSs.

Introduction

In today's world of always-on connectivity and multiple communication devices that people have at their fingertips, communicating with others should be an easy task. Yet, the very variety of options available, along with people's busy schedules often hinders the efforts to communicate in a timely manner. It is often the case that two or three means of communication need to be tried before reaching the needed contact, and this can lead to significant delays and loss of productivity.

There is therefore an important need for systems and services which simplify the task of getting in touch with other people when needed. The solutions are usually called Unified Communication Services (sometimes also Unified Communication Systems), and provide a way of integrating the different means of communication available, so that getting in touch becomes easier and more efficient.

Business analysts such as Gartner predict that within the next two to three years, about 80% of enterprises will deploy some form of UCS. Given the size of this market, it is

not surprising that many big players in the industry are offering solutions and services in this area. Companies such as Microsoft, Cisco, Ericsson, Siemens, IBM, etc. as well as several telcos are rolling out products and services that, to different degrees of completeness, can be considered UCS.

Unified Communications and presence

Overview and motivation

In the current enterprise environment, communications happen in a real-time, always-online mode, which blurs the line between work time and private time. Consequently, people are reluctant to give out their presence information, since it can be misused. Also, there exists a plethora of different communication tools, such as phones (both fixed and mobile), e-mail, SMS, instant messaging (IM), and other non-standard (but still largely deployed) tools, like Skype. These tools work separately, and mostly do not support any form of integration, neither among them, nor with any business process tools. There is, therefore, a need for integrating the available communication and business tools so that work can be done more efficiently and pleasantly.

In an ideal Unified Communications Service (UCS), the communication takes place between users, not devices or programs. This means that the system chooses the most adequate tool depending on the situation at hand. Also, availability and privacy issues are properly addressed. The use of profiles and integration with the business backend ensure that the users' private time and preferences are respected, while maintaining connectivity whenever necessary and avoiding unnecessary e-mails, SMSs, etc., especially when many persons are involved in the communication.

Also, in an ideal UCS the different tools available are used seamlessly, in such a way that the one most appropriate for the current situation is used. This is determined via user profiles and availability information gathered from backend tools. These backend tools, such as calendar systems, time and access control, order and project management, etc. are thus fully exploited to improve the communication between users.

Current commercial systems do not yet provide this level of integration, and often force the users to use proprietary tools, which might limit the usability of the system.

As a full UCS was clearly outside of the scope of our project, and since there are several major industrial products which aim to provide a UCS (with different levels of completeness, and even sometimes different definitions of what a UCS is), it was decided early on that our work would focus on some fundamental aspect underlying

every UCS. Studying the state of the art, it was clear that a key requirement for any UCS is to have an accurate view of the users' current status, or presence.

Interestingly enough, none of the commercial solutions seem to put too much focus on this, and instead focus more on the applications (e.g., call transfer between devices, integration of voice mail with e-mail, etc.). However, in order for a UCS to work properly, it is imperative that the system and its users have a coherent view of each user's presence information. Given that a user's presence can be inferred from several different sources at any given time, and that it may furthermore depend on the user's current context, the problem of inferring what that presence status actually is far from trivial. It is in fact necessary to consider all the communication devices that each user has (note that those devices may at any time provide conflicting presence information, and that their respective priorities may change with the context), the user's relation to other users (his contacts), and possibly other factors such as calendaring and other context (location, for example). These issues have been known in the research community for over fifteen years [1] and yet commercial implementations of UCSs still lack many important presence-related functionalities.

Business landscape and potential

Several studies by Gartner, IDC, and others agree that there is a pressing need for better communications within companies. In particular, they claim that difficulties in communicating with key people within the organisation (e.g., not being able to reach them, or taking too long due to having to try several communication options before actually finding the person in question) lead to problems ranging from loss of productivity to serious project delays.

A study from Sage research [2] surveyed 200 organisations of all sizes, and found the following:

- 36% of employees are unable to contact a co-worker on the first try on a daily basis.
- 52% end up having to use several communication channels to finally reach their co-workers.
- 13% of projects suffer delays on a weekly basis due to these kinds of problems.

The Sage study claims gains of about 70 daily minutes in companies that have deployed some sort of unified communications and unified messaging solutions.

Gartner [3] states that human latency reduces an enterprise's ability to respond and to be agile. Integration of communication-enabled business processes, as proposed in this project can reduce human latency especially with mobile workforce. Up to now, deployments of these kinds of systems have been limited due to complexity and cost of integration, and the return on investment, such as improvements in productivity, is harder to measure. Also, the best practices for deploying UCS are not yet well defined. The reports also highlight that UCS can be used outside the boundaries of a company, to enhance communications between organisations.

Gartner states that the UC services are driven by the need to:

- Improve the speed and accuracy of interactions
- Improve the human quality of the interaction
- Improve the flexibility of use and integration
- Reduce operative costs.

The deployment of UCS benefits from the current situation in communications. In particular, the convergence of communications around internet standards and all-IP communications present significant advantages for UCS. The move of communication applications to open software platforms, which facilitates integration of separate systems, is another factor that benefits the development of UCS. Finally, the proliferation of wireless communications, which allows for ubiquitous network access, makes UCS easily available in mobile contexts, which are becoming increasingly common.

The business potential for UCS, and thus for unified presence systems, is hard to assess, but suffice it to say that Gartner estimates that by 2010 about 80% of enterprises will have deployed some form of UCS. Granted, the definition of UCS is still somewhat relaxed, but in any case, there is definitely a large market for these systems. A further indication of the market potential is the emergence of a significant number of UCS offerings by big industrial players (Siemens, Microsoft/Nortel Networks, Cisco, Ericsson and IBM for example).

From our perspective, the research problems were then complemented by a business viability problem, namely, the need to create something that can still fit in an ecosystem where such big players rule.

Research methodology

The way in which this work has been carried out is quite different than the usual way in which research is currently done at VTT. A key consideration since the inception of this

project was the goal of producing commercially viable results. While a production-level product was not a reasonable expectation, given the scope of the project, it was decided early on that the generation of new IPR and an implementation to showcase the new developments were needed. During the project's lifetime, several departures from the original project plan were made as a result of both intermediate results (see below for some examples) and environmental issues (availability of resources, etc.).

At the beginning of the project, emphasis was put on two aspects. Firstly, the IPR landscape and business potential for a unified presence system were studied. A patent survey was carried out to determine what part of the potential market was already "taken". Several talks were held with industry players, in particular a team within Nokia Research Center who are working on collaboration systems that could greatly benefit from the functionalities provided by a unified presence system. A market analysis performed by RTI International, which yielded a very interesting report [4], helped steer the project in later stages.

At the same time, a second line of research concerned the development of new ideas and possible use cases for a unified presence system. A workshop was held with potential users for the system, ranging from receptionists to researchers and covering very different needs. This brainstorming yielded several very interesting use cases, which were then ranked, and abstracted into more general features that would be useful for a generic unified presence system.

The results from the market analysis performed by RTI International confirmed that the research should aim at producing something to be licensed or sold to industry members developing or doing integration of UCSs. This fact prompted a first departure from the original project plan, in which a company-tailored prototype was to be piloted by one of VTT's partner companies. Since the end-users were not the target, such an effort might prove unnecessary. A second rather large consequence of RTI's report was that the role of the 3GPP's IP Multimedia Subsystem (IMS) in the system design was significantly diminished with respect to the original plan. In the original project plan, the IMS infrastructure played a central role in the system. According to RTI's report, this might have been too premature, since IMS is not yet widely deployed by operators, and the possible UCS business models around it are not clear enough. Similar feedback was obtained from Siemens Enterprise Networks during talks about UCS. The research focus was then directed towards the core logic of a unified presence system, and IMS integration left as a future possibility.

Overall, the way in which the research presented herein has been conducted can be characterised as focused on the potential business aspects, and very flexible. From the development side, this approach was not without inconvenience, since it implied several

double takes along the project's lifetime. At the same time, it allowed the focus to be shifted to where it was most needed, and it also allowed the inception and reduction to practice of several interesting ideas.

A possible lesson for future projects with similar goals is to separate the business analysis from the system conception stages earlier, so as to minimise changes in the direction of the development at later times.

New ideas for unified presence services

As mentioned previously, an important goal of the project was the creation of innovative ideas leading to IPR generation. Six notifications of invention were filed during the duration of the project. Below are short summaries for those innovations.

Method to create, view and use a unified presence status utilising multiple presence sources

This innovation describes a method to create a meaningful unified presence status that is composed of information gathered from several presence sources. This often contradictory information is processed and presented intelligently to provide a coherent interpretation of the user's current status. This invention brings the real time unified presence information as a new commodity for enterprise systems and Internet applications potentially for millions of users. This is achieved by acquiring and processing presence information from multiple devices and services which provide information about the user.

Unified presence status: Specialised presence views

This invention concerns the automatic, rules-based generation of different unified presence views which show, given a user's current presence status, different presence information to the different classes of contacts that the user has. Thus, the user might appear simultaneously as available and unavailable to different contacts, according to his preferences and relation to them. For example, if the user is at work, he could appear as available to his co-workers, but unavailable to his family and friends.

For each update of the user's unified presence, the new state is processed by a rules engine, and new views of the current presence state are generated and then distributed to the user's contacts. The rules engine executes rules defined by the user, and which can be modified at any time. The system provides a "sane" default set of rules, which

provides the same behaviour as any other presence system. However, the user can then specify the view that any class sees for any presence state. This specification does not need to be exhaustive, as defaults can be kept for other state/class combinations, and can be built up over time.

Unified presence status: Status rules

This invention concerns the automatic, rules-based generation of a presence status for a user, based on said user's presence status on several devices (e.g., mobile phone, IM client, Calendar, etc.). It is common nowadays for a user to have several devices which provide, to some extent, information on the user's current presence state. This invention provides a framework to develop automatic ways to combine those separate (and often conflicting) pieces of information and combine them into a coherent, unified presence state for the user.

The proposed invention works by considering the combination of several presence data, coming from different sources, and providing a unified view of the user's overall presence, according to some predefined or inferred rules. The new presence state can also be propagated to other devices, if needed.

Unified presence status: Preferred devices

In order to maximise the usefulness of a Unified Presence and Communications System, it is imperative that a user can be contacted by his contacts in the most appropriate fashion, according to his current presence state. The proposed invention provides a way to supply a user's contacts, along with a unified presence view, a list of devices on which the user may be contacted, sorted by use priority. Thus, the contact wanting to get in touch with the user, would likely resort to the first device in the list (or the first that met the caller's requirements concerning device capabilities). The list of available devices is based on the current presence state of the user, as well as the class of the contact it is being sent to as part of a unified presence view, and the user's preferences concerning device priorities.

Unified presence status: Organisational presence

The proposed invention deals with ways of exploiting knowledge about the organisational structure within an enterprise environment in order to improve the way in which unified presence information is displayed. In particular, the relations between a

user and his contacts are used to provide visual groupings of contacts in different classes, such as managers, co-workers, team members, etc.

Operator-independent active two-way communication for mobile applications and servers

This innovation allows the creation and maintenance of a return channel from a service to an application in a mobile terminal without the need for network changes made by the operator. This allows the users to avoid being tied to the operator's IMS/SIP infrastructure or roaming services, and also allows the server side to detect connection breaks immediately. The invention is meant to be used by global mobile services that are not tied to a specific operator and which can benefit from a simple and more lightweight protocol than SIP.

Conclusions and perspectives

The UCS field promises a large business potential, and despite the presence of several big players in the market, some niche areas remain accessible to smaller ventures. In particular, the unified presence area is not yet encumbered with patents or impressive products. It seems then, that the results obtained from this research project have a good chance of achieving some form of commercialisation.

From a research point of view, many areas of unified presence and unified communications in general are still available for exploration. Of particular interest are the integration with IMS (both from a technical perspective, and also from the business side), and the extension of the concepts about users' presence to resources. This last topic has the potential for a wealth of new applications, especially in the enterprise.

The results obtained will likely also be exploited in two European research projects (ITEA2 ExpeShare and IST mCiudad), and provide one of the foundations for the Teamwork Applications Ecosystem project submitted to the Tekes ICT-SHOK program.

Acknowledgement

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Exergaming – combining real life and virtual communities to improve wellbeing

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Abstract

The urban lifestyle is hectic and information rich. A busy work pace and digital entertainment take time away from real world physical exercise, while lifestyle diseases increase globally. An aging population and diminishing resources for public healthcare cause pressure to move healthcare resources from treatment to prevention of illnesses. Exergaming, which is a term combining "exercise" and "gaming", has a lot of potential to provide various new service business opportunities for the Entertainment and Recreation as well as the Healthcare sectors. We started with scenario work, consumer studies and exergame roadmapping and interviews with potential actors and created two prototype concepts, "Fitness Adventure" and "Figuremeter" in our project. At the beginning of our project, Exergaming was not a very well-known concept. The emerging success stories of Nintendo Wii and everyman GPS devices have shown that combining existing technologies in a novel way has already opened the Exergame-related market and consumers are willing to use such services.

Introduction

ICT plays an increasingly important role in providing relevant health-related information in an interesting way to specified target groups. Diverse playful ways to measure total wellness and provide information could increase the motivation to do sport also for those not interested in current sport. Based on expert interviews we found out key needs in the future to support preventive work for maintaining one's total wellness in the long run. The key aspects are flexible and playful/visual, tailored for the respondents and anytime-and-anywhere-type casual exercise experience. The trend is not only happening in Finland. There is an increasing demand for wellness products and playful ways to provide information internationally.

VTT Service Beyond theme project, Exergame (Sept. 2006 – June 2008) focused on escalating ICT trends: 1) serious games (beneficial entertainment), 2) social media (users as content creators), and 3) mobility. Our hypothesis was that exergames – games

targeted to promote wellbeing and motivate people to do casual exercise – will become a promising business within the next five years. When VTT's Exergame project started, there were not much talk about exergames but soon Nintendo Wii brought up topics related to virtual exercise and the discussion around exergaming started to grow steadily. Another rapidly growing trend of personal navigation systems has also gained popularity.

The starting points of exergame trend were the following: 1) The urban lifestyle is hectic, information rich and mobile. The lifestyle is changing and formulating new needs. Segmented solutions will become more important. 2) The key to reducing health care costs is prevention. One hundred years ago, the major health concerns were infectious diseases like tuberculosis, pneumonia and influenza. Today, our leading causes of death – heart disease, cancer and stroke – are due in large part to our own unhealthy lifestyles.

The development time frame was set to 2–5 years and we decided to utilise technologies and devices already available as well as utilise available information. We highlighted additional focusing in able to get a jump start in the development. We decided not to spend time and money on comparing technologies and gathering information because we saw that there are already many available building blocks for new services although many part were still scattered.

We started with consumer studies, exergame roadmapping and interviews with potential actors. After several workshops and brainstorming sessions, we created two prototypes, Figuremeter and Fitness Adventure, to tackle these problems and encourage people to utilise new concepts for improving wellbeing [1].

This paper first describes the creation process of two Exergame related services, and then moves on to discuss the business area and utilisation possibilities of Exergaming services.

Research methods

The main objective of the Exergame project was to find innovative ways to give positive feedback and playful motivation for people to exercise and grow interest towards their wellbeing. The project focused on preventive healthcare and playful ways for the main focus groups, which are 1) youth, and 2) occupational sport (working people).

We did not want to take a pure technology-driven approach, so we started from future scenarios and concept development. Several innovation workshops were organised to collect and refine initial scenarios and concepts. Workshop participants consisted of experts from various fields involved in the project as well as advisory group company representatives and other interest group members.

In parallel with the workshops, a technology roadmap and a future scenario overview for Exergame technologies was collected and created to help the next stage concept development. From hundreds of items from workshops, ideas were sorted and combined and finally four initial concepts were chosen for further development.

In the beginning of concept development phase, a consumer study of 1,489 respondents was organised to get early feedback to support concept development. Later, the development was narrowed to two prototype concepts: Fitness Adventure and Figuremeter, which were the outcome of the process. The open innovation process used in the project is depicted in Figure 1.

After concept prototype development, a user evaluation for Fitness Adventure was organised. For Figuremeter a commercialisation plan was created.

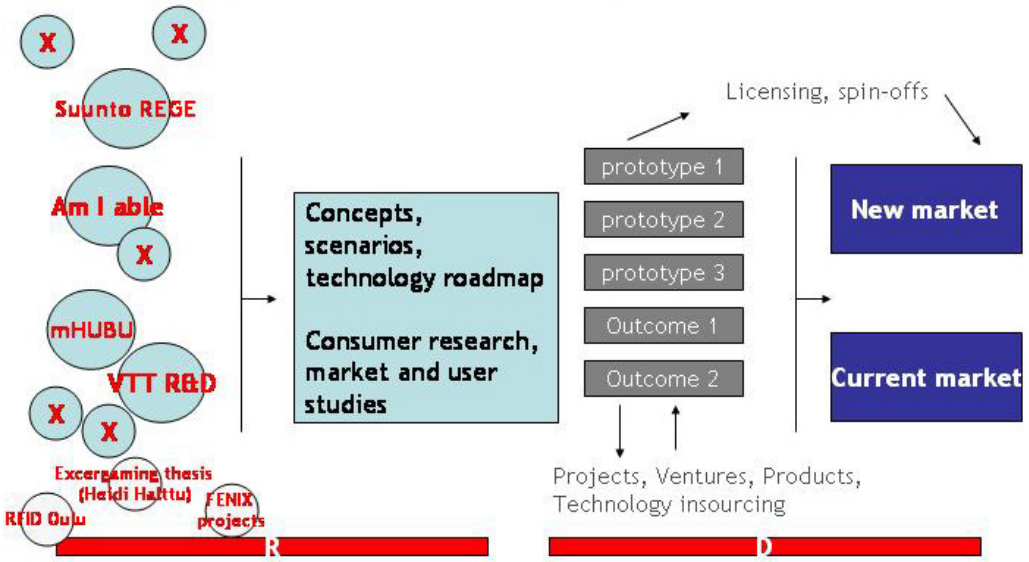

Figure 1. Open innovation process utilised in the project [2].

Consumer study

After the selection of four concepts for further development, a consumer study to support the development was organised. The aim of the study was to examine what factors affect willingness to exercise with new technologically supported playful ways, exergames. We were interested in obtaining whether willingness to participate in exergaming is more closely related to motivations to exercise than to motivations to play computer games. In addition, the relationship between individual computer playing and physical activity was studied. Interest in exergames as well as motivational structures were studied between genders and among respondents at different age groups: adolescents (13 to 18 years old), young adults (19 to 30 years old), workage people (31

to 65 years old), and pensioners (66 to 75 years old). A total of 1,489 respondents answered an internet-based questionnaire. The research method for the consumer study is depicted in Figure 2. [3]

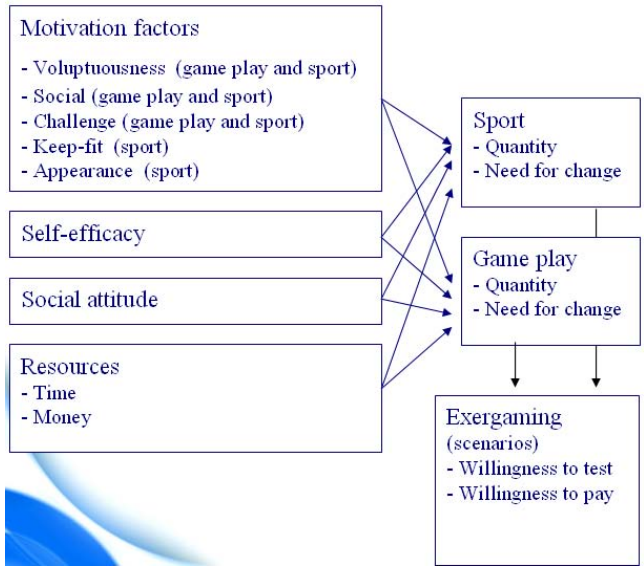

Figure 2. Research method for consumer study (survey).

Technology roadmapping and future scenario overview

A technology roadmap for Exergame technologies was composed to cover a broad area of mobile and wireless cross-media technologies. Another aim was to give a hint how the technologies discussed will evolve over the next five to seven years. Also, the technological and social advances that must be made until the chosen technologies reach the state where they can be efficiently utilised in exergaming concepts were mapped.

Findings and predictions from workshops and other sources were also collected to a future scenario overview of the Exergame technologies. [4]

User evaluation of Fitness Adventure

When a concept prototype of Fitness Adventure was created, a user evalution test was organised. The aim of the evaluation was to collect user feedback of the impact that the Fitness Adventure (FA) application could have on the users' exercise habits as well as the benefits and costs that the application could have. The evaluation took place in September 2006 in the Otaniemi area. First, the users were trained to use the application with the control buttons. Then a short interview was carried out about the users' exercise habits and preferences in gaming and exercising. The users followed the story

of Fitness Adventure from a mobile phone and ran or walked through the routes described in the FA. One of the evaluators observed the users along the route and acted as backup help for the users when needed. [5]

Fitness Adventure prototype

The Fitness Adventure prototype is an application platform supporting physical outdoor exercise. It utilises location information and a mobile phone acts as a terminal device for the game. (Figure 3.)

The aim of the prototype is to combine a mobile game and fitness exercise and thus create new opportunities for the mobile phone to enhance the efficiency of lifestyle improvement and management. The concept is supposed to offer a proactive, locationaware solution that would motivate people to move from place to place with the help of GPS location technology. The person uses the service with his/her own mobile phone. The application allures the person to go out for a walk or a run. It is meant to entertain the user with an interesting fictional story, spiced up with additional information on different sites along the route that the person walks or runs. The concept takes advantage of architecturally interesting buildings, tourist attractions, sights and nature trails around the selected area. Fitness Adventure runs in Series 60 mobile phones and the game itself is a Java application. The game utilises a Bluetooth GPS positioning device. GPS coordinates are transferred to the game software with the GPS reader software. The system recognises the user with GPS location technology as the user enters the spot. [5]

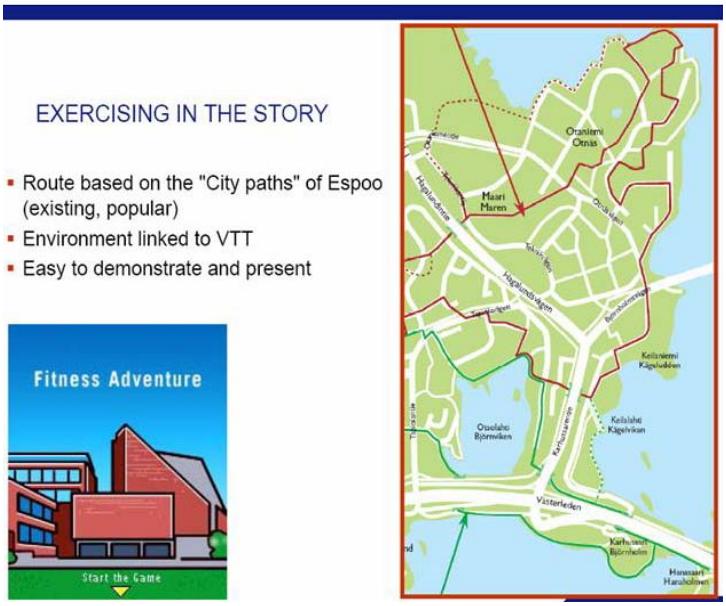

Figure 3. Fitness Adventure.

Figuremeter prototype concept

The Figuremeter concept prototype combiness casual exercise and online communities. Figuremeter consists of a mobile device that measures the physical activity of a user, and software that transfers measured data to a computer and an online community or a game. The aim of Figuremeter is to motivate people to exercise by giving advantages and special abilities in online games and communities according to their real life exercising. Figuremeter device is a combination of a pedometer and cyclometer with wired or wireless connectivity. Figuremeter concept is depicted in Figure 4.

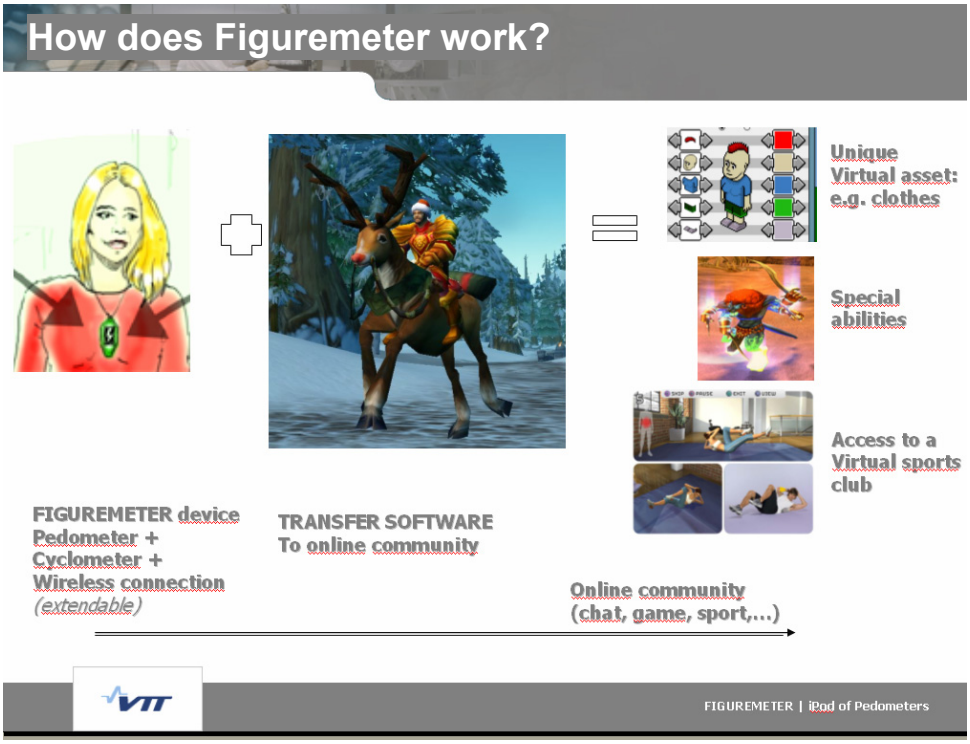

Figure 4. Figuremeter concept.

Exergame business environment

The online gaming market is a growing area with a lot of business potential. Figure 5 depicts the growth of active subscribers for massive multiuser online games (MMOG), which have more than 200,000 subscribers [6]. Novel ideas are needed to keep players active and committed to the game for long times. Online Game Market Forecasted that subscription revenue from online games was $2 billion in 2005 and it was expected to grow to $6.8 billion by 2011. But already in 2007 the PC online game revenue alone passed $7 billion in 2007, not including retail sales. [7] Furthermore, subscription revenue is only one part of the online game business equation. Advertising and digital distribution revenue are also expected to grow significantly.

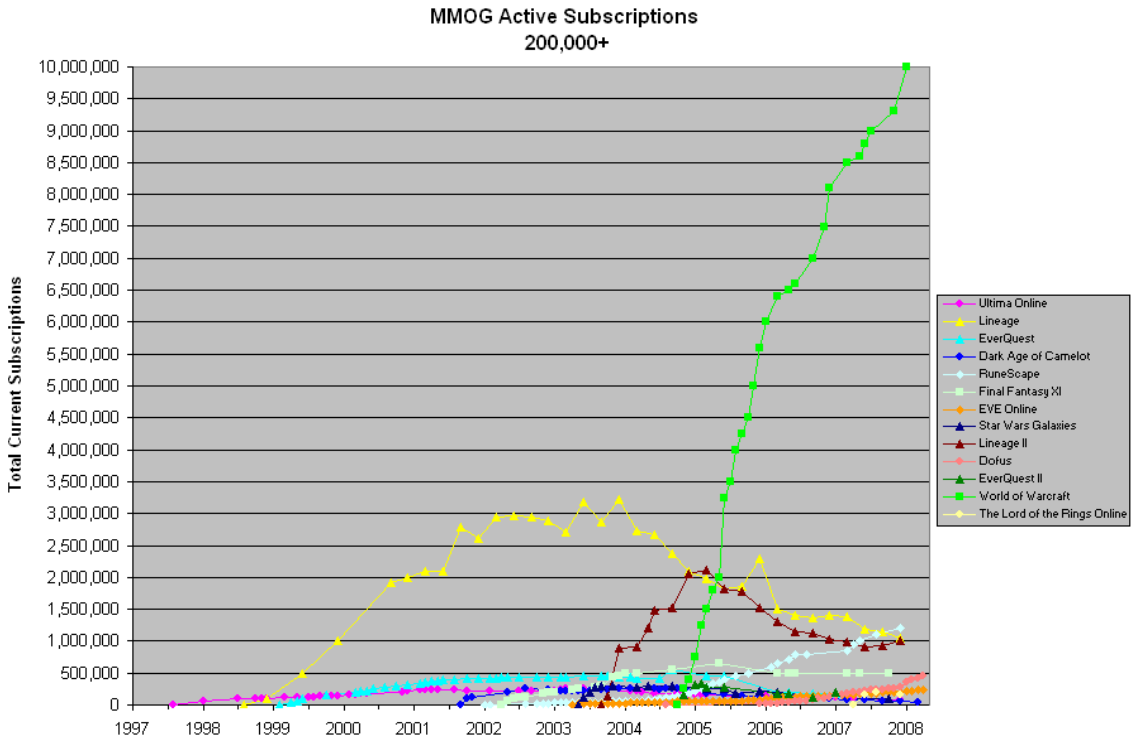

Figure 5. Massive Multiuser Online Games (MMOG) >200,000 active subscribers [6].

Location-based social media is another growing sector. Personal navigation equipment have turned up in everyday devices such as mobile phones and other personal navigator equipment. Existing user GPS devices offer a wide business environment for novel location-based services.

Exergame service providers

The exergaming business area is still an emerging field, but it has already moved from being a field of research to a real business. A huge amount of companies working in the game business already exist, as do other companies working in the exercise business. These existing companies can enhance their service and product offerings by widening their services to the exergame area. For example, game companies have been accused of making games which are too addictive and which immobilise young people. Games can be made even more tempting by combining the real lives of players with the virtual worlds using exergaming concepts. At the same time, when exergaming seduces youth to casual exercise, game companies can raise their social acceptance level. For pure exercise, companies exergaming concepts can make physical exercise more tempting also for current “non-exercisers”, which would increase the customer volume of these companies.

Most computer and video games are currently shackling the player to a console or a computer. The success of massive multiuser online games (MMOGs) and virtual communities have shown that virtual worlds can, in the worst case scenario, take up all of a person's leisure time. Even adding exergame components to these games might not be sufficient to ensure adequate exercise for the "non-exercisers". There is a need for novel game concepts and new game companies which take the exergaming and mobility as their initial starting points when they are defining their game offerings.

Exergaming can also be used in the tourism and experience business to give additional value and new features that are location and user-context aware (e.g. language and preferences) for the customers of these fields.

Last but not least, an aging population and the diminishing resources of public healthcare cause pressure to move resources from treatment to prevention. This opens new opportunities for new exergame related companies, ones which offer services both to the public health care sector and directly to the end users.

Conclusions

Digital life has brought many benefits to humans, but, more negatively, it has also immobilised many people, causing health problems because of unhealthy lifestyles. Gaming and entertainment easily seduce people to neglect physical activities. It is predicted that the worldwide revenue of the video game and interactive entertainment industry will reach $57 billion in 2009 [7]. New service concepts combining real life and virtual communities can be used to tempt people to casual exercise to improve wellbeing. This can also increase the social acceptance of the entertainment industry.

Acknowledgement

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Document-based service platform for telemedicine applications

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Abstract

Telemedicine is increasingly gaining popularity due to its high potential for cost savings and increased efficiency in healthcare. In this paper, we present a generic service platform, which is applicable in a wide range of telemedicine applications and in other areas involving the need for confidential information exchange. The platform particularly addresses the security challenges in the case when the IT technology is outsourced to an external IT company. It also provides semantic interoperability by providing support to HL7 CDA R2 documents. The platform implementation, referred as *PIR document service*, is composed of software components for the health service provider, the IT service provider and the telemedicine customers. These include desktop, mobile and browser-based applications. The platform has been tested in a tele-consultation trial where the Heart Centre of Pirkanmaa Hospital District offered cardiology consultation service for two remote health care units.

Introduction

Telemedicine is increasingly gaining popularity due to its high potential for cost savings and increased efficiency in healthcare. Although there are currently only a few examples of operational telemedicine services, rapid growth in both business-to-business (B2B) and business-to-consumer (B2C) application areas is expected [1]. An interesting opportunity lies in IT outsourcing [2]. Outsourcing allows the health service provider to concentrate on the telemedicine content, while the IT service company takes care of the technology. In this paper, we present a generic service platform, which is applicable in a wide range of telemedicine applications and in other areas involving the need for confidential information exchange [3]. The service platform essentially builds

secure connections between parties over the internet and securely mediates structured and semantic information related to various types of service processes.

Along with the *document engineering* [4] principles, we have identified simple telemedicine process patterns and identified the document exchange needs in two use cases: telecardiology consultation and blood pressure monitoring. In both cases, we have used the HL7 (Health Level 7) CDA R2 (Clinical Document Architecture, release 2) standard as the information model, which provides support for semantic interoperability. Our target has been that all necessary information required by each process is included in the exchanged documents. The document-centric approach is highly attractive since it allows each document to be digitally signed and encrypted. We have implemented document encryption allowing information to be protected during storage at servers, which is a clear security improvement compared to the legacy systems that rely only on the protected connections provided by the *https* protocol. Our implementation, referred to as *PIR (Personal Information Repository) document service* (www.pir.fi), is composed of software components for the telemedicine service provider, the IT service provider and the telemedicine customers. These include desktop, mobile and browser-based applications. These interfaces allow the users to participate in the telemedicine processes referred to above.

Telemedicine service business environment

The telemedicine business is still in its early phase and the business ecosystem is not yet well established. Figure 1 proposes a business architecture, where an IT platform service provider supports a number of telemedicine service providers in their various telemedicine services. As an example, one of the services is telecardiology. The telemedicine service providers may offer services for public or private health service providers (e.g., consultancy) or services directly for the patient (e.g., health monitoring at home). The business model is complicated, since in many cases the telemedicine service user is not the “paying customer”. For example, in services targeted for the patient, the service may be completely or partially paid by the municipalities. The IT platform service provider connects all parties of the telemedicine service processes. The technical infrastructure is typically composed of several elements. In addition to the software platform provider, typically an external hosting service is used for maintaining the required server and communication resources. The service offering may also include the provision of health measurement devices, in which case the IT platform has a business relationship with such companies.

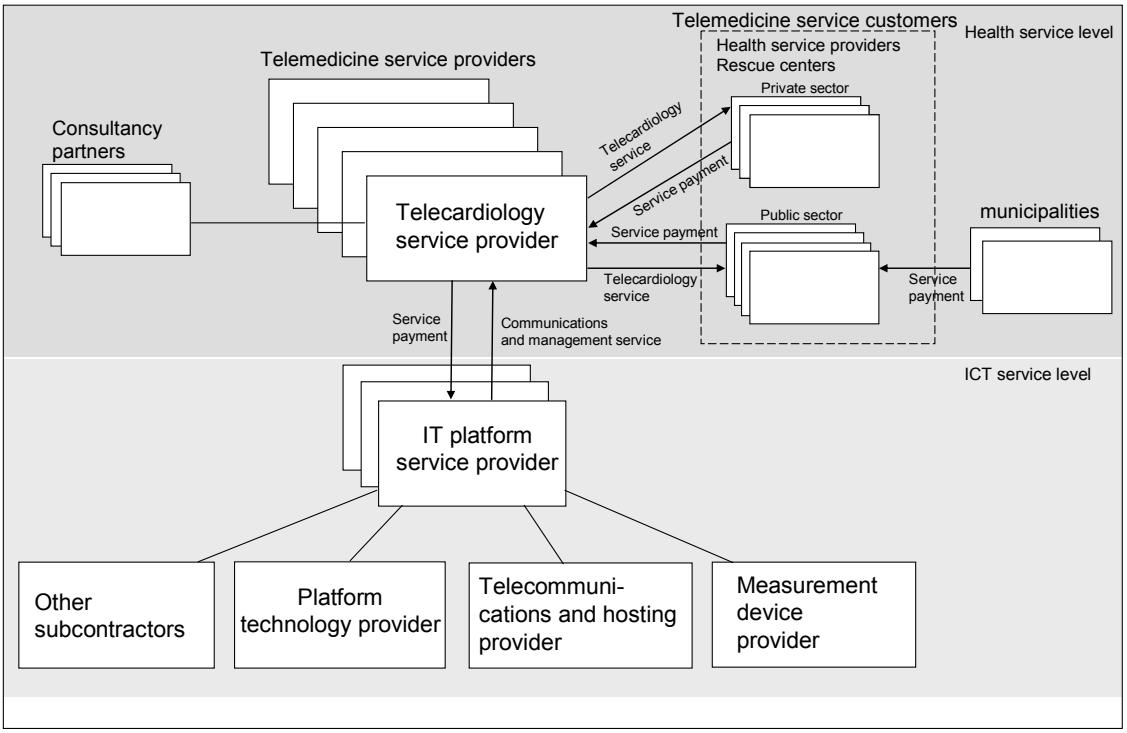

Figure 1. Telemedicine business environment [5].

Remarkable economical benefits could be gained by the outsourcing approach shown in Figure 1, since the same service company could support a wide range of different telemedicine applications. However, currently the problem is that most telemedicine platforms are focused on specific telemedicine applications and can be connected only with a limited set of measurement devices and back-end systems. This complicates the role of the IT platform service provider, since a large number of different telemedicine systems would need to be maintained. The generic service platform described in this paper is expected to reduce operating costs by simplifying the IT service provider role.

Telemedicine processes

In the platform design, we have used two simplified telemedicine processes as use cases: cardiac consultation and home monitoring of blood pressure. Figure 2 provides simplified process flow descriptions, where it is assumed that the service-customer relationship is existing before the process starts. In cardiac consultation, the customer who requests consultation from the service provider starts the process. The service provider who requests the customer to start measurements and reporting initiates the blood pressure monitoring process. From the IT system perspective, the processes are similar. In both cases, the process is essentially a sequence of document exchange actions. Therefore, the central target of the service platform has been to provide a reliable infrastructure for document exchange.

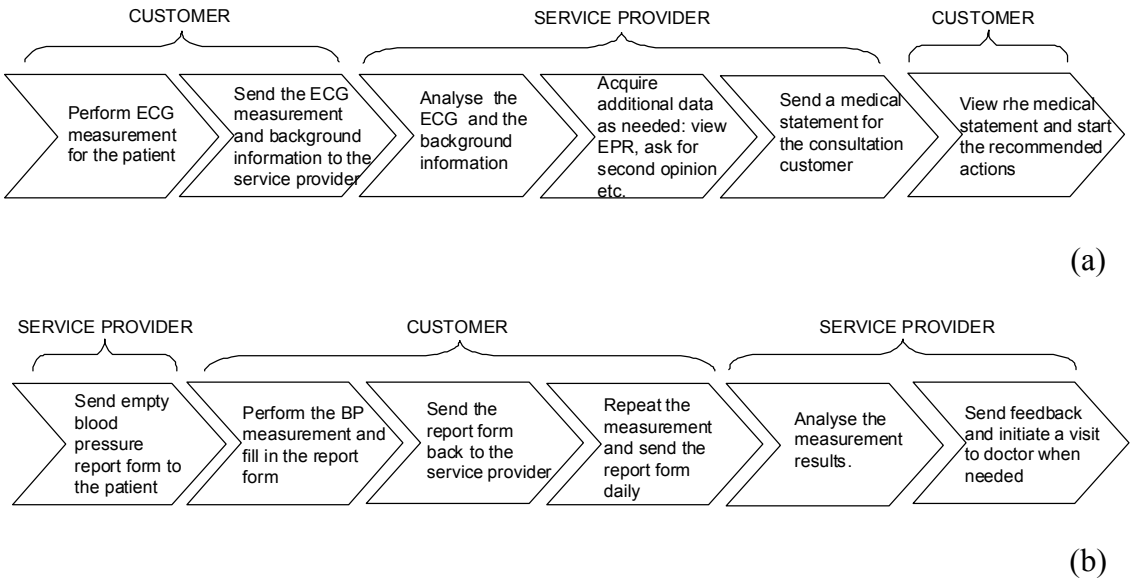

Figure 2. Cardiac consultation and blood pressure (BP) monitoring processes.

Architecture

In the service platform design, we have adopted a division into three layers as shown in Figure 3. The generic platform components provide functionalities for document exchange, service-customer connection building and handling forms. The current form-handling component supports forms of the HL7 CDA R2 type. In addition to the actual telemedicine contents, we have included user interface definition in the documents so that process participation by humans is supported. This has been done by inserting user interface definitions along the W3C's (World Wide Web Consortium) XForms model as local extensions allowed by the HL7 CDA R2 standard. Since the form handling is implemented as an independent component, it is relatively easy to add new components to achieve compatibility with other standards. The generic layer may be used without any application layer components for generic messaging. However, the application layer components are targeted to provide a more user-friendly interface optimised for specific purposes.

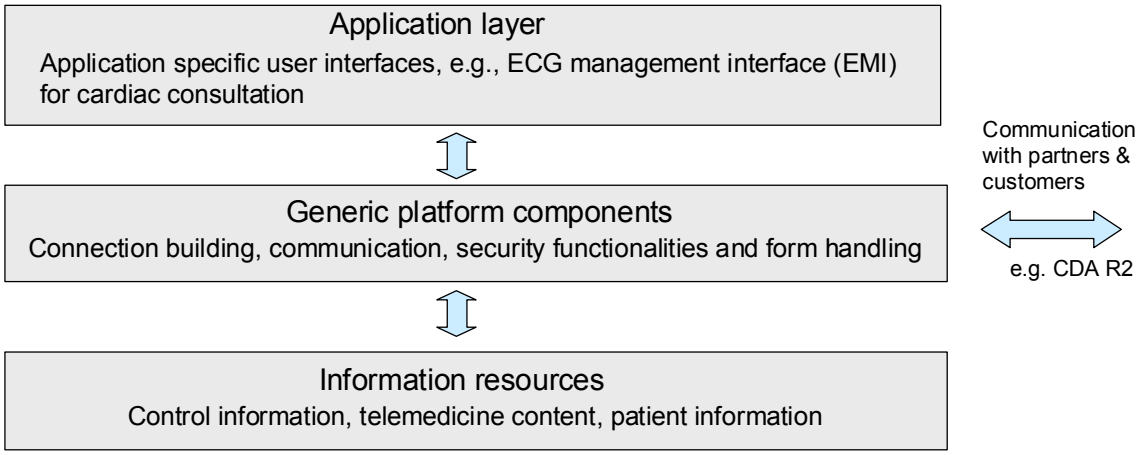

Figure 3. PIR document service layer structure.

The complete PIR document service architecture is shown in Figure 4. The architecture is divided into three parts according to the business model parties. The mediator (IT platform service provider) operates the document server, which handles a large number of connections between *telemedicine service providers* (SP) and *telemedicine customers* (CU). The document server is an intermediate storage to which the transmitting party (SP or CU) stores documents and from which the receiving party retrieves documents. These operations are carried out by using the XML-message based *PIR DS (Document Server) interface* functionalities. PIR DS also provides the functions for establishing and maintaining the secure SP-CU channels. A browser based *Admin Tool* is used for the administration of the document server. Two client applications, *PIR Mailer* and *PIR Case*, are running on the service provider and customer side, respectively. The customer may use the browser instead of the PIR Case application. In this case, the *BR (browser) front-end server* acts as persistent document storage and adapts the browser to the PIR DS interface. Furthermore, the customer may use a mobile phone as the user interface and document storage device. In this case, the *MP (mobile profile) front-end server* matches the mobile *UPHIAC (Universal Personal Health Information Access)* application to the PIR DS interface [6]. Both the service provider and the customer may use either local (workstation specific) or shared storage for documents (SP and CU storages). The most relevant solution depends on the use case.

Due to the open interfaces, it is possible to develop PIR compatible applications. These can be developed at two levels. Any PIR DS compatible application may be connected to the document server. This way, access to information contents can be provided through custom interfaces. On the other hand, *PIR DB (database)* compatible applications may be developed. In this case, the PIR Mailer or PIR Case application is used in background mode for document sending and receiving while the PIR DB compatible application uses the document contents. The EMI component described in the next section is one example of a PIR DB compatible application. When PIR is used

for reporting measurement results (e.g., health monitoring), there may be a need for connecting measurement devices to PIR Case and UPHIAC applications. PIR is not restricted to any specific device interface specification.

PIR document service provides alerting the receiver by SMS (Short Message Service) messages and by email concerning incoming documents. This functionality is supported by the corresponding messages of the PIR DS interface. The alerts are launched from the document server by using the SMS and SMTP (Simple Mail Transmission Protocol) interfaces.

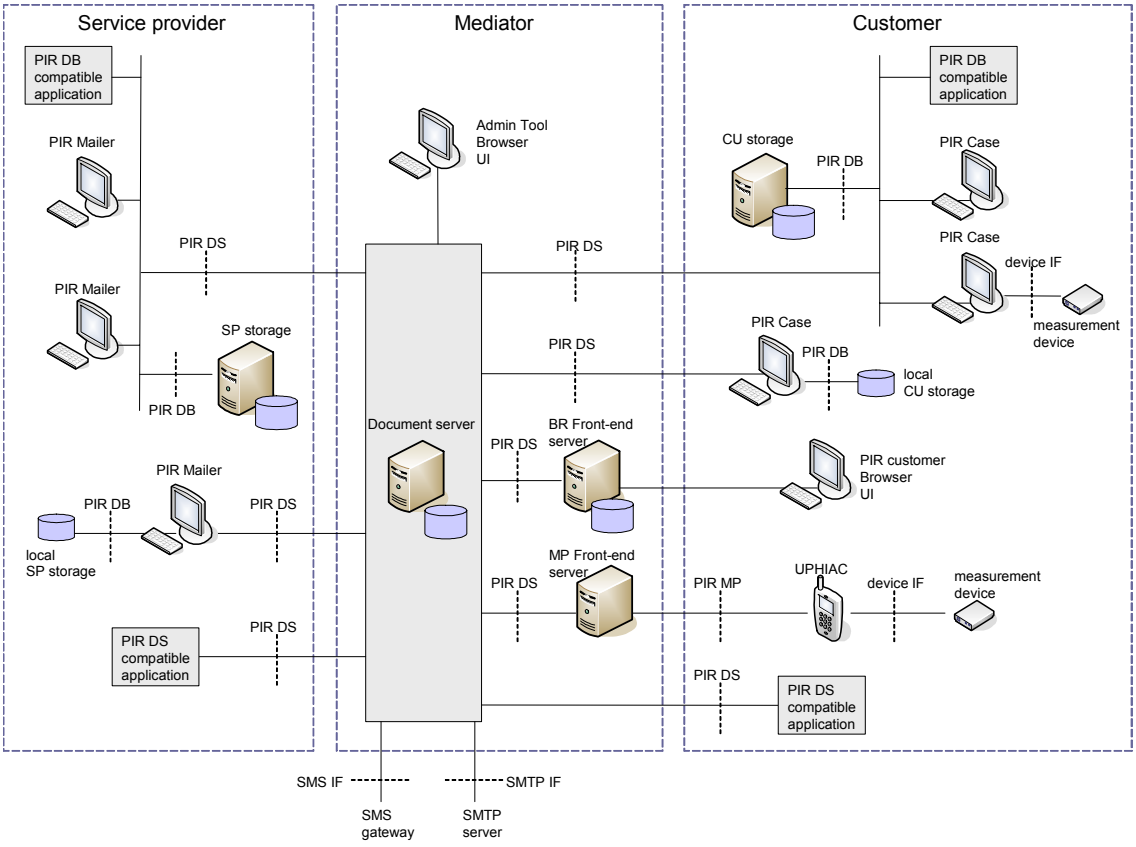

Figure 4. PIR document service architecture.

User interfaces

The Electrocardiogram Management Interface (EMI) user interface (Figure 5) supports the cardiac consultation process. The goal of the EMI design was to provide – not only a cardiac consultation application – but also a generic user interface that could be adapted with minimal customization to various telemedicine processes. EMI provides a front-end for the PIR Mailer (on the service provider side) and PIR Case (on the client side) document services.

EMI organises the incoming consultation requests into tasks. One task will include all documents and messages related to a particular consultation case of a specific patient. The main EMI display is the dynamically updated list of active tasks. The incoming consultation requests and other incoming documents will appear in the task list as well. Each incoming consultation request will be attached to new consultation tasks for further action by the consultant on duty. For each task and incoming document, EMI displays header information such as the request's urgency and the patient's age group.

During the consultation process, documents such as ECG (electrocardiogram) graphs can be attached to an active task. The consultation form can also be forwarded for a second opinion to another telecardiology service provider. Finally, the form will be complemented with the doctor's medical certificate and returned back to the consultation client. The task can be considered as completed and closed. The closed tasks will be achieved for later reference.

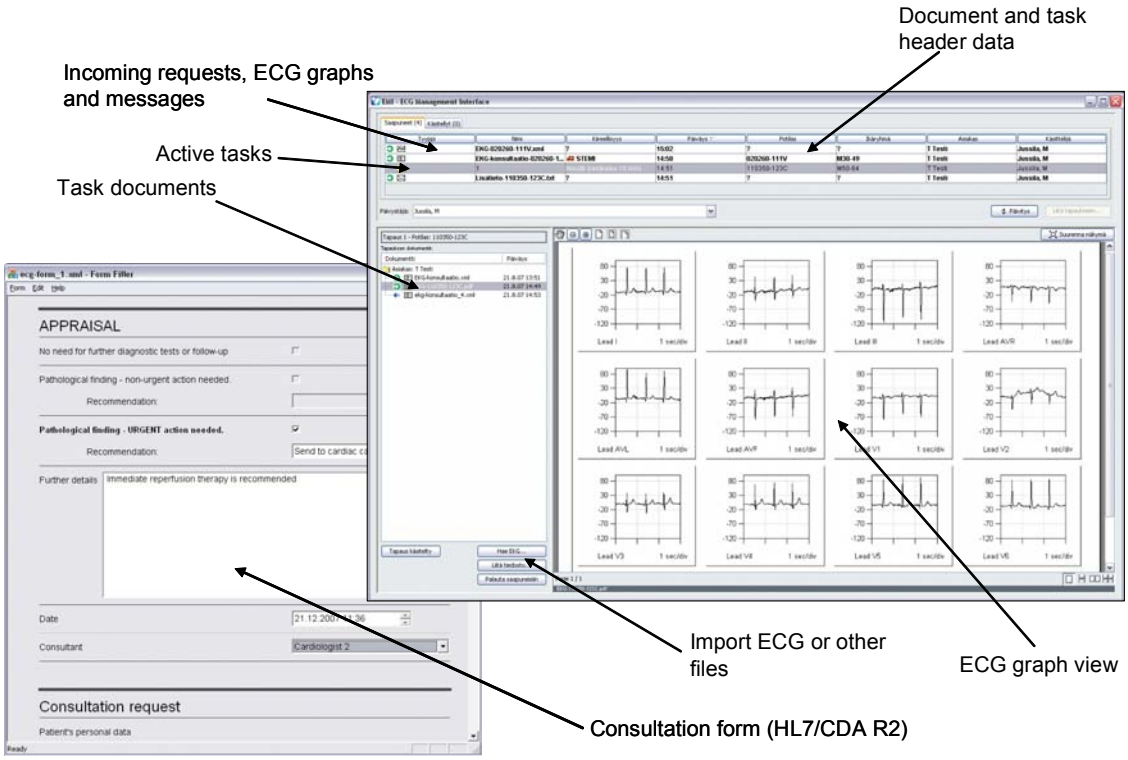

Figure 5. ECG Management Interface (EMI) for cardiac consultation.

UPHIAC provides a customer side application for managing health documents through a mobile phone [6]. The mobile application is capable of accessing the document server over the internet and it provides a Bluetooth interface for measurement devices. The mobile application can receive free text messages or form templates, e.g., questionnaires concerning the user's health from the service provider, and store them locally. On the other hand, the mobile application user can send free text messages to the service

provider, or the user can complete the questionnaire forms based on the received form templates and send them to the service provider. The automatic mode allows the mobile application to read data from the measurement device and to forward the data to the service provider in structured form.

Figure 6 shows examples of the mobile application user interface: The examples from left to right are (a) free text message has been sent to service provider, (b) free text message from the service provider has just been notified to the user, (c) form template from the service provider has just been notified to the user, (d) form is under work by the user to be completed.

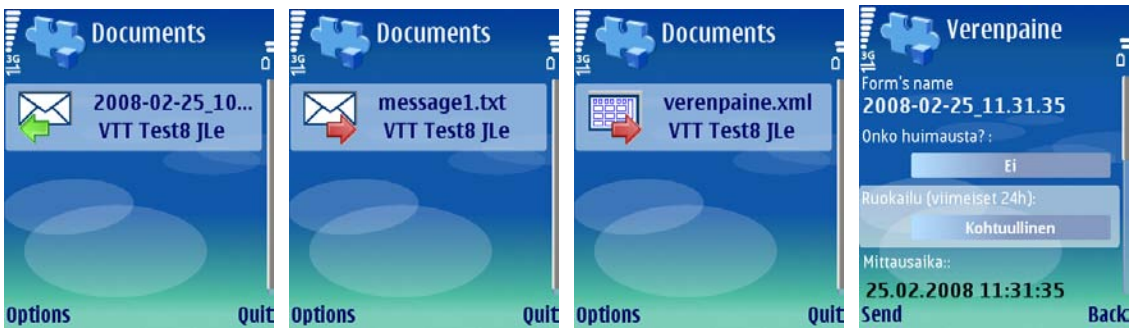

Figure 6. UPHIAC application in blood pressure monitoring use case.

Telecardiology pilot

In the pilot, the Tampere Heart Centre provided telecardiology consultation service for one health centre and for the emergency department of a small hospital. During the pilot, the 12-lead ECGs were immediately stored into a digital ECG archive, with immediate access for the cardiologist to the recordings and, if available, to previous recordings for comparison. The PIR document service was used in delivering consultation requests, responses and other related documents. The pilot comprised thirty consultations. In ten patients, there was a recommendation for change in medication, in five cases, the patient was sent to the emergency department of the Tampere University Hospital, in two of the cases, the physician who asked for consultation had not identified case urgency. It was estimated that in five cases, a planned consultation to cardiologist was avoided thanks to telemedicine consultation, although the pilot process did not involve exact appreciation of how the handling of patients was affected. In four cases, non-urgent referral to a cardiologist was recommended. In most of these cases, the treating physician had planned to send the patient to a specialist. In two patients, an arrhythmia was identified: one necessitated change of medication, and one was potentially fatal. Two cases with silent myocardial infarction and one with unrecognized acute ischemia were noted.

The results of a questionnaire addressing usability of the service, foreseen benefits and the needs concerning operative use, are summarised in Table 1. Each row represents one multiple-choice question. The columns represent the available choices showing the number of received responses for each choice.

Table 1. Telecardiology pilot questionnaire results. Number of received responses and their division (consultation provider/consultation requestor) for each reply option is given (= response only from the consultation requestor). [5]*

Experienced usability	very easy 2 (0/2)	**relatively easy** **6 (3/3)**	relatively difficult 0	very difficult 0	no opinion 1 (1/0)
Experienced security	very secure 2 (1/1)	**relatively secure** **6 (2/4)**	somewhat unsecure 0	very unsecure 0	no opinion 1 (1/0)
Technical problems	no problems 3 (1/2)	**only small** **3 (0/3)**	some 2 (2/0)	many 0	no opinion 1 (1/0)
Benefit for organisation	**high** **6 (1/5)**	relatively high 3 (3/0)	not very high 0	no benefit 0	no opinion 0
Benefit for patient	**high** **7 (3/4)**	relatively high 1 (1/0)	not very high 0	no benefit 0	no opinion 1 (0/1)
Operational service *	**will certainly use** **5**	will likely use 0	will likely not use 0	will not use 0	no opinion 0
Expected need *	several times a day 0	once a day 1	**2-3 times a week** **3**	once a week or less 0	no opinion 1
Feasible price *	100-150€ 0	**75-100€** **2**	50-75€ 1	25-50€ 0	no opinion 2

Discussion and conlusions

The currently available telemedicine service platforms are typically focused to limited telemedicine areas and measurement devices. The PIR document service provides a generic platform with the objective to support an extremely wide spectrum of different applications in the field of telemedicine and beyond. Application specific support is obtained by specific components, which can be easily connected by using open interfaces, in particular the database interface PIR DB and the document server interface PIR DS.

The proposed document-based approach is attractive in many respects. The HL7 CDA R2 document model used is an international standard, which is widely being adopted for Electronic Patient Record (EPR) systems [7]. This provides a good potential for semantic interoperability between the telemedicine system and other patient information resources. On the other hand, the document-based approach allows complete recording of the service process (in the form of a document archive) at both the customer and the service provider side. By adding digital signatures to the documents, non-repudiation of all interactions can be achieved. Digital signature is not yet implemented in PIR, but is included in the future development plans.

Although standard document formats are used and open interfaces are provided by the PIR document service, interoperability remains the main challenge. For example, the existing EPR software vendors provide only limited support for integration with other systems. Improvement in this respect may take place as centralised health information archives ("national EPRs") are being established in many countries, including Finland. The national EPRs are providing standard interfaces through which health information can be inserted and accessed, along with the consent provided by patient.

The pilot hosted by the Tampere Heart Centre showed that a cardiac consultation service is useful even without full integration with the EPR. In the pilot, the EPR could be opened in another window while providing the consultation response. On the other hand, the necessary texts could be moved to the EPR by using the clipboard. Both the Heart Centre cardiologists and the physicians of the remote units considered the benefits of the consultation service to be high. In the consultation cases, cardiology diagnostics and medication could be refined and guidance for patient logistics was provided. The physicians considered it feasible to use a commercial consultation service when available.

Acknowledgement

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Personal health services for occupational health care – an analysis of stakeholders

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Abstract

The Nuadu project is concerned with developing and evaluating technology to allow people to maintain or improve their personal health. In Finland, the main focus of the project is on health promotion and utilization of personal health systems in occupational health care. In order to better understand the business potential of these preventive health management solutions, a stakeholder analysis was conducted related to the Finnish occupational health care system. The roles of different stakeholders were analysed using a power-interest matrix. Opportunities and roadblocks for a preventive health strategy in occupational health care were identified.

Introduction

Stakeholder analysis aims to evaluate and understand stakeholders from the perspective of an organization, or to determine their relevance to a project or policy. In carrying out the analysis, questions are asked about the position, interest, influence, interrelations, networks and other characteristics of stakeholders, with reference to their past, present positions and future potential. [1, 2]

There are several ways to identify and classify the stakeholders. Essentially, all these models seek to identify groups of stakeholders that can block or support new strategic developments, and to give advice as to how the influence of supportive stakeholders could be maximized and the influence of unsupportive stakeholders negated. In this study, we have used a "power-interest matrix", developed by Johnson and Scholes. [3]

The diversity of the stakeholders has lead to various classification structures in the literature – e.g. Clarkson discusses the primary and the secondary stakeholders. [4] In

the Nuadu stakeholder analysis we rather created several layers of various stakeholders. Thus the individuals, their employers and various OHS providers can be see as the key stakeholders. The various "enablers" (pension funds, government, funding agencies, labour market parties, etc.) are seen as other important stakeholders. The classification of stakeholders used in this analysis is presented in Figure 1.

The methodology of the Nuadu stakeholder analysis followed the conventional conduct of the analysis, comprising of

- identification of the important stakeholders
- mapping and assessing their positions and views
- undertaking a diagnosis of their positions and views
- presenting key positions and views in regard to the Nuadu project. [5]

The work methods included desk research and structured, thematic interviews with representatives of key stakeholders. The interviews were undertaken during winter and spring 2007.

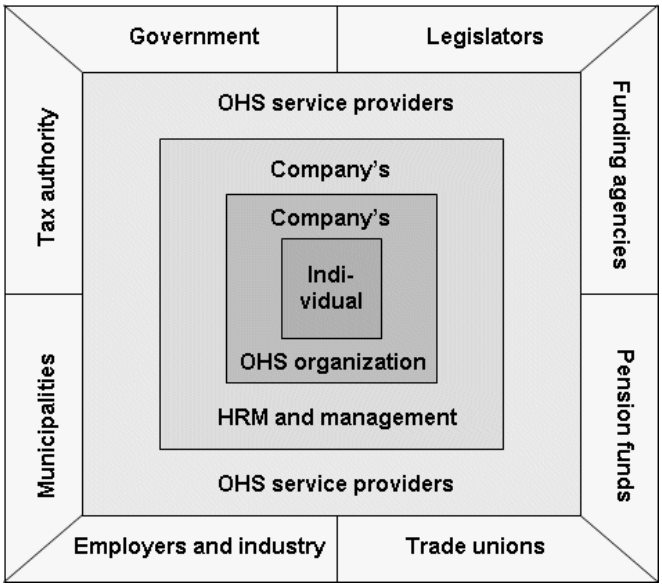

Figure 1. Key stakeholders in occupational health care.

Key enablers of occupational health services

The framework of the Finnish occupational health system (OHS) is based on a three-partite principle: the government authorities together with labour market organizations are involved in the preparation, approval and implementation of occupational health strategies and actions. The goal is to ensure effective OHS resolutions and their practical implementation.

A large number of actors with a multitude of responsibilities must cooperate in maintaining the health and working capacity of employees (see Figure 1). The Finnish Institute of Occupational Health – part of The Ministry of Social Affairs and Health – has the main responsibility in the development of the occupational health development strategy. Other parties include trade unions, the Social Insurance Institution (Kela), local authorities, occupational health care expert organizations and units responsible for occupational health care. These key enablers in occupational health work have somewhat different preferences, which are being settled through collective bargaining and agreements, as well as tripartite collaboration. [6]

National health insurance and tax policies strongly influence the availability of various levels of occupational health services. Kela (The Social Insurance Institution of Finland) reimburses 50% of selected OHS expenses to the employer. Tax authority accepts the remaining cost as tax-deductible costs. While these financial subventions by the government have proven to be effective in promoting safety and health at work, they do not seem to be the real trigger for companies to organize novel occupational health services with long-term benefits. This is partly due to the fact that new proactive measures, such as the use of technologies for promoting wellness and healthy life-style, do not justify subvention by the insurance and tax authorities.

The need for a holistic view on OHS development, reflecting the changing business and operational environment, was emphasized in our interviews. The challenges of occupational health today are quite different from the time when our OHS system was created. While the main focus was earlier on safety at work, one now needs to address multiple issues affecting the employee's health status, such as health promotion, prevention and early detection of health problems, rehabilitation as well as management of chronic illnesses.

Recently, work-related mental problems have become a significant reason for the absences from work. This is a new kind of challenge for the organization's occupational health organization, where collaboration of company's OHS organization together with company's HR and general management, as well as specialized healthcare providers, is needed. Mental well-being has been selected as one of the strategic priorities in the occupational health strategy, published by the Ministry of Social Affairs in 2004. [7]

Stakeholder analysis

The main issues to be studied in the Nuadu project are the feasibility of health promotion and management through occupational health services and the utilization of personal health systems in occupational health care.

The adoption of these proactive and preventive methods can be seen as a strategic change in occupational healthcare, requiring support from several key stakeholders. The ease or difficulty in implementing these changes can be studied using a "power-interest matrix", where

- *Power* indicates the level of influence a stakeholder has in either supporting or resisting a strategic initiative. Stakeholders may exercise their power in many ways, for example through a legal position, possession of knowledge and key resources or even informal networking with other decision makers.
- The *interest* of a particular stakeholder depends on how high this strategy is on their priorities. Interests can be open or "hidden", which makes their assessment challenging. Interests may be based on stakeholder's anticipated economic gain, brand value or power position. The level of interest can be estimated by assessing whether a stakeholder has a long-term commitment to the strategy.

An analysis of the power and interest of each stakeholder is summarized in Table 1. Scores (high, medium, low) are given to indicate the level of power/interest of each stakeholder. This scoring is then used for building a power-interest matrix, presented in Figure 2.

Table 1. Power-interest analysis of the stakeholders.

Stakeholder	**Power/influence**	**P score**	**Interest**	**I score**
Individuals (active)	Responsibility over individual's own health is a prerequisite for the success of proactive health measures. Active individuals are promoters of healthy lifestyles. Active individuals will also use personal financial resources to promote their individual health.	M	There is a large disparity between groups with different socioeconomic status. The number of active individuals is growing. They can see the benefit in improved personal and working ability.	H
Individuals (passive)	No contribution to personal or corporate wellness development activities.	L	Lacking interest, rather resistance towards healthy lifestyle. Need external motivation to participate health programs.	L
Large employers	Large employers are usually interested in supporting health promotion of their employees. Appropriate OHS can also be seen as a competitive advantage in the race for talent.	M	The need for a more holistic and proactive approach in occupational health is recognized. Health promotion has a great potential of improving the cost-effectiveness of the OHS system – but the benefits do not materialize in the short term.	M
Small employers	Small and micro enterprises do not currently have resources for proactive health measures. The small employers also miss other active HRM (Human Resources Management) efforts.	L	Not a priority for small enterprises. Neither do the organizations representing these enterprises have OHS as a preference.	L

OHS providers	OHS providers are seeking more strategic partnerships with their customers. Potential linkages between pension funds and OHS providers could eventually lead to a new landscape for preventive OHS.	M	Current business model based on charges per services – alternative "service contract" model could provide incentive for proactive health measures.	H
Ministry of Social Affairs and Health	Main responsibility in the formulation and implementation of the occupational health development strategy.	H	The importance of preventive healthcare is emphasized in Finnish legislation and health-related policy programmes.	H
Kela	National health insurance strongly influence the availability of novel occupational health services.	H	Benefit through a lower number of work-related insurance claims. (Proactive health care costs, however, do generally not justify subvention from the social insurance.)	M
Tax Authority	Tax policies and regulations define which OHS costs the employers can claim as tax-deductable costs.	M	OHS is not a key priority, as the Tax Authority follows in their practice the guidelines defined by government.	L
Pension funds	Pension funds have huge financial resources at hand, e.g., to prevent early retirement by improving the health conditions of the insured persons. Pension funds have power on vocational rehabilitation decisions.	M	Considerable benefits in avoiding expenses caused by preventing disability and early retirement. Value-added services are critical in the competition between pension funds, because in Finland they do not compete with prices and other financial benefits.	H
Labour market parties: Employer organizations	Labour market parties together with the government authorities form a three-partite forum for preparation and implementation of OHS strategies. The support or opposition of labour market parties can be decisive for the success of workplace initiatives.	M	Labour market parties have somewhat different preferences. Employee organizations are alarmed by the figures of absenteeism and appreciate life-style related health problems. The employer organizations also have clear policy targets.	M
Labour market parties: Trade unions	Labour market parties together with the government authorities form a three-partite forum for preparation and implementation of OHS strategies. The support or opposition of labour market parties can be decisive for the success of workplace initiatives.	M	The main focus of trade unions is on preventing occupational diseases and accidents. Thus their approach is more conventional and the emphasis is not strongly on proactive OHS services.	L
Technology providers	Enablers of new technology-based business models for occupational health care.	L	Occupational health could potentially become a new market for technology products.	M
Service providers	Service providers could be working as "service integrators", but they have to establish their role.	L	Service providers see health promotion solutions as their core field of interest. However, feasible business models have yet to be developed.	M
Finnish Institute of Occupational Health (FiOH)	FiOH is a research and specialist organization in the sector of occupational health and safety, but in policy making it is in an advisory role.	M	As a leading and well-resourced organization, the FiOH has its key interest in occupational health care and its development.	H

Figure 2 summarizes the findings of the stakeholder analysis in a two-dimensional power-interest matrix. Stakeholders are divided into four groups: policy makers and

implementors (marked with symbol 0), service providers (1), technology/tool providers (2) and customers (3). According to our analysis, stakeholders in the upper right corner (high/medium power and interest) are key players in driving the change toward proactive occupational health care.

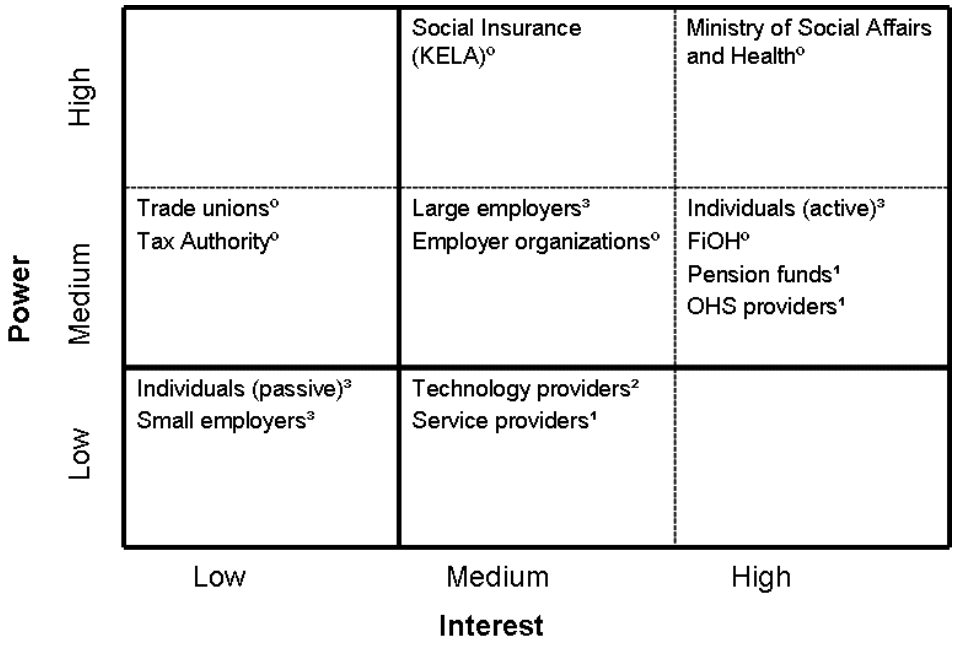

Figure 2. Power-interest matrix.

Basically, in occupational health care the customers (and thus direct beneficiaries of its operations) are both the individual employees as well as the employer itself. However, well organized occupational health care also creates value for many indirect beneficiaries of its operations. For example, public health care will most likely in the long run benefit from the prevention and promotion activities undertaken by the occupational health services. The other stakeholders benefiting from the occupational health care include pension funds (e.g. through longer working careers of the employees) and insurance companies (e.g. through lower number of work-related insurance claims). [8]

An individual's commitment is critical to the success of any health promotion initiative. In the context of occupational health services, an individual actively participates in the "value co-creation", seen as a joint effort of an employee, employer, health service providers and other stakeholders. There are, however, large disparities among individuals in their motivation to take care of their personal health. Active individuals keep up their good health and avoid hazardous life styles. They are open to try what kind of added value personal health tools can bring and can serve as powerful forerunners in the development and adoption of new tools and services for personal health. Passive individuals, on the other hand, lack self-initiative and need much more

systematic motivation and coaching in order to keep up a healthy life style. This is contradictory, because passive individuals are the target group where preventive health care can result in the biggest gains.

There is a large disparity in the way occupational health services are organized among different companies and organizations. Provision of occupational health services to the employees is especially problematic to the small and micro-enterprises. They are typically able to offer for their employees just a bare minimum required by the law. Considering that a great majority of Finnish companies belong to this category, it is necessary to develop novel models of occupational health services that are suitable for SMEs, especially in preventive health care.

The conclusion of our analysis is, firstly, that there are no stakeholders strongly opposing the proposed adoption of health promotion and personal health tools in occupational healthcare. There are, however, great differences in the level of interest among various stakeholders – even some resistance due to different views of OHS system development priorities and allocation of financial resources.

Taking the generally positive attitude towards health promotion among key stakeholders, what is then hindering its implementation? One reason is the difficulty of calculating the return on investments made on health promotion and personal health systems in occupational health care. This is due to the fact that these benefits are long-term by character and may be overridden by more immediate needs. Evidence on the benefits of utilizing personal health systems and technologies is necessary to convince decision makers about the value of these tools.

Secondly, health promotion in general is a very fragmented market, and there is no single stakeholder that is ultimately responsible for its results. The role of the service provider is further complicated by the fact that the buyer, user and payer can be separate entities with disparate interests. [9] Implementation of personal health systems in this kind of a value network, with many interconnections between different parties, would require an orchestrator, or “service integrator” composing appropriate value proposals to customers from the existing provision in the market.

According to our analysis, the Ministry of Social Affairs and Health has a key role in driving the strategic change toward health promotion in occupational health care. The Ministry, together with the Social Insurance Institution (Kela), is in the position to initiate the necessary policy changes and practices affecting the occupational health system. Some of the direct beneficiaries, such as pension funds and OHS providers, could be the driving force behind the strategy implementation. It is also crucial for the success to keep other stakeholders (most notably trade unions, employer organizations

and tax authorities) well informed and involved in the preparation of this proactive health strategy. Finally, selected forerunner organizations (including OHS service providers, technology and service providers and large employers) are needed to serve as pioneers in the new approach.

Discussion

Occupational health system provides a unique access to individuals who are still relatively healthy, but who are at risk of future diseases because of an unhealthy lifestyle.

The benefits of preventive measures of the occupational health system can be seen, not only by the employer, but also widely in the society. However, it is challenging to find methods to measure this efficiency and use it as an incentive for the occupational health provider. The matter is further complicated by the fact that the buyer, user and payer can be separate entities with disparate interests.

Therefore, it is essential to find the parties who have the power and motivation to act as pioneers for this strategic change in occupational health promotion. One of the observations made in this study is the important role of service integrators, who can compose technical and existing service components into an appropriate value proposal. These integrators are currently largely lacking.

Innovations that require the collaboration of many stakeholders are slow to reach their full potential, and it is important to refrain from promising too much too soon. It seems inevitable that in the long run the use of ICT will become widespread in workplace health promotion. In the interim, developers need to find niches where they can profitably refine their technologies, build interoperability, and gain credibility in the eyes of the incumbents. [7, 8]

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Integration and visualisation of highly complex biological and medical data: Application to Lamin A/C mutation

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Abstract

In today's world, we are surrounded by systems that generate vast amounts of data. Consequently, there is an increasing gap between the data generated and the actual usable information extracted from it. We provide new software solutions to address this problem, focusing on the integration of biological and medical data. We developed a *megNet*® software platform that affords the fusing of heterogeneous lifescience and medical data and their visualisation. We demonstrate the software platform utility by integrating imaging and metabolomics data in a case study of patients carrying the Lamin A/C mutation which causes dilated cardiomyopathy.

Introduction

Technological developments over the past decades have empowered us with the ability to acquire, process and store vast amounts of life science and medical data: hundreds of biological databases exist around the world, a high number of different signals is currently recorded during anaesthesia or critical care, and modern hospitals acquire yearly tens of terabytes of image data. Various databases and medical records contain plenty of hidden information. Information on the normal variation of physiology and anatomy exists in databases, but it has not yet been extracted and cannot be therefore utilised to improve patient diagnosis. Although the human genome has already been sequenced by the Human genome project [1], the understanding of a human at a system level and understanding the pathogenesis of different diseases is still at a very early phase. Full integration of the heterogeneous information in biological and medical databases will start a new era where complex relations between genes, environment and different diseases are better understood.

Our overall objective is to develop a comprehensive visualisation and modelling framework for enabling a multi-level integration of biological and clinical data. We aim to address the emergent needs in healthcare: improved diagnostics of complex diseases, early prediction of disease risk for better prevention strategies, and development of novel therapies. This work concentrates on integrating clinical image data with biological data. We demonstrate the use of our *megNet*® software framework using data from a patient population having Lamin A/C mutation causing dilated cardiomyopathy [2].

Several approaches for biological data integration have been developed. Well-known examples include rule-based links such as SRS [3], federated middleware frameworks such as Kleisli system [4], as well as wrapper-based solutions using query optimisation such as IBM Discovery Link [5]. However, we are not aware of software solutions where image-based measures are systematically combined with omics (e.g., proteomics, metabolomics) based measures, and finally applied in diagnostics. In this work, we present a first prototype towards this kind of system.

Methods

Data integration techniques

We developed a visualisation technique that affords qualitative visual analysis of both the subject-to-group and group-to-group differences in the image- and omics-based measures simultaneously. This technique, the so-called fingerprint technique [6], is based on colour-coded boxes that demonstrate both the magnitude and the sign of the differences and their statistical significance, as compared to a reference group (typically a control group of healthy volunteers).

In the fingerprint visualisation, the boxes corresponding to individual measures are ordered so that the measure having the largest differences statistically between the study and control groups is located at the top, and the rest of the measures are ordered below respectively. The only measures shown are the ones that have statistically significant differences between the study and control groups, and therefore have diagnostic importance.

When comparing the study and control groups, the colour codes of the boxes are obtained from the statistical differences between the two groups. If the measure values of the study group are much larger than the values of the control group, the colour used is dark red. On the other hand, if the measure values are smaller in the study group blue colours are used. If the differences are minor, light shades of red and blue are used. The group-wise comparison gives a fingerprint for the disease from which one can easily and quickly perceive the differences between the two groups (for example, how the disease affects the functioning of the heart).

In subject-to-group comparison, the colours describe how well the measure value of a subject fits the distributions of the study and control groups. If it fits well to the distribution of the study group, dark red (blue) is used if the related box of the study group is red (blue). If then the measure value fits better to the values of the control group, opposite colours are used, and if the measure value fits equally well to both groups, a white colour is used for the box. Subject-to-group visualisation provides a fingerprint for the subject. The colour codes of the group-to-group and subject-to-group analyses are comparable. Consequently, the visualisations can be used to study how well the subject fits to the patient group by comparing the fingerprint of the subject with the fingerprint of the disease.

Software architecture

The development of *megNet*® software framework was based on the tool developed previously in our group [7]. It is a client-server software architecture where heavy computations are performed on the server and results are transmitted to the client for visualisation and analysis.

The core architecture of our data integration and visualisation system, called *megNet*, is composed of three layers: back-end, middle tier and front-end [8]. The data, schema maps, and ontology definitions constitute the back-end layer. Most of our local data are represented in XML or RDF formats. The data is stored using XML data management system Tamino XML server (Software AG) in a Redhat Linux Advanced Server v3.0 environment. The databases are queried using Tamino X-Query which is based on XPath 1.0 specification. The queries are enabled through the Tamino Java API. For storing more voluminous data such as gene expression data and in house produced mass spectrometry data, we use Oracle 10g database server (Oracle, Inc.). The Oracle queries are performed using Oracle JDBC Thin drivers. The results obtained from queries to Tamino and Oracle are combined at the Java programming level in the middle tier. The server provides interfaces for several methods that the client can use:

- construction of graphs from complex rules,
- getting information about graph entities,
- modification of graphs,
- text mining for locating interesting sample data,
- computation of correlation between samples, and
- computation of mappings from graph connections: Curvilinear Distance Analysis (CDA), Curvilinear Component Analysis (CCA), Principal Component Analysis (PCA), and Sammons Mapping.

Message passing between the client and server is implemented with Web Services. That is, they communicate using XML messages that follow the SOAP standard. There is also a machine-readable description of the operations offered by the service written in a Web Services Description Language (WSDL) file. This file is a prerequisite for automated client-side code generation that is utilised in the *megNet*® client software building process.

The client-side architecture consists of a main application and four independent and custom-made libraries that each offer important functionality to the main application.

- *megNet*® – main application and domain specific functionality,
- Workbench – platform for implementing scientific visualisation software,
- Services – library for creating service-oriented application architecture,
- Graphs – library for graph management and layout, and
- Clustering – library for computing clustering.

The most important component of the client software is naturally *megNet*® itself, which contains all application-specific code. It is the one communicating with the server, customizing what is being displayed on the screen, creating messages and events, and handling most of the data management. Workbench provides a user interface platform that allows loading of many document types into one windowing environment. It also defines how documents, views, messages, input, and tasks are created and handled. The Services library separates implementation of functionality from the interfaces and facilitates construction of the application from modules that are not heavily coupled with each other. The Graphs library eases management of complex graphs and provides layout methods while the clustering library, as the name suggests, computes clusters from graphs or other data. Overall, the software architecture of *megNet*® client can be thought of as layers and components as shown in Figure 1.

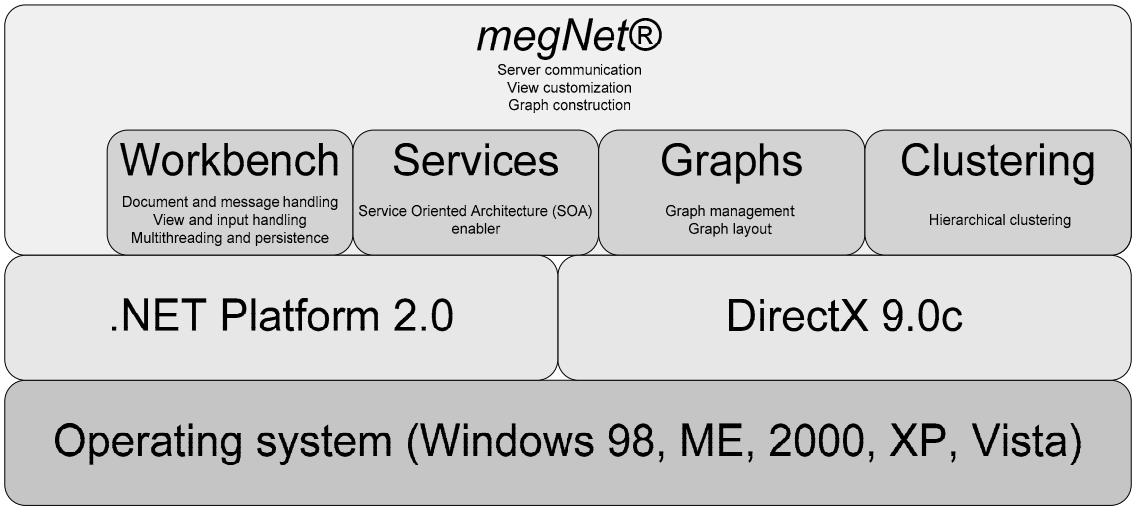

Figure 1. Layers and components of megNet® client software.

All client software and its libraries have been written in C# using Microsoft. NET Framework Version 2.0. 3D visualisation runs on Microsoft DirectX 9.0c platform, which allows hardware acceleration of 3D scenes.

Case study design

Materials. The patient group comprised 12 subjects (5 males; mean age (± standard deviation) 28 ± 8 years, 7 females; mean age 36 ± 13 years) of Finnish origin, who were heterozygotes for one Lamin A/C mutation. The control group consisted of 14 healthy subjects (3 males; mean age 45 ± 12 years, 11 females; mean age 41 ± 12 years).

Cine magnetic resonance (MR) images were acquired with a 1.5 T system (Sonata, Siemens Medical Solution). Short-axis cine stack and a long-axis cine slice of both ventricles were obtained with a section thickness 6 mm, intersection gap 20%, and temporal resolution 42–49 ms. In addition, blood samples were obtained from all subjects.

Image processing. The endocardium and epicardium of the left ventricle and the endocarium of the right ventricle were first segmented from MR images [9]. In total, 86 measurements were then determined from the segmentations. Four types of measurements were used: 1) volumetric measurements, 2) left-ventricular wall end-diastolic thickness, 3) left-ventricular wall thickening from end-diastole to end-systole, and 4) measurements describing the motion of the ventricles. The measurements were determined globally. In addition, wall thickness, wall thickening, and wall motion measurements were derived on a per-segment level [10].

Metabolomics. The serum lipid profile is more complex than the traditional set of total amounts of triglycerides, cholesterol or lipoproteins. Current metabolomics platforms constitute an efficient way to characterize and quantify hundreds of lipid molecules. The blood samples were analyzed using the liquid chromatography coupled to mass spectrometry (LC/MS) based lipidomics platform as previously described [11]. In short, serum samples (20 μl) were extracted with a mixture of chloroform and methanol 2:1. The extracts and the lipids were analyzed on a Waters Q-Tof Premier mass spectrometer combined with an Acquity Ultra Performance LC™ (UPLC). Raw centroid-data from the LC/MS instrument was converted to netCDF files which were processed with the MZmine software version 0.60 [12].

Statistical analysis. The fingerprint concept is well suited to the integration of hetereogeneous data. In this work, each image parameter and lipid profile was first centered to zero mean and unit variance. The partial least squares discriminant analysis (PLS/DA) [13] was applied as the initial clustering method. PLS/DA is a pattern

recognition technique that correlates variation in the dataset with class membership. The resulting projection model gives latent variables (LVs) that focus on maximum separation ("discrimination"). Random subsets cross-validation method and Q^2 scores were used to develop the models. The VIP (variable importance in the projection) values were calculated to identify the most important molecular species for the clustering of specific groups. Multivariate analyses were performed using Matlab version 7.6 (Mathworks, Inc.) and the PLS Toolbox version 4.21 Matlab package (Eigenvector Research, Inc.).

Results

Figure 2 shows a screenshot from the *megNet*® client software when 'Lamin A/C mutation' was used as a keyword in mining different biological databases. The visualisation shows the links between various microscopic entities related to the searched mutation.

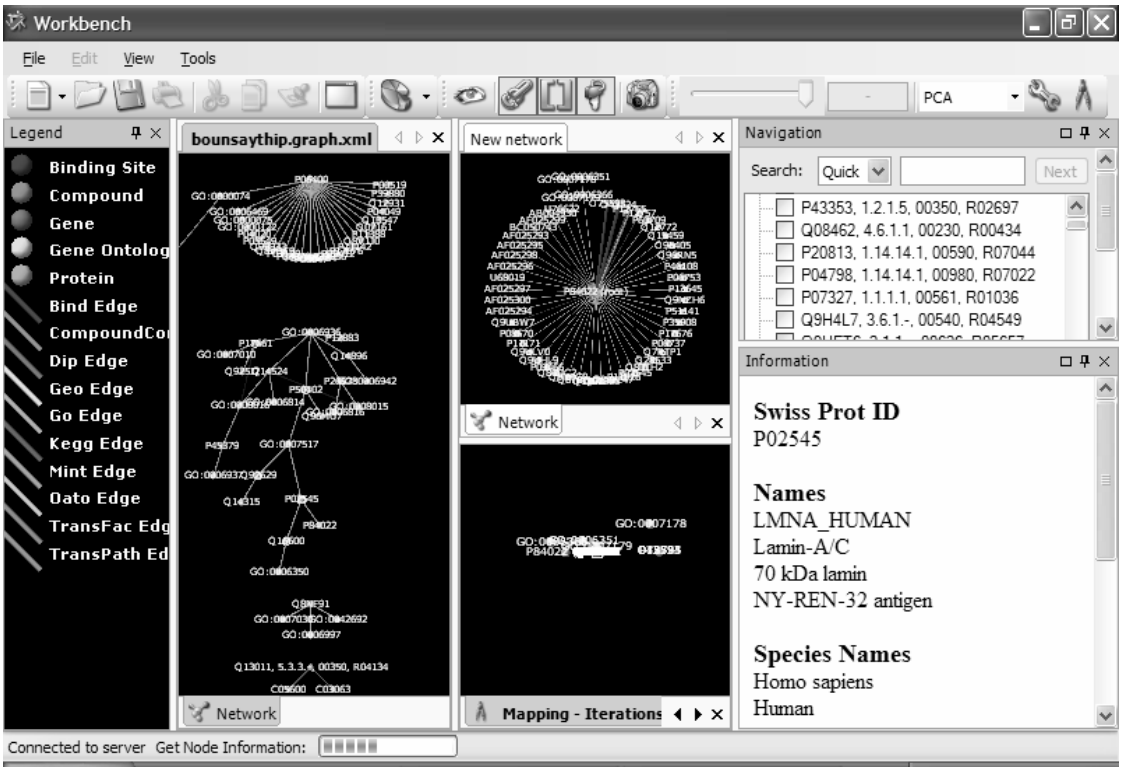

Figure 2. A screenshot from the megNet® client software when "Lamin A/C mutation" has been the keyword.

An example of the fingerprints derived for the mutation carriers and for the whole disease (DCM) is shown in Figure 3. The fingerprints include measures both from imaging and metabolomics. Although a single measure can be different between a

patient and the fingerprint of the whole disease, the overall visual similarity between the fingerprints can be detected. In Figure 3, the measures are listed in the order of their importance in separating mutation carriers from the control group. *megNet*® software also allows different groupings of the measures, e.g., volumetric imaging measures are shown in a different group than thickness-based imaging measures.

The UPLC/MS based lipidomic analysis of patients led to identification and quantitation of 442 lipid molecules, with their concentrations measured in each of the 24 subjects. This data was combined with the 86 parameters obtained from MRI image analysis in the same subjects. Multivariate analysis revealed distinct clustering of the disease group as compared to the control group of subjects (Figure 4). Major differences between the two groups were attributable both to specific lipid molecules as well as image parameters (not shown), thus suggesting a combination of metabolomics and image data provides an improvement in ability to identify the disease, as compared to using either set of data alone.

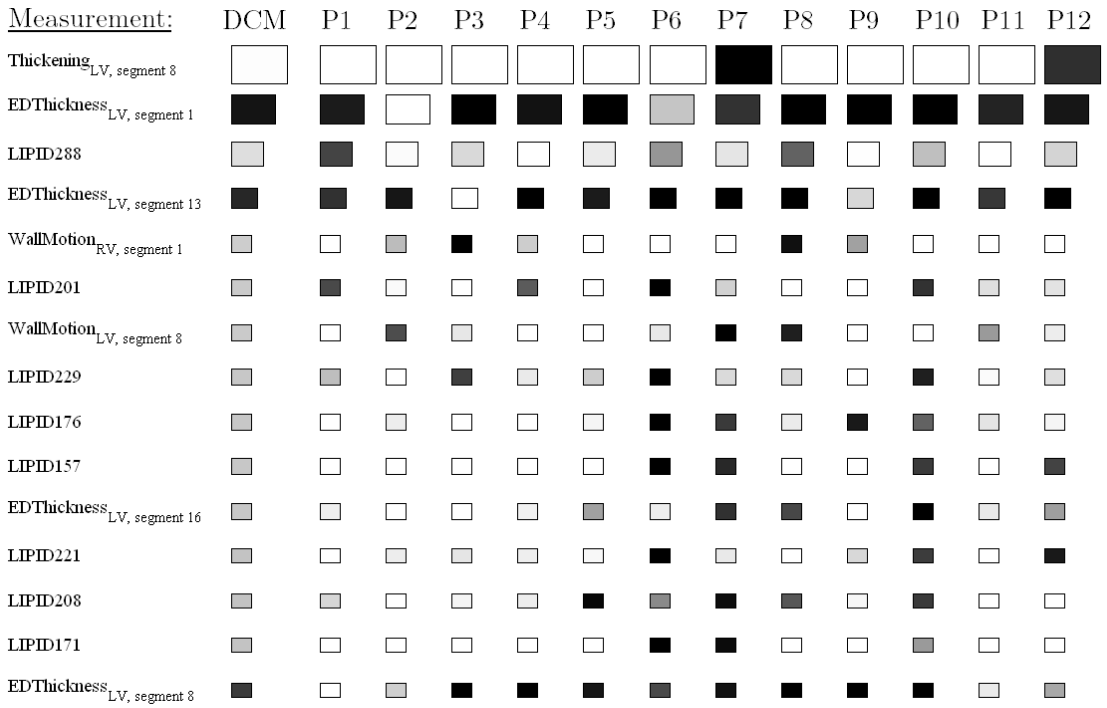

Figure 3. Fingerprints for a disease (DCM) and 12 patients (P1–P12). The fingerprint was transformed as grey-scale image by mapping dark blue to white, white to light grey, and dark red to black.

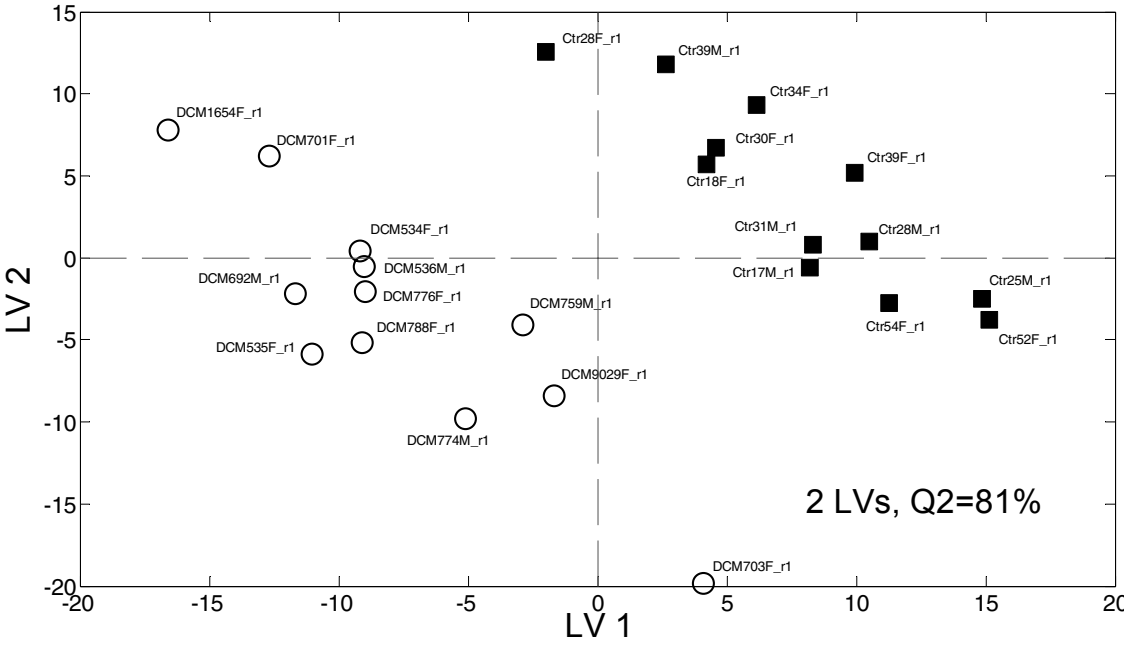

Figure 4. PLS/DA analysis of combined image and metabolomics data. 86 image parameters and 442 lipid molecular species were obtained from each of the 24 subjects (12 cases, DCMxxx; 12 controls, Ctrxxx). Each dot represents a subject, with the disease group marked as white circles and the controls as black squares. Two latent variables (LVs) were used to build the model.

Discussion

We developed a prototype software for integrating, mining and visualising highly heterogenous data. In this work, we demonstrated the concepts developed by using measures from diagnostic MR images and biological metabolomics profiling information.

Extracting and exploiting information from continuously expanding databases is an enormous challenge in many application areas. Two groups of users can be identified for the *megNet*®. First, it is a tool for scientists, e.g., medical doctors and biologists, to better understand the human as a system – such as relations between different microscopic and macroscopic entities – providing new information, for example, for drug development. Second, the finger-print concept is very suitable for assisting clinicians in diagnostics and following the treatment efficacy. Because health-care costs are exploding, e.g., 20% of all costs are expected to go to health-care in the United States by 2015, new solutions for improved diagnostics and patient follow-up are essential. *megNet*® could work both as a product or as a central tool in a company providing diagnostic services.

The field of integrating clinical and biological data is relatively novel and still very much unexplored. In this work, we demonstrated our concepts using a case study: Lamin A/C mutation in cardiac diseases. However, the concepts developed, such as the fingerprint technique and the *megNet*® software tool, are very generic contributing therefore to the whole field. We will further study the power of these concepts as they currently relate to other diseases, such as Alzheimer's disease and schizophrenia.

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Conclusions

VTT's traditional focus has been on the development and application of technology. However, over the past couple of years, our interests have extended to technology-based business and innovation research. VTT has invested in developing competencies in service research, and by taking this path VTT has aspired to increase its leading role, particularly as a developer of service enabling technologies and service business models, keeping in mind the relevance and benefits to Finnish industry and society. To demonstrate and disseminate our competence, an internal symposium was organised to draw up an overview and compile representative documentation on the recent and ongoing service research.

The topics of the symposium covered the whole service and value chain and a wide-spectrum of various types of businesses, from service providers to value-adding offerings of "hardware" providers. Service systems are complex and interdisciplinary by nature, requiring skills and competencies in developing service business, for understanding organizational cultures, human behaviour and the market, and of course knowledge on enabling IC technology for providing shared information to different stakeholders. The symposium papers fall into four key domains of service business: 1) Industrial services, 2) Information services and concept development, 3) ICT based services, where ICT plays a key role in delivering or providing services, and 4) Health and wellness services. Sustainable service business is boosted and facilitated by developments in technology. However, the demands come from customers and from their value creation, which needs to be supported, and the opportunities are created by the technology. In our case, the main focus has been on services enabled and supported by ICT mobility as a novel, horizontally crossing central theme.

The significance of service business is seen in the enlargement of the service sector and in the increase of the service business of traditional industrial companies. The manufacturing industry is moving from capital intensive production towards industrial service business where products and services complement each other in order to support customer value creation. An especially rapid increase of service activities as an ongoing trend among manufacturing companies in the after-sales markets verifies this shift. The driving force is the stable cash flow of services and reduced sensitivity to economic fluctuations. This change will affect organisational culture, service concepts, the management of risks and business processes. Mobile workers will also be supported with better tools to perform maintenance work more effectively. Hence, the papers in the Industrial services section deal with the development of service capabilities, maintenance services including enhanced human technology interaction, semantic technologies in enterprise interoperability and the role of risk management.

In the Information services section, value analysis plays a key role by demonstrating the impact of services in different parts in the value chain. Innovations, innovation management and methodological approaches are needed in service concept development. One of the main goals of open innovation, particularly in the service business context, is to change the role of customers from passive participants to active players with the aid of an online community. Sustainable service is enabled by developments in technology that may change the nature of schemes and strategies or the roles of the different actors within the system.

Concept development, innovation management, and systematic support for strategic decision making and connecting customers and designers were discussed. The change the new technology may have is considered in assessing future transport service.

Information and communication technology plays a key role in collecting, transporting and processing information. This enables services that call for remote monitoring and subsequent diagnostics. Human technology interaction facilitating a natural and context aware interface for the user is essential in turning this information into required actions. Therefore the focus of the papers belonging to the ICT based services section deal with the user interface paradigm and with intensifying and automating service processes. Applications considered mobile facility services, services in the Digital Home or how to improve elderly meal services with Near Field Communication technology. The article on unified communication presence discussed the task of getting in touch with other people in today's world by providing a way of integrating the different means of communication available, so that getting in touch would be easier and more efficient.

The health sector is the second biggest service sector in the world, with considerable business potential in western countries and enormous needs from developing countries. The costs – both social and financial – of healthcare are increasing due to the ageing population, diabetes and lifestyles adopted by many adults and children, which increase their risk of succumbing to chronic health problems in later life. To avoid or mitigate this problem the main focus has been on motivating people to live a healthy life by studying how innovations in electronic, information and communication technologies can encourage people to successfully manage their own health and well-being, and thus, motivate people to live a healthy life. Fitness and wellness services are especially emphasised and considered as a rapidly increasing sector and one of the most potent application areas for ICT based services. Two of the papers in the Health and wellness services part were focused on wellness services. One paper on exergaming, combining exercising and gaming, describes how to combine real life and virtual communities to improve well-being. The other is focused on health promotion and the utilization of personal health systems in occupational healthcare. In the healthcare sector, a paper on a document-based service platform for telemedicine applications was introduced.

Telemedicine is increasingly gaining popularity due to its high potential for cost savings and increased efficiency. It is well-known that there is an increasing gap between data generated and the actual usable information extracted from it. This is the case with biological and clinical data. This gap is narrowed by integration and visualisation of highly complex biological and medical data application to Lamin A/C mutation.

Perhaps the longest traditions in service science at VTT are in the development of services for transport and logistics and for the technology industry. Operational and maintenance services with e-Maintenance technologies and product development for life cycle business have been at the front line on the industrial side. Transport and logistics service research has concentrated on telematic and information services. Otherwise, services are used for operational testing in technology developments. Today, however, the acceleration of service businesses is performed by means of new technologies and concepts. In addition, excellent knowledge of specific application domains with performance and operational requirements is needed. In the future, our scientific goals and technology focus will be on the development of service business and service processes including strategy, earning, and profitability. Innovation and development of service concepts and tools will also play an important role. On the technology side, our strengths are in the implementation of service systems with enabling IC technology. A human-centred design approach for usability plays a key role in expressing information in different contexts through varying interfaces. Of course research on the integration of life-time and life-cycle and real-time information from different data sources and the secure transfer and storage of information for maintaining privacy and security will continue. Our research covers all three main interdisciplinary areas of service systems: business, people in different roles in organisations, and the technology to share the information. The science of service can provide a foundation in creating lasting improvements for service systems. We are only at the beginning of this effort. Service science aims to understand and categorise service systems in order to apply this understanding so as to advance our ability to design, improve, and scale service systems for practical business and social purposes. The study of service systems is an integrative, multidisciplinary undertaking, and many disciplines have the knowledge and methodological competence to contribute to this undertaking. Nothing is settled, however, and we still have much work to do. Significant potential is seen in both the enlargement of the service sector and in the growth of the service business of traditional industrial companies. The characteristics are an emphasis on knowledge, know-how and interaction as well as a focus on intangibles.

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Abstract

This document combines the results of VTT's strategic technology theme Service Beyond and other service oriented research carried out at VTT during the past couple of years. The Service Beyond theme was a research entity during the period 2005–2008 with a strongly business oriented goal, which tried to track new commercial service innovations focused on integrating technology into innovative service concepts, assuming that basic ICT technology was already available. The focus areas of the theme were: 1) Services for citizens – Well-being and quality of life, 2) Industrial services – Enhanced human technology interaction for mobile workers, and 3) Services for living – Living in buildings. To demonstrate and disseminate our competence wider than the theme alone, an internal symposium was organised to take an overview of the service research at VTT. This document compiles representative documentation on recent and ongoing service research in four key areas of service business: 1) Industrial services, 2) Information services and concept development, 3) ICT-based services where ICT plays a key role in delivering or providing services, and 4) Health and wellness services. These topics cover the whole service and value chain and a wide spectrum of various types of business.

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