JYU DISSERTATIONS 470

Hannu Vilpponen

You Get What You Order

Required Expertise in the Procurement of Public Services

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF INFORMATION TECHNOLOGY

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Esitetään Jyväskylän yliopiston informaatioteknologian tiedekunnan suostumuksella
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Cover photo: *Trust and Respect*. Author and a stubborn young bull named Toivo in the 70s.

Trust and respect for the needs of individuals are important factors in dealing with young bulls. The same principles work well with the digitization of services for the elderly.

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Yes, there were times, I'm sure you knew
When I bit off more than I could chew
But through it all, when there was doubt
I ate it up and spit it out
I faced it all, and I stood tall
And did it my way
Frank Sinatra

ABSTRACT

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Technological developments have made the ongoing wave of digitalization possible. Digitization is about automating the production and utilization of information and redesigning processes. The design of intelligent and artificial intelligence-enabled systems requires an extension of the traditional design methods used by experts with engineering and information and communication technology (ICT) design backgrounds to a holistic understanding of human needs and the operating environment. Here, life-based design approach serves as a good tool for designing the necessary service processes and human-technology interaction (HTI) solutions.

The Finnish government is investing in the digitization of public services. The problem with public digitization projects is the lack of resources in municipalities. This applies to the procurement process, design, and implementation of projects, leading to isolated systems and services without being developed in accordance with the enterprise architecture, digitalization, and service design roadmaps. The change in society and the need it creates for an achievable and sustainable system development require a new kind of investment in competence from procurement organizations. Common terminologies and process descriptions among experts in different fields will play an important role in defining and implementing large-scale multidisciplinary information systems. The development of sustainable and cost-effective accessible public information systems and digital services usually requires procurement. This thesis examines the competencies required by procurement processes in public digitization projects.

Keywords: aging, life-based design, human–technology interaction, digital well-being, procurement process

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Vilpponen, Hannu
Saat mitä tilaat: tarvittava asiantuntemus julkisten palvelujen hankinnassa
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Tekninen kehitys on mahdollistanut digitalisaation aallon yhteiskunnassa. Digitalisaatiossa on kyse tiedon tuottamisen ja hyödyntämisen automatisoinnista ja prosessien uudelleensuunnittelusta. Älykkäiden ja tekoälyä tukevien järjestelmien suunnittelu edellyttää perinteisten insinööri-, tieto- ja viestintätekniikan asiantuntijoiden käyttämien suunnittelumenetelmien laajentamista kokonaisvaltaiseen ihmisten tarpeiden ja toimintaympäristön huomioimiseen. Tässä elämäkeskeinen lähestymistapa (Life Based Design – LBD) on hyvä työkalu tarvittavien palveluprosessien ja HTI-ratkaisujen suunnittelussa.

Suomen hallitus panostaa julkisten palvelujen digitalisointiin. Julkisten digitointihankkeiden tyypillinen ongelma on tarvittavien resurssien puute erityisesti kunnissa. Tämä koskee hankintamenettelyä, suunnittelua ja projektien toteuttamista, mikä voi johtaa eriytyneisiin järjestelmiin ja palveluihin ilman, että niitä kehitetään kokonaisarkkitehtuurin sekä digitalisaatio- ja palvelusuunnitelmien mukaisesti. Yhteiskunnan muutos ja sen luoma tarve saavutettavissa olevien ja kestävään kehittämiseen perustuvien järjestelmien hankkimiseen edellyttää uudenlaista osaamista hankintaorganisaatioilta. Eri alojen asiantuntijoiden yhteisillä terminologioilla ja prosessikuvauksilla on tärkeä rooli määritettäessä ja toteutettaessa laaja-alaisia monimutkaisia tietojärjestelmien kehityshankkeita. Julkisten tietojärjestelmien ja digitaalisten palveluiden kehittäminen vaatii yleensä hankintoja. Kestävien, kustannustehokkaiden ja saavutettavien tietojärjestelmien ja -palvelujen hankinta edellyttää, että hankintaorganisaatiolla on riittävä osaaminen ja resurssit tarvittavien määritelmien ja suunnitelmien kehittämiseen. Opinnäytetyössä tarkastellaan julkisten IT-järjestelmähankkeiden hankintaprosessien edellyttämää osaamista.

Avainsanat: ikääntyminen, elämäkeskeinen suunnittelu (LBD), ihmisen ja teknologian vuorovaikutus, digitaalinen hyvinvointi, hankintaprosessi

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I have more than a quarter of a century of experience behind me in various digital systems development projects. I have experienced Nokia's rise as the world's largest mobile phone manufacturer and participated in dozens of ground-breaking research projects over the 16-year career in Nokia research. In the early years of my career, I was able to develop new radio air interfaces, related radio modem algorithms, and radio standards. The best thing about my time at Nokia was that even though I had moved over the years from information theory through microcircuit technology to the development of new service concepts, I can take advantage of everything I learned earlier in my career when I moved closer to a holistic understanding of end-user needs. A good example of this is a personal assistant application which uses the synthesis of sensor data, calendars, and various public real-time data services, combining them with user habits and providing various successions.

The transition from the telecom industry to the public sector was a dramatic change in everything I had learned earlier about decision-making processes and the development of information systems. In public administration, decision-making is influenced by the numerous bureaucracies and rigid practices introduced by the law, but once confusion is overcome, public decision-making processes can be turned to benefit by their predictability. The same principles apply to the development of technologies in both; the systematic development of the enterprise architecture is essential for the success of sustainable development. I have been involved in the procurement of many information systems in public administration and have led some implementation projects. The last big project I led was the implementation of the Apotti system in the municipality.

In the summer of 2010, together with Pertti Saariluoma and Jaana Leikas, we published an article in Tekniikka & Talous weekly magazine [1] with a prophetic message, "The development of the service society must be viewed holistically from the perspective of people's lives and activities. The worst threat to the development of human-technology interaction in design is selective operating culture". This message has been the guiding star of my working life ever since. Changes in the operating culture and operating environment have created new competence needs for procurement processes over the years. Understanding people's behavior and needs is increasingly taken into account in the design of services. Pure technical thinking can improve the usability of an interface, but it does not take the whole into account. Many times, it would be best to redesign the entire service process before redesigning the interfaces.

The development of high-speed data connections and the introduction of tablets have made it possible to use nature as a research environment. I lost several moose during the moose hunting seasons in Vehmersalmi when I had to

[1] Saariluoma, Kuisma, Leikas & Vilpponen. Tekniikka & Talous (13.8.2010), "Mobiilipalvelujen kehittäminen tarvitsee humanisteja".

concentrate on research publications and moose came to observe my focus on science—apologies to my colleagues at the Rito-Roikka hunting club.

I would like to thank the dissertation supervisors, Professor Pertti Saariluoma, and Docent Jaana Leikas for their inspiring and professional commentary and numerous advice on my dissertation work. I am very grateful to Professor Saariluoma for the humorous game technique with which he planted the seed of cognitive science into my mind, which helped me grow out of the engineer's short-sighted view of the development of usability. I want to thank, Professor Pekka Abrahamsson, and Adjunct Professor Tuomo Kujala, for their excellent observations and comments during the writing process.

I would also like to thank my long-term supervisor, Mr. Mikko Hokkanen, from the City of Kerava, who understood the possibilities of academic networking and made it possible for me to participate in the ETAIROS project, for example. My good friend, Industry Professor Mika Grundström, has been a spiritual touchstone since my time at Nokia, with whom I have discussed everything between earth and sky and developed numerous research ideas, and I hope that this same process will continue for decades to come.

I received from home important building blocks for exploring new things, first at our farm at Vehmersalmi and later at various locations in globe. I want to thank my mother Anja and late father Veikko for their faith in my choices. There has been a joke in my own family: *Dad is a "Wannabe Doctor" until his dissertation is accepted*. Now the writing process is over, and I want to thank my children, Viivi, Aatu, and Miina, for allowing me to be disturbed when I was in my thoughts. However, the final thanks for completing my dissertation go to my dear wife, Minna, who has selflessly allowed me to spend my time on research.

Järvenpää 10.9.2021
Hannu Vilpponen

FIGURES

TABLES

LIST OF INCLUDED ARTICLES

I Hamiti, S., Hakaste, M., Moisio, M., Nefedov, N., Nikula, E., & Vilpponen, H. (1999). Enhanced circuit switched data for real time services over GSM. In *Gateway to 21st Century Communications Village – VTC 1999-Fall: IEEE VTS 50th Vehicular Technology Conference* (pp. 578–582). IEEE.

II Papadimitriou, P.D., Sexton, T.A., Varshney, P., & Vilpponen, H. (2001). Turbo coded modulation over GSM channels. In *Proceedings of 2001 International Conference on Third Generation Wireless and Beyond* (pp 787–791). Delson Group Inc.

III Vilpponen, H., Grundström, M., & Abrahamsson, P. (2018). Combining social service and healthcare as the first country in the world: Exploring the impacts on information systems. *Journal of Advances in Information Technology*, 9(4), 84–88.

IV Vilpponen, H., Grundström, M., & Abrahamsson, P. (2020). Exploring the critical success factors in social and health care information systems project procurement. In *Recent Developments in Engineering Research, Vol.8.* Book Publisher International.

V Leikas, J., Saariluoma, P., Rousi, R., Kuisma, E., & Vilpponen, H. (2012). Life-based design to combat loneliness among older people. *Journal of Community Informatics,* 8(1), 7–14.

VI Vilpponen, H., Leikas, J., & Saariluoma, P., (2020). Designing digital well-being of senior citizens. In *2020 13th International Conference on Human System Interaction (HSI)* (pp. 40–44). IEEE.

Articles I and II were written in close collaboration with the research team. I participated in the ideation phase and development of innovation, as well as in the simulation of results as a member of the research team. Article V was written in close collaboration with the research program team members. Saariluoma and Leikas focused more on theoretical ideas, and I contributed to the technology related aspects. In Articles III, IV, and VI, I was the principal author and responsible for the main lines of thoughts, innovation, data collection, analysis, and conclusions, as well a structure of the text.

CONTENTS

1 INTRODUCTION

The digitalization of industry and society is ongoing throughout the world; for example, Society 5.0 (Fukuyama, 2018), Industry 4.0 (Xu, Xu, & Li, 2018), and Smart Cities 2.0 (Barns, 2018) are projects where cyberspace and physical space merge, and the work and control people had in the past moved to big data-related artificial intelligence (AI) and robots. This has been made possible by the rapid technological developments of the last decade, such as the increase in data transfer speeds, cloud computing, the Internet of Things (IoT), and various sensor solutions, as well as the development of AI.

In the public sector, opportunities for digitalization and the development of new technologies and digital services have created new challenges for the development and procurement of public digital services. In Europe, there are significant differences in regional population structures. Dynamic high-cost metropolises are typically inhabited by younger people, while coastal areas and the countryside are considered areas for relatively affluent retirees. Other rural and remote areas with declining populations and an aging age structure are leading to declining services (Eurostat, 2020). It is well-known that aging may cause social isolation from family and friends, which can cause feelings of loneliness and other psychological symptoms, such as depression, anxiety, and low self-esteem (Chaumon, Michel, Bernard, & Croisile, 2014).

The number of digital services has grown exponentially over the last decade, and digital services have become an integral part of citizens' daily lives. The rapid development of digital services has created new challenges to ensure equal treatment of citizens outside the mainstream of digitalization. Keeping pace with digitalization poses challenges, especially for small- and medium-sized municipalities, which typically lack resources and development funding, even though the benefits of digitalization are visible in society. The development of information and communication technologies (ICT) and social media has had a positive effect on the well-being of the elderly in particular (Delello & McWhorter, 2017). Many digitalization projects overlook the needs of special groups. A good example of this is the elderly, who are a growing group due to increasing life expectancy.

The silver economy serves as a good example of an important consumer segment whose needs industry and digital service developers should listen to. In the successful development of digital services, it is not enough to consider only technologies, information systems, and human-technology interaction (HTI), but the development must start from a deeper level where people and their lives are taken into account holistically. Here, the life-based design approach enters the scene. The goal of developing digitalization must be to improve people's digital well-being. The thesis also contains a case example of the social and health care information system reform, the Apotti project, which combines, in the first system in the world, social services, specialized and primary health care systems in a single system.

The Apotti project is Finland's largest information system project to date, but in the future, information system projects may be even more expensive and more widely influenced. The traditional method was used to define and procure the Apotti project. After deploying the system, it is important to research what needs to be improved in the process. Technologies for the Elderly and the Apotti project are some examples of different types of procurement; all the acquisition of information system projects requires extensive expertise in many areas of society, in the lives of users and in technology.

The development of public digital services usually requires procurement, either in the form of necessary consulting work or ready-made service concepts. It is not enough that the procurement of digital services complies with procurement law, the EU's legislation for the General Data Protection Regulation (GDPR) (GDPR.eu, 2018), or Web Content Accessibility Guidelines (WCAG) (W3C, 2018). The tender must specify the functionality, quality, usability, and acceptance criteria for the product or service for the procurement. Companies that produce the subject of the acquisition do not want to invest in work for which they cannot bill. This requires the contracting entity to have in-depth expertise in a wide range of operating areas. It is not enough to have contracting entity procurement professionals and representatives from the field of the production of the service, but they must have expertise in, for example, enterprise architecture, IT development roadmaps, and user-centric development competencies to optimize usability.

This dissertation contains six articles, all of which highlight the different competence needed to perform the described task. In this work, competencies describe the knowledge and behavior required to perform the operations. Articles I and II deal with the development of wireless communications and the competencies associated with this work. The competencies in information theory and simulations described in Articles I and II are still the basis for the development of air interfaces for wireless digital services. Article III describes the development of the Finnish municipal information system field. Article IV analyzes typical success factors in medium-sized municipal information system development. Article V deals with the holistic consideration of human life in design using the life-based approach, and Article VI examines the development of digital well-being. The competencies presented in the attached articles are

basic for the development of public digital services. It is not enough to define the desired service; it is necessary to pay attention to all the factors influencing the development of the service, such as IT infrastructure, enterprise architecture, and technology and service development roadmaps. In addition to this, the available resources, budget, procurement, and legislation set the boundary conditions in public administration. The design of a sustainable digital service that can be achieved by all customer groups must take into account the needs of end users as a whole, which places high demands on the design process.

1.1 European data strategy

The aim of the European data strategy is to create an internal market for data in which data can move freely between countries and industries. This benefits companies, researchers, and public administrations alike. EU has set the "target for adults with at least basic digital skills to 80% in 2030" (European Commission, 2021a). The value of the data economy is estimated at € 829 billion in 2025. Europe is moving toward a circular economy that invests more in the smooth use of data than in physical material (European Commission, 2019a). Digital transformation is made possible data that shaped by our production, consumption, and lifestyles.

The GDPR, which entered into force in Europe in 2018, regulates the processing of personal data in the EU (GDPR.eu, 2018). The regulation defines the processing of personal data and gives people the opportunity to influence the use of their own personal data. According to the GDPR regulation, the automatic processing of data must take into account privacy concerns, such as the right to be forgotten, the transparency of the use of data, and the verification and correction of data must be possible (Ilves & Osimo, 2019). This is a major change in terms of information systems and automated data processing. The GDPR must be taken into account in all information systems, information system development projects, and related procurement.

1.2 Digitalization volume in the global economy

The COVID-19 pandemic, which began in 2020, has highlighted the key role of ICT in guiding policymakers to invest in ICT and digital ecosystems (ITU, 2020). Digitalization serves as a global trend and growth factor in the modern economy and enables new services and practices. Data digitization takes place at three different levels: in clouds and data centers, in infrastructure, and in terminals, such as smart and IoT devices. Global datasphere grows from 33 Zettabytes[2] (ZB) in 2018 to 175 ZB by 2025 (Reinsel, Gantz, & Rydning, 2018). The self-driving car alone can account for 5 terabytes per hour of data generation (Miller, 2020).

[2] One Zettabyte (ZB) is 10^{21} Bytes.

"Between 2020 and 2024, the direct investments into digital transformation are projected to reach a total of $7.8 trillion" (Mlitz, 2021). High-speed real-time network connections are essential for the safe operation of autonomous cars. The digitalization of public services produces less data than, for example, autonomous transport, but the organization of digital services requires investment in the necessary infrastructure development. For example, the use of sensor data related to personal health care and automatic decision-making based on that data will require reliable and secure connections.

Decisions about technological infrastructure have a big impact on people's lives and consumption habits. Wrong technological solutions in the race to develop digital services can distort the competitive position of technology companies or jeopardize citizens' privacy. It would be important for technical solutions to be standardized worldwide and for data storage not to be controlled by companies or governments. The EU has sought to regulate the use of personal data through the GPDR, but third countries, such as the USA, do not comply with this legislation (European Data Protection Board, 2020). When transferring personal data outside the EU, these countries must commit to a level substantially equivalent to EU data protection.

1.3 Service digitalization—end user focus

The purpose of digitalization of services is to make life easier for end users. Digitization is a social, economic, and cultural process in which individuals, different social groups, organizations, and communities' access, adopt, and exploit digital technologies (Merisalo, 2016). The digitalization of services enables place- and time-independent transactions. Robotics and AI can be combined with digital services in the background, which streamlines service processes and enables real-time operations. The digitization of a service also has cost implications for service providers, for example, in terms of the reduced need for service points and staff, which acts as a motivation for the digitization of various services. Procurement plays an important role in the development of digital services.

In the procurement phase, it is possible to outsource part of the development work to the companies participating in the tender in the form of various development demos or service model descriptions. If a company participating in the tender does not become a selected service provider, the company cannot bill for the development of a digital service; this directs the company's product development to be systematic and enables the development and further utilization of various service interfaces. Service providers should follow the principle of continuous development in their architecture and development roadmaps, in which case all work serves the development of the whole. However, in a well-managed tender, some of the design costs can be rolled out to the companies participating in the tender, thus obtaining wide-ranging and high-quality results with their own small resources.

Cooperation between municipalities in procurement can affect the roadmaps of the entire industry, making it easier for companies to develop their own products. However, this required the procurement department to have an excellent definition of resourcing and an understanding of the service to be procured and the technologies involved.

Digitalization is about automating the production and utilization of information and redesigning processes. Digitalization will not bring real benefits unless the processes are changed at the same time, as the digitization of an old service concept or process is not enough in itself. The digitalization of services and social life has changed the way society operates over the last decade. It has launched a significant change in the operating environment, which poses new challenges for the development of accessible public services where sustainability must also be taken into account. It is changing the content, working methods, and work organization of the traditional services on offer, especially in the traditional bureaucratic public sector. The goal of public administration is to create equal opportunities for a good life for all. According to the customer management strategy set by the government, public authorities must ensure that digital channels are the most attractive option for customers, including special groups (Ministry of Finance, 2021).

Before acquiring digital systems, it is important to understand the potential of user-centric design methods, the need to modernize service processes, the interoperability of services, and data security and data protection. The dilemma is how to design, specify, procure, and implement system cost-effectively. Many public sector actors, such as municipalities, must procure system development as external work. The procurement organization should find the necessary subject matter experts to support the procurement process. When you buy new services or development projects, the old saying "you get what you order" applies. Changes made after ordering usually increase costs and affect schedules.

In the field of engineering and technology, many design criteria have been studied to guide the design process, for example, the works of Ulrich, Eppinger, and Yang (2020) and Dym and Brown (2012). When designing digital services, it is important to understand the implications of human interface and usability. HTI provides a good design basis for this, although it focuses more on technology than on human understanding itself. To take into account the special needs of people, the life-based design (LBD) approach can be used, which takes into account the human, environment, and needs as a whole (Saariluoma, Cañas, & Leikas, 2016).

The development of new technologies and systems requires the cooperation of many kinds of expertise, especially with the aging population (European Commission, 2018). It is not enough to involve technically skilled engineers and coders in the design, but the development must take the end user into account holistically to take into account the specific needs of the users of the services. Considering the socio-economic impact is important for the development of an equal society.

1.4 Approach of the study

This study deals with the Finnish municipal[3] public administration, which has the tasks prescribed by law on the organization of municipal services. Municipalities can also make their own decisions about the organization of services, which can be a positive image factor for businesses and residents. The development of municipal services is carried out with tax funds, so residents can influence the use of municipal tax funds by voting for municipal authorities who approve the municipality's development budgets.

The research questions are as follows:

RQ1 How can development projects be implemented in small or medium-size municipalities?

RQ2 What needs to be taken into account when starting to acquire large public information systems in the case of social and health care?

RQ3 How can we ensure the accessibility of publicly procured digital services for the elderly population?

The aim of RQ1 is to find out the challenges faced by small and medium-sized municipalities in acquiring digital systems and what they should invest in. RQ2 deals with the implications of joining a large regional information system development project. RQ3 defines the consideration of the needs of special groups and their dependence on the general development of technical solutions for services. An example of a special group is the elderly.

[3] In 2021, Finland has 303 independent municipalities

2 BACKGROUND AND MOTIVATION

Consumers have become quality-conscious and know how to demand digital services for ease of use and versatility. They can influence and guide guidelines for service development through their behavior. The development of technologies and digital services into increasingly sophisticated intelligent systems will make it possible to organize almost all human activities digitally in the future. This will change people's actions and the level of demands. The first stage of digitalization is going on in the automation of routine work and in the intelligent automation of decision-making for various services. The actual march of AI applications will be visible in the near future, for example, in the form of autonomous traffic.

2.1 Finnish digital strategy

The foundations of the Nordic welfare state include equality and the pursuit of curbing inequalities, such as gender and age, based on social status or ethnicity (Kvist, Fritzell, Hvinden, & Kangas, 2012). As a Nordic country, the goal of the Finnish government is to increase the technology and digitalization capacity of the public sector and to develop public-private cooperation through digital programs, which will make public services available to citizens and companies digitally by 2023 (Ministry of Finance, 2021). The goal of the government is to create, through digitalization and technological development, new, and better, more reliable service chains for a good life and different life situations.

The implementation of the law on the provision of digital services will support the achievement of the objectives of the digital program. The law requires that public services be accessible and that authorities provide customers with the ability to send and receive messages and materials in a secure manner. Alongside the program to promote digitization, the government created other spearheads to reach digital goals (Ministry of Economics Affairs and Employment, 2020). The most important of these are the National Artificial

Intelligence Program (Ministry of Finance, 2020a) and Digital Identity Development Program (Ministry of Finance, 2020b). For more than a decade, the government has been working to carry out social and health sector reforms that would allow for consistent information system development and Enterprise Architecture. Municipal finances are usually limited, and the voluntary development of digital services has not been the primary task of municipalities, but development has been guided by the laws and regulations set by the government.

Socio-technical systems involve people, user practices, and institutional structures. Socio-technical changes take into account social and technical factors that affect the functioning and use of technology and information systems (Baxter & Sommerville, 2011). For example, socio-technology cannot be ignored in health care because it is constantly used to interact with different types of information in the electronic health record (EHR) and humans (Hämäläinen & Hirvonen, 2020).

It is estimated that digitalization and the development of AI will affect all societal practices, including care for the elderly, over the next 20 years (Pekkarinen, et al., 2020). Socio-technical change must be taken into account in the development phase of systems so that the necessary social and technical aspects and their interdependencies are duly taken into account and their relationships can be optimized together (Baxter & Sommerville, 2011). If the needs of users and the organization are not sufficiently listened to, changes in the organization and practices resulting from the development of information systems may provoke resistance from end users (Doherty & King, 2005).

2.2 Silver economy

Different digital services have been developed in last decade. Typically, digital services have been developed for specific business segments or to serve all groups of people in general. Gerontechnology (Bouma, Fozard, Bouwhuis, & Taipale, 2007) study aging and technologies that can be used to make life easier for older people. The market related to the elderly is called the silver market, or the silver economy (Kohlbacher & Herstatt, 2011).

The silver economy serves as a good example of a significant customer segment that should be taken into account when developing digital services. The silver economy is a growing number of individuals (age 50+) with a wide range of life experiences, both in their work and personal life. This group has seen many great technological leaps in its lifetime and is accustomed to receiving and demanding quality services. Developers of digital services need to take the wishes and needs of the silver segment seriously, as in industrialized countries, the silver segment comprises almost a third of the population. This group also has the wealth to acquire the quality services they want.

The EU has a population of 511 million (2016) and is projected to grow by 9 million to 520 million by 2070, while the number of people of working age (15–

64 years) will fall from 333 million to 292 million (European Commission, 2018). At the same time, the proportion of elderly people in the population will double to 152 million by 2060, and the "share of those aged 80 and over is expected to rise from 5% to 12%" (European Commission, 2014). In countries with the oldest population structure, the proportion of Internet users varies between 4% and 61% between the ages of 65 and 74 (Niehaves & Plattfaut, 2014). The change in the structure of society in Europe has affected the traditional multi-generational family structure (European Commission, 2014), and older people are increasingly living alone or in married couples, leaving them alone with the challenges of the digital world.

As the population ages, the silver economy has increasingly become an important part of the economy. The volume of the silver economy in Europe is estimated at € 3.7 trillion, and its impact on the economy will increase to €5.7 trillion by 2025 (European Commission, 2019b). The silver economy benefits from technological innovations that enable the development of a variety of digital tools and services that can facilitate the development of digital services for target groups with special requirements, such as impaired vision, health, dexterity, mobility, and cognitive performance disorders. In the future, various innovations such as AI, smart cities, and IoT will solve many problems typical of the silver segments.

The population in silver economy can be divided into three age-independent categories according to a person's ability to function: active, fragile, and dependent (Figure 1). The most expensive groups in society are dependent. They are completely dependent on outside help and cannot act independently. Supporting a fragile group is important and profitable for society. Considering the special needs of this group in the development of services can prevent them from slipping into the dependent class. An active group operates independently and can demand the services it wants.

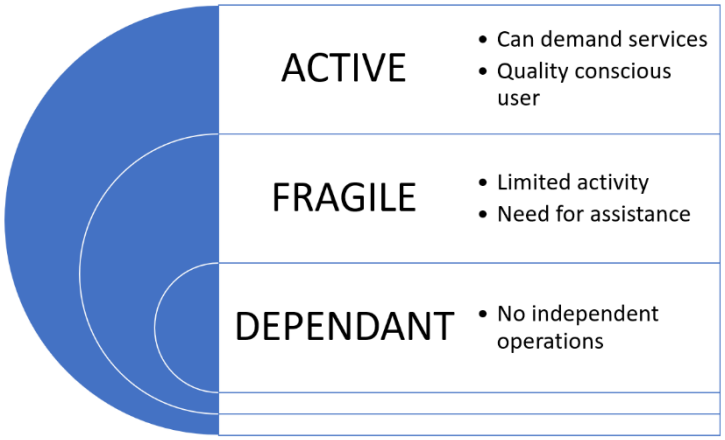

FIGURE 1 Segmentation of the silver economy

At present, the youngest part of the silver economy was born in the early 1970s, and digitalization has become familiar to them from an early age with

various console and computer games. They have been taught information technology at school and have been at the forefront of development since entering the world of work. The older part of the silver economy was in working life in the revolution of digitalization and computerization of the operating environment in the 80s and 90s. Learning IT skills was not self-evident to them. Then there is the oldest group who had already retired with the arrival of the digital revolution. They did not have the opportunity to learn the necessary skills in working life and operating in a new kind of information society is a challenge for them.

In technological development, several early adopters play an important role in bringing new technology to the masses. Older people are easily left out of networks where new technology is spreading due to the lack of suitable social networks or the lack of influence of the younger generation on the use of new technologies in the family circle. Efforts should be made to guide and support the use of new digital services for older people. A study (Wessberg & Kuusisto, 2020) found that older people want personal training from a person in the same age group to close the gap in life experience and learn between the trainee and the educator.

2.3 Technical evolution of wireless data

This section discusses the development of technology using the development of wireless communication over the last few decades as an example. The development of mobile digital services requires wireless data transmission. In 2018, 75% of Finns used the Internet on a mobile phone, but a large part of the older population has never used the Internet by any means (Official Statistics of Finland, 2018). Roughly every 10 years, a new generation of mobile network technology and infrastructure changes of the service became available. The first mobile data services appeared in the second generation (2G) in 1992.

Figure 2 illustrates the development of wireless broadband technology generations, related air interface speeds, and typical services. The development of mobile broadband has continued and will continue in the future. An example of this is the air interface (Layer 1) research projects in the early 2000s, when many research organizations invested in the development of OFDMA modulation, multi-antenna (MIMO), and beamforming solutions (Varshney, Borran, Vilpponen, & Papadimitriou, 2003). There is currently an ongoing transition from 4G to 5G. 5G opens the door to new technologies, such as wearable devices, IoT, and various smart city solutions, and enables the spread of telemedicine applications.

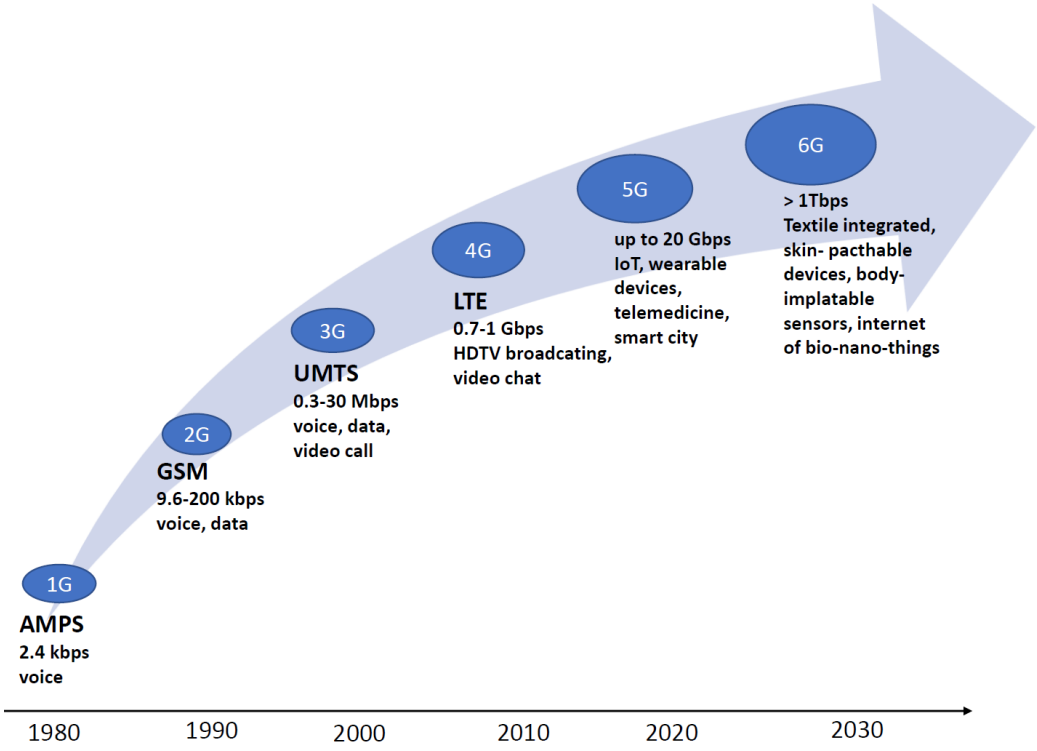

FIGURE 2 Major generations of mobile data development

In the early 1990s, Global System for Mobile Communications (GSM) became the digital standard for mobile communications in Europe. The GSM standardization body 3GPP (3GPP, 1999) set the goal of creating a mobile data standard for GSM technology. At 2G, the data rate was a few tens of kilobits per second, which allowed for light multimedia messaging and Internet connection. The potential of mobile data has been recognized at an early stage in the mobile industry. 2G data speeds were quickly found to be deficient, and various development projects began in Europe, Asia, and the USA. In the early 2000s, the widespread use of 3G technology created an opportunity for the development of new digital services, the mobile gaming industry, and the public mobile Internet.

The development of mobile technology, sensor technologies, increased data speeds, and different cloud services have enabled the exponential growth of digital services. The OFDM modulation, beam forming, adaptive antenna, and multi-antenna technologies (MIMO), which have been the subject of active research at the turn of the millennium, are now basic technologies in the air interface of 5G networks for optimizing the performance of radio signal. The 6G will connect the physical, biological, and digital worlds (Viswanathan & Mogensen, 2020).

Moore's Law (Moore, 1965) familiar with integrated circuit technologies, serves as a good indicator of technological development. It doubles the computing power every year. This trend has almost come true with the development of wireless data as well. In the early 2000s, the data transfer rate was a few tens of kbps, and now, after almost two decades, users have managed to measure data in a commercial 5G network at a speed of 8 Gbps (Nokia, 2020).

This trend follows quite for Moore's Law. The growing real-time transmission needs of emerging technologies have forced the industry to introduce new frequency bands that have made it possible to increase data transmission capacity. In information theory, the Shannon theorem (Shannon, 1949) indicates the maximum transmission rate of a communication channel, which is inversely proportional to the noise contamination level of the communication channel.

2.3.1 Radio access network (RAN)

The air interface refers to a radio path between a base station (BTS) and a mobile terminal (MS). Radio performance is affected by interference components, such as noise, inter-symbol interference, adjacent channel interference, and co-channel interference. Transmission frequencies, bandwidth, and power are tightly regulated, resulting in a variety of standardized channel coding, modulation, and antenna configuration models to optimize radio path performance. BTS and MS also transmit control data, which are used, for example, in connection establishment, and power control. Radio network design optimizes, for example, BTS transmission power, cell size, locations, antenna sectoring, radio performance, and ensuring seamless hand-offs. Network constantly tracks MSs within a cell, and when a user reaches the border of a cell, the network automatically hand-off the connection and the connection is assigned a new cell. New wireless generations, for example, 5G, have enabled the transition from a traditional radio network architecture to an architecture in which a radio access network (RAN) consists of macrocells, microcells, picocells, and femtocells that overlap among themselves. Figure 3 illustrates the radio access network (RAN) architecture. RAN is an access point to the network. The core network provides services,

> such as telephone calls and data connections. The transport network keeps the access network connected with the core, and the base stations within the radio access network connected with each other. The interconnect network connects different core networks with each other (Ericsson, 2018).

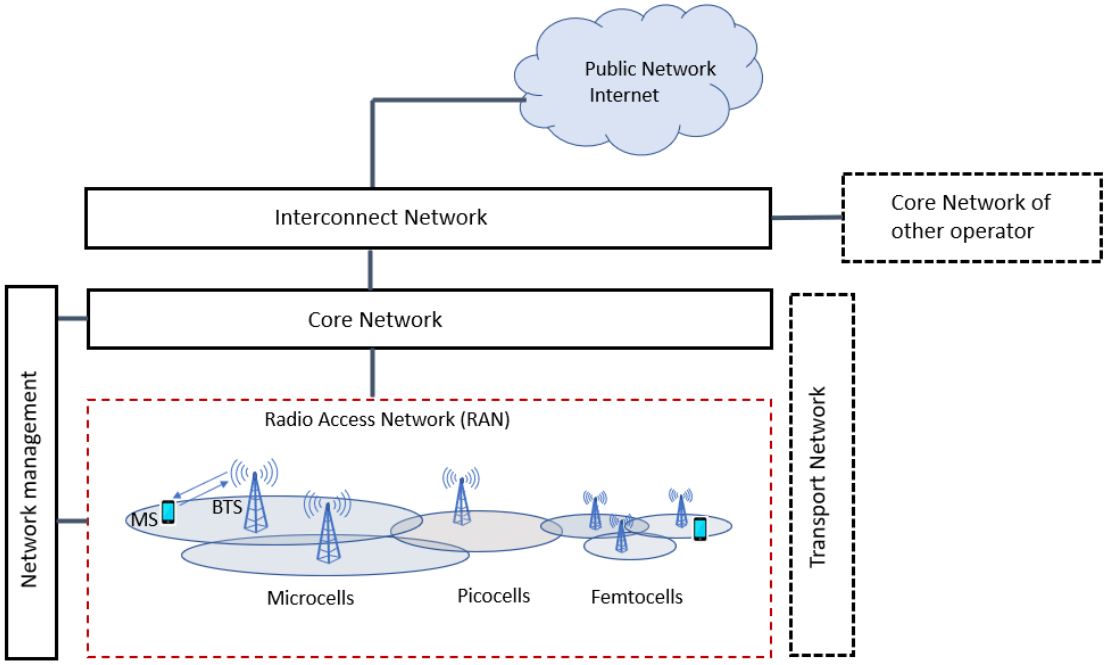

FIGURE 3 Radio access network architecture

Macrocells provide coverage up to tens of kilometers, microcells a few hundred meters, picocells up to 100 meters, and femtocells 10–50 meters (RF Wireless World, 2021). The 5G core network architecture is the same as classic networks (2G, 3G, and 4G), but cell sizes are smaller in radio access network. The most remarkable difference in moving from 4G to 5G is the increased peak data capacity and reduced latency. The 5G network can support the use of many simultaneous devices, which is important, for example, in IoT development.

2.3.2 Green cellular networks

In addition to environmental considerations, the energy efficiency of mobile networks is a cost issue for mobile operators. Coverage of the base station area depends on the transmission power and propagation conditions. Even if the traffic density is low, base station coverage needs to overlap neigh boring cells to ensure necessary mobility management, and full coverage must be ensured at all times, even if there is no active user (Capone, dos Santos, Filippini, & Gloss, 2012).

Energy efficiency can be improved by increasing spectrum efficiency, for example, by increasing the modulation level or by using more antennas, allowing the same amount of data to be transmitted with lower energy consumption. If the green network utilizes power-reducing techniques, such as sleep modes with a flexible control signaling model, then the BST "can just wake up periodically to send synchronization signals, broadcast necessary system information, and detect Random Access Channel (RACH)" (Li, Chen, Xu, Tian, & Huang, 2020), which is used for connection set-up.

2.4 Engineering design thinking

Traditional design, such as that presented by Dym and Brown (2012) addresses issues related to electromechanics based on the natural sciences. Traditional design thinking does not take into account the human side of the design process but focuses on technical design and related theories in a way that ignores the needs of the end user (Datye, 2012). As technologies evolve and things become digital with massive multifunctional technologies, the understanding of human life as a whole grows as a design requirement.

Figure 4 illustrates the placement of future real-time 6G mobile broadband technology in the middle ground of the physical, digital, and biological worlds (Viswanathan & Mogensen, 2020). LBD approach provides a good tool for tie-together development of human-machine interfaces, knowledge systems, sensing systems, and ubiquitous computing so that the combination of these results will bring benefits to people's lives.

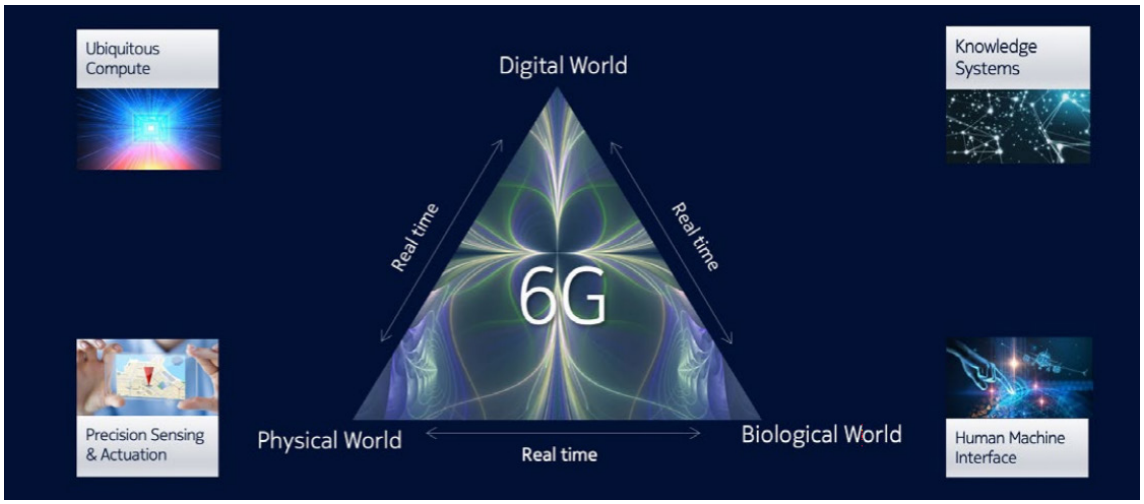

FIGURE 4 Future 6G mobile broadband connects physical, biological, and digital worlds (Viswanathan & Mogensen, 2020)

2.5 System development process

Ulrich, Eppinger, and Yang (2020) defined a generic six-phase development process. The process begins with a planning phase in which the output is the project mission statement. The planning phase is guided by the definition of corporate strategy and assessments of technology development and market objectives. The output of the planning phase is direct input for the concept development phase. In the concept development phase, the needs of the market and possible alternative product solutions are studied, from which a selection is made for further development and testing. System-level design phase includes

the definition of product architecture and detailed design responsibilities. The output of the system-level phase is control documentation. Detailed design phase includes complete specifications and process plan established.

The testing and refinement phase includes several prototype phases and builds and their evaluations, from early *alpha* testing to subsequent performance and reliability tests to *beta* tests. In the production ramp-up phase, remaining problems are identified in production process. Product launch is the last step in the product development process, exploring ways to improve the product development process for future projects.

FIGURE 5 Product development process (Ulrich, Eppinger, & Yang, 2020)

The product development process presented by Ulricht is also suitable for the process description of information system projects. The fift chapter describes the procurement phase of the Apotti project, in which the stages of the development process described above have become established. It is also important to consider the customer in the design process. According to Tuunanen et al. (2010), the following key challenges in the development of information systems need to be overcome:

- Service process experience, how, and when encourage consumer involve and participate to the development process,
- Respect of customer participation to co-creation of value and service production,
- Customer goals and outcomes— the actual use of the system to be developed cannot be assessed with sufficient accuracy.

The speed of technological development and the development of various digital services have created a need for the continuous adoption of new digital service concepts. Young people in the digital generation have grown up with the constant development of digital services and are able to embrace change. For the older age group, rapid cyclical change poses challenges for the use of new digital services and wireless devices. This puts people in an unequal position and widens the digital divide. It is difficult to anticipate because development is non-linear, the pace of development varies from sector to sector, and changes cross-sector (Valtioneuvoston kanslia, 2021). The next chapter discusses digital well-being, which is emerging as a focus for a large proportion of people.

3 ENSURING THE DIGITAL WELL-BEING OF CITIZENS

Digital well-being refers to the impact of digitalization, changes in the digital environment, and maximizing the availability and accessibility of services, which make it possible to live a life that is good for human being (Burr, Taddeo, & Floride, 2020). The Ministry of Finance has defined that public digital services must be functional, easy to use and secure. (Ministry of Finance, 2019).

Historically, studies on HTI have focused on the description of technological innovations and how efficient such systems are. The LBD approach to design thinking, however, starts by considering human beings and their life conditions as a whole. The human requirements for digital well-being are based on two main concepts: the digital divide and the requirements of inclusive design (Attewell, 2001; Hilbert, 2011; Leikas, 2009). In inclusive design, products and services are designed so that even the weakest members of the target group can use them. Understanding accessibility and user needs plays an important role in inclusive design. If the technological development has not taken sufficient account of accessibility and adoption of products and services, a digital divide may form (Leikas & Koivisto, 2015).

The reasons for the digital divide can be grouped into three main categories: access, use, and quality of use (Hänninen, et al., 2021):

- **Access divide**: The socio-economic situation in different countries and between people creates inequalities in access to digital services.
- **Use divide**: There is a lack of digital skills, which hinders the processing of technology.
- **Quality of use divide**: Users may have digital skills, but they do not have the knowledge that digital services can take advantage of and get the most out of it.

The use divide is a major problem in developing countries, where only now are the first digital technology solutions beginning to become more widespread. In industrialized countries, the same problem may arise as new technologies flood into the market, and, for example, older people are unable to keep up with

developments. “For example, the digital divide for senior citizens can be caused by an inability to use the services due to a lack of knowledge, education, and training, and even a reluctance to acquire and try new technologies” (Leikas, 2009). Technology can be used to increase the well-being of older people in many ways (Keränen, et al., 2017). The development of technology is supposed to improve the interaction between humans and technology in a way that enables digital well-being regardless of time and place (Vilpponen, Leikas, & Saariluoma, 2020).

3.1 Digital service development stakeholders

Digital service stakeholders include a wide range of different areas:

- **End users**: Usage levels and requirements can vary greatly according to the user’s skills and needs.
- **Digital service providers:** These can be private, commercial, or public service providers.
- **Device manufacturers**: Computer, tablet, and smartphone manufacturers are constantly developing new platforms for digital services, as well as various application stores.
- **Technical infrastructure:** This group includes, for example, data networks, wireless broadband, and cloud services providers.
- **Regulations and laws**: International and country-specific laws and regulations governing technological development, the implementation of data security and data protection, and the organization of digital services.
- **Research and development**: Universities, research institutes, and industries are constantly developing new technologies to improve the digital environment, such as intelligent autonomous systems and devices.

End users and their needs are the main stakeholders in public digital service development. For example, the elderly has special needs that need to be taken into account when designing services. Usually, additional features and stand-alone solutions to services increase the price of the digital service to be procured. The sourcing organization should carefully consider the cost impact of the service compared to the normal level of service.

The services must comply with the minimum level set by the WCAG; all that comes on top of this will increase procurement costs. Typically, in a public procurement organization, expertise is focused on the procurement process, and the necessary expertise on the functionalities and technologies of the procurement object is lacking. The procurement organization needs a wide range of experts to ensure high-quality and cost-effective procurement.

In many cases, system vendors play an important role in public procurement, as smaller organizations do not have their own resources to produce the necessary requirements specifications. Improving accessibility should be a key feature of the way system vendors operate. The government of

Finland is working to promote and guide the introduction of various digital services, which should also have a strong accessibility perspective that considers the needs of the elderly and other special groups, such as the disabled and immigrants.

3.2 Digital inclusion

Digital inclusion is an assessment framework that assesses the readiness of communities to provide access to the digital world. It is built on the acceptability, high quality, and ease of use of digital services. Digital inclusion refers to the actions needed for the most vulnerable individuals to access and use information and communication technologies (NDIA, 2020).

Digital inclusion is one of the EU's goals to ensure that everybody can contribute to and benefit from the digital economy and society (European Commission, 2021b). In Finland, key public sector themes are the utilization of digital operating models in service production and the close relationship between inclusion and digital inclusion (Hänninen, et al., 2021). Also, equality, protection of privacy, inviolability as a user of the service, and personal safety are also important parts of the digital inclusion framework. Digital inclusion can be divided into subcategories (Salminen, 2020), as shown in Figure 6.

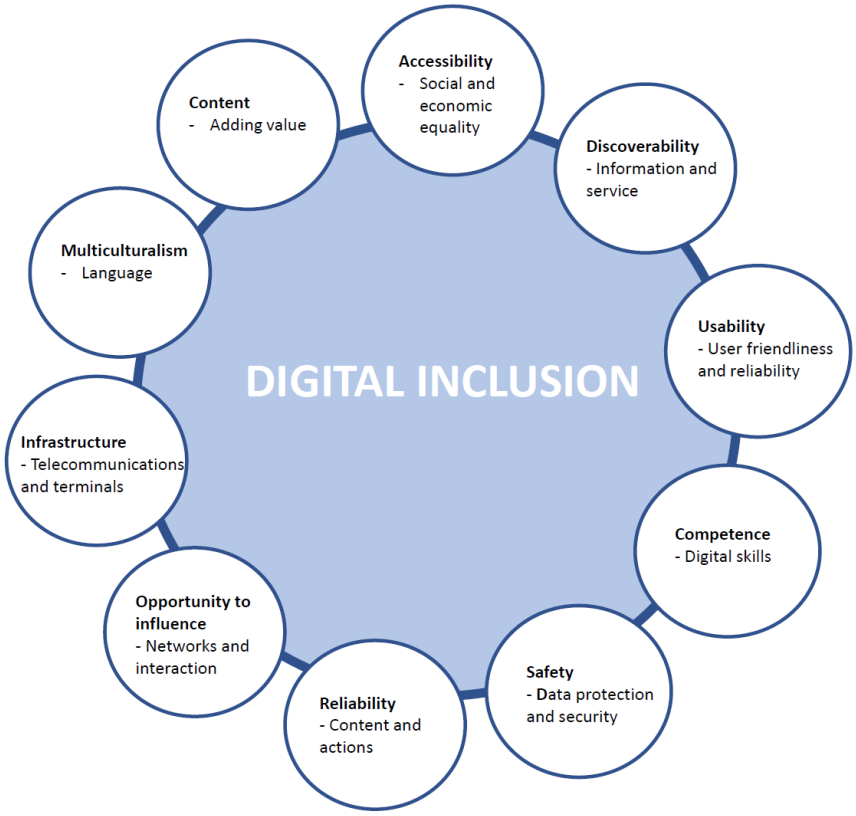

FIGURE 6 Subcategories of digital inclusion (modified from (Salminen, 2020))

Accessibility refers to social and economic equality and the promotion of understanding. Discoverability ensures information and services aggregation, as well as sharing and search services. Usability includes user-friendliness, reliability, and suitability for operation. Digital skills, motivation, and media literacy are areas of competence. Data security and data protection are fundamental elements of safety. Reliability consists of the content, operation, and transparency of the service. Networks and interactions affect opportunity to influence. Infrastructure is built on telecommunications and terminals. Multiculturalism brings with it different languages and ways of operating culture. Lastly, content that adds value is real-time and needs-based.

From the point of view of equality, it is essential to consider how to raise those who have fallen out of the information society back to awareness of digital services and what support measures they need. How can we reach those who do not know about the existence of a digital service option? When procuring digital services, it is important to take into account accessibility aspects in all groups of digital inclusion.

In the future, different AI solutions will allow services to be tailored to the needs of the user, but human-like AI is still several years away from the breakthrough of commercial solutions. It is now important to invest in the development of procurement processes so that, in the future, as AI applications develop, procurement will also have an understanding of the object of the procurement and its impact on the development of services.

3.3 Digital services in the public domain

In Finland, ministries, state institutions, and municipalities are responsible for organizing public services. Some public services are mandatory by law, but some municipalities have been able to expand the services they provide to a wider than mandatory level.

The goals of the government's digitalization program (Ministry of Finance, 2021) are:

- High-quality digital public services are available to citizens and businesses.
- Paper transactions and on-site visits have decreased significantly, and several digital-only business services are available.
- Digital support is available throughout the country and is being developed to serve businesses as well.

The EU has regulated WCAG (W3C, 2018), which have four principles: perceptibility, manageability, comprehensibility, and reliability. Under these principles, 12 guidelines are identified, defining a slightly more specific framework, general objectives, and detailed criteria. An example of the instruction is, "Implement all functionality so that it is accessible from the keyboard." The WCAG criteria are divided into three levels: A, AA, and AAA

level criteria. An online service that meets the AAA-level criteria ensures accessibility for the widest possible range of people with physical or cognitive limitations. The strictest requirements apply to this level; for example, the darkness contrast between the text and the background must be higher than the AA level.

In Finland, the Digital Services Act obliges public actors to implement online services to meet the criteria of the WCAG 2.1 standard at the A and AA levels (Celia, 2021). WCAG has entered into force in all digital public procurement in 2020. Public tenders must consider the requirements of the WCAG specification for the information system or service interface. Intelligent technologies and services are evolving at a rapid pace, and WCAG specifications focused on web services and user interfaces are not enough to define the accessibility and ease of use of future services. It is advisable to use an LBD approach as a design basis that considers the whole person. This adds to the challenge for the procurement organization's resources and expertise.

3.4 Reasons for the failure of public IT development programs

The failure of IT development projects is very typical. The topic has been studied extensively, but the same mistakes and problems are repeated from year to year. Many studies and presentations identify about 5 to 10 critical factors that contribute to the success of an IT development project (Petter, DeLone, & McLean, 2008; Cooke-Davis, 2002; Wateridge, 1995; Heeks, 2006). Table 1 lists 10 typical factors whose success is critical to IT project completion (Rosacker & Olson, 2008).

TABLE 1 Success factors in project implementation

Factors	**Description**
Project mission	Clear statement of goals and objectives
Top management support	Necessary resources and authority present
Client consultation	Communication, consultation, and active listening to all stakeholders
Schedule/plan	Detailed specification of actions required for project implementation
Personnel	Recruitment, selection, and training of necessary team personnel
Technical tasks	Availability of required technology and expertise
Client acceptance	The act of selling final projects to their ultimate intended users
Monitoring and feedback	Timely provision of an appropriate network and necessary data to all key actors
Communication	Appropriate network and necessary data to all key stakeholders in project implementation
Troubleshooting	Ability to handle unexpected crises and deviations from plans

These success factors are widely accepted, and enterprise-wide design is agreed to be the key determinant of information system project success. However, there is also a human factor in the development process that needs to be considered. User specific characteristics or social factors within a user's peer group can affect the success of implementation of an information system (Petter, DeLone, & McLean, 2013). There seems to be haste and pressure from both customers and management in development projects, and resources and budget are usually challenging. This raises the possibility of human error in the processes. This should also be taken into account in procurement, as a human error at the procurement stage can lead to costly and time-consuming procurement contract negotiations or additional procurement.

3.5 Digital system design

Technological developments have made it possible to build new digital services. Most citizens benefit from these, but the personal needs of older people are easily overlooked. The government and the EU guide the development of digital services for all user groups through regulations and various development programs. However, there is a large proportion of people who have never used the Internet (Parikka, et al., 2019) or their motorial or cognitive ability to interact with digital media is impaired. These individuals will not be able to use digital services, even if they are made accessible. A good example of this is the elderly, whose physical and cognitive abilities may be impaired, or they may not be able to operate modern digital devices at all (Vilpponen, Leikas, & Saariluoma, 2020). Technologies that are designed to be useful for older adults support the adoption of new technology in this user group (Mitzner, et al., 2019).

3.5.1 Design requirements

When procuring digital services for special groups, such as the elderly, the procurement process must involve experts with in-depth knowledge of organization enterprise architecture, the technical environment, interfaces, and the digital development roadmap. The process should also involve service experts for a comprehensive view of the customers and the service provided. End users, both customers and professionals, must be taken into account when defining the user interface and functionalities. It would be best if there were a professional service designer with an in-depth view of the HTI who could utilize the technical and end user problems and needs as a model of the desired digital service on the basis of which the procurement could be made.

After understanding human requirements, "designers must make assumptions and decisions about which technologies are most compatible with the human requirements and can be used to help people can be used to help people reach the state of digital well-being". In planning, it is very important to

take into account the boundary conditions set by the operating environment (Vilpponen, Leikas, & Saariluoma, 2020):

- Digital services should be accessible to all users regardless of their cognitive abilities.
- All user groups should be considered when implementing new services.
- Fading technology behind the user interface should be invisible to users.
- A personal interface level should be customized each user profile.

3.5.2 Digital accessibility to special groups

Digital services and a variety of digital technologies can support the independent living of people with disabilities, the elderly, and immigrants. Examples of technological aids include chat bots, screen readers, subtitles, and virtual interpretation. Clear and user-oriented service packages and well-functioning online forms make it easier to work with digital services. Achieving digital inclusion in assisted living often requires the help of an outside facilitator. Many services require authentication, which is essentially personal. When one must take care of another person's affairs, identification can cause problems (Vilpponen, Leikas, & Saariluoma, 2020).

In the autumn of 2019, the Ministry of Finance published a call for municipalities for a digitalization support program, where the studied municipality received funding to develop the accessibility of digital services for special groups (Ministry of Finance, 2021). As part of the funded program, the Technical Research Centre of Finland (VTT) conducted an interview study (Wessberg & Kuusisto, 2020) for special groups including the elderly, immigrants, and disabled. The needs of the special groups interviewed are described in four fields in Figure 7, where the y-axis describes the nature of the operation and the X-axis describes the level of independent activity.

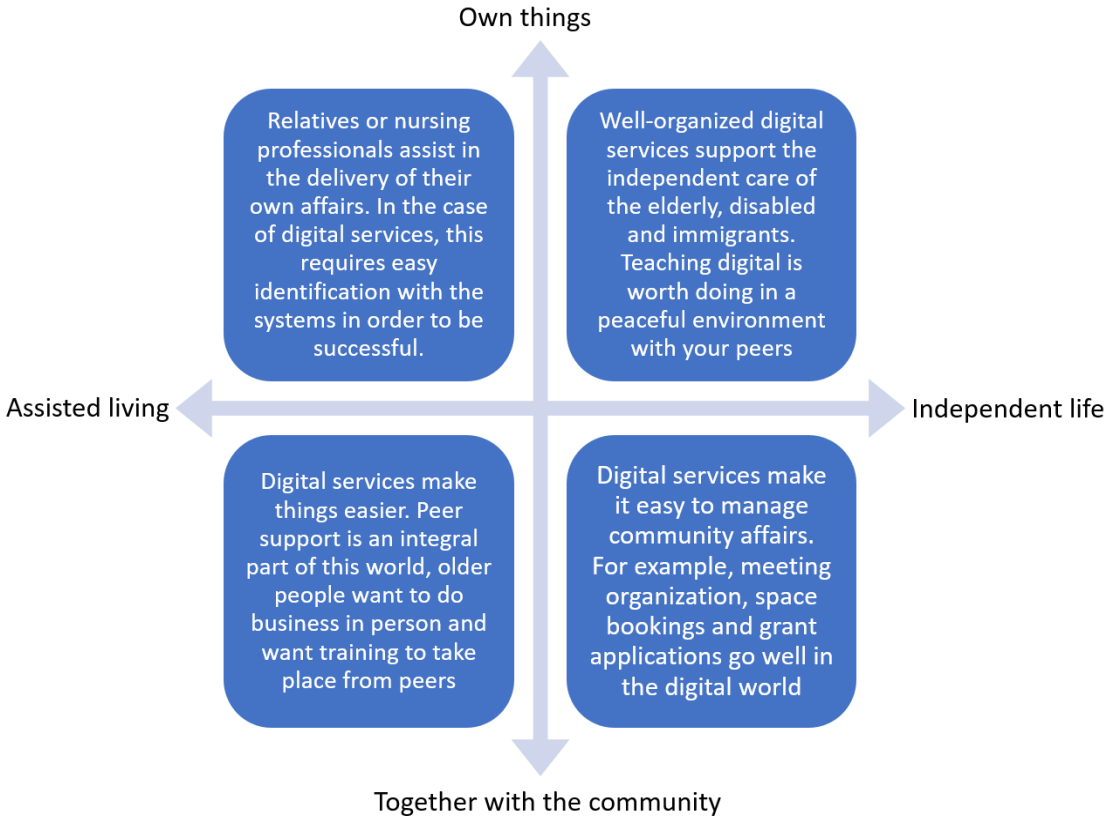

FIGURE 7 Findings and grouping digital inclusion for special groups based for (Wessberg & Kuusisto, 2020)

In comparing independent living with supported life, the following was observed:

- **Independent life** — Taking care of their own and common things.
  - Well-organized digital services support and enable the elderly, the sensory impaired, and immigrants to interact independently in various digital services.
  - In the oldest age groups, dealing with a person is often required.
  - The mobile phone is currently the most popular tool for doing things, but new generations are likely to change it.
- **Assisted living** — Taking care of their own and common things.
  - In practice, matters are delivered by relatives or nursing professionals.
  - In the case of digital services, this requires easy identification with the systems to be successful.
  - Immigrant communities, in particular, have people who help community members as needed.

The elderly people interviewed belonged to the active group of the silver economy, which is why their needs consisted mainly of the ease of use of digital services, both technically and in terms of logical service structure. The fragile part of the silver economy was not considered in this study with sufficient weight. Doing things in an independent life compared to an assisted life is easily found

in the fact that in an assisted life, a person operating digital services knows how to use the necessary tools and services, while a person living independently can get into trouble with new equipment and services. In the future, virtual communities will also be further strengthened with special groups. Virtual events, such as museum visits or virtual coffee by various interest groups, are becoming increasingly popular. The community is always more and more virtual, including services. Accessibility is a vital part of digital inclusion. If accessibility and digital inclusion are taken into account for special groups, all others will, in principle, be taken into account.

Acquiring research such as the one described requires special expertise for an understanding of the research topic, research methods, documentation, and the necessary networking. These competencies are not part of a typical municipal procurement process.

3.5.3 Sensor systems

Various IoT devices and Smart Home concepts have entered the market (Jo, Ma, & Cha, 2021). The term IoT refers to a device that can connect to the Internet to send and receive various data, either in real time or in timed or activity-triggered transmission cycles. IoT devices and related services can see many good aspects for the service provider, such as the municipality. For example, in independent living for the elderly, IoT devices can be used to increase safety by installing motion detectors in the home that alert the respondent if movement has not been detected for a long time (Ministry of the Environment, 2017).

The smart home and smart city solutions being developed raise the question of who can acquire these systems and how the data produced will be utilized. "Older adults were concerned about social stigma after adopting the system because living in smart homes may be viewed as a loss of the ability to be independent" (Chung, Dimiris, & Thompson, 2014). Various sensor systems have been built in homes and service homes for the elderly to help alert or predict possible changes in health. In these systems, the customer has been asked for separate consent for technological monitoring, but what will happen in the future when the residential environment is full of IoT devices and various sensors? The control of these systems is in the hands of service providers, and the Personal Data Act (Finlex, 2018) does not keep pace with developments.

In Finland, many municipalities operate as home care providers for the elderly, either by purchasing services from an external service provider or by providing the services themselves. This raises the question of whether the service provider can be obliged to use IoT products or whether the customer has the option to refuse to use IoT solutions. Acquisition of the service described above requires special expertise in addition to the production of the service task itself, as well as technological understanding of, for example, IoT, data security, and data protection legislation.

4 SUMMARY OF INCLUDED ARTICLES

The technologies, systems, and usability concepts presented in the articles reflect the field of activity of the modern public service sector filled with information systems. The production of public digital services or a large-scale information system requires an ICT infrastructure and the development of a service concept. Public administration typically does not have its own resources for different areas of technology, and expertise must be acquired from external parties. The public sector serves all residents; thus, for equality, it is very important to take into account the needs of special groups, such as the elderly.

The articles in this dissertation discuss various models and technologies related to the organization of digital services. The articles present the need for specific expertise in many areas, from wireless technologies to behavioral science, through understanding the socioeconomic needs of older people to public information system development. Articles I and II focus on wireless communications. Articles III and IV deal with municipal information systems, social, and healthcare information system reform, and critical success factors in municipal information system projects. Articles V and VI deal with the LBD approach to digital well-being and the development of digital services for the elderly.

All the special competence areas presented in the articles are an integral part of the development and acquisition of public digital services. The procurement organization must have at least a good idea of all the special expertise required for the sustainable procurement of digital services. It would be best if the contracting authority had in-depth expertise to ensure procurement definitions. This highlights another factor influencing the success of procurement. Typically, experts in different areas of technologies and functionalities have their own special language of expression that works effectively between those who do the same job but does not open up to outsiders correctly. An example of this is the cloud-based acquisition of Enterprise Resource Planning (ERP) system for healthcare use. Nurses working with the patients are not familiar with the technical terminology and practices used in cloud technology, while telecommunications experts are not familiar with the data protection rules

related to the processing of patient records and workflows. The procurement organization must understand the particular importance of terminology at the tendering stage, as unclear interpretative definitions lead to extra work and, in the worst case, procurement failure or large extra costs.

4.1 Article I: Enhanced circuit switched data for real-time services over GSM

Hamiti, S., Hakaste, M., Moisio, M., Nefedov, N., Nikula, E., & Vilpponen, H. (1999). Enhanced circuit switched data for real time services over GSM. In *Gateway to 21st Century Communications Village -- VTC 1999-Fall: IEEE VTS 50th Vehicular Technology Conference* (pp. 578–582). IEEE.

Research objectives

The purpose of this study was to develop a circuit-switched mobile data feature for GSM (2G) technology.

Findings

In the late 1990s, the emergence of various digital services began. Mobile phones were combined with cameras and real-time video transmission, and other Internet services expanded to include mobile use. The growing need to increase the real-time data rate has created a need to increase the data rate in GSM. This study presents an increase in the GSM data rate of 14 kbps by the enhanced circuit-switched (ECSD) solution, which demonstrated that the data rate can be increased by converting GSMK modulation to 8-PSK modulation. An 8-PSK signal can carry 3 bits of data per modulated symbol, while GSMK can carry only 1 bit. The maximum air interface data rate of the ECSD radio was 43.5 kbps, compared to the maximum GSM air interface speed of 14.4 kbps.

TABLE 2 GSM and ECD radio interface data rates

Service name	Modulation	Radio interface rate (kbps)
GSM TCH/F14.4	GMSK	14.5
ECSD TCH/F28.8	8-PSK	29.0
ECSD TCH/F32	8-PSK	32.0
ECSD TCH/F43.2	8-PSK	43.5

The ECSD radio interface control channel (FACCH) presented in the article is patented (US Patent No. 7,031,334, 2006) by the authors of the article, and it is a mandatory feature in all tens of billions of GSM devices produced over the years (3GPP, 1999b). Continuous technical development and its integration into usability is very important now and in the future.

Specific competencies required for the procurement of digital services

The work described in this article required in-depth knowledge of information theory, related simulation tools, standardization of wireless communication systems, and a practical understanding of patenting processes. When procuring specific information systems or development work related to wireless data transmission, the procurement organization must have sufficient knowledge of wireless standards and systems, network development tools, and development roadmaps. The development of new digital services may create a need to improve wireless network connectivity for capacity or other telecommunication parameters.

The development of digital services is also putting pressure on the development schedules of network operators. Public administration actors, such as municipalities, do not need to be involved in the basic development of wireless networks, but it is good if public administration actors are familiar with current state-of-the-art and wireless network development plans. It is important to monitor technological developments and engage in dialogue with other municipalities, operators, and service providers. A good tool for that is to involve university cooperation where possible, as the practical experience gained in the field is valuable to academia and produces good candidates for future employment needs.

4.2 Article II: Turbo-coded modulation over GSM channels

Papadimitriou, P.D., Sexton, T.A., Varshney, P., & Vilpponen, H. (2001). Turbo coded modulation over GSM channels. In *Proceedings of 2001 International Conference on Third Generation Wireless and Beyond* (pp 787–791). Delson Group Inc.

Research Objectives

The data rate of the GSM system is limited in enhanced general packet radio service (GPRS), especially the speed of downlink needs to develop. The study presents a way to increase the data rate using different levels of QAM modulations.

Findings

The development of GSM led to the emergence of the Enhanced Data Rate for GSM Evolution (EDGE) standard (3GPP, 2003). EDGE specification features packet capability, Enhanced General Packet Radio Service (EGPRS), and an Enhanced Circuit Switched Data (ESCD). In EGPRS, the data rate is increased by changing the modulation from GSMK modulation to 8-PSK modulation, and no changes to the core network are needed, except for the updates related to the radios at the transmitting and receiving end. Table 3 shows the maximum information data rates that can be achieved with different coding rates.

TABLE 3 Maximum information data rates

Rate	Modulation	Data Rate
3/4	16-QAM	473.6 kbps
4/5	32-QAM	631.5 kbps
4/6	64-QAM	789.3 kbps

The development of mobile broadband has continued and will continue in the future. An example of the steps of development is OFDMA modulation and related technological development in the early 2000s (Varshney, Borran, Vilpponen, & Papadimitriou, 2003). Current 5G radio networks are based on OFDMA technology and various multi-antenna (MIMO) and beamforming technologies, which were studied in the early 2000s.

Specific competencies required for the procurement of digital services

This is a research topic related to the basic research on mobile broadband air interface (Layer 1) development. The 2G radio standard described in this article and the improvements planned for it are now in the 4G and 5G networks. The QAM-modulation and multi-antenna solutions presented in this article can improve the quality and speed of data connections. Especially in 5G radio networks, MIMO and radio beam-forcing technologies are needed to ensure a high-performance data connection. The requirements for digital services and wireless systems for network connections are high. For example, in the Apotti system, the nurses' mobile workstation used for home care needs a good network connection to work. Not all locations in home care have sufficient 3G/4G/5G coverage, so when solving problems with network operators, it is important that the municipal representative understands the technological boundary conditions when examining the problems.

The digitalization of services poses great risks to the organization of operations if the network or information systems fail, and in the case of health and social care, patient safety issues arise when the network and information systems do not work as planned. The network and information systems procurement contracts should clearly describe the responsibilities and liaison officers through which problems are resolved. At the procurement stage, it is important to define the service level agreement and related sanctions. This work requires in-depth knowledge planning and operation of network and data connections, as well as knowledge of end-user work processes and needs, such as on the activities of social and health professionals in the field.

4.3 Article III: Combining social services and healthcare as the first country in the world: Exploring the impacts on information systems

Vilpponen, H., Grundström, M., & Abrahamsson, P. (2018). Combining social service and healthcare as the first country in the world: exploring the impacts on information systems. *Journal of Advances in Information Technology*, 9(4), 84–88.

Research Objectives

This study describes the scope and methods of Finnish social and health care reform in the Helsinki-Uusimaa reform project.

Findings

The article describes the information system landscape of 26 municipalities in the Helsinki-Uusimaa region and examines in more detail the information system structure of a typical mid-size municipality with hundreds of interconnected information systems tailored to the needs of that municipality over the years. The Finnish government has a goal during 2017–2018 to implement social and health care area reform.

The reform was intended to replace the social and healthcare systems maintained by the municipalities with one new system in the area to be established. In the Helsinki-Uusimaa reform project pre-screening phase, more than 1900 information systems were identified, most of which belonged to the hospital systems of the hospital district. One problem was that municipal versions of the same original information system had been customized, and the data structures and interfaces were incompatible. The Helsinki-Uusimaa reform project ultimately failed because political decision-making at the government level in 2019 failed to agree on the necessary legislation. The government decided to suspend the reform in 2019.

Figure 8 shows the information system map of the medium-sized municipality and the integrations between the systems. A typical medium-sized municipality has about a hundred different information systems, approximately 20% of which are social and healthcare systems. Some information systems are linked to each other.

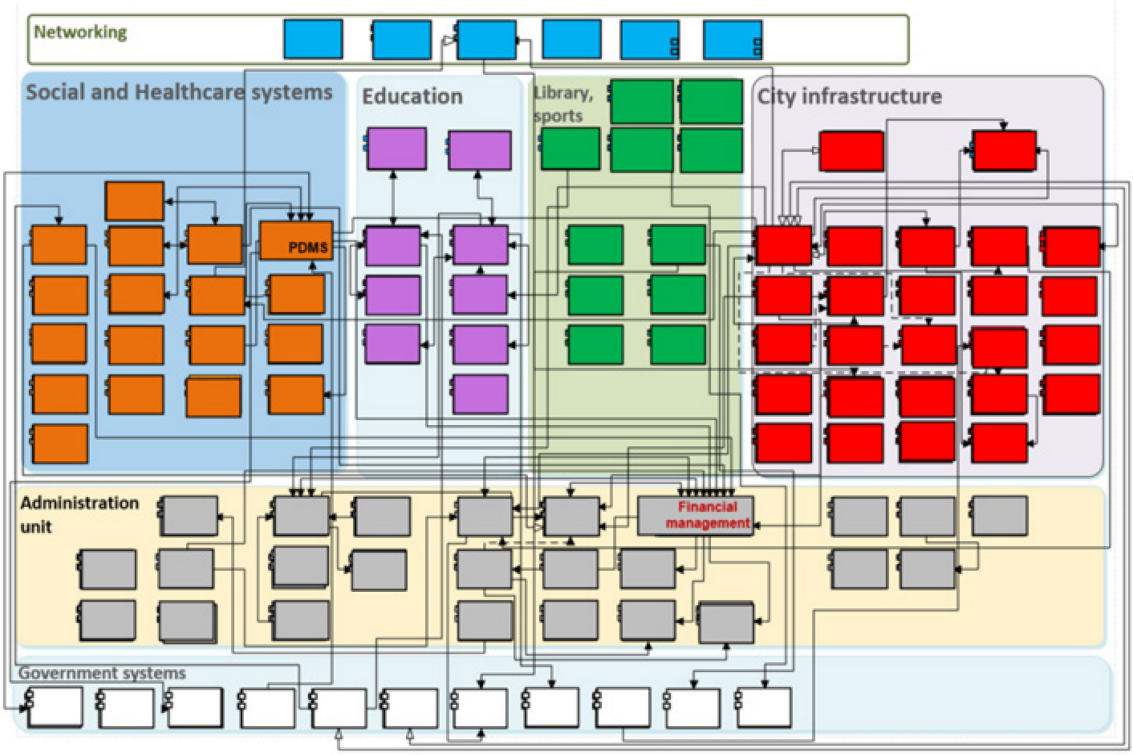

FIGURE 8 Information systems map for typical medium-sized municipality

Specific competencies required for the procurement of digital services

When developing the information system portfolios of a municipality or a larger public entity, the most important competence is to understand the enterprise architecture and the life cycle of the information systems. Knowledge of the procurement process is vital, as procedural errors in the procurement of systems easily pose a challenge to the Market Court, which delays the completion of the process, even if the municipality receives an exemption decision. Another important consideration, in addition to technology and procurement processes, is an understanding of how customers and staff live and use the systems. It is easier to instruct and train users with staff, but it is good to understand customers' behavior and practices in advance. In the best case, the needs of customers can be taken into account in the definition phase of the tender, and the introduction of a system that is good in terms of overall economy and usability can be achieved.

4.4 Article IV: Exploring the critical success factors in social and health care information systems project procurement

Vilpponen, H., Grundström, M., & Abrahamsson, P. (2020). Exploring the critical success factors in social and health care information systems project procurement. In *Recent Developments in Engineering Research, Vol.8*. Book Publisher International.

Research Objectives

The study presented in the article aims to identify the most typical problems in the procurement of IT systems in a medium-sized municipality.

Findings

Results of interviews are presented of the survey results in primary empirical conclusions (PEC's). In the analysis of the results of the interview survey, six categories emerged. The categories are shown in Table 4. To achieve a successful information system project in a public organization, the system must have a clear owner with an adequate budget that includes the necessary resources. The project owner should systematically monitor the project and correct any deficiencies.

TABLE 4 Primary empirical conclusions

PEC's	Description
Ownership	The system must have a clear owner who is equipped with an adequate budget that includes the necessary resources. The project owner should systematically follow the project and address any shortcomings as they arise
Legislation	Public sector operating environment and tendering rules are very strictly regulated by the Procurement Act, which poses challenges for fast-paced information system development.
Legacy systems	Vendor lock-in forces municipalities to use a certain product or service, regardless of its quality, because switching away from it can be challenging, and the switching costs may be substantial.
Procurement	A lack of practical expertise during the planning and definition phases of information system projects, affects the quality of the outcome.
Political decision-making	Delays in political decision-making leads to delays in social and health care reform, which further complicates the information system design due to changing priorities and goals.
Enterprise Architecture	The development of a unified enterprise architecture for the whole region is critical to the success of the social and health care reform.

Various laws and regulations have a decisive effect on the operating environment of the public sector. Procurement and tendering rules are strictly regulated by the Procurement Act, which poses challenges to the rapid development of information systems. The vendor lock-in, which has emerged over the years, forces municipalities to use a particular product or service, regardless of its quality, because switching from it can be challenging, and replacement costs can be significant.

The competencies of procurement organizations are oriented toward procurement processes, and the lack of practical expertise in the design and specification phase of information system projects greatly affects the quality and final price of an information system project. The government has repeatedly sought to reach a decision on social and health care reform, but delays in political

decision-making have led to delays in implementing the reform, further complicating the design of information systems due to changing priorities and objectives.

Finland does not have a unified enterprise architecture in social and health care, and municipalities and associations of municipalities can make their own solutions based on their needs. The regional enterprise architecture could be used to ensure the interoperability of information systems, the portability of data, and the co-development of services. This brings synergies to the development of common digital services, and makes relevant the dynamics of magnitude, making development projects better able to negotiate cost-effective development projects from digital service providers. Medium-sized or small municipalities do not have a voice when acting alone.

The research focuses on the observations of healthcare management and professionals, IT managers, procurement experts, and system vendors about the critical success factors of health care information system projects. The end user's view of the systems is missing from the study. The same critical factors also become more widespread in the context of public information system procurement.

Specific competencies required for the procurement of digital services

The professionals interviewed in the article represented the knowledge of their own specialty; what they had in common was that the operating environment was a municipality, and everyone had strong experience in acquiring and ramp-up various systems. The definition of information system procurement related to a specific functional area requires practical, specific knowledge of the organization of activities and operational details, interfaces, and related legislation. For example, the definition of an ERP system in school student care differs much from the definition of a healthcare patient information system. Both systems process sensitive personal data that are relevant to the operation of the system and the handling of customer-related tasks, but the data protection specifications for healthcare information systems are much more tightly regulated by law and monitored by the authority.

4.5 Article V: Life-based design to combat loneliness among older people

Leikas, J., Saariluoma, P., Rousi, R., Kuisma, E., & Vilpponen, H. (2012). Life-based design to combat loneliness among older people. *Journal of Community Informatics,* 8(1), 7–14.

Research Objectives

The aim of the study is to define HTI design principles to reduce the loneliness of older people using the LBD approach.

Findings

The identification of ways to reduce the sense of loneliness in older people is accomplished by examining people's lifestyles, values, and everyday situations and effectively integrating these into the LBD approach. LBD is a multi-dimensional and holistic approach to understanding older people's lives as a basis for the creation of design ideas and for concept design.

Form-of-life analysis should generate human requirements for the product or service. These requirements define how people's lives in a specific form of life should be improved. The basic idea of LBD is that knowledge about the structure of forms of life can be used when designing digital services to improve quality of life. In this article, the following steps summarize our procedure for a service design that decreases the feelings of loneliness among older people:

- Identify the pivot problem: Loneliness among aging people
- Analyze its human dimensions: Mental and conceptual properties of loneliness found in large psychological studies.
- Conceptualize the technical solution models: A service for loneliness.
- Harmonize the model with human and contextual information: What kinds of sub-services are required?
- Analyze possible usability problems: Usability metaphors and simplified procedures, icons, and interaction language

Specific competencies required for the procurement of digital services

The article describes form-of-life analysis as part of LBD and how it utilizes user-centric information about human requirements. In-depth understanding of human behavior, usability, and socio-economic knowledge combined with technological HTI know-how provide the best starting point for the development of the topic. The loneliness of the elderly is a matter for the municipalities, as a well-to-do vibrant citizen enjoys and feels better and does not necessarily need special care as quickly as an elderly person suffering from loneliness.

When procuring technical aids and systems to minimize loneliness for the elderly, the procuring organization must have an understanding of the need and its implications, as well as the architecture and applicability of the technical solutions to the municipal environment. In the future, a large part of basic nursing work will be carried out with the help of robotics, which will raise the ethics of nursing work to a large extent in the design of AI and robotics related to nursing work. How are clients' own will and desire taken into account in their care? Who defines a good life, and how do clients experience a lack of human contact? Addressing these issues requires a holistic understanding of human activities and needs.

4.6 Article VI: Designing the digital well-being of senior citizens

Vilpponen, H., Leikas, J., & Saariluoma, P., (2020). Designing digital well-being of senior citizens. In *2020 13th International Conference on Human System Interaction (HIS)* (pp. 40–44). IEEE.

Research Objectives

The purpose of this study was to define design principles for ensuring the accessibility of digital services for the elderly. Currently in the public sector, services digitalization has progressed on a case-by-case basis without considering the whole, and efforts have been made to take advantage of the porting of an existing service to a digital interface. Digital services require a smartphone, tablet, or computer, which represents a challenge for older people who have experienced a decline in physical or cognitive functioning.

Findings

After understanding human requirements, designers must make assumptions and decisions about which technologies are most compatible with identified human requirements and which technologies can be used to help people reach the state of digital well-being. In planning, it is very important to consider the boundary conditions set by the operating environment.

The following design requirements presented in this article should be considered:

- Digital services should be accessible to all users, regardless of their cognitive abilities.
- All user groups should be considered when implementing new services.
- Fading technology behind the user interface should be invisible to the
- A personal interface level should be customized to suit each user profile.

The article describes an architectural model (Figure 9) of an intelligent interface to enable the accessibility of services for the elderly, which allows the user to find the service that best suits the user's needs and the situation. The intelligent interface identifies the customer's personal cognitive and physical abilities. Then the user interface then automatically selects the appropriate service level and service based on the customer's service needs and selects the services that best suit the customer.

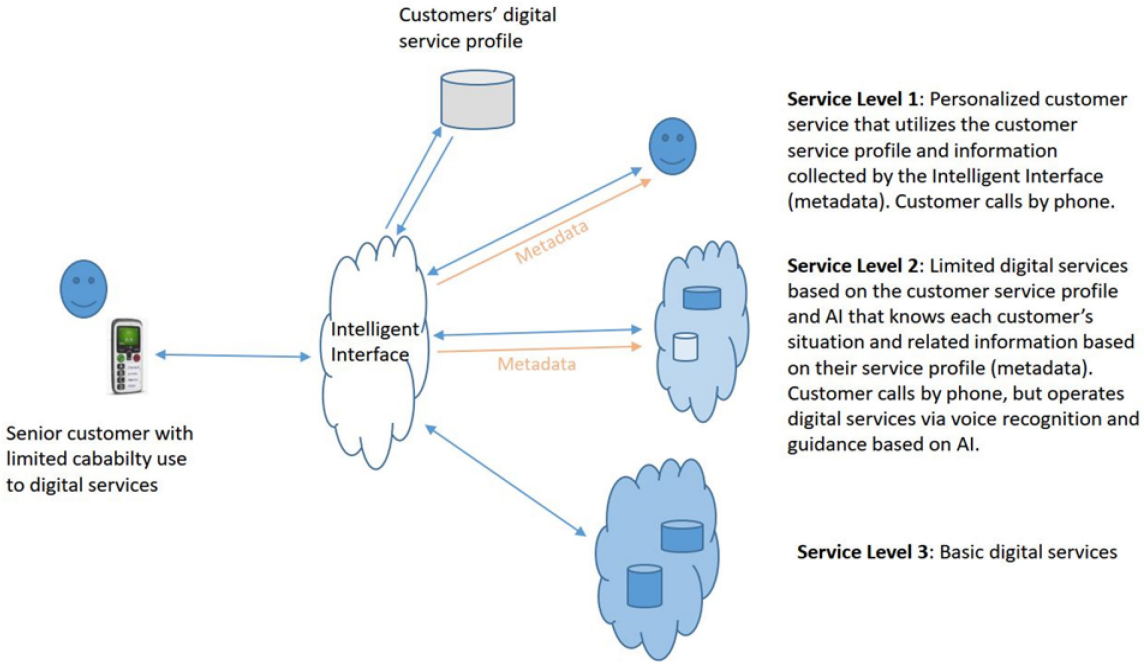

FIGURE 9 Intelligent interface with customer-specific digital services

Specific competencies required for the procurement of digital services

The article provides definitions of how the needs and aspirations of older people should be taken into account to ensure their digital well-being in the development of new digital services. The key competencies in developing the digital well-being of older people relate to understanding people's behavior, emotions, and in-depth knowledge of older people's life and environment. The designer must understand the elderly as a whole, considering their life situation.

The same issues arise in the procurement of digital services for the elderly. Typically, digital services are optimized for the general population, whose ability to interact with digital services is at a good level compared to, for example, the elderly belonging to a fragile group. To take the needs of older people into account in the best possible way, older people should be involved in planning at the definition stage.

New technologies and interfaces can cause problems for older people when adopting a new service. Technology details should be hidden from end users. Service design and technology developers should be involved at an early stage in development planning. Older people and their needs should be used in defining digital services for them, as they are the best experts in assessing the usability and ease of use of services. Thus, service designers and technology developers must not exclude end users' feelings about whether their needs have been consulted and whether they can rely on the digital service and its privacy. When acquiring digital services for the elderly, it is worthwhile to utilize experts who have a holistic view of the lives of the elderly and the available technical solutions, as well as the fit of the digital service to the roadmap for the development of digitalization.

5 DISCUSSION

5.1 Information systems procurement competencies

The development of wireless data networks and the increase in data transfer speeds have made it possible to create various digital services and applications. There are 1.9 million applications in the Apple Store alone (Bullfire, 2021). This has brought with it an information overflow that requires special digital media literacy skills (Salomaa & Palsa, 2019). The services using the first digital data were slow, and simple systems were offered to produce a single service, such as multimedia messaging and lightweight Internet browsing. Today, data speed (Nokia, 2020) does not limit the development of services, and new digital services are emerging increasingly, which poses challenges for the adoption of new services, especially for the elderly. The first lessons of digital use are no longer enough in the flood of new digital services. Older people need peer-to-peer networks (Wessberg & Kuusisto, 2020) through which they can embrace new technologies, share concerns, and take advantage of new technologies. Technological development steps from social networking sites to robotics and artificial intellectual services have reduced social isolation, loneliness, and feelings of social connectedness (Neves, Franz, Judges, Beerman, & Baecker, 2017).

5.1.1 Public service digitization

Accessibility is part of digital inclusion. Accessibility and digital inclusion affect everyone—especially taking into account the needs of older people in the design of services is part of both (Vilpponen, Leikas, & Saariluoma, 2020). If accessibility and digital inclusion have been considered for the elderly, all other users will automatically be noticed. The Finnish government has put in place several support programs to increase digitization in public services, and enacted numerous laws to promote digitization.

To ensure equitable access to public digital services, the EU enacted the WCAG Accessibility Directive, which entered into force in autumn 2020. The directive must be transposed nationally in each EU country by 28 June 2022. According to WCAG, a website is accessible if the following principles are followed. The webpages must be perceivable, operable, understandable, and robust. The WCAG principles set a minimum condition for the accessibility of Internet web services. However, these minimum conditions do not consider all the challenges that digitalization brings to older (Vilpponen, Leikas, & Saariluoma, 2020). It is not enough, even if the interface contrast and font are in accordance with the specifications, or the system menu is easy to use. Determining the requirements of age requires a holistic understanding of users and their needs. Following an LBD approach, the needs of the elderly can be taken into account holistically, adapted to the existing technical environment, or created by new solutions that are also suitable for the development of organizations' enterprise architecture.

In the public sector, the development of digital services for the elderly faces many challenges due to the tight economic situation. In the municipalities, different business areas strive to improve their own service offerings by digitizing the services they currently operating. Often, only the user interface is digitized from the services, and the original information system is left in the background. This helps significantly in the availability of services, as digital transactions can take place 24/7 and staff resources are not committed to customer service work. Accessibility of digital services is often deficient, especially when the needs of the elderly are not taken into account. Making the service accessible would cost too much, or in some cases, changes to the service are not possible due to the old information system.

Digitization projects are usually of such a size that they must also be put out to public tender[4]. One of the basic problems in service digitalization is application programming interfaces (API), which are used for data transfer between systems. APIs normally belong to the service provider's intellectual property rights, and the third party is unable to build a functional interface for these systems. For this reason, it is important to have open APIs that make it easier to build the necessary interfaces and connections to information systems. Therefore, it is essential to take into account the use of open APIs in the procurement phase, which makes it easier to develop and build user interfaces and integrations between information systems in the future.

The development of digital services must be organized based on enterprise architecture; stakeholders must draw up an organization-wide digitization plan and co-operate with other municipalities and ministries (Vilpponen, Grundström, & Abrahamsson, 2018). First, there must be a vision of digitalization and a strategy to implement it. Second, there is a need to decide on an information system development model, whether the development remains a standalone

[4] In accordance with the Finnish Procurement Act (25§), system procurements costing more than 60,000€ must be put out to tender

solution or moved completely to the cloud and virtual world, or a hybrid between these.

The specification of requirements is a demanding task (Lemmetti & Pekkola, 2014). The procurement of digital public services requires a wide range of expertise in technologies, enterprise architecture, and operational activities. Administration and legal resourcing also play an important role for the whole (Karjalainen & Kemppainen, 2008). Many public information system procurements are under-resourced, leaving procurement specifications incomplete and causing additional work and costs during the construction phase. It is not enough to make the systems work with each other; usability and availability must also be considered with internal and external users, as well as with their possible special needs.

5.1.2 Examples of large information system development projects in Finland

In small or medium-sized public information system projects, a typical problem is the integration of other information systems and operating services as well as possible financial challenges for the further development of the service. Moving to large information system projects worth hundreds of millions of euros raises new challenges that require large-scale reorganization of production methods, training in the operation of the system, and possible changes in legislation. A good example of such projects is the Apotti system, which replaces thousands of separate information systems in social and health care and creates a regional information system (Vilpponen, Grundström, & Abrahamsson, 2018; Apotti, 2021).

The Apotti system is used for about one-third of the Finnish population (1.7 million) and is by far the largest information system change project in the entire history of Finland. Apotti system design principle was to build a single system to replace the old systems. Other exploratory projects are underway in Finland, such as the Aster project (Aster, 2021), a joint project of four hospital districts. Here, the acquisition was made by breaking down health and social care into their own systems, making it easier to compete in different areas and combining the best actors in a cost-effective way into one package. The Aster tender is over, and selected suppliers have begun planning together with hospital districts. Aster system will serve about 700,000 people. The third example is the information system project of the Keusote (Central Uusimaa Social and Health Care consortium of municipalities) (Keusote, 2021), which acquires a social and health care information system to serve a little over 200,000 inhabitants. Keusote´s goal is to tender for a modular customer and patient information system on the market to be purchased as a service that must operate at the provincial level.

In Finland, it is typical in large public procurements to challenge procurements and take them to the Market Court for resolution. Examples of this are the Apotti system acquisition Market Court proceedings cases: 2015/8–13, 2015/258–263 and 2015/299–304 (Markkinaoikeus, 2015). The acquisition of Keusote's social and health care information system has also been the subject of

legal proceedings, which has led to the suspension of the procurement process (Keusote, 2021). In both cases, although the preparation of tendering materials has involved very experienced procurement and legal teams, under the Procurement Act, the procurement can be dragged to market litigation, which typically causes a delay of up to a year in the procurement process.

5.1.3 Development process and ontologies in the procurement of a large social and health care system – a case study of the Apotti system

This section describes the main phases and necessary ontological research questions of Apotti system acquisition from idea to product. The section also describes which design problems had to be solved, why the Apotti system was acquired, and what kind of expertise was needed in the process (Apotti, 2021).

Apotti's system design and procurement process follows the system development process defined by Ulricht, Eppiner, and Yang (2020). In the pre-planning and planning phase, a fundamentally new product plan was developed based on the goals set by the four-organization procurement ring, which were based on capabilities, constraints, and the competitive environment. Such a project involves more risks than the further development and modification of an existing product. The Apotti system requirements definition phase included the concept development, system-level design, and detailed design steps introduced in the following.

Pre-planning phase

In the pre-planning phase, the main ontological research question was: *What is needed to launch a project?* The question posed the framework for the project. The question was used to lay the foundation of the project and define the initial objectives, as well as the partnerships, organization, and management practices of the project. At this stage, it was very important to involve social and health care professionals with a good view of the field, as well as large-scale public joint projects. This phase also laid the foundation for the quality of the HTI and the requirements derived from it.

Planning Phase

At the beginning of the planning phase, the project objectives, schedules, and resources were specified. The implementation of the project was planned and prepared in detail. The materials needed for the oncoming negotiations were also prepared during the phase, and the processes to be jointly developed and the support made possible by the system were agreed upon. During the planning phase, several studies, analyses, market analyses and meetings and visits to both social and health care organizations were conducted. Research questions in this phase of the HTI domain were related mainly to technology and legislation; for example, *What is the technology used for? What are the constraints and provisions of the legislation?* The planning phase required in-depth project expertise for large multi-stakeholder projects. At this stage of the project, emphasis was placed on

social and health care expertise, and the project involved a wide range of experts in various fields.

Political decision-making

For the Apotti project, a procurement ring was established for the municipalities participating in the procurement—Helsinki-Uusimaa Hospital District (HUS) and national joint procurement unit KL-Kuntahankinnat Oy. The procurement community agreed that the customer and patient information system services would be managed, utilized, and developed centrally in accordance with jointly agreed objectives. Ontological research questions at this stage focused on policymaking and legislation: *What are the constraints and provisions of the legislation? How do changes in political decision-making affect operating environment?* This step was not affected by HTI ontologies. At this stage, the project needed contract and procurement expertise, as well as decision-makers from the municipalities.

Procurement process

In the dialogue phase, the ontological research questions also included HTI ontologies: *What is the technology used for? How is it supposed to behave and be manageable? How does it fit into the skills and abilities of the users*? The technical dialogue for the Apotti project was carried out in two phases. The purpose of the first phase of the dialogue was to gather information on social and health care information system suppliers on the market and their solutions. The aim was also to discuss with potential bidders the operational and technical requirements of the social and health care information system to be procured, as well as the details related to the procurement. In the second phase, suppliers were asked to comment on the clarity of the procurement documents and the timetable for the request to participate phase. At this stage of the project, there is a need for in-depth expertise in social and health care for various activities, as well as ICT competencies.

Acquisition of operating services

The tendering for the operating services required technical infrastructure, such as acquiring data center services. Technical definition requires in-depth ICT, cybersecurity, legislation, and procurement expertise. Ontological HTI research questions affect only a small portion of ICT experts: *What is the technology used for? How is it intended to behave and be controlled*?

Acquisition of an information system

The procurement of the information system by tender included an implementation project, a pilot project, and a procurement ring deployment project, which included the design of defined integrations and national and regional services for the subscriber's other information systems. Ontological research questions are strictly focused on the procurement process, such as the following: *What are the constraints and provisions of the legislation*? This stage mainly required procurement process expertise and procurement legal expertise.

Requirement's specification phase

During the in-depth requirements specification phase, a project functionality map and the first version of the requirements definition were created, which included functional requirements, adaptability, and usability requirements—a total of more than 6,000 requirements lines. Operational requirements were collected mainly in large-scale social and health definition workshops. They were attended by more than 200 professionals, and more than 600 pages of user stories were created. In this phase, ontology questions for HTI were widely used: *How is it intended to behave and to be controlled? How does it fit users' skills and capabilities? How does it produce a motivating emotional experience?* Following the definitions, workflow reviews were conducted, inviting thousands of social and health care professionals to work out guidelines on how to adapt social and health care workflows to the Apotti system. Workflows that required modification were then corrected based on the imported feedback received, and new workflow review sessions were held to verify and ensure that they were usable.

Implementation phase

The Apotti project is a complex and extensive information system project, and it took over four years from the pre-planning phase to the start of the implementation phase. In acceptance testing, the finished system was tested by representatives of customer organizations who approved the functionalities of the Apotti system based on the tests. If critical errors still occur in the system during acceptance testing, they will be corrected immediately, but longer-term improvement suggestions will also be collected for further development.

Deployment phase

During the deployment phase, organization-specific migrations and conversions, and site-specific configurations were performed. An important part of the deployment phase was user training and the transfer of old customer and patient data to the Apotti system. In addition to learning to use fluently, the training focuses on the ways in which the system is used, and the operating models required for the change in operations. New uses and operating models include, for example, the structured recording of the Apotti system, operating models for electronic transactions, and elements of operational control.

5.1.4 Findings from professionals for usability in Apotti

Although in the Apotti project, the definitions were heavily invested with project resources and with the help of hundreds of professionals, end-user satisfaction with the built system is insufficient. A study carried out by the Finnish Medical Association on *the use* of *patient information systems as a doctor's tool* shows that there is still room for improvement in the usability of the Apotti system (Finnish Medical Association, 2021). In the study, the Apotti system's technical performance was at a good level but clearly lower in usability than other patient information systems. Usability was assessed by the straightforwardness of routine tasks, from which the Apotti system clearly received the weakest reviews.

Similar findings on the poor usability of performing routine tasks can also be found in a study of nursing staff (Kyytsönen, et al., 2020). At the time of the doctor's survey, the Apotti system was introduced in the municipality's primary health care, while in the survey of nursing staff, the Apotti system was used only in one hospital.

One reason for the lack of Apotti system usability is the complexity and scale of the system. Apotti is the world's first information system that combines social and health care (Apotti, 2021), so workflows and solutions previously tested with separate customers and patient information systems could not be directly used to define and build the system. In addition, unclear and incomplete legislation required changes during the development phase, which caused additional work and affected the project schedule. The most important thing in deploying the Apotti system was to ensure patient safety. To ensure patient safety, the addition of new functionalities and the optimization of usability were done gradually by extensively testing new functions before exporting to production. Usability is constantly being developed based on findings from professionals. The gradual improvement in usability based on professional findings is the main reason why the Apotti system received a poor rating from doctors in the study regarding its usability.

Apotti is a new system, and the professionals only used the system for a short time before the study, and the workflows still required optimization and various improvements. More attention should have been paid to the usability needs of the system during the system definition phase, systematic usability testing should have been carried out by professionals such as doctors during the system construction phase, and usability should have been considered as one of the readiness indicators. Another issue that caused practical problems at the definition stage was the terminology used by Apotti, which differed from the terminology used by municipalities. The Apotti system is based on the American Epic system (Epic, 2021), which is widely used in specialized care in hospitals worldwide. The municipalities had their own terminology and procedures, which were harmonized with the Apotti system. The fact that the Apotti system is the world's first information system combining social and health care provided its own challenge; thus, constructing social care definitions and building operating models in the Epic system was new to everyone[5].

5.2 Unifying the development of digital public services

It is difficult to create unambiguous guidance to support the development of public digital services or the acquisition of a system. Each project is an individual with its own specificities, depending on the resources of the public organization, the systems in place and their life cycle management, and political guidance and decision-making both at the state level and within the municipality.

[5] Analyze based on interviews with professionals worked with Apotti system.

5.2.1 Answers to research questions

RQ1: How can development projects be implemented in small or medium-sized municipalities?

Municipalities procure a large portion of ICT services from external companies. In large cities with more than 100,000 inhabitants, the share of external ICT service procurement is 76%, 69% in medium-sized municipalities and 60% in small municipalities (Merisalo, et al., 2021). In small and medium-sized municipalities, the problems of information system projects are typically related to a lack of development and procurement competencies, costs, and limited resourcing. Inadequate procurement expertise is, in many cases, a bottleneck for successful information system projects.

Municipal information management and development resourcing are usually very light, and the focus is on organizing operational activities. Municipalities often use external procurement consultants to define tenders. This typically ensures high-quality procurement and the release of one's own resources for other tasks. However, external definition work should also take into account the development of sustainability, accessibility, usability, and the operating environment. When procurement work is outsourced, the technical and operational know-how related to procurement can be lost, which weakens the organization's ability to make sustainable plans for the development of the organization. Information system projects require a strong ownership approach, which can ensure the resources required for the project and the prioritization of staff tasks. Development projects usually lack the necessary technical, operational, and usability expertise. This is also reflected in the procurement process.

The annual budgeting of municipalities brings an additional challenge, as the next year's development budget must be approved as early as last autumn. If there are delays in the project, then it is difficult to carry over the annual budget to the next period. In this case, the available budget may not be sufficient to complete the project to the extent and quality necessary. For the acquisition to be successful, the organization must invest in at least the following:

- **Ownership**: The system must have an active owner who understands the effects of operational development in practice and is able to influence the development of operational processes, as well as to support the necessary professionals for the project.
- **Technical expertise**: Development of ICT, enterprise architecture, and infrastructure need to be based on sustainable development, optimizing cost implications, and working with neighboring municipalities and public administrations to ensure the transparency of interfaces.

Municipal organizational structures and available resources are limited in small or medium-sized municipalities, typically resulting in competence and resource problems in the planning of development projects. Development ideas can come from operations in the field, or the impetus for the need for development comes from an external party. Small and medium-sized

municipalities do not normally have allocated resources for the development of digital services but must procure them from external service providers. The Procurement Act (Finlex, 2016) prescribes, according to the value of the procurement, the procurement process, which in many cases is a public tender. Digital service development projects compared to a single service process project are fast-passed, and interfaces to other systems or services are more limited.

The owner of the digital service process to be developed usually thinks of the development project from the perspective of the activities they lead, in which case the service to be developed does not necessarily follow the enterprise architecture of the organization, making further development or integration with other services more difficult. Once the idea of developing the digital service has progressed to the planning stage, the procurement organization should be involved at an early stage to ensure the flow of information for the future procurement process. The design planning must also take into account the effects of the procurement on the schedule and cost structure, as well as the suitability of the service to be developed for the organization's enterprise architecture and digital roadmap.

External service providers perform what is required in the offer; additional tasks are billable extra work, which is why a competitive bidding process is worth investing in. The procurement organization has a major responsibility to ensure that the specifications and other details required for the procurement process are defined in the tender documents with sufficient precision. In public procurement, the problem is usually urgency and the fact that the competencies of the procurement organization are in the procurement process, but it lacks knowledge of the service processes and technologies that are the subject of the procurement itself. Procurement organizations should include broad knowledge of technologies, enterprise architecture, usability, and service processes.

It has been found that the best way forward is a proof-of-concept style piloting approach, in which case, with small resources, it is possible to gain an understanding of boundary conditions of environment, resource needs, and cost implications of the system to be developed. Once an organization has built a pilot culture, it is easy to try new things and make detailed decision proposals for development projects based on the pilots. It is well known that the involvement of experts from different fields of expertise provides a better overall picture of the challenges ahead. Each expert has their own vision and way of solving the problem (Mittal & Dym, 1985; Levitt, Jin, & Dym, 1991). A team with representatives from operational activities as well as IT development should be reserved for piloting.

Often, smaller municipalities should seek the help of external consultants due to limited own resources. After the piloting, the success of the piloting and how things should be done in the actual development project are analyzed, and a high-level project plan is prepared with the resource and cost implications for the management decision. At this stage, information management should be included to ensure that the project fits into the enterprise architecture and IT development roadmap. Ownership of a development project is vital to success,

and a pilot project must always have a clear owner who can ensure that sufficient resources are prioritized for the project and that the project fits the municipalities' goals. They also ensure the planning of the continuation of the project and the making of the necessary decisions in the organization. It is beneficial if procurement expertise is included in the project at an early stage, in which case the aspects affecting procurement should already be taken into account at the planning stage.

RQ2: What needs to be taken into account when starting to acquire large public information systems—a case of social and health care

Finland has been undergoing social and health care reform for several governments, but the implementation of the reform has been stalled in political decision-making, either because of the parties' own goals or for constitutional reasons. This reform aims to create larger regional entities, thus eliminating small separate service production areas, harmonizing information systems, and ensuring seamless data transfer between different business units. Due to this slowness of the law-making process, independent social and health care production areas have been established in Finland, managed by municipalities, which are able to provide regionally social and health care services and at the same time harmonize their information systems (Vilpponen, Grundström, & Abrahamsson, 2018). Typically, large public information system projects[6] are designed using well-defined and proven design, specification, and procurement processes. Further, sufficient investment in the procurement process with adequate competent resourcing is carried out in the initial phase of the project.

An example of such a major development project in Finland is the regional social and health information system reform project, the Apotti system, which affects the service production of 1.7 million customers. The cost implications are hundreds of millions of euros, the project employs thousands of people, and the detailed design phase of the project takes several years. Prior to the development and implementation of the Apotti system, municipalities had to make a political decision to commit to future costs that would tie up municipal resources for several years. Municipalities had to make decisions based on the information available and commit to the cost structure.

As the Apotti system was the first system to combine social and healthcare, not all of the complexity and workload required by the system could be accurately assessed in advance. As a result, the cost of the project has increased (Mediuutiset, 2020) and has implications for municipal finances and other development funding. The development and implementation schedule has a direct impact on the municipality's IT development roadmaps. Delays in the development of the Apotti system may force the municipality to acquire a new version of the old system due to legal requirements. Large information systems have regular development versions and updates; typically, new development versions are paid for by municipalities and can have a significant cost impact on operations.

[6] In large information system projects, the total cost is several million euros.

The development and implementation of the new system also had a major impact on the resourcing of professional staff. A significant number of professional resources had to be set aside for the definition and implementation of the Apotti system, which affected the normal functioning of social and health care. In addition, with the new system, workflows, and the system's user interfaces changed, which meant that all personnel had to be trained. The duration of the training depended on the person's job duties and was typically 2-4 days. For example, in the spring 2021 deployment cycle, 17,000 professionals were trained over two months, requiring approximately 51,000 working days in healthcare to be adjusted with extra resources or operational changes (Etairos, 2021).

Interviews with three professionals involved in the Apotti system deployment in customer organizations raised some issues:

> The biggest challenges of the Apotti project were the scale and cost of the project. When several organizations and even more different professional groups have been involved in the project, the coordination of the whole has understandably been challenging. Schedules have often been tight, and the result has not always been as good as it should have been. The project has also taken too long, and many people are tired of it. The cost of the new system is also significantly higher compared to current systems. Of course, the new system is of a higher quality than the old ones, and the system will certainly bring some savings. However, the savings are not enough to cover the new costs that will be incurred, which will further complicate the situation of municipalities in difficult financial situations. (Interviewee 1)

The Apotti system was a very large-scale complex multi-player acquisition for more than a ten-year deployment period. The organizations participating in the project had their own policies, workflows, organizational models, budgets, and resources. Concurrent attempts by the government to reform social and health care services also influenced the activities of the participating organizations:

> Professionals replicated their old traditional processes into the system, unable to take advantage of the new approach. Old practices and untapped operational potential caused an unsatisfactory outcome. As an organization, Apotti failed badly in this regard as well as in the coordination of patient safety and data protection. (Interviewee 2)

Unclear legislation, an entirely new type of approach replacing social and health care systems with one common system, surprised the Apotti project organization with its workload. Although the design had taken into account the future complexity of the system, it was not possible to anticipate all the variables. Apotti system project steering was from the participating organizations, and the cost of the project was distributed in proportion to the population. All changes affecting the schedule and costs had to be approved by a unanimous decision of the steering group, which affected the agility of the project:

> The intervention of the Data Protection Ombudsman clarified the obligation to keep social and health care data separate. This concern would not have been

> resolved in any other way. I wonder to what extent, in general, it is appropriate or necessary to cross-data at all. In my opinion, the clientele, which is a client of both social and health care, is quite marginal, and the specific issues related to them should be solved, for example, through enhanced communication or a personal system, not a new information system for everyone. My suspicions would have been allayed if questions from small municipalities and requests for financial reporting had been answered in a transparent and reasoned manner. I would also like to assess how the achievement of equality of care is affected by a doctor's possible knowledge of the clientele of social care or its quality. Does equitable access to care develop in a positive or negative direction? Is any positive development worth the potential data protection issue posed by the system? (Interviewee 3)

During the design phase of the Apotti system, there was a general perception that working across registry boundaries would be possible, making multidisciplinary work more efficient. Legislation did not develop as expected, and social and health data had to be kept separate, leading to changes in the originally planned workflows and data protection practices.

RQ3: How can we ensure the accessibility of publicly procured digital services for the elderly population?

A broad understanding of the operating environment is essential in the development of digital services for the elderly. There is a need for insight into available and evolving technological solutions and services. In addition, a clear understanding of end users and their needs and desires is needed (Vilpponen, Leikas, & Saariluoma, 2020).

Customer stories can be used to find out about the upcoming service process, its critical points, and special needs. To increase the quality and number of digital services that meet the needs of older people, service providers need to add a holistic consideration of older people for development core values without the need for a specific request from the contracting authority. This is a fundamental change in thinking. Today, everything outside the mainstream is a separately billable development. Planning should start with special groups, such as the elderly, in which case accessibility can be ensured at the planning stage. The special needs of the elderly must also be taken into account in the development of the enterprise architecture. This requires special expertise in the user-centric development. The LBD approach is a good tool for defining the needs and technological goals of different user groups.

The procurement organization must have the ability to understand the needs of special groups as a whole and what dependencies they have on the overall development of technological solutions for services. The procurement organization must be cost-conscious, as the service to be procured must fit into a digital development plan and budget, according to which digital services are developed. All municipalities have similar service tasks prescribed by law, in the digitization of which it is worth cooperating, in which case joining forces will create a larger procurement entity, and then it will be easier to negotiate cost-effective development with service providers. Through cooperation, a regional

development roadmap can be created to steer the product development of service providers in the right direction.

5.2.2 Expertise required in procurement

As has become clear above, it is not possible to give a single overarching concept for organizing procurement. Each acquisition of an information system is different due to the environment in which the information system is to be built, the interfaces with other systems, the differences in the functional requirements of the systems, and the level of consideration of end-user needs. The requirements for statutory systems come from legislation, and any further development in addition to them depends on the will of the subscriber.

For example, the procurement of an accessible digital service for the elderly would enable the elderly to operate in services provided by the municipality using smart devices. The procurement process requires a definition of the details of the digital service and the technical implementation. The procurement definition is divided into two parts. The first part deals with the needs of the user and the objectives of the service to be developed and addresses the question of why the digital service is being developed. The other part focuses on the analysis of the technological environment and how the service can be implemented cost-effectively. The procurement entity must have the competence to manage the tendering process, and must be responsible for ensuring that the procurement specifications are made with sufficient accuracy.

The following competencies should be included according to the sourcing definition process:

- Procurement expertise ensures the smooth running of procurement processes in accordance with the law and takes into account the technical details of the contract.
- The subject area expertise ensures that the service needs of the special groups, for example, the elderly, are taken into account by the municipality perspective.
- Service design ensures that the needs of special groups, such as the elderly, are taken into account from the customer's perspective using the LBD approach.
- Consideration of the enterprise architecture and digital roadmap ensures that the system to be procured is suitable for the needs of the municipality.
- Cooperation with other municipalities and actors is important for references and joint development.
- Data security and data protection are essential elements of information system procurement

Some medium-sized or smaller municipalities do not have separate resources for all the above components, so the contracting entity is responsible for handling a wide range of competencies, which may reduce the quality of procurement.

5.2.3 Political decision-making

The political decision-making of the municipal administration is regulated by municipal and administrative law (Finlex, 2015; Finlex, 2003). In municipal political decision-making, a strategy for the municipality is approved for the election period, and a digital roadmap is prepared for the municipality based on this strategy. Large and expensive development projects must be taken to political decision-making. Municipal officials prepare a draft annual budget for the municipality, which provides funding for development projects. Political decision-making can affect the budgets, timing, and implementation of future projects. In large projects, such as the regional social and health care information system reform, the municipality commits to a joint procurement contract for a long period, and the municipality's ability to influence the costs incurred is limited.

The problem with decision-making in this case is the lack of perspective on the future and the potential cost implications that bind municipal resources. In preparing the decision, the aim is to analyze the system to be acquired as accurately as possible to support the decision-making process, but large multi-annual projects always involve uncertainties. Political decision-makers do not have the expertise to analyze large complex development projects themselves and their effects on the municipality's operations but must rely on the proposals prepared by the officials in preparing the decision. In political democratic decision-making, the agendas of different parties and individuals can differ, and this can slow down or even completely block decision-making. Democratic decision-making is characterized by the use of various political compromises as a decision-making tool, in which case the weight of technical issues may be weakened as a basis for decision-making. Politicians are elected representatives of residents who also have responsibility toward the voters, which can influence decision-making.

Another problem is municipal annual budgeting. Officials will have to make the next year's budget proposal for political decision-making as early as the fall, in which case future projects will need to be included in the budget. This poses major challenges for the preparation of the IT development roadmap and overall budget. The government imposes regulations and laws that require changes to information systems, and these statutory projects must be prioritized before normal development projects. The annual budget must be used during the budgeting period and cannot be carried over to the following year, which causes a problem, as project schedules are delayed. These boundary conditions, combined with the requirements of the Public Procurement Act, must be taken into account when planning procurements. Figure 10 illustrates the municipal information system development decision-making process in a typical large information development project.

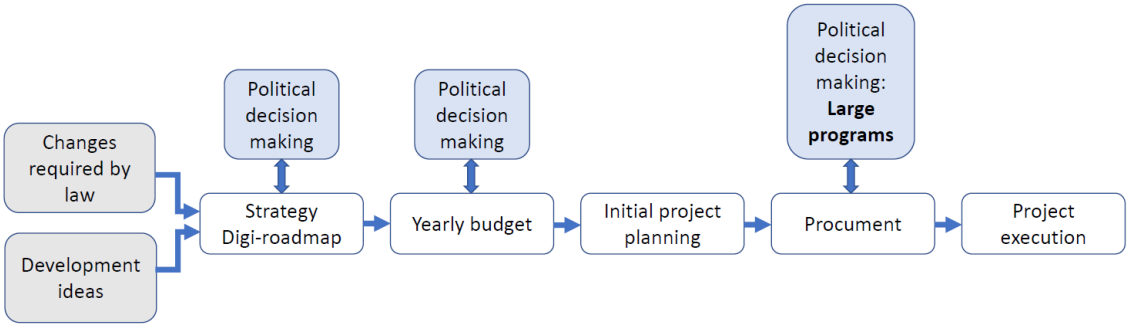

FIGURE 10 Procurement decision-making process

Political decision-making influences the acquisition of an information system at many levels, first through strategic-level policies and then through the operational budget. Major long-term information system acquisitions may require many policy decision-making stages.

5.3 Unique opportunity for holistic design

Intelligent technologies using AI built for humans are either active with users or relatively passive to targets (Saariluoma & Salo-Pöntinen, 2021), while autonomous AI devices and systems can operate independently in industry and transport, for example. The avalanche of new AI systems is putting pressure on municipalities to follow this accelerating trend. The government's focus is on developing AI applications for various service interfaces that can be used to streamline and diversify public service offering. It will be some time before autonomous AI solutions are able to fully self-manage and have self-trained models for their own goals, beliefs, aspirations, intentions, plans, values, limited consciousness, and the ability to communicate, negotiate, and collaborate with each other.

However, the development and design of these autonomous AI agents requires an understanding of users and their needs. LBD approach and ethical rules related to the development of AI are becoming increasingly important in the future (Viljanen, 2021). In the development and procurement of AI systems, this is reflected not only in ethical rules, but also in legal liability (European Commission, 2021c). The development of AI-based digital services requires a holistic understanding of human life, needs, and activities, including limitations in human perceptual, cognitive, and responsive abilities.

5.3.1 Responsible Research and Innovation (RRI)

In the European Commission funding program Horizon, Responsible Research and Innovation (RRI) is implemented as a package that addresses accessibility, gender, and ethics in the content and process of research and innovation

(European Commission, 2021d). RRI (RRI, 2021) seeks to address societal challenges holistically posed by, for example, financial instruments, ICT, public policy or community innovations, distribution, service, or system innovations technology, legislation, ethics, and social frameworks (Sutcliffe, 2011). Nieminen & Ikonen (Nieminen & Ikonen, 2020) suggest that RRI should be integrated into the activities of the implementing organization(s) by asking "How can RRI be integrated into the entire value chain and design?" and "Can foresight and ethical and social impacts be analyzed in the context of current organizational procedures and practices?" impact assessment is carried out in the context of existing organizational procedures and practices? Using RRI allows for company benefits, such as the following (Ikonen, Leikas, Tyynelä, & Mäkinen, 2017):

- Enhancing the company's reputation
- Strengthening links with customers and end users
- Decreasing business risks and unintended consequences
- Strengthening public trust in the safety of products
- Increasing the acceptability of products
- Adopting an environmentally friendly profile

5.3.2 Sustainable ecosystems

A rapidly changing society requires a new kind of thinking, with old, slowly changing networks and long-term partnerships replaced by ecosystem thinking, which allows for continuous development and multidisciplinary innovations (Valkokari, Hyytinen, Kutinlahti, & Hjelt, 2021). For people, well-being is an experience of what they value in being and doing. For example, biodiversity is a fundamental part of many ecosystem services that sustain human well-being (Butler, Duraiappah, Kumar, & Chopra, 2003). The challenge of creating an ethically sustainable service ecosystem is particularly relevant to application and software design, which are responsible for developing systems for the benefit of humankind (Leikas, Sigfrids, Stenvall, & Nieminen, 2020).

There is a Green Deal program in the EU that states that public authorities should lead by example and ensure that their procurement is green (Halonen, 2021). "The investment plan will mobilize at least €1 trillion in sustainable investments over the next decade" (European Commission, 2020). The development of digital technologies can make a significant contribution to achieving the European Green Deal. "The deployment of digital solutions and the use of data will help in the transition of a climate-neutral circular economy" (European Commission, 2021a). Sustainable procurement implements three key themes of sustainable development: environmental responsibility, social responsibility, and economic responsibility (Keino, 2021).

The analysis of statistical data can be used to assess the economic responsibility of procurement and changes in society. The total expenditure on public procurement in Finland in 2018 was EUR 42 billion, of which the share of local government, to which the municipalities belong, was about EUR 27 billion (Merisalo, et al., 2021). The biggest constraint in assessing the effectiveness of

public procurement is the lack of procurement data. Digital and Population Data Services Agency has created *avoindata.fi* service that contains all purchase invoices related to government and major cities' procurement since the beginning of 2016 (opendata.fi, 2021).

The development of robotics in the future care services and well-being sector must take into account the ecological dimension, the compatibility of different infrastructures, the growing need for energy, and the life cycle management of robots as a whole: production, use, and disposal (Niemelä, et al., 2021).

5.3.3 Design for life

Human activity is based on an awareness of one's own needs, plans, and emotions. In the LBD approach, technology aims to improve people's quality of life by utilizing an understanding of human life as the basis for creating design criteria and design concepts. Ethical choices and values are reflected in design decisions that examine what is ethically acceptable—that is, what is "good" for end users. LBD approach focuses on the study of the biological, psychological, and socio-cultural lifestyles of target users (Saariluoma, Cañas, & Leikas, 2016). In the LBD approach, the first phase asks, Why is technology needed at all? LBD approach considers people and their living conditions as whole. Technologies and digital services should improve quality of life, make life easier, and add value to everyday life.

The LBD design process is a multi-dimensional and holistic approach that takes into account people's needs in form-of-life analysis, which can be used to make a design definition. "Form-of-life analyses of a specific user group should generate the human requirements that define how a product or service will improve a particular aspect of people's lives" (Saariluoma, Cañas, & Leikas, 2016). Digital service design projects often fail because the design is based on intuitive thinking about HTI and ignores research on human activities, goals, and everyday life (Leikas, Saariluoma, Rousi, Kuisma, & Vilpponen, 2012). Accessibility is usually implemented on the basis of the requirements of the law, but if it is built on a universal design, which is a continuous improvement process (Hole, 2013), it supports equity and equality.

Similarly, the procurement process can follow the LBD approach if the outcome of the procurement has been able to improve the quality of life of the end user. However, this requires that people's needs be taken into account in the procurement process from the very beginning of the procurement definition phase. Procurement entities must define criteria to ensure that end-user needs, laws, and regulations, economic aspects and compatibility in the development of the enterprise architecture are already taken into account in procurement definitions. At the same time, the special needs of the elderly, for example, must be taken into account, which can have a major cost impact on further development if the needs have not already been taken into account at the planning stage. The LBD approach is a good tool for defining the special needs of the silver economy.

5.3.4 Ontologies

Ontologies provide a good tool for designing to manage design questions and guide the design process. Ontologies are descriptions of the most general concepts in some field. Questions formed in the ontology should always be answered when designing the technology and its relationship to users. In information systems science, the central use of ontology is the sharing of information between people, databases, and applications. Ontologies are used to capture, represent, and model data in a machine-readable way so that people and machines can understand, interpret, and reuse it. While in the HTI design process, design questions are asked and resolved by defining ontologies in the design process that start with questions that are independent of basic problems and other products. There is a need for product-specific questions and the resulting ontologies to manage HTI development, allowing scientific knowledge to be utilized to solve design problems.

The fundamental interaction design concept in the HTI design answers the following key questions: "Can people use technology?", "Do they want to use them?," and "How do they work with them." Traditional HTI design methods do not take into account the person and his or her needs as a whole. Saariluoma and Leikas (Saariluoma & Leikas, 2010) proposes to add the fourth fundamental dimension of human life to HTI's design principles. The following questions can be used to analyze human life (Saariluoma & Leikas, 2012):

- What is the form of life?
- What are its characteristics?
- What kind of activity belongs to it?
- What kind of life facts and values define people's goals?

The HTI and LBD approaches and ontologies can be utilized moderately straightforwardly in small and medium-sized public development projects, but in large and highly complex projects, many practical constraints take precedence. In addition to usability and user experience, for example, large public social and health care information system projects must take into account data protection and data security. Legislation on the keeping and processing of various social and health records has strictly defined data-processing rules that do not take into account the usability aspect. System design has primarily considered functionality and legality, in many cases, usability has had to give way to the main design principle.

According to Saariluoma concepts,

> questions and ontologies provide a means of managing corporate thinking and making corporate knowledge explicit. When thought processes are explicit, it is possible to support them, to provide correct knowledge to thinking, to foster innovations, and to move tacit knowledge from one process to another. (Saariluoma, Cañas, & Leikas, 2016)

This process can also be used to define boundary conditions against large projects that place constraints on HTI and usability. This process can be used to define the boundary conditions and requirements that the system must inevitably meet

in the projects. The problem with large information system projects is the incompleteness of the specifications at the procurement stage.

The fundamental ontological questions of HTI design are as follows (Saariluoma, Cañas, & Leikas, 2016):

- What is the use or purpose of the technology?
  - This question deals with designing the structure, functional relationships, and content of the life form.
  - The question addresses the biological, psychological, and sociocultural aspects of innovative technological development.
  - Technology development usually involves an interface with different buttons or menus that the user must operate to obtain the desired service event.
- How is technology intended to behave and be controlled?
  - This question clarifies what the technology will achieve and helps define its functions and technical interface.
  - The successful use of technology requires a plan for training, its implementation, and further development.
- How does it fit users' skills and capabilities?
  - This question concerns the suitability of the technology for users' ability to use it.
  - The ability of the elderly to operate the system is central to this issue.
- How does it produce a motivating emotional experience?
  - Emotions are important in design because they define the human position in an interaction situation.
  - To understand the emotional dimensions of human experience, it is necessary to understand human emotions and motivation.

When the boundary conditions imposed by the political environment, legislation, procurement processes, and the economy are added to the fundamental questions of HTI design, the HTI ontological issues of large information system projects can be defined as follows:

- What are the constraints and provisions of the legislation?
- How do changes in political decision-making affect the operating environment?
- How does the quality of procurement specifications affect usability?

Especially in startup business, a minimum viable product (MVP) design model used. MVP is defined as products with just enough features to gather validated learning about the products and is a major focus in the early stages (Duc & Abrahamsson, 2016). MVP launches a version of the product with only the most important functionalities ready. MVP is an economical approach to having a product that is demonstrable to investors and early customers. In large development projects, it may also be useful to use the MVP approach, which makes changes in operations easier to manage. It is dangerous if the MVP level cannot be determined, and it moves on unplanned due to schedule and financial

consequences. In this case, degrading the MVP level can negatively affect functionality, usability, and product quality.

5.3.5 Necessary elements for the success of public development projects

Before preparing public digital service projects, an organization must be prepared for the change in practices. This change starts with the organization's strategy, which should define digitalization as a strategic goal. After this, the management of the organization should be trained to the required level so that they understand at a high level the benefits of digital services, the technical framework conditions, and the requirements for the change in operational work.

The success of digital service development requires management commitment, which is only achieved if management has a good understanding of future development and its implications for operational activities. An owner must be appointed for the development project, who ensures the financing and resources needed for the development project in the organization and directs the activities in a steering group consisting of experts and managers in the fields (Vilpponen, Grundström, & Abrahamsson, 2020). The task of the steering group is to ensure that the needs of the entire organization are identified and that the seamless exchange of information and cooperation between different units is enabled.

The development project itself requires many different capabilities. The project must have a professional leader who is responsible for the progress of the project, keeping to the schedule and budget. For example, in the development of digital services for the elderly, the project must have knowledge of the development of special technological aspects and services needed by the elderly, and a good understanding of the lives of the elderly as a whole is needed. During the project planning phase, it is important to network and look for references to already implemented digital service development projects, and to try to pick out the best features and practices that are suitable for the development project.

The implementation of the project should be done in a proof-of-concept style, so that usability can be developed and tested piece by piece. Here, a skilled implementation of resourcing and usability know-how is required. The method for publishing a completed digital service can contribute to the success of the service implementation. There is a need for clear guidance and communication on the service developed and the related change process that takes into account the needs of special groups; this requires communication and marketing expertise.

After the publication of the digital service, the usability of the service with different user groups is analyzed, and, if necessary, a plan is made for further development needs. The developed service is distributed to the networks so that the development input used can be utilized in the development projects of other organizations.

6 CONCLUSION

It is very challenging to define one model by which the conditions for the success of public information system development projects would be maximized. The sizes, processes, and practices of public organizations, as well as human resources, financial constraints, legacy information systems, and development plans, pose different challenges for each public organization. However, a common denominator can be found in the fact that procurement is often required in development projects. It is important that the procurement organization has sufficient resources and the necessary expertise at the procurement planning stage. Experts in various fields must be involved in the procurement process from the very beginning, in which case the suitability of the procurement for the organization's operating processes, enterprise architecture, IT development roadmap, and digitalization strategy can be ensured.

In the development of digital services, end users must be taken into account holistically, especially for special groups, such as the elderly, and the accessibility and usability of services will be at the center. The LBD approach takes the operating environment and user needs holistically into account.

In the future, public information system projects will include more and more AI components, which is why a comprehensive team of professionals and management representatives should be involved in project-related procurement from the very beginning. If the management does not have the necessary competencies for understanding to utilize AI in the development of the organization and processes, the acquired AI component may remain as an independent system and not all the opportunities it brings to be utilized. (Leikas, Nieminen, Koskimies, & Stenvall, 2021)

6.1 Limitations of the work

The dissertation includes articles with many types of research starting with the development of the mobile technology air interface, where the focus was on

information theory, practical creation of simulators, and execution of needed performance simulation results. Another set of articles dealt with public information system projects with problems and key success factors through personal interviews with various experts in the field, followed by the end users' level analysis of digital well-being.

The study also includes case studies on the development of practical systems in the public domain. The theoretical review focuses on typical engineering design methodologies, and its practical implementations. The author's role as a reflective practitioner (Schön, 1983) gives the work a solid practical contact surface. In the future, it could be useful to extend the research to other design principles and theoretical models and their connection to realized system projects. The work describes the necessary special competence needs in the procurement process of public sector information systems and practical examples of development processes.

Although the cases presented concerned the development of digital services for the elderly, as well as social and health care information system reform, the same ideas can be extended to other information system development projects. Research has been conducted on information systems science procurement processes and the conditions for their success (Riihimäki & Pekkola, 2021). However, studies have not taken into account a holistic approach to end-user needs.

6.2 Future research questions

It is important to provide guidance to public administrations on public information system procurement that considers the needs of end users and special groups as a basic assumption. Encouraging public actors to develop common minimum standards to ensure digital well-being can guide the industry in developing digital information systems that are accessible to special groups and easy to use for all stakeholders. How can the minimum requirements for the development and acquisition of accessible and sustainable public digital information systems be established, and what are the key minimum requirements?

It is also worth noting that cognitive functions are increasingly being developed for robots, and their safety has improved, enabling the use of robots in health and wellness services in the future. The development of robots and AI for the welfare and healthcare sectors requires sustainable ecosystem thinking. How should AI and robotics be taken into account in the development of care services for special groups, such as the elderly? How can ethical issues be resolved?

YHTEENVETO (SUMMARY IN FINNISH)

Väitöskirjassa tutkitaan julkishallinnon digitalisointihankkeisiin ja isoihin ICT-järjestelmähankkeisiin liittyviin kilpailutuksiin vaadittavaa erityisosaamista käytettävyyden näkökulmasta. Julkishallinnossa on usein epäonnistuttu tietojärjestelmien ja digitaalisten palveluiden hankinnassa. Tähän on ollut syynä joko kasvaneet kulut, myöhästyminen tai käytettävyysongelmat.

Väitöskirjassa lähestytään käytettävyysongelmaa kahden eri asiakasryhmän tarpeiden pohjalta. Julkisten palveluiden digitalisointi vaikuttaa kansalaisten asioiden hoitamiseen. Asiointiprosessien sähköistäminen mahdollistaa asioinnin paikasta ja ajasta riippumatta. Palveluiden tulee olla saavutettavia, mitä ohjaa EU:n saavutettavuus direktiivi WCAG (Web Content Accessibility Guidelines). Julkishallinnon palveluiden tulisi olla vähintään WCAG kriteeristön luokan 2 tasoisia. Kriteeristö on hyvä kompromissi, mutta se ei ota huomioon kaikkien erityisryhmien kuten ikäihmisten erityistarpeita. Tyypillisesti vanhusten motorinen ja kognitiivinen tila alentuu ikääntymisen myötä. Sähköisten järjestelmien ja palveluihin liittyvien käyttöliittymien tulisi olla helppokäyttöisiä ja loogisia. Niiden tulisi tukea itsenäistä asioiden hoitamista. Ikäihmisiä palveluiden kehittämisessä ja hankinnassa tarvitaan kokonaisvaltaista ymmärtämistä asiakkaiden tilasta ja tarpeista. Tässä elämäkeskeinen lähestymistapa (Life Based Design – LBD) on hyvä työkalu.

Toinen väitöskirjassa käsitelty käyttäjäryhmä on suurten operatiivisten tietojärjestelmien ammattikäyttäjät. Esimerkkinä tästä on sosiaali- ja terveydenhuollon satoja miljoonia euroja maksanut tietojärjestelmä Apotti, joka korvaa satoja kuntien ja sairaaloiden käytössä olleita asiakas- ja potilastietojärjestelmiä. Apotti on erittäin laaja kokonaisuus, johon on yhdistetty sosiaali- ja terveydenhuollon käytössä olevat sadat eri prosessit ja toimintamallit ensimmäisenä järjestelmänä maailmassa. Apotin käyttöliittymässä kirjaaminen on tehty rakenteiseksi, toimintaa ohjaavaksi ja lukuisten eri valikoiden avulla tapahtuvaksi. Jokaisella käyttäjällä on tehtävään sidottu rooli ja rooliin sidottu käyttöliittymänäkymä. Apotin käyttöä on käyttäjätutkimuksissa moitittu hankalaksi, mikä johtuu pitkästä hankintavaiheesta, suunnitteluvaiheessa tehdyistä toimintamallien kompromisseista, lainsäädännön hitaasta muutosnopeudesta, rakentamisvaiheen monimutkaisuudesta ja aikataulupaineista. Apotin rakentamisessa pääpaino on ollut potilasturvallisuuden varmistamisessa ja tietosuojan toteutumisessa, minkä takia käytettävyys ei ole toteutunut ajatellulla tavalla.

Julkisen sektorin palveluiden digitalisointi ja kehittäminen vaatii hankintaorganisaatioilta yhä laajemman osaamispohjan. Tyypillisesti organisaatioilla ei ole omia resursseja, joten työ ja järjestelmät joudutaan hankkimaan ulkopuoliselta taholta. Hankintaorganisaatiolla tulee olla käytettävissä riittävät resurssit ja erityisosaaminen onnistuneen hankinnan varmistamiseksi. Väitöskirjan otsikossa on tiivistetty esiin nostettu ongelma: *saat mitä tilaat*. Järjestelmätoimittajien liiketoimintamalliin ei kuulu ylimääräisen laskuttamattoman työn tekeminen, joten kaikki kilpailutuksessa määrittelemättömät lisätyöt ovat laskutettavaa työtä. Laadukkaalla kilpailutusmäärittelyllä voidaan minimoida tarvittavan lisätyön

tarve ja varmistaa järjestelmän tai sähköisen palvelun käytettävyys ja soveltuvuus organisaation IT- ja palvelutiekartan mukaiseen kehittämiseen kaikille asiakasryhmille.

Tulevaisuudessa tekoäly tulee mukaan tietojärjestelmäkehitykseen yhä kasvavassa määrin. Väitöstutkimuksessa osoitetaan, että kehittämisprojektit ja hankinnat vaativat johdolta sitoutumista hankkeeseen, mikä voidaan saavuttaa vain, jos sillä on hyvä ymmärrys organisaation palvelu- ja kehittämistiekartasta ja sen kehittämisestä. Hankkeille tulee asettaa omistaja riittävän korkealta organisaation johdosta, jotta voidaan varmistaa tarvittavien asiantuntijaresurssien ja hankintojen rahoitus sekä hankinnan jalkauttaminen toimintaympäristöön. Tutkimustulokset osoittavat, ettei julkisten organisaatioiden johdolla ole tällä hetkellä riittävää kykyä ymmärtää tekoälyn tuomien mahdollisuuksien hyödyntämistä kokonaiskehittämisessä. Vaarana on hankittavien tekoälykomponenttien jääminen irrallisiksi ratkaisuiksi.

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ORIGINAL PAPERS

I

ENHANCED CIRCUIT SWITCHED DATA FOR REAL TIME SERVICES OVER GSM

by

Shkumbin Hamiti, Markus Hakaste, Martti Moisio, Nikolai Nefedov, Eero Nikula, & Hannu Vilpponen, 1999

Gateway to 21st Century Communications Village — VTC 1999-Fall: IEEE VTS 50th Vehicular Technology Conference (pp. 578–582). IEEE.

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II

TURBO CODED MODULATION OVER GSM CHANNELS

by

Panayiotis D. Papadimitriou, Thomas A. Sexton, Prabodh Varshney, & Hannu Vilpponen, 2001

Proceedings of 2001 International Conference on Third Generation Wireless and Beyond (pp 787–791). Delson Group Inc.

TURBO CODED MODULATION OVER GSM CHANNELS

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Abstract: The supply of high data rates is a major goal of the communication industry. Towards this goal one solution is to use high level modulation combined with powerful coding. We propose a turbo-coded high-level modulation system (16/32/64-QAM) for the downlink that could be used for example in the future evolution of the EGPRS. The evaluation of such a system over the GSM channels is performed through simulations.

I. Introduction

GSM is the dominant deployed cellular system globally. GSM data rates have been extended by the use of 8-PSK, creating the EGPRS standard. Motivation exists to incrementally extend EGPRS in order to obtain higher data rates, but with as few physical layer changes as possible. The ability of a new system to coexist with old mobiles is important. In order to do so, it is necessary to preserve the framework of how mobiles are addressed on the physical layer. This calls for maintaining the EGPRS burst structure and symbol rate in the evolutionary system. As a result, the most straightforward way of increasing the data rate on a single EGPRS carrier is by making use of a higher level of modulation combined with powerful coding.

Turbo Codes [1], have been shown to achieve remarkable performance in both AWGN and independent fading channels with medium and large frame sizes. The combination of this powerful coding scheme with gray-coded QAM (Turbo Coded Modulation – Turbo-CM) has been also shown to achieve promising performance in these types of channels, [2],[3].

Recently, evaluation of the Turbo-CM scheme over correlated single path Rayleigh fading channels with perfect CSI was presented in [4]. A comparison with convolutional codes of the same complexity was performed, and the coding gain was found not to be as significant as in the independent channels. However the Turbo-CM was found to be superior to the corresponding convolutional coded modulation.

Here we benchmark the performance of the Turbo-CM over the demanding GSM channels [5], where channel estimation and equalization is required. We use about the same slot structure as in the EGPRS standard, see [4] for details. The maximum throughput with the Turbo-CM scheme using rate 5/6 64-QAM will be approximately K×98.667kbps for a K-slot mobile (i.e. a mobile user occupying K slots within the TDMA frame). The system evaluation is performed through simulations.

The paper is organized as follows. In Section II we give the system overview, and in Section III we present the simulation results. The conclusions are in Section IV.

II. System Overview

The simulation chain is depicted in Fig. 1. The turbo encoder of rate 1/3 is a parallel concatenated convolutional code (PCCC). It consists of two 8-state identical recursive systematic convolutional encoders (13_8,15_8) combined in parallel through an S pseudo-random bit interleaver [6],[4], (see Fig. 2). Parity bit puncturing is employed to get overall code rates from 1/2 up to 5/6.

A form of pseudo-random channel bit interleaving is employed to break the correlation of the channel. The symbols selected from the QAM constellation are filtered using a root raised cosine filter, with rolloff factor 0.4 and 61 taps. The power spectrum of the pulse shaping filter is given in Figure 3 for a measurement bandwidth of 30 kHz. The modulations used are rectangular 16 and 64 gray coded QAM, and 32 cross-QAM.

At the receiver, an LMMSE (Linear Minimum Mean Square Error) channel estimator is employed [7]. Since we demonstrate the performance over the typical urban (TU) and rural area (RA) channels we model the channel (from the channel estimation perspective) as a 4^{th} order symbol-spaced FIR filter. For these channels all the path delays are concentrated around the first symbol period interval, [5]. The

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symbol period is 3.692 μs, and the carrier frequency is 900 MHz. An MMSE (Minimum Mean Square Error) prefilter [8] is used after the channel estimator and prior to a reduced-state equalizer. The equalizer employed is a soft-output DFSE (Decision Feedback Sequence Estimator), [9]. It has M MLSE (Maximum Likelihood Sequence Estimator) states, and M^3 DFE (Decision Feedback Equalizer) states, where M is the number of the modulation levels. The equalizer outputs are de-interleaved, de-punctured and fed to a MAP turbo decoder [10]. The complexity of the coding scheme with 3 decoding iterations is less than the complexity of a 256-state (rate 1/2) convolutional code employing the Viterbi algorithm for decoding [11].

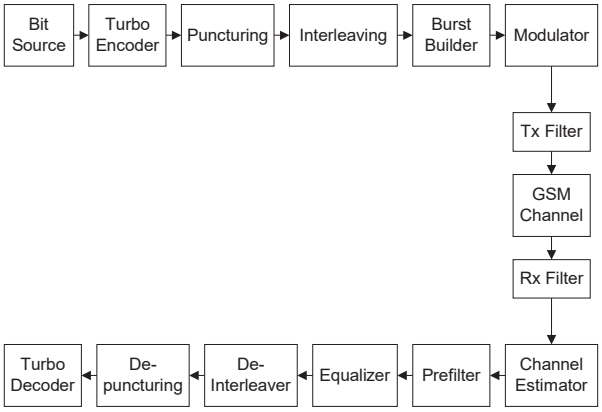

Figure 1. Simulation Chain.

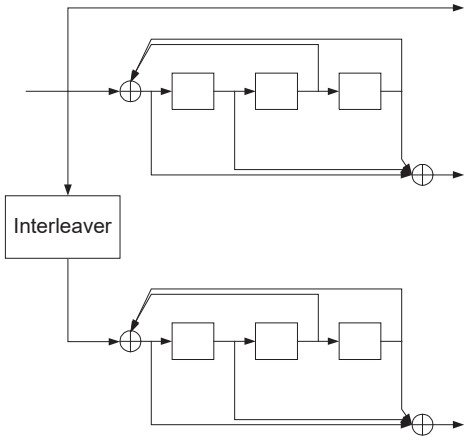

Figure 2. Turbo code (13_8,15_8).

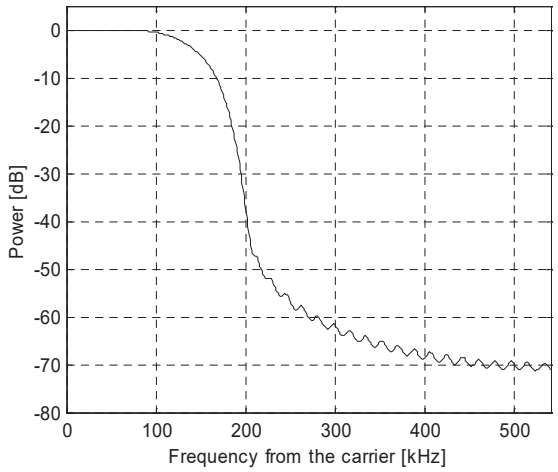

Figure 3. Spectrum of the pulse shaping filter.

Figure 4. Slot structure.

The slot structure is similar to the EGPRS, and is described in detail in [4] (see also Figure 4). It is comprised of 3+3 tail symbols (TS), 58+58 data symbols (DS) and a 26-symbol wide training sequence. In the current configuration, in the DS part of the slot, both headers and data symbols are handled as user data (performance wise). Each radio block makes use of 4 TDMA frames (8 slots make a TDMA frame) and we assume that a user occupies K slots per TDMA frame. Therefore the block size is equal to N=464×K×throughput bits, where the throughput is defined as the number of information bits per data symbol, i.e. for rate 3/4 16-QAM the throughput is 3 bits/symbol. In the block error rate (BLER) calculations, the block corresponds always to N_b=464×throughput bits. The maximum information data rates that can be achieved with such a system are shown in Table 1.

Since this system employs Turbo coding, it is advantageous to use as large blocks as possible. This would also increase the channel bit interleaver's size, which is critical for the good performance of the system over fading channels. Fortunately, the existing EGPRS system has defined the multi-slot mobile. A user, in order to achieve higher throughput, can occupy multiple slots in the same TDMA frame. In order to take advantage of this capability we encode the whole resulting information block. In contrast, in

the current EGPRS system, the information blocks to be encoded correspond to one slot per TDMA frame.

Table 1. Maximum information data rates.

Rate	Modulation	Data Rate
3/4	16-QAM	473.6kbps
4/5	32-QAM	631.5kbps
5/6	64-QAM	789.3kbps

III. Performance Evaluation

When using Turbo codes under processing load limitations, a compromise must be made on the number of (decoding) iterations required for a satisfactory performance. By performance we mean the plot of the BLER versus the signal to noise ratio per information bit (SNRb). The systems are denoted in the figures by their overall code rate, i.e. a system having throughput η bits/symbol and using 2^m QAM modulation is denoted as 'η/m'. Ideal frequency hopping (iFH), when used, is assumed to be over TDMA frames and not over slots.

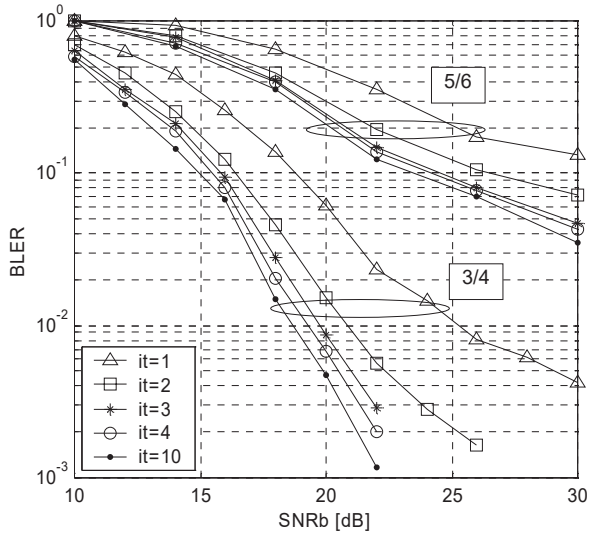

Figure 5. Turbo-CM performance as a function of the number of iterations over TU50 iFH.

In Figure 5, we have plotted the performance (single-slot case, K=1) as a function of the number of iterations ('it') for the TU50 iFH channel. In the sequel we use 3 iterations, since it seems to be a good compromise between complexity and performance. Note that by going from 3 to 10 iterations we get only 0.9 dB for 3/4 16-QAM and 1.1 dB for 5/6 64-QAM improvement at 10% BLER.

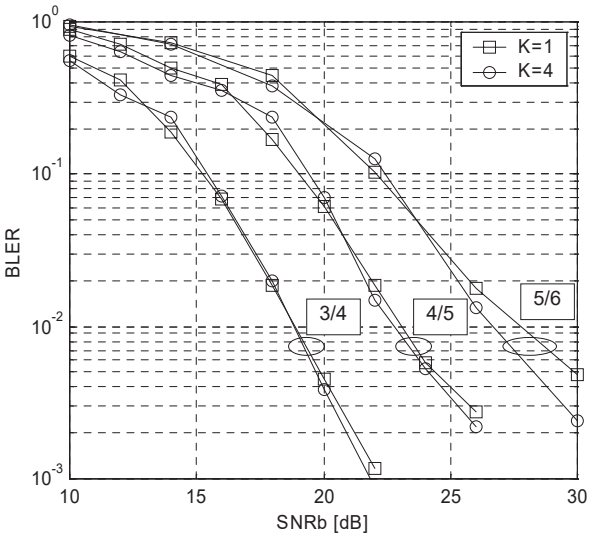

Figure 6. Single and multislot performance over TU3 iFH.

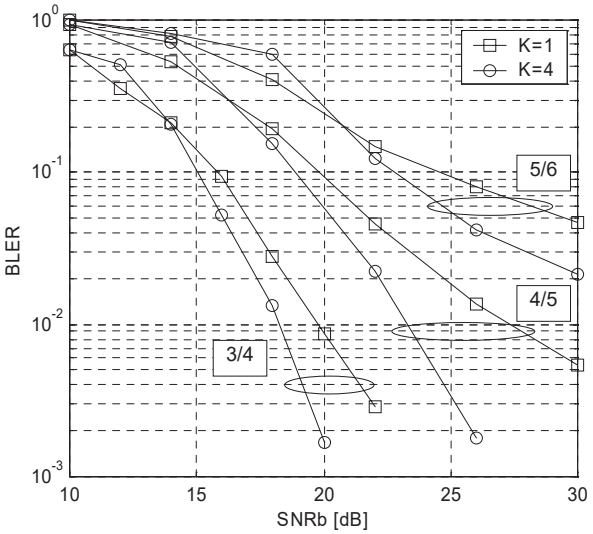

Figure 7. Single and multislot performance over TU50 iFH.

Figures 6 and 7 illustrate the performance of the 3/4 16-QAM, 4/5 32-QAM and 5/6 64-QAM schemes for the TU iFH channel with 3km/hr and 50km/hr correspondingly. For

the single slot case we see that the more slowly fading channel performs better than the more rapidly fading. This is in contrast to what we have seen in a single path channel with perfect channel state information (see for example [4]). The reason here is that the slower the channel, the more accurate the channel estimate. On the other hand, the effects of the slow fading are compensated from the inherent TU channel (multipath) diversity.

The channel estimation is based on the assumption that the channel remains constant in the slot duration. This is because we estimate the channel based on the training sequence, which is located in the middle of the slot. Upon the estimation, the estimate remains the same during the equalization of the slot. In the 3km/hr the assumption is approximately true and in 50km/hr it is hardly true. But in the speed of 250 km/hr it doesn't hold at all for the current configuration (i.e. the current slot structure).

Therefore at 250km/hr the channel estimate is very unreliable, and the impact of this is catastrophic for the high density constellations (i.e. 32/64 QAM). Under these conditions the 4/5 32QAM and 5/6 64QAM schemes don't reach 10% BLER for the RA250 nFH (no frequency hopping) channel. So in Figure 8 we have shown only the 3/4 16QAM scheme over the RA250 nFH channel. Even the 16QAM scheme seems to suffer from the bad channel estimates.

It is worthy to note the gain we get by using a multi-slot mobile in the fast fading channels. On the other hand, in the slow fading channels, the gain is diminishing due to the big fade duration.

The multi-slot mobile will be a must, since this is the only way (by allowing a user to occupy multiple slots within the TDMA frame) to get the high data rates. In practice, the information block length of our scheme must be reduced to leave space for the necessary headers, and the back-off (peak-to-average power ratio) needs to be taken into account. These will penalize the performance of the system presented in this paper. Another mismatch, as compared to the EGPRS, is the different pulse shapes used; i.e. EGPRS uses a linearized GMSK pulse for the Tx filter.

In order to improve further the performance of the system, receiver diversity (2 Rx antennas) may be employed, especially for 64-QAM in the demanding GSM channels. The receiver diversity employed here is simply combining the soft outputs of the two equalizers (one for each receive antenna). The signal's amplitude prior to transmission has been multiplied by $2^{-0.5}$ in order to have fair SNRb comparison with the one-antenna case. The simulation results are depicted in Figure 9 for the TU50 iFH channel. The improvement over the one antenna case at 10% BLER is 3.4dB for 3/4, 3.7dB for 4/5 and 5.9dB for the 5/6 system.

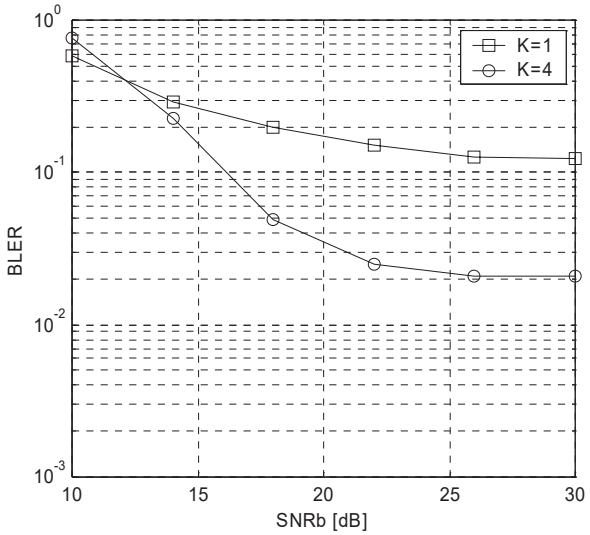

Figure 8. Single and multislot performance of the rate 3/4-16QAM over RA250 nFH.

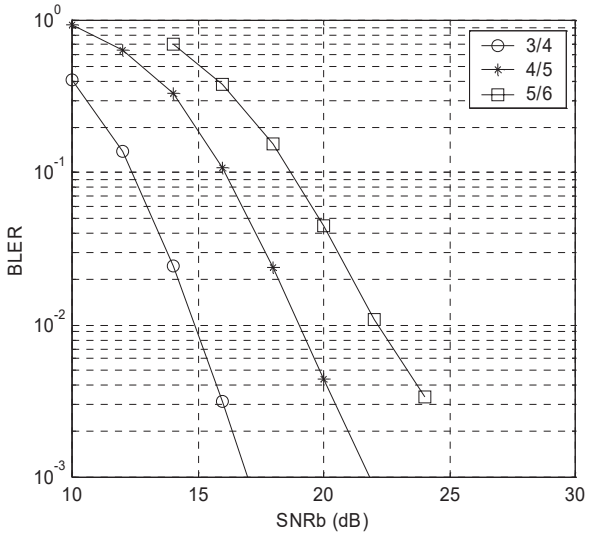

Figure 9. Single-slot performance with 2 Rx antennas over TU50 iFH.

It is very likely that basestations will employ two transmit antennas in the future. For a system with two transmit antennas and one receive it has been shown that Turbo-CM

achieve better performance than the best space-time codes, although for different types of channels [12]. Another alternative for such a system is the employment of the Alamouti scheme [13]. It is believed that any of these approaches can be employed under our system, improving its performance.

IV. Conclusions

In this paper we investigated the performance of a Turbo coded M-QAM TDMA system under GSM channels. Performance curves showed that this system is promising in the range of interest. The block length was shown to be very critical, while the increase on the number of iterations doesn't seem to provide significant gain. In the literature it is common to approximate fast fading wireless channels with independent fading channels. This assumption is not realistic at least for the kind of system presented in this paper (the same conclusion is apparent in [4] for the single path channels).

Antenna diversity provides a significant gain and it seems to be a must for higher order modulation schemes under wireless channels.

Current efforts are focused in the improvement of the performance of 64-QAM under fast fading channels (e.g. RA250), and development of suboptimum decoding and equalization techniques.

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III

COMBINING SOCIAL SERVICE AND HEALTHCARE AS THE FIRST COUNTRY IN THE WORLD: EXPLORING THE IMPACTS ON INFORMATION SYSTEMS

by

Hannu Vilpponen, Mika Grundström, & Pekka Abrahamsson, 2018

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Combining Social Service and Healthcare as the First Country in the World: Exploring the Impacts on Information Systems

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***Abstract*—The Finnish government has decided to implement a reform in the social and healthcare system by combining the two in the future. There are several drivers for this change that have been identified. Large number of information systems that are not interoperable, challenges in data management and isolated service offering are the most significant ones. In the government's strategy for the future the digitalisation will provide tools to solve these challenges. In this paper the landscape is outlined and the architecture choices are discussed. The enterprise architecture is applied for the largest county comprising of over 1900 social service and healthcare related information systems. The target is to design one joint system with maximum of 300 supporting information systems resulting in 3 B EUR savings.**

***Index Terms*—healthcare reform, welfare system, enterprise architecture, information systems, data driven**

I. Introduction

The welfare reform in Finland paves the way for future combined social and healthcare system. One needs to define a robust and cost-effective implementation of system enabling municipalities to run the service and citizens to utilize it. The concept is novel and the reform is due to come into force on 1st January 2020. The current social and healthcare system and local government services relies on municipalities, sometimes with very small populations. A similar structure can be found in other Nordic countries. There are 5, 5 million inhabitants in Finland, one third living in Helsinki-Uusimaa region. After the regional reform there will be 18 larger counties in Finland, which are responsible in organizing all social services and public health care in their area. Some other duties will be transferred to the counties as well, from Centres for Economic Development, Regional State Administrative Agencies, Regional Councils and other joint municipal authorities and municipalities. The aim of regional reform is to provide Finland with a modern, cost-effective public administration that serves all inhabitants. The reform will ensure key services and streamline transactions. The reform will help to bridge a large part of the sustainability gap in general government finances. The Government's aim is to save EUR 10 billion, of which approximately EUR 3 billion should be covered through the reforms in the branch of government of the Ministry of Social Affairs and Health [1].

Building an integrated system is complex task. The massive amount of depencies and number of non-integrated systems make it inherently such. As the digitalization has progressed a number of steps to right direction have been made. Today, the documentation of patient data in Finnish healthcare system is 100% digitalized. In public hospitals, the electronic patient record availability has been 100% since 2007. In public primary health care centers, the 100% availability was reached in 2010 and in private health service providers even earlier than that. Patient information created by health care service providers is transferred to the National Patient Data Repository - Kanta [2]. All public and private healthcare providers are linked to Kanta services. Kanta data archive stores and transmits providers' medical records and the central repository already contains more than 600 million documents (situation 12/2016). Electronic prescription is mandatory since the beginning of 2017 for all physicians prescribing medicines and currently about 5.35 million ePrescriptions are issued monthly, with 170 million ePrescriptions cumulatively to date [3].

There are several studies related to the healthcare IT reform in the literature [4]-[9]. However, studies are generally qualitative and do not describe the complexity of the field in terms of concrete data regarding the systems and their connections. Our research aims at demonstrating the complexity of social and healthcare information systems by case study with actual system configuration.

The first author is acting as a reflective practioner [10] in the field. Research methods that he used were participating observation, professional survey and a case study. In this article, we focus on determining the information systems used in Helsinki-Uusimaa region in social service and healthcare areas. We answer the following particular research question: How systems can be classified, identifying systems that are replaced with

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Epic system [11] delivered by Apotti project, and reducing number of parallel systems. The remainder of the paper is organized as follows: First section introduces Finnish regional reform and Kanta system. The following section describes used enterprise architecture methodology. Finally, last section focuses on the Helsinki-Uusimaa region, and examines the system map of the medium-sized municipality and information systems dependencies.

II. Enterprise Architecture Is an Essential Part for Execution of the Finnish Regional Reform

ICT reforms in support of larger public sector reform have been ineffective and unsustainable, although many ICT reforms have been successful in a narrower context. Enterprise Architecture (EA) has seen as an important tool for reducing information management silos that successive governments have unsuccessfully tried to reduce. The EA can be used as an approach to ICT governance but it can also be applied as a more wide–ranged and strategically oriented method to serve growing organizational needs [12]-[14]. Effective communication is essential in sharing knowledge, achieving a common understanding, agreement and a shared view of the enterprise architecture scope, vision, and objectives, as well as of the developed models and other artifacts. Furthermore, communication is an important means of gaining commitment to the enterprise architecture effort [15]. EA is part of the strategic work of an organization, its management process and financial and operational planning. Fig. 1 shows the dependencies of the EA of the public sector in Finland. EA is structured view of a functional entity including the relations, dependencies, principles and guidelines [16].

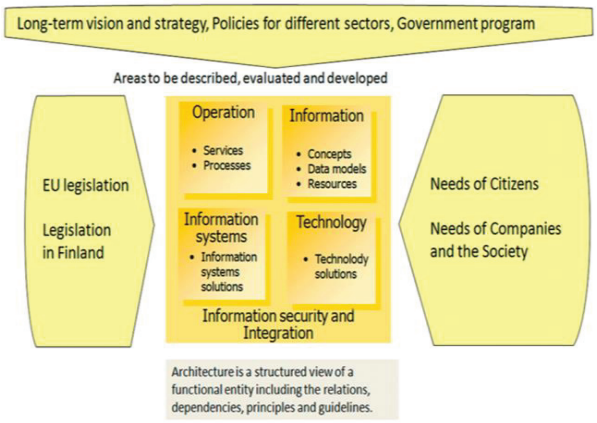

Figure 1. Enterprise architecture in public sector.

In Finland, the use of EA has recently been mandated by the newly passed Act on the Direction of Public IT Governance [17]. EA has been promoted as a key tool for transformation and modernization of government [18]. EA work follows the enterprise architecture method, Public Administration Recommendation JHS179 [19], which is based the international, open and most widely used enterprise architecture framework, TOGAF® [20]. JHS179 provide information management guidelines for public administration, both governmental and municipal. The JHS179 system aims to improve the interoperability of information systems and the compatibility of data in them, to facilitate cross-sector process development and to make the use of existing data more efficient. Information systems that are intended to be attached directly to the Kanta services are classified to category A systems. Supporting information systems used in social and healthcare are classified to category B systems. Table I describes classification of social and healthcare information systems [21].

TABLE I. Classification of Information Systems

Category	Connection to Kanta	Examples
A	Directly connected	Patient data information systems, social service data systems, oral healthcare data systems
B	Not connected	Specialized hospital systems, patient classification systems, laboratory systems, X-ray archive, analytics

III. Case: Helsinki-Uusimaa Region (Uusimaa2019 Program)

The largest new county is Helsinki-Uusimaa region. It is situated on the south coast of Finland, and it is home to around 1.7 million inhabitants, which is about 30 percent of the country's total population. Fig. 2 shows Helsinki-Uusimaa region geographical position in Finland. In the Helsinki-Uusimaa region, the social and healthcare services of 26 municipalities and specialized medical care from HUS (Hospital District of Helsinki and Uusimaa, Helsinki University Hospital) and about 55,000 employees will be transferred to the county to be formed. At the same time, the province is also responsible for the transfer of 25 different governmental activities that have been either state activities or statutory activities organized by municipalities. The Epic system delivered by Apotti project has been selected as a social services and healthcare system supplier in Helsinki-Uusimaa region. Apotti is an extensive Finnish change project of the social services and healthcare field. Apotti project is building the world's first information system that integrates social services and healthcare services [22].

Figure 2. Regions in Finland.

Helsinki-Uusimaa region council set up Uusimaa2019 program [23] in early 2017. Uusimaa2019 program contains two tracks. Main project focuses to operational changes, service concept development and ramp up social and healthcare services. Second track is ICT project that aim is build ICT functionalities, information systems and infrastructures that are needed for running services that Helsinki-Uusimaa region will provide starting at 1st January 2020.

Typical medium size municipality in Helsinki-Uusimaa region has about 100 information systems, which about 20% are social and healthcare systems. Fig. 3 shows information system map for city of Kerava. Kerava is a medium sized municipality with 35000 inhabitants and is located in the middle of the Helsinki-Uusimaa region. The aim of the system map is to describe the impact of the reform on the Kerava information systems portfolio. Kerava has 95 systems, 18 of which are social and healthcare systems, including 3 category A systems. Information systems are classified and visualized according to operational units, as each unit has its own budget to cover the purchase and maintenance of systems.

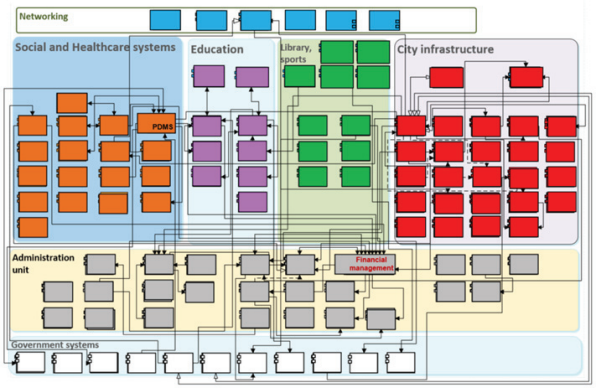

Figure 3. Information systems map for typical medium sized municipality.

Classification of systems by operational units makes it easy to figure out which services, related information systems and interfaces are going to Helsinki-Uusimaa region. City of Kerava has five operational units. The units are Social and Healthcare services, Education services, Culture and Sports, City Infrastructure and Administration unit. In the upcoming reform, all social and health care services will be transferred to Helsinki-Uusimaa region, whereby the systems used to produce the services will be removed from the municipal information system portfolio. Information systems are connected with various application and system interfaces. Patient Data Management Systems (PDMS) is a good example of a critical information system with 9 interfaces to other systems. Another important system is Financial Management system, which has interfaces to 13 different systems. The problem is if one system is changed, it will effect a number of other system. All municipalities has different set of systems and integrations.

The ICT project started in the spring 2017 with pre-screening phase. The target of pre-screening was to find out what kind of information systems municipalities are using in social and healthcare services. The survey was conducted with a questionnaire addressed to municipalities, which was used to identify the systems used by municipal social and healthcare services. Results of the pre-screening survey shows that municipalities are using currently 1902 different information systems, 43000 workstations, 10700 mobile devices (tablets etc.), 1250 servers and over 6400 networking devices. There are large number of critical social service and patient data systems (category A). The problem is that the same information system has been tailored to municipality-based versions, causing uneven data structures and migration requires special attention and extra work. Category A information systems will be replaced with Epic delivered by Apotti project. The Epic will also replace also most of the social and healthcare services supporting information systems that are not directly connected to Kanta (category B). The aim of the reform is to reduce the number of systems in use. After the reform, there is one class A system, and 100-300 general and social and health care support systems. Specialized hospital systems will be mainly remain and only small fraction of those systems can be replaced with Epic. The first launch of the Epic is in November 2018 at city of Vantaa and gradually being expanded to other municipalities and is in use throughout the Helsinki-Uusimaa region in 2022.

During the autumn 2017 ICT project was projected to sub-areas whose mission was to form detailed project plans for project implementation. ICT projects followed EA guidelines and ICT roadmap that was created based for the JHS 179. The ICT project is time critical because the Helsinki-Uusimaa region Interim Administration will start operating in the summer of 2018, decision making and archiving systems must be in place in early summer 2018. The next step is create infrastructure and general systems like HR, Payroll, ERP, CRM and Financial management. Those systems rely on current HUS information systems and contracts, which are extended to cover the entire Helsinki-Uusimaa region. One important part of the project planning is risks management. This very comprehensive reform directly affects 55,000 people. When completed, Helsinki-Uusimaa region is the largest employer in Finland. Because of the scale of the project, risk management requires a great deal of attention. Table II shows information systems classification.

TABLE II. INFORMATION SYSTEMS CLASSIFICATION (2018)

Category A			Category B		General
Health care	Oral health care	Social service	Specialized hospital systems	Social and healthcare supporting systems	HR, payroll, logistics, CRM, financial management
6	3	5	536	476	876

The risks are shared to cover the operating environment, technologies, organizations, timetable, budget and system vendors. There are about detailed 80 risks identified that are regular evaluated during the project. Two largest risks are out of the project control and changes will effect entire ICT project structure and schedule. Largest risks are legislative incompetence, and size and complexity of the project. The project involves dozens of organizations and system vendors, as well as hundreds of different information systems whose are integrated or replaced with Helsinki-Uusimaa region systems. Individual employees with their personal IT capabilities is difficult take into account in the risk evaluation in this phase of the project. For example, the Epic system requires end users an average of 2 days of certification training. This means over 110,000 training days in Helsinki-Uusimaa region area.

IV. Conclusions

The reform in social and healthcare systems in Finland has been described in this article. The complexity in terms of information systems has been outlined. Clearly, the needs that vary between the regions and the wide spectrum of services call for modular and scalable architecture that should be based on unified approach in defining the data structures, interfaces and interoperability. In this study, a number of parallel systems is reduced and replaced with Epic system defined by Apotti project.

It is evident that the social and healthcare system chosen will impact a large number of individuals being part of the end-to-end process including the professionals and user or customers alike. The change should improve the experience of individuals in all aspects of the process taking advantage of the digitalization that is fundamentally changing traditional mechanisms and ways of working. Part of solution is based on customers using electronic self-service tools. The professionals would utilize new digital interfaces that would provide added value being integrated across the domains and containing the accurate up-to-date information provided by end-to-end EA system. The basic building blocks of the reform are Data Lake and Data Warehouse solutions that can be used to utilize massive raw data in operational use, service optimization and research purposes.

The client's freedom of choice, the use of personal budgets and the service vouchers in health and social services [24] need a new information architecture and systems. A long transition period is needed before all municipal systems are replaced by the Helsinki-Uusimaa regional systems pose challenges to the project. Municipalities continue to develop their operations, digitalize their services and make system development, as a result of which systems and interfaces are changing. An interesting question is how massive operational and technological reform can be deployed to a heterogeneous end-user most efficiently within a tight project deadline. Also, it is an interesting question to future work to research how clients use and experience the new services. For example, the transfer of health records between municipalities is being developed and this from user perspective is substantial change in the process flow.

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IV

EXPLORING THE CRITICAL SUCCESS FACTORS IN SOCIAL AND HEALTH CARE INFORMATION SYSTEMS PROJECT PROCUREMENT

by

Hannu Vilpponen, Mika Grundström, & Pekka Abrahamsson, 2020

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Exploring the critical success factors in social and health care information systems project procurement

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***Abstract* — The Finnish government is implementing a welfare reform that involves combining the social and healthcare systems. Several motivations for this change have been identified, the most significant of which are that many information systems are not interoperable, and challenges associated with data management and isolated service offerings. In the government's strategy involves digitalising to address these challenges. This paper outlines the landscape of the reform and discusses the architecture choices and critical success factors of the proposed digitalisation process. The enterprise architecture is applied to the largest county, which comprises over 1,900 social service and healthcare-related information systems. The target is to design a single joint system with a maximum of 300 supporting information systems resulting in 3 billion EUR in savings. The findings are presented as six primary empirical conclusions.**

***Index Terms* — Healthcare reform, welfare system, enterprise architecture, information systems, data driven, critical success factors**

I. INTRODUCTION

Finland's recent welfare reforms are paving the way to combine the country's social and healthcare systems. A robust and cost-effective system will need to be implemented to enable municipalities to run the service and citizens to utilize it. As in other Nordic countries, Finland's current social and healthcare system and local government services are operated under at the municipality level administration; some municipalities have very small populations. One-third of the country's 5.5 million inhabitants live in Helsinki-Uusimaa region.

The planned regional reform will create 18 larger counties instead of current 295 municipalities, which are responsible for organizing all social services and public health care in their area. The reform seeks to provide a modern, cost-effective public administration that serves all inhabitants. It will ensure key services and streamline transactions, and help to bridge a large part of the sustainability gap in general government finances. The government aims to save EUR 10 billion, of which approximately EUR 3 billion should be covered by the reforms in the branch of government of the Ministry of Social Affairs and Health [1].

The authors' previous analysis of the system entity and related enterprise architecture (EA) modeling has been published in [2]. This paper extends previous research with an empirical analysis designed to identify the critical success factors in the case counties.

Building an integrated system is a complex task, given the large amount of dependencies and number of non-integrated systems. As digitalization has progressed, a number of steps in the right direction have been made. For instance, patient data in the Finnish healthcare system is now 100% digitalized. In public hospitals, electronic patient record availability has been 100% since 2007. In public primary health care centers, this threshold was reached in 2010 and in private health service providers even earlier than that. Patient information created by health care service providers is transferred to the National Patient Data Repository, KANTA [3], to which all public and private healthcare providers are linked. The KANTA data archive stores and transmits providers' medical records; the central repository contained more than 600 million documents as of 12/2016. In addition, electronic prescriptions have been mandatory since the beginning of 2017. Approximately 5.35 million ePrescriptions are issued monthly, for a total of 170 million to date [4].

Several prior studies have assessed healthcare IT reform [5, 6, 7, 8, 9,10]. However, these studies have generally been qualitative and do not describe the complexity of the field in terms of concrete data regarding the systems and their connections. Our research aims to describe critical success factors for public IT system development programs and to demonstrate the complexity of social and healthcare information systems using a case study of an actual system configuration.

In this article, we focus on the information systems used in Helsinki-Uusimaa region in the areas of social service and healthcare. We examine the factors that contributed to the high rate of failure of public sector information system projects in a case county and how systems can be classified. We identify systems that have been replaced by the Epic system [11] delivered by the Apotti project, thus reducing the number of parallel systems.

II. Related work

A. Critical success factors

Several studies have examined why IT projects fail repeatedly [12,13,14,15,16]. Rosacker [17] identifies ten factors that are critical to the success of project implementation, which are listed in Table 1.

Table 1. Critical success factors in project implementation

Factor	Description
Project mission	Clear statement of goals and objectives
Top management support	Necessary resources and authority present
Client consultation	Communication, consultation and active listening to all stakeholders
Schedule/plan	Detailed specification of actions required for project implementation
Personnel	Recruitment, selection and training of necessary team personnel
Technical tasks	Availability of required technology and expertise
Client acceptance	The act of selling final projects to their ultimate intended users
Monitoring and feedback	Timely provision of an appropriate network and necessary data to all key actors
Communication	Appropriate network and necessary data to all key stakeholders in project implementation
Troubleshooting	Ability to handle unexpected crises and deviations from plan

These success factors are widely accepted, and enterprise-wide design is agreed to be the key determinant of project success. But there is also a human factor in the development process – usability – that needs to be considered.

It is not enough to make the systems work with each other; their usability and availability must also consider their internal and external end users, as well as their specific needs [18]. This is still a valid problem. An example is the design of digital services for the elderly. Public digital services are often acquired by people who are unfamiliar with the complexity of the requirements. Even full-time professionals may find it difficult to keep up to date in this field [19].

B. EA – an essential element of implementing the Finnish regional reform

Information and communications technology (ICT) reforms in support of larger public sector reform have been ineffective and unsustainable in the past, although many ICT reforms have been successful in a narrower context. EA is an important tool for reducing information management silos that successive governments have unsuccessfully tried to decrease. EA can be used as an approach to ICT governance, but it can also be applied as a more wide-ranging and strategically oriented method to serve growing organizational needs [20,21,22].

Effective communication is essential in sharing knowledge, achieving a common understanding, agreement and a shared view of the EA scope, vision, and objectives, and of the developed models and other artifacts. EA is a structured view of a functional entity that includes the relations, dependencies, principles and guidelines [23]. It forms part of an organization's strategic work, management process, and financial and operational planning. Communication is an important means of obtaining a commitment to the EA effort [24].

In Finland, the use of EA has recently been mandated by the newly passed Act on the Direction of Public IT Governance [25]. EA has been promoted as a key tool for transforming and modernizing government [26]. EA work follows the enterprise architecture method, Public Administration Recommendation JHS179 [27], which is based on the international, open and most widely used EA framework, TOGAF® [28]. JHS179 provides information management guidelines for public administration, both governmental and municipal. The JHS179 system aims to improve the interoperability of information systems and the compatibility of data within

them, and to facilitate cross-sector process development and more efficiently use existing data.

Table 2 describes the classification of social and healthcare information systems [29]. Information systems that are intended to be attached directly to KANTA services are classified as category A systems. Supporting information systems used in social and healthcare are classified as category B.

Table 2. Classification of information systems

Category	Connection to KANTA	Examples
A	Directly connected	Patient data information systems, social service data systems, oral healthcare data systems
B	Not connected	Specialized hospital systems, patient classification systems, laboratory systems, X-ray archive, analytics

III. STUDY 1: EMPIRICAL STUDY

This case study is designed to determine what factors contribute to the high rate of failure of public sector information system projects in a given county. Semi-structured interviews were chosen as the primary data collection method. We interviewed ten experts in a mid-sized city in Southern Finland to find out if an important underlying problem could be identified. The interviewees were asked to identify the most important determinants of success and failure in their experience concerning public sector information systems. The interviews lasted 30–45 minutes. The data were analysed with the assumption that the interviewees are trustworthy experts and that their comments reflect their experience. The interviews were transcribed in a way that relies on the authors' interpretation. The key findings are presented as **primary empirical conclusions (PECs).**

"There is a lack of expertise in making contracts…large systems require specialized expertise that is not available enough." (**I1 – Chief Information Officer**)

"The commitment of the necessary resources for both the preparation and implementation of the procurement is important." (**I6 – Director of Nursing**)

"The overall picture and consideration of the enterprise architecture is lacking in procurements that are procured on a substance-by-substance basis." (**I5 – Director of Dental care**)

PEC1 The system must have a clear owner who is equipped with an adequate budget that includes the necessary resources. The project owner should systematically follow the project and address any shortcomings as they arise.

We found that the most important problem was the unsystematic allocation of responsibility for the product development process, which has led to problems in leadership, requirements engineering, resource allocation and communication as projects have progressed. The operational mode is tailored to a stable or minimally growing system. The municipalities are not well equipped to work in rapidly changing dynamic environment.

"Acquiring a new information system should have an evaluation system to ensure benefits and usability, this is expertise. Systematic decision making for a longer period of time. A small acquisition can be made quickly, but larger information system acquisitions must be implemented systematically." (**I3 – ICT Development manager**)

"When purchasing a new system, the criteria for evaluating the system and the benefits to be obtained should be defined in advance." (**I4 – Lawyer**)

"In acquisition, it is important to see and identify the whole, which is an almost overwhelming task today because there are so many parts. It is not necessarily important knowing the all details, but important is understanding the goal." (**I6 – Director of Nursing**)

"Procurement law is really rigid and strict; it is ill suited to information system procurement. Information technology is a rapidly changing and evolving field. There will be a lot of changes and updates to social and health care information systems. Legislation imposes requirements, including restrictions on personal data and other laws. Coordinating legislation and information systems is challenging." (**I8 – ICT Designer**)

"Because the budget is tight, only the required minimum is made." (**I9 – Client manager, vendor 1**)

PEC2 Public sector operating environment and tendering rules are very strictly regulated by the Procurement Act, which poses challenges for fast-paced information system development.

The public sector environment, such as tendering regulations and its processes, is rigid, time consuming and cumbersome to organize. Successful tendering is very challenging. Technically and economically, the best solution may not win the tender if the tender is not well defined. Tenders often lead to a complaint to the Market Court, which further delays the project.

"Municipalities are in a forced marriage with a supplier. To add a third-party system of current systems causes an awful amount of work." (**I10 – Service manager, vendor 2**)

"Being tied to one supplier and system, breaking out of it is a big and expensive project." (**I2 – ICT Development manager**)

"The overall picture and consideration of the enterprise architecture is lacking in procurements that are procured on a

substance-by-substance basis." (**I5 – Director of Dental care**)

PEC3 Vendor lock-in forces municipalities to use a certain product or service, regardless of its quality, because switching away from it can be challenging, and the switching costs may be substantial.

A small number of suppliers in Finland dominate the public sector information system field. Information systems are tailored to a specific municipality, and even products from the same system supplier may not be compatible with each other but require a lot of integration. System suppliers take advantage of the rigidity of legislation and the bidding process, making it almost impossible for municipalities to switch systems without high costs and time-consuming procurement processes.

"The statistical system is very difficult to master; the trainings were completely detached from everyday reality." (**I3 – ICT Development manager**)

"The end user's view has not been taken into account in the design of the systems." (**I5 – Director of Dental care**)

"In the health care division, we work with people. Information technology is just a tool for working with people and a tool for measuring cost effectiveness." (**I10 – Service manager, vendor 2)**

PEC4 A lack of practical expertise during the planning and definition phases of information system projects affects the quality of the outcome.

The planning phase of information systems should also consider the system's usability in operational activities. Interview data show that public digital services are often designed by people who are unfamiliar with the practical operations and processes. It is important that operational experts from the field are involved, and their input is taken into account in the definition stage.

IV. STUDY 2: HELSINKI-UUSIMAA REGION CASE

The second study is based on an actual systems configuration evaluation. We employ a case study to demonstrate the complexity of social and healthcare information systems.

The country's largest region is Helsinki-Uusimaa. It is situated on the south coast of Finland, and is home to around 1.7 million inhabitants, or about 30% of the country's total population. The social and healthcare services of 26 municipalities and specialized medical care from HUS (Hospital District of Helsinki and Uusimaa, Helsinki University Hospital) and about 55,000 employees will be transferred from the region to the new county to be formed. The Epic system delivered by the Apotti project has been selected as the social services and healthcare system supplier for a large part of the region. Apotti is an extensive Finnish change project in the social services and healthcare field. The project is building the world's first information system to integrate social and healthcare services [30].

In early 2017 the Helsinki-Uusimaa region council set up the Uusimaa2019 program [31], which contains two tracks. The first (main) track focuses on operational changes, service concept development, and ramping up social and healthcare services. The second track is an ICT project that aims to build ICT functionalities, information systems and infrastructures that are needed to run services that the region will provide. Due to a political decision-making process, the project was suspended in 2019 and put under new political preparation. New social and healthcare reform is scheduled to enter political decision-making in the fall of 2020.

A typical medium-sized municipality in Helsinki-Uusimaa region has about 100 information systems, approximately 20% of which are social and healthcare systems. Figure 1 shows the information system map for the city of Kerava, a medium-sized municipality with 35,000 inhabitants located in the middle of the region. The system map illustrates the impact of the reform on the city's information systems portfolio. Kerava has 95 systems, 18 of which are social and healthcare systems, including 3 category A systems. Information systems are classified and visualized according to operational units, as each unit has its own budget to cover the purchase and maintenance of systems.

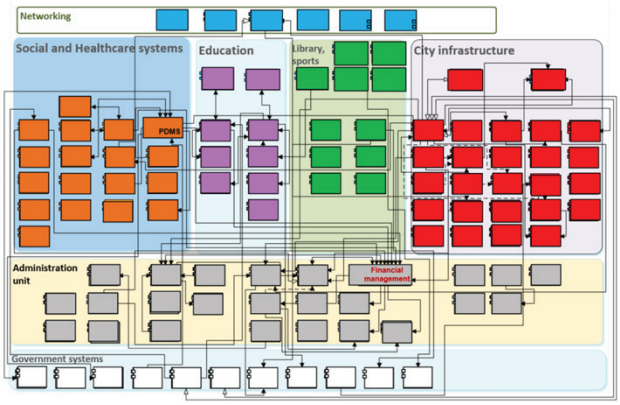

Fig. 1. Information systems map for Kerava, a typical medium-sized municipality

Classifying systems according to operational units clearly illustrates which services, related information systems and interfaces are going to Helsinki-Uusimaa region. The city of Kerava has five operational units – Social and Healthcare services, Education services, Culture and Sports, City Infrastructure, and Administration. In the upcoming reform, all social and health care services will be transferred to the region, and

the systems used to produce the services will be removed from the municipal information system portfolio. Information systems are connected with various application and system interfaces. For instance, Patient Data Management Systems are a critical information system with nine interfaces to other systems. The Financial Management system has interfaces to 13 different systems. The problem is if one system is changed, it will affect a number of other systems. All municipalities have a different set of systems and integrations.

The ICT project started in spring 2017 with a pre-screening phase. The target of this phase was to find out what kinds of information systems municipalities are using in social and healthcare services. The survey was conducted with a questionnaire addressed to municipalities, which was used to identify which systems they use for social and healthcare services. The results of the pre-screening survey show that municipalities are currently using 1,902 different information systems, 43,000 workstations, 10,700 mobile devices (tablets, etc.), 1,250 servers and over 6,400 networking devices. There are large number of critical social service and patient data systems (category A). The problem is that the same information system has been tailored to municipality-based versions, causing uneven data structures; migration will require special attention and extra work. Category A information systems will be replaced by the Epic system delivered by the Apotti project. Epic will also replace most of the social and healthcare services supporting information systems that are not directly connected to KANTA (category B). The aim of the reform is to reduce the number of systems in use. After the reform, there will be one class A system and 100–300 general and social and health care support systems. Specialized hospital systems will mainly remain; only a small fraction of those systems can be replaced with Epic. Epic was launched in November 2018 in the city of Vantaa and is gradually being rolled out to other municipalities.

In autumn 2017 the ICT project was rolled out to sub-areas whose mission was to form detailed plans for project implementation. ICT projects followed EA guidelines and the ICT roadmap that was created was based on the JHS179 system. The ICT project is time critical. Risk management is an important element of project planning, particularly due to the scale of the project. This very comprehensive reform directly affects 55,000 people. When completed, the region will be the largest employer in Finland.

Table 3. Information systems classification (2018)

Category A			Category B		General
Health care	Oral health care	Social service	Specialized hospital systems	Social and healthcare supporting systems	HR, payroll, logistics, CRM, financial management
6	3	5	536	476	876

The risks will be shared to cover the operating environment, technologies, organizations, timetable, budget and system vendors. Approximately 80 detailed risks are regularly evaluated during the project. The two largest risks – legislative incompetence and the size and complexity of the project – are out of the project's control; changes will affect the entire project's structure and schedule. The project involves dozens of organizations and system vendors, as well as hundreds of different information systems that will be integrated with or replaced by Helsinki-Uusimaa region systems. Individual employees' personal IT capabilities are difficult to take into account during the risk evaluation phase of the project. For example, the Epic system requires end users to complete an average of 2 days of certification training, which will require a total of over 110,000 training days in the Helsinki-Uusimaa region area.

PEC5 Delays in political decision-making lead to delays in social and health care reform, which further complicates the information system design due to changing priorities and goals.

The first attempt at social and health care and regional reform started in 2006. Since then, various governments have put forward their own solutions.

PEC6 The development of a unified EA for the whole region is critical to the success of the social and health care reform.

Municipalities in the area have hundreds of information systems with cross-integration and data models. The information system reform required by the change is a very challenging task; a unified EA will be key to solving the problem cost effectively.

V. CONCLUSIONS

This study and previous efforts demonstrate the important role that system design architecture plays in the technical context. Furthermore, architecture documentation serves as an elementary tool in communicating with vendors, decision-makers, users and the rest of the community including municipalities and cities.

This paper has described critical success factors and findings. Legacy information systems in the healthcare and social care fields are the key limiting factor in combining the systems as part of the country's welfare reform. Difficulties associated with integrating these systems have limited the pace and extent of the reform.

Future research could explore a scenario in which this legacy constraint is lifted when the system can be built from scratch. An interesting case study could be developing markets, for example in Africa, where the opportunity space in this respect allows more flexibility

and grounds for innovation. The frugal innovation opportunity is another trend that could be examined in future work [32]. First steps in this direction have been taken by the AiRRhow alliance, which explores opportunities in Namibia together with local authorities and actors [33].

This paper discusses the critical success factors associated with a complex multiple provider domain with a considerable legacy. So far, the legacy systems have served the Finnish nation well. Understanding the limits of the new system will pave the way for developing the next level of services and innovations.

The social and healthcare system chosen will impact a large number of individuals who form part of the end-to-end process, including the professionals and users or customers. The change should improve the experience of individuals involved in all aspects of the process by exploiting the potential advantages of digitalization, which is fundamentally changing traditional mechanisms and ways of working. Part of the solution is based on customers using electronic self-service tools. The professionals would utilize new digital interfaces that would provide added value that is integrated across the domains and contains accurate, up-to-date information provided by an end-to-end EA system. The basic building blocks of the reform are Data Lake and Data Warehouse solutions that can be used to process large amounts of raw data in operational use, service optimization and for research purposes.

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V

LIFE-BASED DESIGN TO COMBAT LONELINESS AMONG OLDER PEOPLE

by

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Life-based design to combat loneliness among older people

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Introduction

Technologies should be constructed to improve the quality of life. They are meant to help people in realizing their action goals in life, and thus, making life easier. Thus, to improve people's quality of life, technology should not exist for itself, but rather for bringing added value to people's daily life (Cockton 2008; Leikas and Saariluoma 2008; Mesthene 2003). This is the key to consumer satisfaction. Developers should understand how people can and wish to live with technology, not only how they use it. For example, nanotechnology, which is used in designing paper machines, does not exist for its own sake; rather it guarantees, e.g., that the newspapers we read during breakfast look appealing.

The concept of *user need* and its variations has been used to point out that technologies are made to serve people. This concept has also found a solid role in the design of functionalities of technologies from a human point of view (Kaasinen 2003; Pahl et al. 2007; Ulrich and Eppinger 2008). However, the connections between various technologies and everyday life are rather complex. Thus a mere intuitive idea of a user or customer need is seldom sufficient for designing artefacts or systems that would improve the quality of people’s daily life. Relying only on this particular concept leaves many important questions unasked.

The current human-technology interaction (HTI) research has brought user needs to the fore with its emphasis on assessing the experience of interacting with technology already in the process of being developed. HTI research thus concerns mainly immediate usage situations; it does not provide any concepts for studying those needs that arise from the entire contents of people’s life and that could be met with the help of technology. Such design would have significant novelty value to the user in the short run, but its use could decrease in the long run if the product itself did not fit in the user’s form of life (Marchitto and Cañas 2011).

Concentrating only on immediate usage situations easily sets aside the more important question of what a technology is actually used for. In addition to examining user needs in usage situations, it is important to ask how the analysis of human life could be integrated in human-technology interaction (HTI) design. All too often projects in ICT-service design have failed due to the fact that their design has been based on intuitive thinking of human-technology interaction instead of research on people’s actions, goals and daily life. The Wireless Application Protocol (WAP), for example, failed because the starting point for the design was the invented technology and the new ways to apply it. Issues such as user acceptance and user experience were tackled too late (Ramsay and Nielsen 2000). These kinds of technology-driven cases, with the starting point in the technology itself (Rosson and Carrol 2002), are common in the area of technology design. They may serve well in developing new technologies as such. However, to ensure that we have products that satisfy the users and fit into their daily routines, an analysis of people’s lives and living conditions is needed (Leikas 2009; Saariluoma and Leikas 2010). Furthermore, we need clear conceptualizations and methodological processes that would describe how to apply this knowledge in technology design. Efficient design procedures would mean satisfied users and lead to less costly solutions for clients (Mayhew and Tremaine 2005).

Form-of-life analysis: the Whys and What fors

The principal aim of Life-based design (LBD) is to release technology that will be widely accepted by people (Leikas 2009; Saariluoma and Leikas 2010; Saariluoma and Leikas 2011). This is realised by a thorough exploration of people’s forms of life, values and everyday contingencies and an efficient integration of these into the design as the actual drivers of HTI design processes. LBD is a multi-dimensional and holistic approach, which emphasises the importance of

understanding people's lives as a basis for the creation of design ideas and for concept design. It derives design goals for new technologies from human research based on the analysis of forms of life. A holistic approach means that, fundamentally, all design issues in LBD are biologically, psychologically and socio-culturally motivated.

The process of LBD begins with a form-of-life analysis and ends by clarifying the way in which new technologies can be incorporated as working innovations into life. Different phases in the procedure guide the designers' thinking along the design process. People's forms of life may differ according to the combination of a number of factors such as age, family and marital status, social status, profession, health issues, education, gender, and skills. These factors ultimately impact everyday needs, e.g., related to communication and companionship. These two in turn influence the ways in which people experience and evaluate available products and services and the kind of 'worth' that technology could offer them (Cockton 2006).

Being the main component of LBD, the form-of-life analysis aims at discovering information about different facts of life, i.e., different situations in life that people live in, their values and actions (Leikas 2009; Saariluoma and Leikas 2010). The nformation that is gathered in the very first stage of the design process is then efficiently entered into the design with the help of technology-supported actions. The general goal is to get a clear understanding of the properties of that particular form of life. The main steps in this investigation are:

- Analysis of a selected form of life,
- Definition of design goals;
  What people need in their life, and how technologies could improve their life,
- Analysis of the role and function of the technology in use;
  How technology is used in life to reach the action goals.
- Explication of design relevant problems;
  Extraction of all the design-relevant human-based problems to define possible problematic side issues and putting them under scrutiny,
- Analysis of typical actors;
  A realistic understanding about potential users or actors and their properties, such as education, age, gender or technology skills,
- Analysis of contexts;
  Including both physical and social conditions and social relations activated before, after and when using the technology,
- Analysis of other relevant characteristic actions.

The form-of-life analysis should generate *human requirements* for the product or service. These human requirements define how people's life in a specific form of life should be improved. This is information which explains the *Why's* and *What for's* that should guide the design process from the beginning to the very end. The human requirements create the basis for the next phase in the design by introducing the design theme and the explanatory facts behind it. They are based on the methods and results of human life sciences and do not yet define the requirements for technological concepts, which could be used in addressing the defined design goals of the specific form of life.

Situations in life constitute different facts of a form of life that make the kinds of real needs that arise from people's everyday contexts understandable. They include actions, tasks and activities (Anderson 1983, 1992; Sun 2008; Kuutti 1996; Mayhew 1999; Nardi 1996). The circumstances of a situation in life can be determined by, e.g., illness, wealth or poverty, youth or old age. The importance of situations in life is that they dictate what life can be and thus can make it comprehensible as to what kinds of everyday contexts people live in. To use an extreme example, poor women in developing countries cannot easily get education, but in developed countries it is quite possible even for older adults to study at universities.

Of course, situation in life is one but not the only pivot concept upon which LBD can be grounded. There are other ways to carry out LBD. Values and actions in life can equally well serve as

starting points. We can design for some defined systems of values or for some specific action. There are also other types of facts in life that we can begin with. However, the situation in life is an important ground, and therefore there is some justification in choosing it here as a pivot problem.

Loneliness - a situation in life

This paper introduces loneliness as a situation in older adults' lives, for which to apply LBD. We assume that reduction of the effects of loneliness or the feelings of loneliness would improve the quality of life of older people, which in turn could add new value to their lives and also substantial benefit for the relatives and the society as far as the homecare of the elderly is concerned. Our aim is to illustrate the kinds of design processes needed when developing services based on these considerations.

Loneliness is a factor that in most cases essentially decreases the quality of life (Cattan et al. 2005; Masi et al. 2010; Rosedale 2007; Russell et al. 1984; Stokes 1985). Many older people experience loneliness: up to 32% of adults over 55 report feeling lonely at any given time (Masi et al. 2010). Loneliness is unlike social isolation, which appears often simultaneously with loneliness. Our social networks can usually be objectively measured, but loneliness is always a subjective feeling. For example, living alone does not necessarily mean that a person is lonely, whereas someone can feel lonely even when surrounded by many people. It is clear that loneliness can provoke depression in the way that a person without contacts to other people can become depressed and turn inwards (Stuart-Hamilton, 2000). Loneliness can be negative, but depending on people and context it can also become a positive experience of solitude.

It has been noticed that people experiencing loneliness have more interpersonal mistrust than those who do not. They rate themselves more negatively, and do not trust themselves as much as those who feel less lonely (Masi et al. 2010). They also have a lower feeling of self-worth, and are more likely to expect others to reject them. They behave in ways that increase the probability of rejection. Shyness, anxiety and anger tend to be higher among those suffering loneliness. Overall, lonely people seem to lack self-confidence and social skills (Cattan et al. 2005; Masi et al.; 2010).

The loneliness of older people differs from loneliness among other age groups (Asher, Hymel and Renshaw 1984; Cattan et al. 2005). It plays a crucial role in older people's social capacity. According to studies, approximately 30% of older people are in danger of becoming isolated due to a decreased number of social relationships (Holmén et al. 1992; Prince et al. 1997; Samuelsson et al. 1998; Tijhuis et al. 1999). Changes in social practices, such as less visiting among neighbours, more home based entertainment, and changing socio-demographic patterns, such as a larger number of older people living alone, have led some older people to experience diminution in contacts and communication. Even older people who have children and who are visited regularly by them sometimes lack companionship and opportunities for involvement with peers.

When entering the fourth age, and especially the last elderly phase, the feeling of loneliness tends to become even more common. The fourth age is a phase when a person needs an increasing amount of help from others to manage in everyday activities (Stuart-Hamilton 2000). During the fourth age, the need for care and dependence on others increases due to illnesses and declining functional capacity. Also, during this period the need for social services, especially health care services, increases (Karisto and Konttinen 2004; Jyrkämä 2005). This is influenced by loss in meaningful relationships and a decline in functional capacity, which is often a result of restrictions caused by chronic illness and lack of meaningful participation. Health problems prevent some people from getting out, and this may also lead to boredom and loneliness. Studies show that living alone and being socially isolated tend to increase the likelihood of experiencing loneliness. In contrast, having an intensive social network decreases the feeling of loneliness (Jylhä 2004).

Studies concerning the relationship between old age and the feeling of loneliness are somewhat contradictory. In general, cross-studies show that people feel lonely more often when older than during their younger years (Holmén et al. 1992; Prince 1997). On the other hand, it has been shown that age as such has no clear connection to the increase of loneliness, and that the incidence of loneliness is relatively stable among age cohorts (Creecy et al. 1985; Samuelsson 1998). The number of people experiencing loneliness seems to increase among people over 75 years of age but evens out after the age of 90 (Anderson 1992). Moreover, men of a much older age have been found to have more experiences of loneliness than those of younger ages, which may be related to moving to institutionalised care, becoming widowed or experiencing poor health (Tijhuis et al. 1999). Age may also relate indirectly to the increasing experience of loneliness through weakening health and functional capacity (Holmén et al. 1992; Mullins and Elston 1996). Also, decline in cognitive capacity, low income, infrequent social relationships and diminishing participation in networks, as well as infertility, depression and anxiety are all related to the experience of loneliness (Lampinen 2004).

Depression amongst older people is unfortunately often a consequence of isolation. It can sometimes even lead to suicidal thoughts, and thus be the main reason for the decision for institutionalised care. There are different ways to prevent depression; physical exercise and social relationships are some. Studies show that physical activity strengthens the essential components of a mentally healthy human being (Korhonen 1999). These components include self-confidence, self-appreciation and self-assertion. It is also known that loneliness can have physiological consequences. Loneliness is a stress factor, which in turn has links with many aspects of our bodily health. Blood pressure, sleep problems, adrenocortical activity, diminished immunity, white blood cell count, cardiovascular disease, obesity, and cholesterol are examples of the physiological problems associated with loneliness. Even cognitive decline and Alzheimer's disease are a part of the problematic consequences. It is thus evident that loneliness can be serious and problematic for a human being, and interventions are needed to decrease the feeling of loneliness.

Foundations of intervention practices for loneliness

After studying the properties of the chosen situation in life, we can start designing concept ideas and technological solutions to improve the quality of life in this context. Loneliness is not a simple phenomenon, as it may have many different causes. Due to this, it is essential first to consider different types of interventions that are required. Thus, in the following, we discuss the foundations of intervention practices for loneliness, and explicate design-relevant problems.

Typical intervention procedures in cases of loneliness have been socially activating in nature. Naturally, the intervention practices must target not only *social* but also *individual factors* inherent in loneliness. Both are commonly eliminated by means of interaction, peer or treatment groups. In groups, social learning can undermine the underlying factors of loneliness. People experiencing loneliness can directly get in contact with other people and make friends; they can learn to cope with their emotions and communication practices. They can also learn social skills and improve their social cognition (Cattan et al. 2005).

More concretely, these groups can facilitate social skills training, caregiver support, education and self-help education. They also give social support. They can work against negative feelings experienced during social encounters and help people experiencing loneliness build their social self-confidence and break social isolation. An important theme is also that of correcting maladaptive social cognition.

Recently, *contextual factors* in relation to loneliness have been receiving more attention in scientific studies. The results indicate that the amount of participation in social networks and their positivity is lower among people experiencing loneliness (Stokes 1985). An especially important part of a social network is a spouse or a partner. It has also been noticed that people experiencing loneliness are often linked with others who are experiencing the same. It is more difficult in these cases to break out of loneliness if no additional intervention means are used.

Negative interaction models are typical to people experiencing loneliness, as they often communicate negatively and thus raise negative feelings in their environment (Masi et al. 2010).

A relatively obvious contextual factor of loneliness is the *geographic distance* from relatives and friends. This kind of social isolation is a major property of loneliness. Therefore, one of the main strategies of intervention must be based on breaking the vicious circle of social isolation. Very often people are isolated as a consequence of their inability to get out and form social contacts, and in turn the isolation decreases their capacity in this respect. They may lose their social skills and thus be unable to form social relationships. Consequently, they will be trapped into loneliness. Social media now offers many possibilities to improve socialising with people who live geographically far apart. With the help of fast Internet connections, it is possible to keep up contacts with other people even between different continents. In this way, the issue of distance has become a technical matter. More challenging cases of loneliness are those in which people cannot organize any possible solutions to their problems of loneliness due to psychological or contextual reasons.

The properties of loneliness introduced above can be used in building intervention practices. Thus enhancing social relations becomes a significant challenge for designers who are interested in preventing loneliness by means of LBD. In the following, possible models of technological solutions for decreasing loneliness are introduced.

From situation in life to concept design

Life-based design stresses the importance of enhancing people's quality of life through understanding the cultural, social and psychological facts and values that explain people’s actions during a life stage (Leikas 2009). Loneliness has its roots in social and psychological factors. Consequently, avoiding loneliness is a social and psychological precondition for a good life.

In literature, there are observations which suggest that people experiencing loneliness actively use the Internet. This suggests that these might be people who could benefit from technological systems developed to decrease the feeling of loneliness (Stepanikova, Nie and He 2010). However, there is no definite positive relationship between the feeling of loneliness and, e.g., usage of social media (Prezza, Pacilli and Dinelli 2004).

The pivots in loneliness are social relations. Therefore, it is logical to think that social media might provide a proper technological context to develop services for intervention into lonelness. Social media refers to a group of mainly web 2.0 based Internet services, which allow users to provide content. Some of these are suitable for building genuine social relationships and some are much less so. Despite many anti-technology arguments throughout the mass media, communication technology and social media do not have to restrict or replace other forms of social contact. Quite the contrary, these technologies should be seen as tools to facilitate them.

As has been evidenced in the Facebook phenomenon, a vast majority of users appreciate the way they are able to re-connect with old acquaintances, friends and family with the help of social media. This would seem to be of benefit to older people, too. Being able to expand connections to reach those whom you once knew, or even making new friends with similar interests and experiences, should work to decrease the feeling of loneliness. Of course, one of the main obstacles for older people using social media as a tool for gaining and finding social contacts is not just whether or not they can use the technology but also whether or not their friends and peers are present in cyberspace.

Prevention of loneliness presupposes face-to-face contact, although genuinely interactive kinds of social media can form the basis for the prevention of loneliness. In this context, the interactive web refers to interaction among human beings. Not all types of social media and all types of Internet uses are suitable for creating social contacts. There are many non-personal social media

services such as wiki blogs which are not interactive. These are not the most suited media for preventing loneliness. Instead, they are able to provide entertainment or infotainment.

One can also use social media in ways which are less purposeful. It is easy to hide oneself behind avatars instead of using the net to meet people in real life. Entertainment and simulated human relationships can reduce the sensations of loneliness, but they cannot replace genuine human face-to-face contact to prevent loneliness. This means that, generally speaking, web-phone, phone, chat-roulette, messenger and Facebook, might in principle, provide good tools for building relationships and finding people. However, they are not designed directly for these goals. The problem on a general level is that these services are not directly targeted to people experiencing loneliness and, therefore, they do not necessarily offer means to resolve difficulties people have with respect to their negative strategies and emotional patterns.

Possible models of technological solutions

In concept design, we innovate technical solutions to solve problems or to improve possibilities in a defined situation in life. This means that we define people's actions that can be supported with a technology and the role of technology in achieving action goals. Here, the solution ideation is based on the idea of a service for lonely people. This means that anyone willing to look for help via the Internet could log into the service that provides all the major intervention aids for eliminating loneliness. The solution relates to what kinds of activities the service should provide to people experiencing loneliness. This is a central design problem. Therefore, we make some suggestions, which seek to explicate the process of designing a concept of service with different subservices.

The following subservices can be seen as logical steps in concept design:

1. *Discourses;*

   a) Everyday chat - an easy way to build trust between people and to approach other people.

   b) Hobbies - another important type of relatively neutral way to approach other people with similar interests.

   c) Thoughtful consideration - earnest chats to deepen relationships.

2. *Sharing;*

   a) Memoirs - memoirs and the possibility to find people with similar backgrounds, can be used in the search for friends.

   b) Photographs –an easy way to communicate with people.

3. *Tutorials (brief videos on communication, feelings and social habits);*

   a) Tutorials – brief pieces of information presenting typical problems associated with loneliness and coping with communication and emotional models.

   b) Social discourse practices – can be helped by presentations.

4. *Events;*

   a) Information about where one can meet other people.

5. *Friend finder;*

   a) A service to contact other people via definable criteria.

The main design goal here is that the contents of the service are directly targeted towards older lonely people. This means that people who identify themselves in this group can immediately be included in and interact with the service. From this holistic service they can find what they desire, including other people with similar needs, just by logging into the service. Thus, one could say that this type of a service is in fact a special interest service for lonely people.

Older people as users of technology

According to the LBD paradigm, the main concern in design is to understand *what the possible technological item is used for* (Saariluoma & Leikas 2011). This is related to how people use technologies in their lives and the kinds of action goals they have when they use a specific technology. Another basic issue is to ensure that people *can use* the technology in question. This forms the problem of usability. At the conceptual design phase, it is important to discuss how people will use the product or service and what kinds of realistic possibilities they have for this. In addition, the intended users have to be considered in terms of their skills, willingness and facilities to use the technology being designed. This means that we have to have a good idea about what kinds of technologies older people have learned to use. This knowledge makes it easier for us to think about the criteria for user interface design.

Technology generations

Mental models of older people often reflect the historical timing of computing innovations and their diffusion into productive and cultural spheres, linked with the time period in which a cohort comes of age (McMullin et al. 2007). In designing for older people, research into technology generations can be of real benefit as it brings to the fore the kinds of mental models involved in the direct usability thinking of different age groups (Leikas 2009).

Sackmann and Weymann (1994) introduce four generations based on the experience of technology usage available in the formative period. These are the pre-technical generation, household revolution generation, advanced household technology generation, and computer generation. Studies have also outlined different technological eras (Lim 2010) generally divided into the ‘mechanical’ (M) era (people born before 1930), the ‘electro-mechanical’ (EM) era (people born 1930 – 1960), and the ‘digital-software’ (DS) era (people born after 1960). Lewis, Langdon and Clackson (2007) have similarly categorized the time era during which one was born and the interface technology. Their categories are the electro-mechanical era (pre-1928), followed by the remote control era (1928-1964), then the dominated by displays era (1964-1990), and finally the era where, post-1990, layered menu systems are generally prevalent and popular.

Three major interaction styles of consumer products have been identified by Docampo Rama (2001). These are the mechanical style (1930/1940), the electro-mechanical style (available 1930-1980), the display style (available 1980-1990), and the menu style (implemented 1990 ->). Docampo Rama (2001) introduces three technology generations, which are the electro-mechanical generation (those born before 1960), the display generation (those born 1960-1970), and the menu generation (those born after 1970). McMullin, Duerden Comeau and Jovic (2007) have studied the phenomenon from an ICT technology point of view and have discovered five technology generations. These are the pre-ATARI generation (those born prior to 1955), who came of age before computing technology had widespread cultural appeal or was widely used; the ATARI generation (those born 1955-1963) among whom the ATARI home video games became popular and in whose workplace the first PCs were introduced; the console generation (those born 1964-1973) who used the Commodore64, TRS-80, Tetris, Apple MacIntosh and Windows 3.0 and who had great opportunities to use the new computer technology at home; the Windows generation (those born 1974-1978) who used Microsoft, Windows 97/98, Excel, Adobe pdf, Email, SimCity, Doom and witnessed the launch of the Internet in the mid-1990s, although it was not immediately or widely embraced during this period; and finally the Internet generation (those born after 1978) who are familiar with the Internet, Yahoo, Google, Instant Messaging (MSN), Windows XP and iPods.

Usability and user experience

Usage of ICT technology is concentrated around a triangle which consists of the hand, eye and ear. Common examples of these devices are keyboards, mouse pointers, mobile phones, remote controls, card readers, digital displays of many household machines and the touch screens of different automated machines. In order to cope with the technologies in our everyday life we need to have relevant capacity at least in our hands, fingers and eyes. Unfortunately these are the very body parts that will eventually be affected by ageing and many will experience a decline in their capacity. Modern technology brings forth difficulties for older adults for two reasons (Leikas 2009). Firstly, design is not consistent with the experience that older people have gained from technology during earlier periods in their lives, i.e., it does not reflect the experiences of earlier technology generations.

The looks of the devices may be strange and the operational logics unfamiliar. User interfaces are incomprehensible, as they do not seem to have any relation to the life that the person has lived nor the experiences that he/she has earlier gained with tools and equipment. Secondly, the changes in people's physical and cognitive condition brings about many problems in using ICT appliances (Gill 2004). For example, hearing, vision and mobility impairments may arise in parallel, and combinations in these make it difficult to use ICT products and services. Decline in motor functions of the hand can make holding a handset difficult and keypad or touch screen operation slow and inaccurate. For users of a wheelchair or a walking stick, access to machines and devices can be difficult.

However, difficulties in using a technology do not always arise just from poor usability but also from many other factors, such as previous experiences in the usage of that technology. This is connected to the importance of consistency in operational logics of user interfaces. Thus the way of using devices and applications should be familiar and somehow congruent with earlier experiences. For many older adults with declining cognitive abilities and vision, consistency in the user interface is one important aspect of usability. The feeling of self-efficacy arises from the experience of competence, i.e., from the feeling that one is able to use a system or device. In older people's lives, self-efficacy is an essential factor of coping.

If we wish to eliminate the difficulties encountered with usability, it is essential to find usability metaphors which remind the user of past technologies, such as the use of the traditional ringtone as an option in modern mobile phones. It is also important to eliminate any unnecessary steps in accessing a service, and it is essential to consider the difficulties of usage caused by age-related decline in vision, hearing and dexterity. The main thing is to maintain familiarity with the kinds of interfaces the target people have used over the years.

Elimination of unnecessary steps in accessing the service can be achieved by icons with familiar metaphors for older people and accompanied by clearly readable texts. There must be direct icon based navigation, in which all conceptual themes, such as touch screens and other modern UI models, regardless of the age of the user, are considered.

Life-based design procedure for service design

The aim of this paper is to describe a model for the LBD procedure for a certain service based on a specific fact describing human life. This fact has been referred to as a situation in life, which means a stable contextual and psychological state in life. It is the kind of life fact which can be taken as a pivot problem for design thinking. In our example, the subject has been loneliness among older people.

First, we identified the situation in life as well as the form of life with which it is associated. After that we analyzed the main human properties of a particular situation in life. We then identified social isolation and the reasons for this isolation. We separated the cases where the cause for isolation is social and individual factors from those where the cause is contextual. Next, technical means for avoiding or at least decreasing these problems have to be sought. Finally, a usage

culture for this type of technology among people who require it has to be created. This means that we have to solve the usability problems as well as inform people about the existence of the technology and create a need to use it. If any of these points in the road map remains unsolved, the attempt will fail.

The following steps summarize our procedure for service design to decrease the feeling of loneliness amongst older people:

1. *Identify the pivot problem*

   Loneliness among ageing people

2. *Analyse its human dimensions*

   Mental and conceptual properties of loneliness found in large psychological studies

3. *Conceptualize the technical solution models*

   A service for loneliness

4. *Harmonize the model with the human and contextual information*

   What kinds of sub-services are required?

5. *Analyse possible usability problems*

   Usability metaphors and simplified procedures

   Icons and interaction language

Discussion

Technology for older adults should not be targeted only at the design of technical aids for compensating the decline in functional capacity. It should be applied to support the strengths of older people and to facilitate their participation in society. The knowhow gained during the course of aging is a remarkable asset, which should be utilised in society in different ways. Older people have tacit knowledge of life, which is meaningful and beneficial for the whole community. This is why technological solutions should be facilitating the usage of this knowledge for the common good and increasing the role of and participation opportunities for older adults as members of society.

People should be adequately prepared for the technological change in the information society. The change should thus be carried out in terms of people, based on the life world and positive experiences they have of technology. These experiences form the true value that technology brings to the lives of people, and can be discovered only by focusing on people's lives and the values that people follow in them. If this principle is accepted, the information society will proceed in a meaningful manner.

The issue of replacing social relationships with technology has many times been brought up in discussions about older adults and technology. This is of course, possible in cases where the already limited contacts of a lonely person are replaced by, for example, new solutions utilizing ubiquitous computing and ambient intelligence. However, technology should be seen also as a facilitator for social networks. It cannot remove isolation, but it can remove the feeling of loneliness by creating social networking possibilities for people who are not able to leave their home due to a motor disability. This is why each case should be examined from the point of view of individual needs in relation to opportunities provided by technology.

The core idea of Life-Based Design is that the knowledge about the structure of the forms of life can be used when designing technologies such as ICT-services to improve the quality of life. In this way, we call attention to the fact that designing for life is focused on new possibilities instead of merely solving problems. Technology will ultimately change the structures of the society and daily lives of people in a profound way. What kinds of expressions the society will have depends significantly on the design approaches for ICT society. Promoting social relationships, preventing loneliness and facilitating meaningful roles for older people are all challenges for technology design. Life-Based Design is one potentially useful approach for meeting the human demands of the information society.

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VI

DESIGNING DIGITAL WELL-BEING OF SENIOR CITIZENS

by

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Designing Digital Well-being of Senior Citizens

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***Abstract*—In this paper, we illustrate a concrete case to apply the Life-Based Design approach to identifying human goals for technology to achieve. We focus on a form-of-life method of design, which seeks to reach a mental state of "digital well-being." Digital well-being aims to facilitate digitalization and changes in the digital environment, and to maximize the availability and accessibility of services. We evaluate the target group of senior citizens, who are facing an accelerating pace of digitalization of the services in their daily lives. This increases their sense of anxiety and undermines their well-being.**

Keywords—Life-based design, digital services, service design, digital well-being, ageing

I. Introduction

Technology design is becoming increasingly multidimensional. In the 1960s, the idea of using psychology to improve computer use or people as models of intelligent programs was in its earliest stages. Today designers can integrate all kinds of knowledge, ranging from nanotechnology to sociology, to construct working products—i.e. those that people can adopt and apply to their daily lives [1,2,3].

All too often, people have to try to use non-intuitive information systems. Information systems are frequently considered ready when they are technically *operational*, but still cause major worries to end users—or are incomprehensible to them. These systems may lack the necessary knowledge or be unable to use the knowledge they should use. In any case they do not work properly or do not meet the needs of users, despite their high price tags.

Digitalization is a social process, which makes it complicated to design. Communal software for public digital services is often acquired by people who are unfamiliar with the complexity of the requirements. Even full-time professionals may find it difficult to keep up to date in this field. Thus it is hard to develop rational design processes for communal software. For various technical reasons, some systems which are designed for a particular purpose may be hard—or impossible—to adapt to other practical uses. Finally, these problems highlight the need to integrate all necessary expertise into a rational design system instead of battling with systems that are outdated when adapted to practical applications.

The average age throughout the world is increasing due to improvements in health care. This rise in life expectancies is a positive development, but it also leads to problems that should be solved using information technology and emerging technologies, such as artificial intelligence (AI). The rational adoption of intelligent technologies calls for a multidisciplinary approach to managing complex systems with various kinds of expertise.

In this paper, we investigate how such expertise should be used to develop new types of digital systems in the field of gerontechnology. Gerontechnology concerns technology that directly impacts the daily lives of people aged 65 or over [4]. Our goal is to define the main user-related design problems and the kinds of expertise required to create communal information systems for older people.

II. Digitalization and the use of Internet by the elderly

The population of elderly people in Europe will almost double from 87.5 million in 2010 to 152.6 million in 2060. The share of those aged 80 and over is expected to rise from 5% to 12% during this period [5]. In countries with the highest percentage of elderly people, Internet adoption in the 65–74 age group ranges from 4–61% [6].

In Europe, the traditional multi-generational family structure has changed [5] and the elderly people are increasingly living alone or as couples without help from the younger generation to access new technologies and digital services. The public sector aims to improve access to digitalized services through legislation and support for digitization projects through various forms of grants. Digitization has led to an increase in the number of services available, the speed of transactions and location-independent operations. Yet during this rapid technology change, the needs of special groups have not been adequately addressed before services are brought into production. Many older people lack the necessary equipment and ability to use modern technology and digital services. Data protection legislation restricts the development of seamless digital services. Many digital services require strong authentication procedures, which is an overwhelming task for many older people.

Finland's society is strongly based on information and its utilization, and digital services are considered the fastest and easiest way for citizens to interact with the authorities. When the use of digital services becomes more widespread, public service provision becomes more efficient, which helps to conserve public resources.

More than 500,000 of Finland's population over the age of 55 does not use the Internet or digital services [7]. One-fourth of Finnish people over 65 (242,000) have never used the Internet. Most of them have challenges using digital devices such as computers or smart phones [8]. A study by the Finnish Institute for Health and Welfare shows that there is a great

discrepancy between age groups. An estimated 78% of men and 81% of women aged 55–74 use the Internet for e-services, but only 48% of men and 38% of women over 75 do so [9].

III. DIGITAL WELL-BEING AS A FORM OF LIFE

Most studies on human–technology interaction are focused on how efficient such systems are. The Life-Based Design (LBD) approach to design thinking, however, starts by considering human beings and their life conditions. The main tenet of LBD is that the purpose of technology and services is to improve the quality of life [2]. LBD aims to seek explanations of the "why's" and "what for's" related to technology use on human research grounds. According to LBD, this information (produced in a form-of-life analysis) should guide the entire design process. Form-of-life analyses of a specific user group should generate the human requirements that define how a product or service will improve a particular aspect of people's lives. The human requirements are based on the methods and results of human life sciences and create the basis for the design by introducing the design theme and the requirements for achieving the design goal—i.e., the technology's impact on the lives of the target users. This article evaluates digital well-being as a form of life and human requirements for digital services for the elderly. The human requirements pave the way for technological concepts, which define design goals for the specific form of life.

According to the LBD approach, exploring the nature of the form of life of older people is necessary in order to understand how technology can be harnessed to help them achieve the emotional state of "digital well-being." The goal of form-of-life analysis is thus to help define a design problem by contextualizing and identifying the problem area and its human elements.

The human requirements for digital well-being originate from two primary concepts: the digital divide and requirements for inclusive design [10,11,12,13]. The *digital divide* is caused by the failure of technology development to sufficiently consider democratic accessibility and the adoption of products and services. For example, the digital divide for senior citizens can be caused by an inability to use the services due to a lack of knowledge, education and training, and even a reluctance to acquire and try new technologies [14]. Digital services should thus be designed to meet seniors' needs at the service concept design stage.

Many seniors may be unable to access (or are uninformed about) the services offered through technology, as commonly used types of interactions may be beyond their competence. Difficulties in accessing new technologies and services due to a decline in vision and hearing can exclude many from benefiting from their advantages in several aspects of life. Others may be unable to understand the logic involved in operating new technological solutions. Some seniors are reluctant to invest the necessary time and effort to learn to use new solutions, especially if they have had bad experiences using other products or services. Such experiences can cause anxiety in the midst of ever-increasing digitalization in seniors' everyday lives.

The concept of *inclusive design* [13] recognizes age and disability as part of the normal life course, and offers a rationale for design that is more closely aligned with contemporary social expectations. According to this approach, design should move away from specialist solutions and assistive devices towards increasing accessibility and inclusivity in mainstream design.

The remainder of the paper analyses the properties of digital well-being and the need to create human requirements for concept design. It then considers a more concrete analysis of the role of technology in fulfilling the human requirements associated with digital well-being.

A. Human requirements for digital well-being

Kaijanen and Stenberg (2018) [8] suggest four recommendations to enhance inclusion in today's digital society. First, old people need to be included in service development. The focus should be on easy-to-use devices, the reliability of digital services, and technology usage that does not depend on user ability. Second, professional low-cost advice should be offered when choosing, buying, or using technological and digital services. Third, digital services should be free of charge (public) or at least low cost. Fourth, service accessibility needs to be promoted and the possibility of face-to-face communication kept as an option. Finland's Ministry of Finance has likewise stated that public digital services must be functional, easy to use and safe [15].

Leikas [14] proposes four main ethical requirements for services for older people—self-efficacy, privacy, trust, and autonomy. *Self-efficacy* refers to an individual's ability to achieve a desired outcome; it influences their choice of activities as well as their maintenance [16]. Self-efficacy is particularly important when a task requires specific knowledge and skills, because it is necessary for people to have—and to believe to have—knowledge of how to achieve a desired outcome [17]. The feeling of self-efficacy in using technology is influenced by the complexity and versatility of the technology and the support offered by social networks (family members, service providers, technical support of the workplace, etc.).

In order to efficiently serve older citizens, applications and systems increasingly collect private information about them. Older people must be able to *trust* that this private data in different systems and services is protected, and that no one can misuse this information (such as a personal code or account information). User control is an essential factor when designing trust [18]. The user should be able to trust that the system or device functions as it should and remains in full operational order. When consciously adopting a technology, a person should also be able to trust that they can decide whether to operate the system/device or not and, for example, to turn it off whenever they wish [14].

Assuring the user's *privacy* requires considering the following issues [14]:

- Only very essential information about the user should be gathered.
- The user should be able to easily verify this information.
- The user should be aware of the span of the personal information stored, and this span should be abided by.
- The information gathered for a specific purpose cannot be used for another purpose without the user's permission.

- All information gathered during the usage of a service should be considered private (except where a serious crime is suspected).
- The user should be informed about the content of the data gathered during the usage of a service, and for what purpose and how this data is exploited.
- The user should be able to easily cancel their permission to gather and use personal information.

Autonomy is the perceived ability to control, cope with and make personal decisions about how one lives on a day-to-day basis, according to one's own rules and preferences [19]. It is a basic element of human rights that should be seriously taken into account when designing technology for older people [14].

B. From human requirements to concept design

Digital well-being should also be examined from the point of view of innovation: Is it possible to create a solution that would prevent the further loss of well-being of senior citizens as users of technology? In other words, would it be possible to create technology to eliminate the negative impacts of digitalization? If technical developments cause—directly or indirectly—a digital divide, underuse of technology or "technostress" [20], it is fair to ask whether modern technology can be used to counteract these affects in order to achieve digital well-being. This paper uses the LBD approach to explore novel ways to reach a state of well-being supported by technology.

Technology can enhance the well-being of older people in many ways [21]. It should also be able to contribute to human–technology interaction in a way that enables digital well-being when needed, regardless of the time and place. Hence, the digital well-being of older people should be studied as a combination of technology impacts and approaches to human–technology interaction, taking three factors into account:

- actions, i.e. the desired states of digital well-being,
- user interface paradigms, and
- background technologies.

Accordingly, the following design requirements should be considered:

- Digital services should be accessible to all users, regardless of their abilities. Older people with poor manual dexterity and declining vision and cognitive capacity can find accessing services with small control devices very difficult.
- All user groups should be considered when implementing new services.
- Fading technology behind the user interface should be invisible to the user.
- The personal interface level should be customized to suit each user's profile.

After understanding the human requirements for the digital well-being of older people, designers must make assumptions and decisions about which technologies are most compatible with the human requirements and can be used to help people reach the state of digital well-being. While there are various ways to design digital well-being, some of which are culture dependent, there are common technological elements. These common elements are studied below as examples of services and applications with emerging technologies that can help achieve digital well-being.

IV. THE PROBLEM OF DIGITAL IDENTIFICATION

In Finland, a minimum of Web Content Accessibility Guidelines (WCAG) level of AA is typically required for the availability of public web services. WCAG recommendations are focused on making Internet content accessible to a wider range of people with disabilities, but they do not take into account the special needs of older people [22]. The public sector has hundreds of information systems, and there is no common service interface. Independent service digitization solutions lead to the fragmentation of services and numerous stand-alone technical solutions [23].

In Finland, user authentication is a critical issue in accessibility, which is strictly controlled by law. Many digital services require strong authentication, which can be an overwhelming task for older people that prevents them from using such services.

Finland's Population Register Center maintains the free *Suomi.fi* identification service. Each citizen's electronic identity is linked to their personal data in the Finnish Population Register System [25]. In 2018, there were 81.7 million identification cases in the public administration system. The center conducted a study in 2019 [24] to identify an operational model that would make electronic identification for public administration services available to the entire population without discriminating against anyone regardless of their age or physical restrictions. It proposed developing a national identity wallet that can be accompanied, in addition to verification, by various licences such as driving licence information.

Other countries have developed their own systems for managing electronic identities such as Myinfo in Singapore [26], Smart-ID in Estonia [27] and BankID in Sweden [28]. However, such systems require users to have the necessary equipment and ability to utilize authentication in digital services.

A new social and health care information system called Apotti [29] has recently been launched in Helsinki region. Apotti's patient and client portal, Maisa, allows patients and clients to digitally manage services, appointments and information, and to communicate with health care and social care professionals. Signing up for the Maisa portal requires strong authentication via a smart device such as a smartphone. Seniors can authorize someone else to act on their behalf in Maisa [30].

Another public service that is relevant to the elderly is Kanta, which provides digital services from social and health services agencies, such as prescription renewals and viewing their own patient information. Strong authentication is required to log into this service, and an individual can authorize another person to act on her behalf [31].

V. TECHNICAL SOLUTIONS

Digital services require a smartphone, tablet or computer, which represents a challenge for older people who have experienced a decline in physical or cognitive functioning. A possible solution for expanding senior citizens' access to

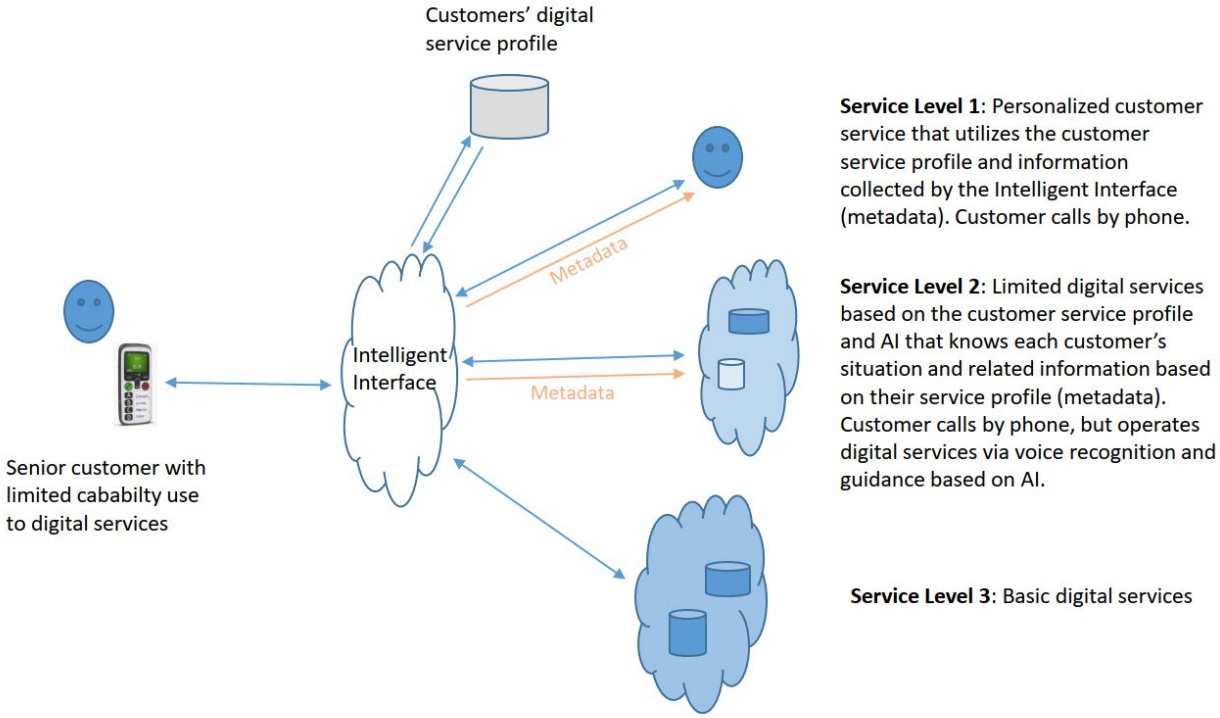

Fig. 1. Intelligent interface with customer-specific digital services

The proposed intelligent interface would identify the customer's cognitive and physical abilities to interact with digital services. The interface would then choose the appropriate form of service based on customer needs and select the needed services that best suit the customer. This selection would be performed without the customer having to actively make any choices. A digital service can have different levels of service:

- Service Level 1: The customer calls by phone to receive personalized services based on their profile and information collected by the intelligent interface.
- Service Level 2: The customer calls by phone and receives service via voice recognition and AI.
- Service Level 3: The customer receives digital service adjusted to the customer service profile level.

In the intelligent interface, the customer can be identified, for example, based on their identity wallet. Each user is provided with an identification code and associated service profile that allows them to adjust the level of digital services to fit their needs. Individual service profiles should be defined based on the LBD approach described above. For digital service providers, an intelligent interface and personalized service profile provide an opportunity to address the specific needs of older people in service design. The service profile can be located in the cloud or be stand-alone metadata on the customer's smart device, allowing the intelligent interface to provide the necessary level of digital services based on attributes related to the user's needs (residence, services used in the past, age, cognitive level, date and time, etc.). The interface can deliver customer-related metadata that can be utilized in customer service design or digital services built with AI components. Each customer's digital service profile information is updated at each service event, allowing service providers to adjust services in real time.

VI. DISCUSSION

Ensuring older people's digital well-being requires placing their everyday lives at the centre of the design process and taking it as a starting point for technology design. This makes knowledge of human sciences important in the design process. Designers need to understand the forms of life in which older people live and act, and the three basic elements of forms of life—biological, psychological and cultural.

This article presents a possible technical solution for a service architecture that enables unrestricted access to digital services for older people. This architecture allows elderly people to automatically access the service, hides the authentication process and, if necessary, redirects them to a personalized telephone service or simplified digital service view. Data protection will play a key role in designing solutions that can bypass the existing strong technical authentication systems and enable the use of digital services by the elderly.

It is important to consider how to ensure that an intelligent interface prevents user errors in the use of the services—i.e. to make sure the user understands what he or she is doing and the resulting effects. The proposed service interface also enables the further development of digital services by taking into account different levels of user needs: the view of the digital service provided is tailored to each user. A personalized telephone service benefits from an intelligent

user interface that can automatically transmit disease information related to a service event and streamline the service process.

The development of new digital services must take into account the needs of specific groups such as senior citizens during the early design stage. This poses a major challenge for developing digital services, but enables the elderly to live as independently as possible, and thus brings savings to society. The article outlines the design requirements that should be considered when developing digital services for senior citizens: 1) Digital services should be accessible to all users, regardless of their cognitive abilities. 2) All user groups should be considered when implementing new services. 3) Fading technology behind the user interface should be invisible to the user. 4) A personal interface level should be customized to suit each user profile. These requirements also serve the needs of other special groups.

We are currently at the forefront of AI development. This article presents an architectural model for an intelligent digital interface to bring existing digital services to the end user, but this model is only a stand-alone entity and does not consider the whole. Future services will feature multiple levels of AI components that optimize the relationship between users' needs and the service provided. Identifying user needs, even those that the user does not know exist, is used to trigger service development across layers of a dynamic service pool.

The main goal of design is to improve the quality of life. This is possible only if the concept is understood on all required levels. The designed applications must make sense in everyday situations and support the form of life of the users. As these everyday contexts are linked to psycho-social rather than technological questions, it is essential to outline the ways in which communication operates in the design processes of modern IT systems.

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