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Semantic Infrastructure for Service Environment Supporting Successful Aging

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Abstract

Demographic changes and the rapid increase of aging people are occurring throughout the world. There is a need for step-by-step developing service environment to support elderly living as old as possible at home. Digital equipment and technology solutions installed at home produce real-time data which can be used for predictive and optimized service creation. New technology solutions have to be tested at home environments to get certainty of usability, flexibility, and accessibility. The implementation of new digitalization has to happen according to ethical rules taking into account the values of elderly people. The data gathered through digital equipment is used in optimizing service processes. However, service process misses common ontology and semantic infrastructure to use the gathered data for service optimization. The service environment and semantic infrastructure, which could be used in social and health care, are introduced in this article.

Keywords: aging, home care, data mining, social and healthcare ontology, semantic infrastructure, ethics

1. Introduction

World society is facing demographic changes in aging population. Digitalization creates potentiality for service creation. The more frailty elderly are, the more services they need. Senior citizens living independently at their own homes need various kinds of services. All solution data and personal health data gathered from home environment create an opportunity for various types of services. Technology solutions have to be tested before they are accepted at home environments.

The municipal authorities, on the other hand, are closely paying attention to the data gathered and its usability for punctual service creation cost efficiency of the services. The new solutions and gadgets have to be also interesting and easy to use for senior citizens. There is lack of information in behavior research involving especially the oldest group of people.

Digitalization is rapidly increasing, and enterprises must find new ways to innovate for business advantage. Through digital transformation by using technologies, e.g., artificial intelligence, data mining, machine learning, and open data, it is possible to create new smart services or renew health pathway by lean operations. It is essential to manage the available open and gathered life cycle data as data to service process to produce value-added services to home environment for senior citizens.

Caring for elderly people need responsible business leadership and democratic innovation culture and co-innovation. This article introduces also some features of how ethical values are fulfilled when applying digitalization in caring older people at home by the methods of responsible business leadership. In order to sustain competitive advantage, health technology companies making products and solutions for the use of healthcare and well-being are expanding their product offering to service solutions over the product life cycle. Responsible leadership is understood as a social-relational and ethical phenomenon, which occurs in social processes of interaction communication.

Services are created to support the elderly and their families in maintaining a high-quality life at home. It shows that the Internet has had a positive impact on the health information acquired by seniors but not all seniors. There is lack of information behavior research involving especially the oldest group of people. The objectives of digitalization in home care environments are:

- To support and increase the autonomy of older people and independent coping at home
- Efficiency and effectiveness of nursing at health and well-being environments

Healthcare and well-being technology companies have started a project TELI in Finland to promote business opportunities in implementing digitalization into the healthcare and well-being solutions. Häme University of Applied Sciences is focusing on digitalisation of home care in this article. University has together with the municipal authorities established real-life piloting environments to enhance the adoption of the healthcare and well-being sector technology and digitalization in the way of using the data gathered in building semantic infrastructure to support service environment in creating integrated services for elderly customers.

The objective is to determine how the gathered data can be used in optimizing service processes, logistic routing, and focused use of medicine and medical equipment at home visits. However, there is missing generic data to service process, common ontology, and semantic architecture to use the gathered data for service optimization. Common ontology is essential as shared domain knowledge in services [1]. Communication and data transfer infrastructure in home care services require:

- Standardization of the formal semantics to enable data and service management on healthcare pathway

- Approaches to define real-world semantics linking social and healthcare process content with meaning for humans based on care terminology

Novel technology brings new opportunities for responsible business models. The transformation toward responsible business takes a long time, and that is why it is important to fully understand the strategic concept, identify the key issues, and harness the associated opportunities. Service environment and semantic infrastructure, which could be used in social and health care, are introduced in this article.

The concepts in this paper are valid also within European Innovation Partnership of Active and Healthy Aging (EIP AHA), where EIP AHA Task Forces focus on information and process modeling, upscaling, and business models [2].

2. Theoretical background

Key elements of the new service approach are the innovative solutions and revised health-care and social welfare legislative reform proposal. The reform aims also to promote cooperation between municipal officers, local universities, and digital equipment and service system suppliers.

Services are continuously being created in Europe to support the elderly and their families in maintaining a high-quality life at home [3]. The Internet has had a positive impact on the health information acquired by seniors but not all seniors [4]. There is lack of information behavior research involving especially the oldest group of people.

Digitalization of services and information management are no longer a question of if, but of when, and to what extent it will influence a specific well-being sector. It is no longer a negative reactionary tactic to moderate home care service environment but a positive proactive strategy to accelerate long-term service environment. It is not just about data and service management, but a social and healthcare-changing paradigm integrating innovation, differentiation, and transformation.

There is a new logic behind open innovation which embraces external ideas and knowledge in conjunction with internal R&D [5]. This offers a novel way of creating value. New value for the customer is created in the form of a product or service offering, and it results in life cycle innovation [6]. It is essential to know whether there is also a transition into a new business model of the well-being service. System thinking is the art of simplifying complexity [7]. It is about seeing through chaos, managing interdependency, and understanding choice. Concepts are important to explain chaos.

It is substantive to increase awareness of Industry 4.0 outside the group of industrial key stakeholders. There is lack of understanding on the importance of the need of implementing common Internet of technology, IoT, infrastructure on all stakeholders (large and small firms, healthcare authorities, and municipalities) [8]. The widespread adoption of information and communication technology (ICT) is increasingly accelerating the blurring of boundaries

between the real physical world and the virtual one. The linkage is becoming increasingly smart [9]. Presently Industry 4.0 is more industrial driven, but this will change and broaden out. Company democracy model [10] can be characterized as a multidisciplinary science, as it integrates many management (strategy, leadership, etc.), engineering (process knowledge, innovation), social (human resources, ethos, etc.), financial (marketing, extroversion, etc.), and other disciplines.

3. Research questions and research approach

The role of digitalization and growing amount of data collected from home and older person himself as a business driver is growing and has to be carefully taken into account in well-being business transition. The opportunities of digitalization have not been understood in full context and as new service innovation. The main research questions are:

- a. What does digitalization mean in home care of older persons and well-being service business context?
- b. How to cope with the dramatically growing amount of data increased through digitalization? How this data can be turned as generic data to be used in optimizing service process in value network operations?
- c. How the geriatric data and data mining are used in caring elderly people?
- d. How the semantic infrastructure should be used supporting service environment creation in social and health care for aging people living at home?
- e. How to cope with ethical values and loneliness when digitalization creates new opportunities for caring of older people at home?

This article introduces a concept model for utilizing digitalization as a business and innovation driver to facilitate the transition toward the new service economy and service environment on well-being business. This paper introduces preliminary results and experiences of the applied research project partially already executed.

4. Multidisciplinary and cooperative environment on home care

TELI-project promotes business opportunities in implementing digitalization into the healthcare and well-being solutions and services. Municipal officers have with the help of Häme University of Applied Sciences established real-life piloting environments for enhancing the adoption of the healthcare and well-being sector technology and digitalization. **Figure 1** introduces home care apartment with functions executed by digital assets, equipment, and services.

Figure 2 illustrates the roles and partners in home care piloting environments. In the center there is a customer, who is utilizing home care services. Red arrows describe equipment and

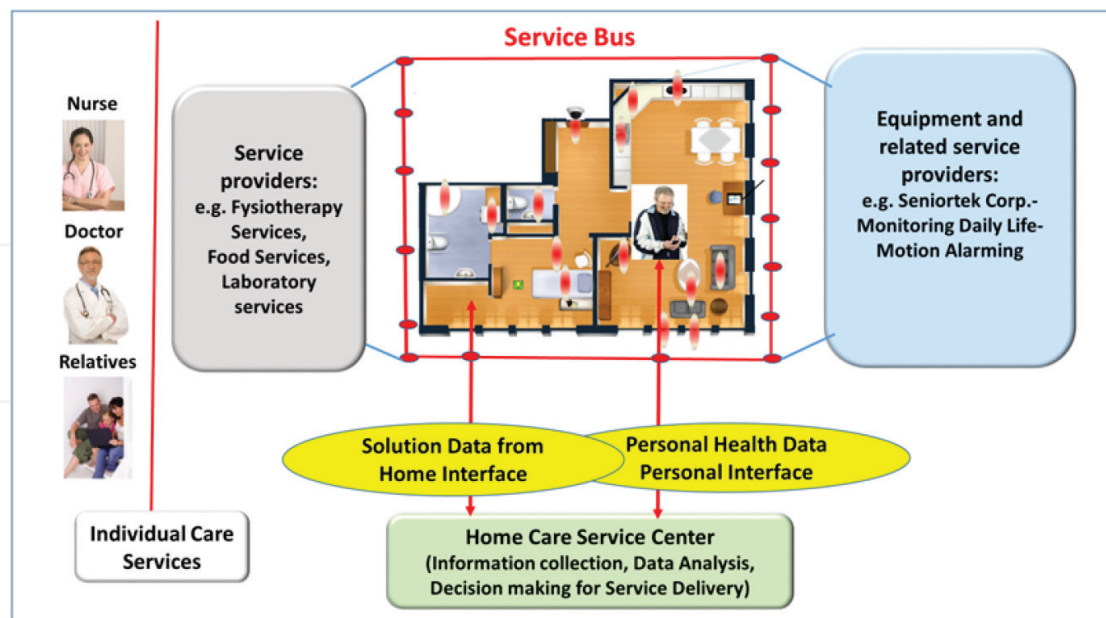


Figure 1. Elements of home care environment.

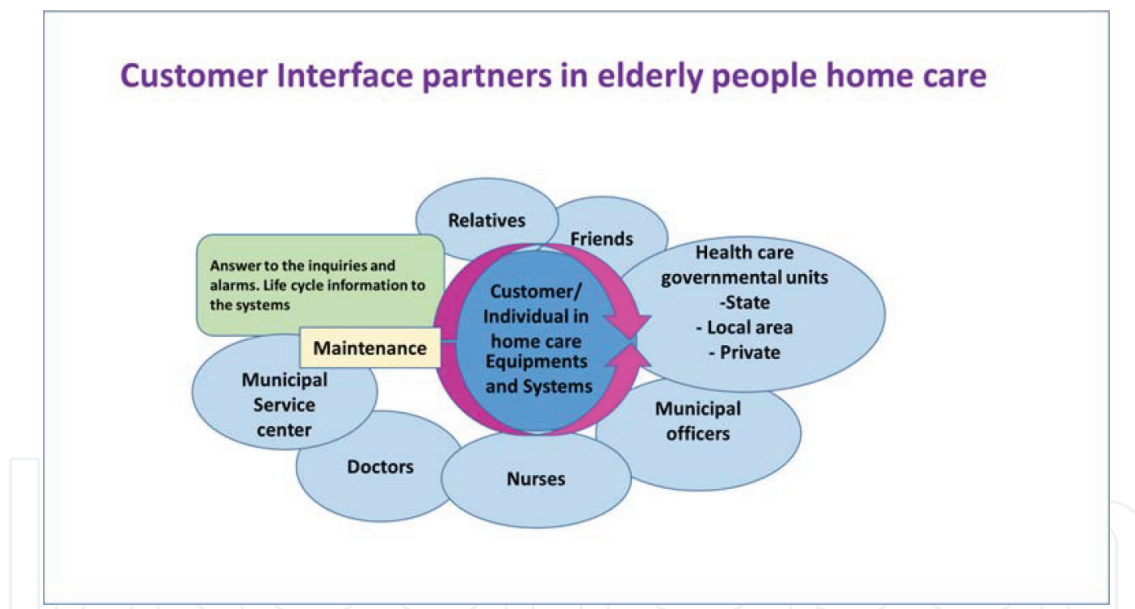


Figure 2. Conceptualized scheme of customer interface partners and systems in home care.

systems, which are involved in home care events. Equipment may be like medication dispenser, wireless smart flower stands monitoring customer daily life, like falling overs. Systems are patient databases; there is all relevant information about customer (basic information like age, gender, medication, etc.).

All relevant information is booked into the system, like changes in the medication, etc. Maintenance of systems and equipment should be provided. It will be absolutely important to arrange answer to inquiries and alarms, if the customer has been, e.g., fallen down or has not

been taking necessary medicine. Essential events have to be booked into the system, e.g., if medication has been changed. Persons to answer the alarms may be relatives, municipal service centers, nurses, or even friends. Municipal officer or healthcare units will decide how much support will be provided by the municipality or conjoint municipalities. Medical doctors will decide changes, e.g., medications and other actions in their fields.

Fourteen health and well-being equipment, system, and service companies participated in TELI-project and were partially funding it. New health and well-being solutions including wireless motion detecting, medication dispenser, and INR- and EKG-measuring equipment were piloted in real home environment.

User requirements were gathered from elderly people, nurses, and service people of home care center in municipal areas of Forssa and Hämeenlinna cities. The gathering of data and experiences was executed by students of Häme University of Applied Sciences by the help of researchers and teachers. They had opportunity to learn to use the digital equipment and use later the knowledge in education purposes. Elderly customers did learn not to be afraid of digital equipment. Their mindset became more open toward utilization of digital gadgets in their homes to increase safety. Municipal officers at home care service centers recognized the importance of data to be used in optimized service creation and predicting diseases and dangerous situation at home environment. It is possible to streamline service processes, route logistic, and improve the use of medicine and medical equipment at home visits. It is possible to achieve also savings in home care visits.

In **Figure 3** is described what type of possibilities wireless Senior Safety- system will give in home care. In this context smart flower stand is a gateway sensor equipment with individual ID address, which is collecting data from sensor network. Smart senior safety equipment is actually a system itself, which is connected semi-automatically to healthcare system.

When older persons are leaving the apartment at night (random walking), opening the fridge, having epilepsy or other seizures, having problems with circadian rhythm, and forgetting that

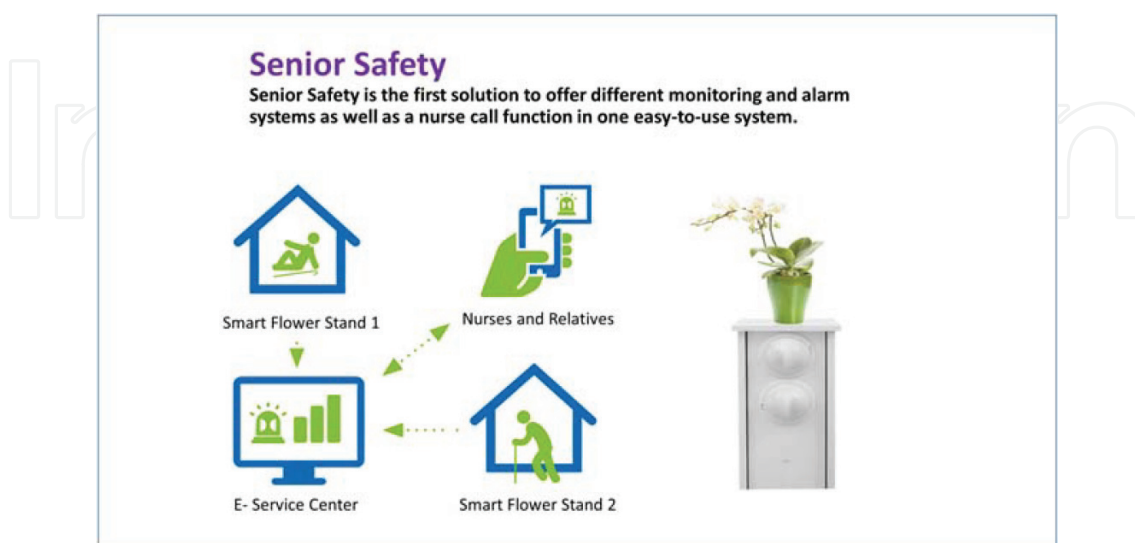


Figure 3. Wireless senior safety.

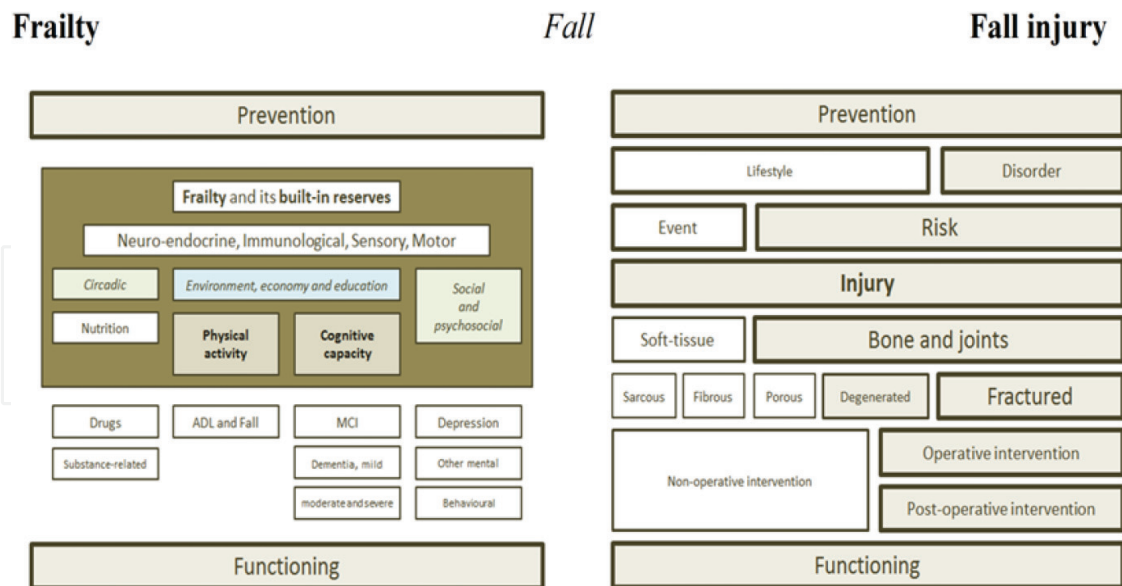


Figure 4. Orthopedic view of monitoring and assessment of geriatric data.

the stove is on, alarms can be controlled with mobile phone, optimized to summon the nearest nurse; functional abilities can be adjusted according to customer; and there is an external alarm option. All rooms of an apartment can be provided with motion sensors for different levels.

This then relates to monitoring and assessment of geriatric data [11] and can also be further specified, e.g., for fall risk assessment and assessment related to frailty (**Figure 4**).

The development of business environments is understood to be the responsibility of public sector and government. Public sector is however multilayered (e.g., legislative, national, provincial, regional, municipal, areal). There are many committees and operations, which have the duty to develop business environment.

The digitalization changes functions and operational processes of well-being and home care. Deployment of new functions and operational processes often needs new type of legislation which creates rules for the co-innovation and operations generated and new business opportunities (government). It is seen rather as enabler than restrictor. Industry 4.0 IoT and platform architecture are becoming the standard approach for all domain areas [12]. Planning of social and healthcare areas influences remarkably on settling and placing of enterprises and prerequisites for operation (e.g., nursing and logistics). Health care 4.0 (Industrial Internet, Industry 4.0) enables functional optimization of entire value network. Collected data from the whole value network can be used for purposes of functional development or predicting diseases. New entrepreneurship and new digital services can be created through digitalization activities.

5. Continuous development in social and health care

The cooperation between the government, enterprises, and universities is essential to succeed in coevolution when building up cumulative competence in creation of solutions for home care

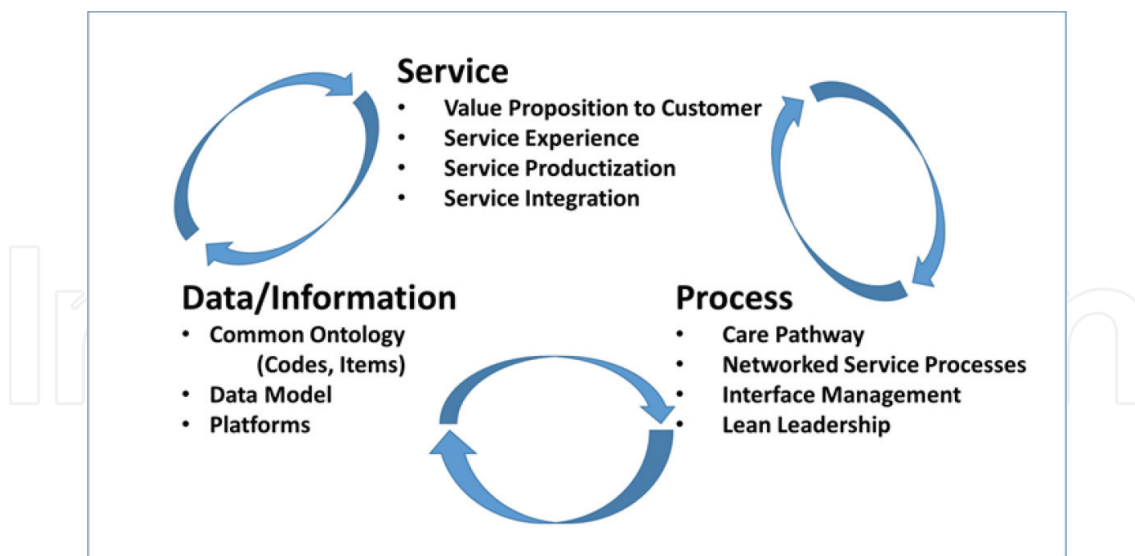


Figure 5. System model of continuous development in social and health care.

and older people. It is also essential to have a common vision to direct the local operation and funding. Otherwise the activities can splinter into small pieces and do not form parts of the whole vision.

Continuous development of service environment is highly dependent on linked process (care pathway), service, and data management development (**Figure 5**).

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On legislation, national legislation in the Nordic countries also develops in direction of regulating responsibilities related to injury prevention. In Finland, in the current law of the elderly people's social and health services (L:28.12.2012/980), municipalities have to promote the health and well-being of elderly people, also specifically as related to assuring safety (§14) and assessment of functioning with requirement of care services and levels (§15).

6. From data to service-process supporting business coevolution

The amount of scattered and structured data around us is increasing dramatically. It is a great opportunity to exploit that data for business purposes. Well-being and home care consist of huge amount of data, for example, the lifetime data from well-being of older persons and

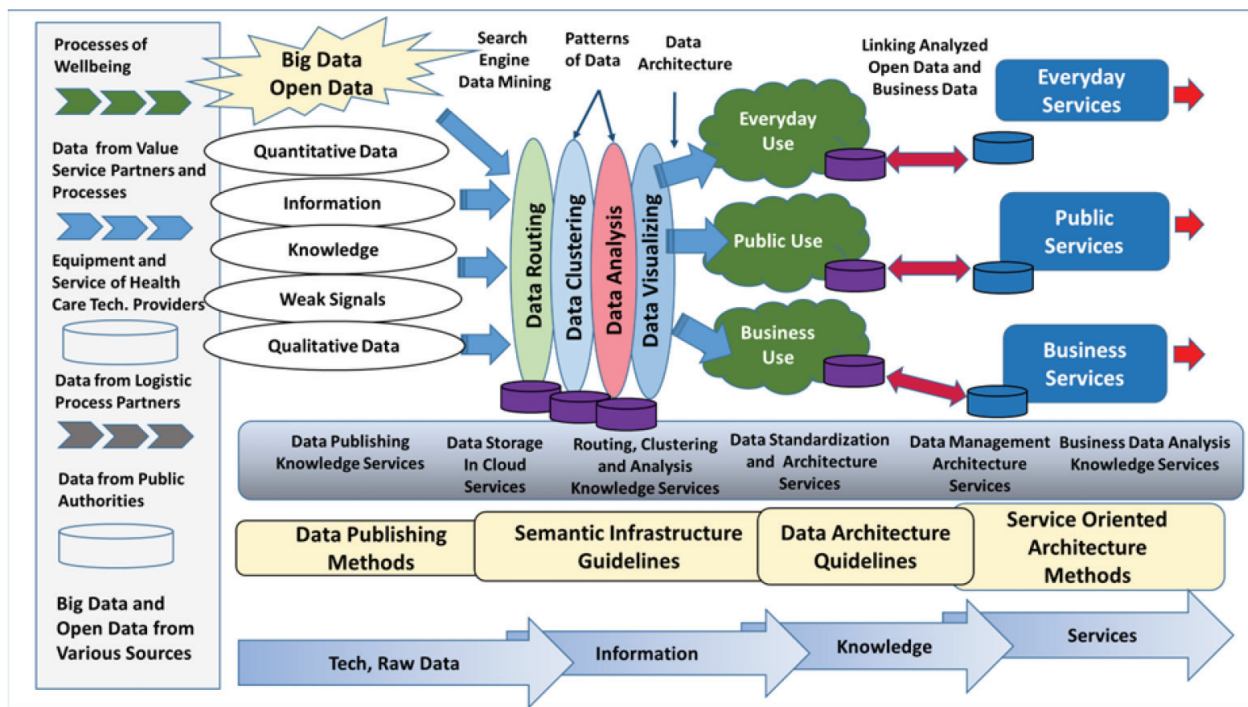


Figure 6. From data to service process in business coevolution of well-being and home care.

home where he is living. Understanding the value proposition in growing value networks is essential. Management and analysis of data coming from various sources are routed through data-to-service process in business coevolution of well-being and home care (Figure 6).

Decision-making of optimizing functionality and creation of new services is cooperative activity by several stakeholders in home service environment. It is essential to gather data from various data sources, different processes, and different systems. Automation system or sensor network (IoT) at home is creating data, which is gathered, clustered, analyzed, and compared with the data gathered earlier. After that decisions are made on what nursing operations, which medication, which type of rehabilitation, and what type of logistics are needed. It is essential to build data mining operations on various parts of the process. It is also important to have all types of experts in virtual network optimizing material, medication, logistic, and nursing processes to support this value network process.

Knowledge and capability of various stakeholders in home care environment are activated in order to manage economical, ethical, and technical risks in service creation. The created service should be evaluated as a value for elderly persons, nursing staff, and network service partners.

7. Exploiting digitalization and big data in service coevolution

Integrated services and technologies are connected on the same platform, which is a new innovation in domiciliary home care and at care homes. The definition of interfaces is nowadays

missing, and combining of data gathered and life cycle data is not possible, or it is very difficult. The common interface layers are strategy (e.g., contract), process, information, data ownership, and security and communication. It is essential to understand all the stakeholders in home care environment and define functionally interface structure between partners (Figure 7).

New Internet of thing, IoT, and other distant service solutions are developed. They support combining data gathered from home digital systems (solution data from home environment

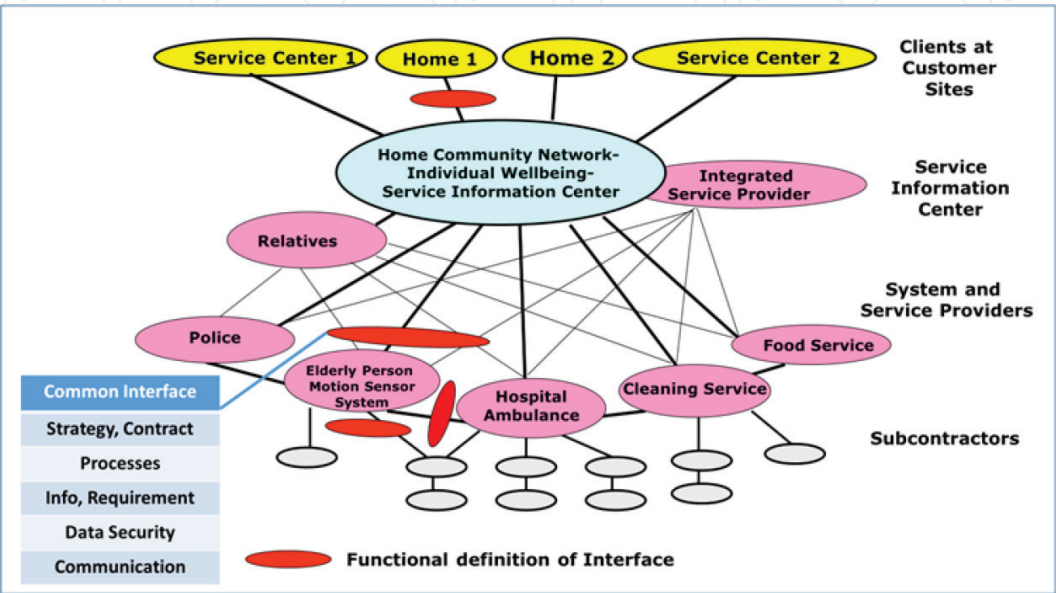


Figure 7. Functional definition of interface in networked environment.

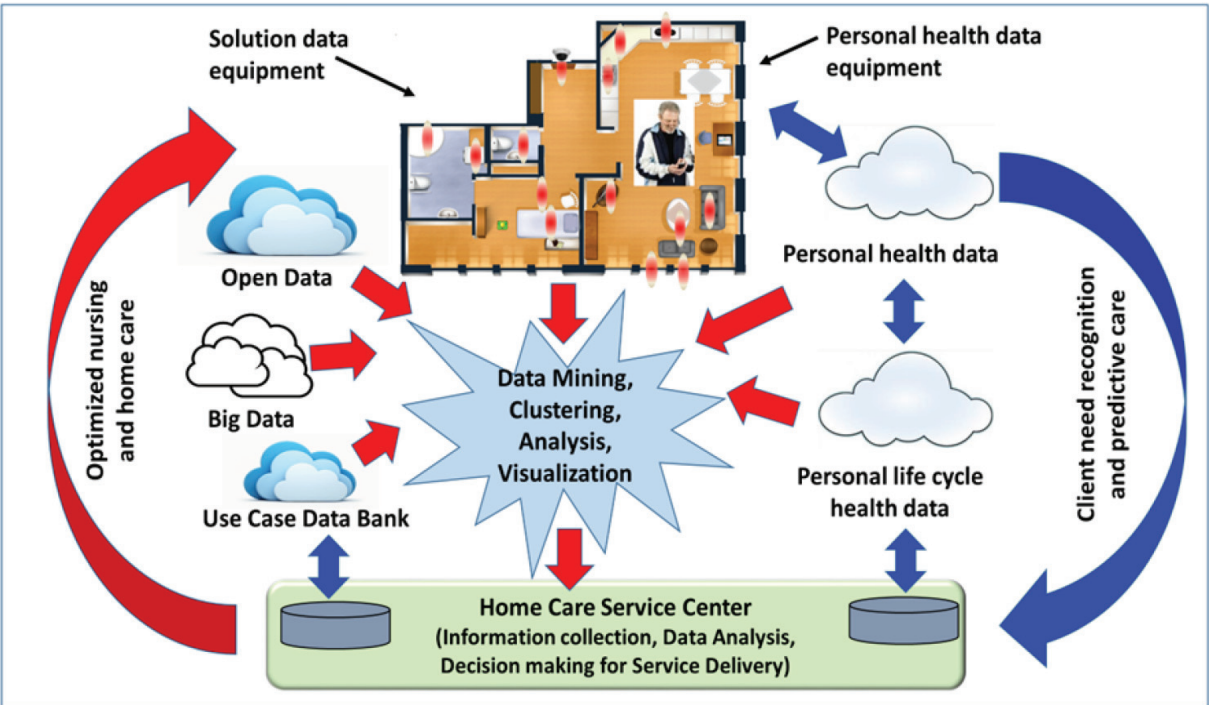


Figure 8. Predictive care planning according data mining and analysis.

and individual own well-being data) and information from open data in real time to home care service center, doctors, nurses, dental nurses, and other experts. This information is recorded in patient information systems so that it is available to all persons participating in care process. Digitalization brings new information on health and well-being by following ways:

- Through physiological information recognition, person’s activity level can be maintained at a good level, thus making it possible to contribute to living at home and to slow the progression of diseases such as Alzheimer’s disease.
- The well-being process allows information management and home care and nursing homes; the collected data (personal data and big data) is processed on the basis of analysis to be used in decision-making. Digitalization can be used to create a new care culture [11], which is based on documented and analyzed data (Figure 8).

Digitalization in home care and well-being sector are rather new topics, and there are few experiences in exploiting digitalization in municipal service functions and service providers. It is important to commit stakeholders in care pathway on cooperative co-innovation and demonstrations, when creating new services in home care environment. Most of the innovations will be created at customer interface.

8. From ontology formulation to semantic infrastructure

When a request involved in any format should answer the end-to-end performance, the Semantic definition needs to be clear from the request structure [15]. There will be four structural classes, such as health, social, process, and controls. A database links automatically. Social and healthcare

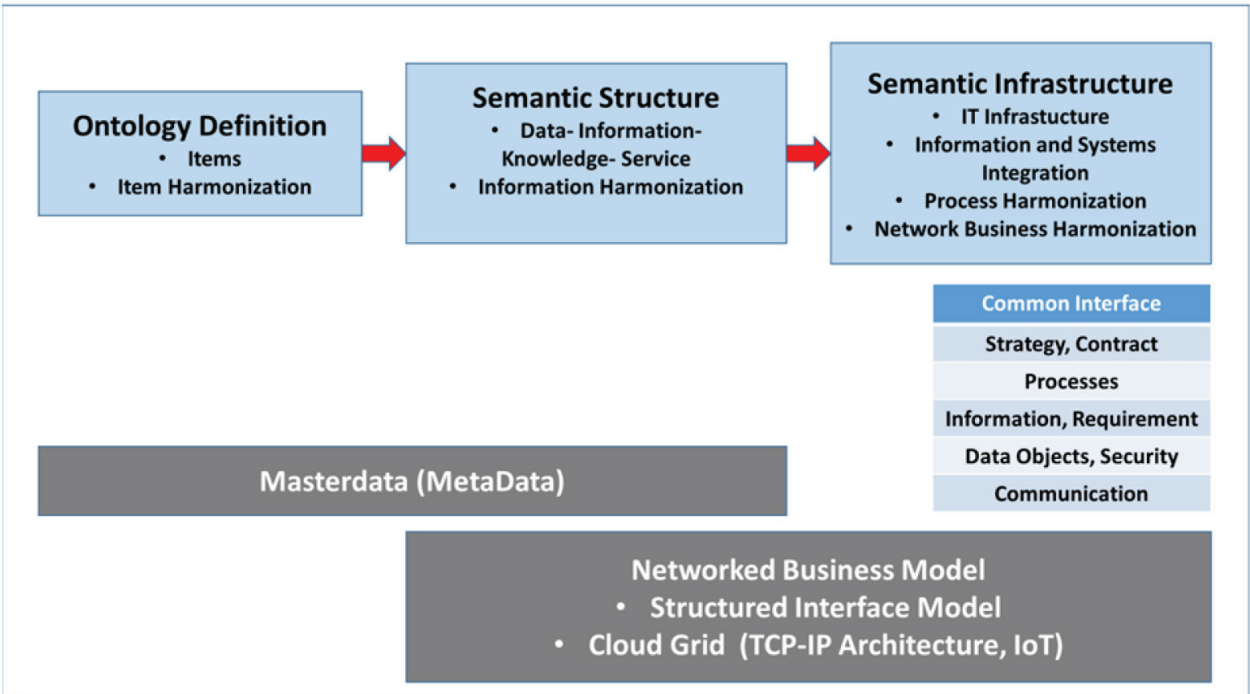


Figure 9. Semantic infrastructure creation for home care environment.

ontology definition is starting point in process harmonization. Ontology with item harmonization is the backbone for semantic structure and information harmonization. The functionality of semantic infrastructure has been built upon semantic structure and master data definition (**Figure 9**). Process definition, care pathway, is guiding process harmonization in semantic infrastructure. That is also the key for networked business harmonization. Service environment in elderly care is highly networked.

9. Ethical values and digitalization

Older people like to live meaningful life at their own home. Clients of home care have self-determination about their life and care activities. Living at home has to be the person's own choice. Very often elderly are frail and weak persons who need a lot of help. Generally they have many diseases and disabilities, and caring of them is often challenging and needs complex arrangements and careful planning. Elderly want the right to decide whether or not to use the digital services. It is important to develop solutions for supporting the safety and quality of life of elderly. All services provided to the elderly must be based on client's personal needs with respect of their own autonomy. Home care professionals can recognize clients' individual resources. Caring and all services have to support elderly's own performance and individual resources [13]. Unfortunately home care of older people is based on an illness-centered approach that focuses only on their physical resources, and development of home care services is urgent [14]. Digital services and applications can help us to develop elderly care for better direction.

Older people encounter difficulties in many activities of daily life. The market has a lot of different technological solutions for elderly. Older people need versatile services for living at home. Elderly can get benefit from technological applications and solutions that we already have in society. This would be fair for the elderly. The technology for elderly home care and all aging-related applications and solutions are a growing market in the business field. Technology professionals are responsible for developing digital solutions for the elderly. It is important to develop technological solutions from the perspective of the elderly in the first place [15].

In nursing practice we also have effective technology for nurses. Nurses are often in hurry, so applications can help them in decision-making [16] and documentation [13] and in clinical work [17]. We take care of the clients as possible and with the help of updated information. With digital solutions it is possible to develop safer caring pathway in social and health care for elderly.

Demographical change is a large political, social, and economic question, and it is a global phenomenon. In the political point of view, many countries have to make changes and develop organization of services. Elderly need more services, and this is also an economical question. Elderly services have to be flexible and cost-effective [18]. Belgium, France, Italy, Portugal, Spain, and the United Kingdom have an organizational model in which health and social services are separate. In other countries, especially Denmark, Finland, and Sweden, policy-makers recognized the advantages of providing home care as one integrated organization under the responsibility of municipalities [19, 20].

It is most important that person's service package is an integrated and appropriate wholeness. One of the key challenges of home technologies is the need to control and integrate many separate systems, as technologies are often purchased one by one [21, 19, 15]. The services for the elderly must have consistent quality and be fair for all the elderly [22]. Digital services can complement and defragment the customer care and thus improve the quality of care. The longer the elderly are able to live in their own homes, the cheaper it is for the society [15].

Among results of earlier research [14], home care services need to provide a service that meets clients' specific needs including psychological and social resources. Older persons try to find strategies to cope with the changes and difficulties that arise in relation to aging. Technological solutions can be used in activities of daily living to compensate lack of elderly's performance. The technological solutions promote elderly's safety and the feeling of safety also to client's family members and relatives.

Home care professionals need more education for exploiting digital applications in client's care at home. They need more information on what kind of applications is available for care. When the treatment is planned, the possibilities of digital services should be taken into account. Client orientation is most important in developing digital services for the elderly. Elderly as a social and heterogeneous group with diverse interest, variable education, health, and socio-economic level has to be taken in account, when creating and producing services.

It is a well-known fact that loneliness is a significant problem for elderly. Technology is not the answer to everything [15]. It cannot replace human relationships, but suitable technological solutions can support elderly's social life. The ability to live safely at home should be considered carefully respecting older people's own choices. The focus is on technological solutions that can extend the time the elderly continue to live in their own homes independently and safely. There is no universal technological solution that suits everyone; hence they should be applied by configured way. Technological solutions can give elderly opportunities to participate and socialize instead of isolating at home.

10. Well-being and home care: conceptual model for adaptive development

Digitalization in home care and well-being sector is a rather new phenomenon. There are still few experiences in exploiting digitalization in municipal service functions. The best and widely accepted innovations and services are created at customer interface. Research and learning environments at municipal customer environment have been used in succeeding business coevolution and continuous innovation. Cooperation requires engagement of municipal authorities and nurses. It requires trust on information and experience delivering. It is ought to be continuous on various organization levels. Cooperation and learning together on research and learning environment supplied in TELI-project case by university are basis for new innovations and continuous development. Development of superior competitive power through principals of well-being and home care is built by lean and digitalized value networks. It is important to succeed in exploiting multidisciplinary competence and open information sharing.

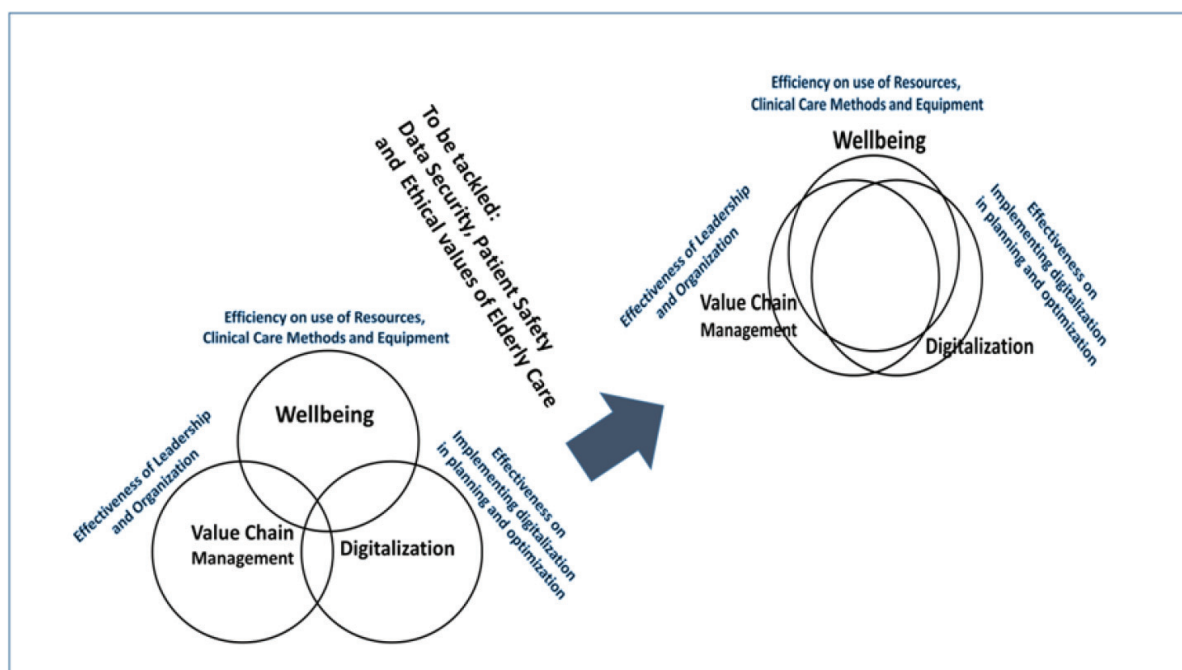


Figure 10. Proper implementation leading on more intensive overlapping.

Sustainable growth and responsible business management are not possible to achieve by linear way but adaptive way. **Figure 10** describes the conceptual model of adaptive development toward successful well-being operations and home care services. Value chain management, proper digitalization, and data management are the key developing features. The objective of well-being economy is resource efficiency and maintaining ethical values on all operations. Continuous digitalization increases effectiveness on optimized services. Value partners need to streamline effectiveness of leadership and interface processes. The trend on well-being service innovation in home care environment is that ethical care pathway, digitalization, and value network development are increasingly overlapping. The increasing digitalization and management on data-to-service process are key enablers in business coevolution.

Succeeding co-innovation on well-being and home care requires data mining practices, data-to-service management process, and creation of adaptive multidisciplinary cooperation model for common semantic infrastructure and solution development. The experts making applied research with customers have to have content on individual nursing of older persons and home care process knowledge at customer site; they have to be capable to work in teams on distributed way with other experts in value network and have to have certain collaborative skills to work together.

11. Ethical considerations

The study followed good scientific practice and guidelines [23, 24, 25]. The clients and all professionals volunteered to participate to the research. Ethical questions related to the

research were evaluated. Target organizations gave research permissions and decisions based on ethical evaluations. All students have signed a separate confidentiality agreement.

The clients were informed of the research with a written notice. They were asked for permission to the research by home care staff. The informants gave their consent to interviews both in writing and orally. The anonymity of the participants was secured throughout the research process. Participants were able to withdraw from the study whenever they wanted to do that.

12. Discussion and conclusions

Combining the principles of home care service to value network thinking and digitalization with data mining practices gives opportunity for remarkable competitive performance on whole the well-being environment. Recognition of older persons creating actual customer needs combined with life cycle calculation creates opportunities for life cycle services on home care environment.

Experiences on executed TELI-project show that it is essential to engage municipal authorities and public sector on conceptual development work when creating services for home care environment. It is also relevant to develop acceptable legislation, which enables the use of new digital equipment and delivering of created new services.

Universities can support municipal officers and technology application providers to provide and maintain research and learning environments for continuous piloting of new technologies and preparation of new business models on home care environment. Häme University of Applied Sciences supported demonstration of digitalization of versatile home care environment in Finland at Forssa municipal facility and Hämeenlinna Home Care division.

The data gathered through digital equipment can be used in optimizing service processes. It is important to have generic data as common ontology of service process and semantic architecture to route the gathered data. In this article is introduced, what type of ontology-based semantic architecture could be used in social and health care and how geriatric data should be integrated in caring elderly people. This article introduces experiences on co-innovation of home care services cooperatively together with public and private organizations.

This article introduces experiences on responsible business leadership. Older people like to live meaningful life at their own home. Clients of home care have self-determination about their life and care activities. Living at home has to be the person's own choice. Elderly want the right to decide whether or not to use the digital services.

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