Smart Cities and the Ageing Population

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I. INTRODUCTION

Due to a growing number of elderly people, it is a necessity to create the cities that are aware of the special needs of all their citizens including the needs of aging populations. This paper shows that by combining smart homes with smart cities, we are able to provide an ICT infrastructure that exploits the entangled connections between the ambient assisted living, the smart homes, and the smart cities.

In smart cities the citizens activities are not limited to their homes; they live their lives in an entangled society. Health care is important for citizens in general and in particular for the elderly. Smart cities need to address elderly people needs across such as housing, social participations health care, and community support services, leisure, and culture, in order to make smart city environment more elderly friendly. ICT will enable this integration into the home and urban environment where elderly people live.

For the EU between 2010 and 2060 total government spending on pensions, health care, long-term care, unemployment benefits and education will increase by almost 20 per cent, while expenditures for long-term care will double [1]. Such rapid growth of elderly people will require not only far-reaching economic adjustments to health budgets but also the implementation of smart ICT solutions in order to achieve better and more efficient health care and social services. ICT can improve the quality of life, provide personalized solutions, reduce high costs of health and care services and support social interaction with friends, families, health and social supports and neighbourhoods. ICT solution implemented in the cities can help overcome mobility, visual, and cognitive problems.

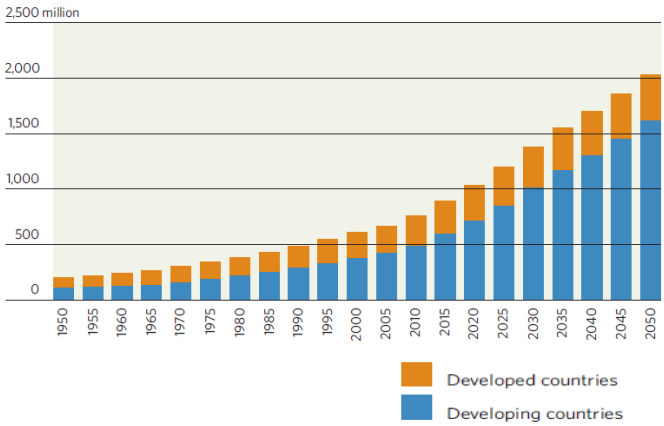
Smart cities need the latest information and communication technology (ICT) and its services to create a better sustainable and cost efficient environment. Modern ICT communication infrastructure fuels sustainable economic development and a high quality of life together with a wise management of natural resources. So, it is necessary to create the cities that are aware of the specific needs of aging population to support independent elderly living. Using ICT in a smart city/home context can provide personalized health care, social services and intelligent community services.

Homecare systems for elderly people are becoming important due to economic reasons as well as patients' preferences. The expected future trend is the sensor-based surveillance technologies and that the elderly citizen will gain benefits of avatar-based 3D visualization system, exploiting wearable sensors and human activity simulations resulted both positive and negative impressions of the concept utilizing activity recognition and 3D virtual world design.

In this paper we will discuss how the recent development in ICT, and its particular components, Internet of Things (IoT), Clouds of Things, the Advanced Artificial Intelligence, can become building blocks between elderly people, smart homes and smart cities. Also, we will present a brief overview of a selected number of projects within the fields of health and home care, social interaction, supply with daily goods and chores and safety. As an example an overview of the services of the city of Oulu for elderly citizens' will be given.

II. THE AGEING SOCIETY

The global population is forecast to reach 9.3 billion people by 2050 and at the same time, the majority of countries have an increasingly ageing population. Elderly people represent a growing share of the world population. In 1950, there were 205 million persons aged 60 or over in the world. By 2012, the number of older persons had increased to almost 810 million. It is projected to more than double by 2050, reaching 2 billion. [1], [2], [3]



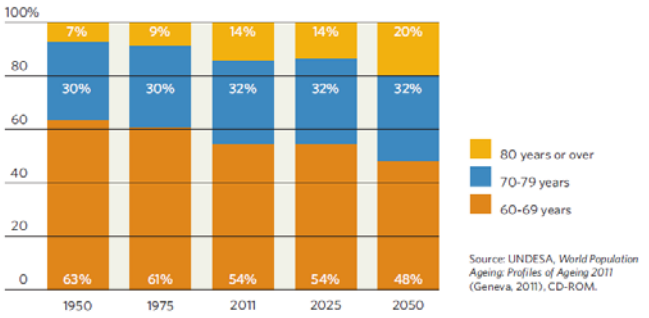


Fig. 1. (a) Number of people aged 60 or over: World, developed and developing countries, 1950-2050 and (b) Distribution of population aged 60 years or over by broad age group: World, 1950-2050, [3]

According to Population Reference Bureau, 25 percent of all Europeans will be over 60 by 2030 [4]. At the same time, populations are projected to decline, as fertility levels are expected to remain below replacement levels in Europe.

This demographic change will have a huge impact on social and economic issues and can be illustrated by the potential support ratio (PSR) - the number of persons aged 15-64 years per one older person aged 65 years or over. From 1950 to 2005, the potential support ratio PSR fell from 12 to 9 people in the working ages per each person aged 65 years or over. By 2060, the PSR for the EU is projected to fall to 2 working-age persons for each person aged 65 years or over [5]. PSRs have important implications for social security schemes, particularly related tax and contribution burden of social expenditure, such as pensions, health and long-term care. [6]

For the EU between 2010 and 2060 total government spending on pensions, healthcare, long-term care, unemployment benefits and education will increase by almost 20 per cent, while expenditures for long-term care will double. Strictly-age-related public expenditure is projected to increase on average by 4.1 percentage points of GDP by 2060 in the EU. [5]

Managing health care quality and costs for this demographic change is one of the key focus areas in many countries. According to European Commission, already by 2020 we will face up to 2 million vacancies in health and social care.

Such rapid growth of elderly people will require not only far-reaching economic adjustments to health budgets but also the implementation of smart ICT solutions in order to achieve better and more efficient health care and social services. ICT can improve the quality of life, provide personalized solutions, reduce high costs of health and care services and support social interaction with friends, families, health and social supports and neighbourhoods.

III. OVERVIEW OF THE SMART CITY CONCEPT IN THE LIGHT OF THE ELDERLY PEOPLE CHALLENGES

The concept of a smart city itself is still emerging, and the work of defining and conceptualizing it is in progress. The concept is used all over the world with different nomenclatures, context and meanings. [7] A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement. [8]. The notion of empowerment of citizens and "democratizing innovation" should be added [9]. The Cityzentrism concept stresses the need for public and private stakeholders to put the citizen at the heart of any Smart City project where citizens, which are the inhabitants of the intelligent cities become agents of change, fully aware of the city challenges and play a qualified role in the civic network, characterized by participation, civic engagement, territorial commitment and the will of sharing knowledge of creativity [10].

The elderly challenges in the cities and societies are mostly related to the fact that ageing causes age-specific barriers, such as limitations of mobility, visual and hearing impairments and a high disease susceptibility, especially for chronic diseases (diabetes, Parkinson's disease, dementia, cardiovascular diseases).

ICT solution implemented in the cities can help overcome mobility, visual and cognitive problems.

Visual problems:

- Audible and vibrotactile signals for pedestrianu augmented with systems able to tell people where they are
- Accessible shopping for visually impaired people through mobile technologies: navigation system and a product recognition system
- Assisted city apps adapted to blind users

Hearing problems:

- System which translate voice to text or which convert and reproduce sign language
- Cognitive problems:
- Devices that can guide the elderly through their everyday tasks
- Rehabilitation systems and video games to enhance cognitive functions

Information and Communication Technology-based Independent Living Services can play an important role in helping older citizens to live independently.

Presently there are several EU projects supporting independent living and quality of life in an ageing society by means of ICT applications. Many Ambient Assisted Living programme aims to extend the time older people can live in their own homes by increasing their autonomy and assisting them in carrying out their daily activities. [11]

Innovations in areas such as remote sensors, embedded systems, robotics or wireless mobile networks provide building blocks for intelligent ambient systems that can support elderly people and allow them to stay in their home environment while being medically treated. Examples of such systems include portable or wearable devices for health care applications, or remote sensors and alarm installations that can detect and alert users to health emergencies in the home environment. [12]

Assisted living environments can help an ageing population to remain active and independent for longer period by taking into consideration their individual needs. In order to facilitate a better understanding of the individual requirements of elderly, the European Executive Board of the AAL Association and the German company VDI/VDE-IT, together had developed a model which classifies needs of elderly people for their well-being in accordance with important stakeholders. (Fig. 2)

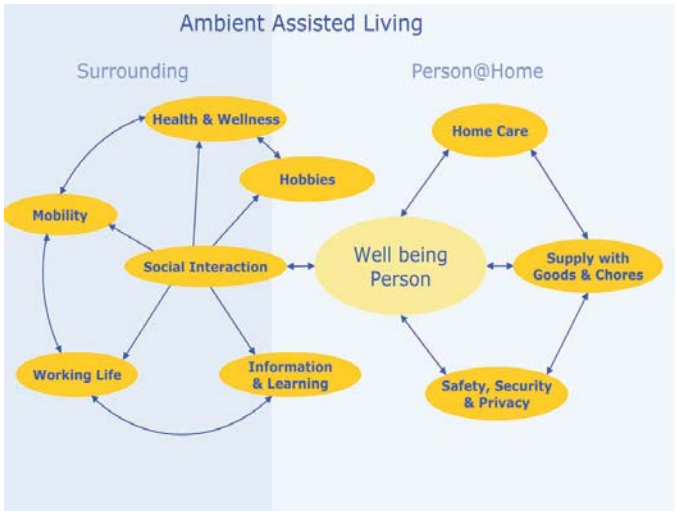


Fig. 2. A multi-factor model displaying the needs of (elderly) persons for continued well-being, [13],

Social interaction will play an important role in elderly peoples' life. Research has shown that social interaction can help older adults maintain good physical and emotional health and cognitive function. [14] Staying social active and maintaining the relationship are an important part of healthy aging. New technology can enable older people to develop social contact, interact in new ways with family and friends, engage actively in their communities and share learning, skills and experience with others.

Smart cities need to address elderly people needs across following dimensions: housing, transport, social participations, social inclusion, health care, communication and community support services, leisure, and culture, in order to make smart city environment more age friendly. ICT will be integrated into the home and urban environment where elderly people live.

Due to a growing number of elderly and disable people, it is a necessity to create the cities that are aware of the special needs of all their citizens including needs of aging populations.

ICT technologies can be used not only in treatment, rehabilitation and health promotion for older people but also to support social interaction and fitness activities.

IV. Discussion of the Economical, Market, Ethics, and Life-Quality Perspective of the Suggested New Concept and its Services

Earlier times is was expected that the ICT technology and services will change mainly younger and business people way of life, but now we are seeing that it will change and provide great benefits for elderly peoples' life. Internet provides a platform, which learns people's preferences where ever they are: home, hotel, at airport.

The GSMA with the support of AT&T, Deutsche Bank, KT, Telenor Connexion and Vodafone, and in partnership with Machina Research, has released a research [15] that outlines the market opportunity and revenue potential for connected devices. Following the research it is expected that the number of total connected devices will increase from approximately 9 billion today to more than 24 billion in 2020, and within that, mobile connected devices will grow 100 per cent from more than 6 billion today to 12 billion in 2020. This explosive growth will support an addressable revenue opportunity for mobile operators of nearly US$1.2 trillion by 2020, a sevenfold increase from expected revenues in 2011. This will also provide significant growth potential for the entire ecosystem. From the regional point of view mobile network operators could compete for a share of US$1.2 trillion. Regionally, the MNO US$1.2 trillion addressable revenue opportunity equates to: Asia Pacific: US$447 billion, Europe: US$305 billion, Latin America: US$92 billion Middle East & Africa: US$87 billion and North America: US$241 billion.

Based on more general approach to IoT market, it expected market value is $8,89 trillion [16].

However, there will be a number of products and use cases coming to the forefront in the next 4-5 years around this concept of IoT. Cisco [17] believes Internet of Things could be a $19 trillion market. Before all of the money starts to be spent on bringing these devices to life, here's one way to think about IoT.

Following the SVB analytics [18] (Fig.3) there is a clear business case. Demographic changes leading to an increasing target market:

- Rapid decrease in size and cost of devices
- Federally mandated readmission penalties leading to increased provider demand for telehealth and remote patient monitoring solutions
- Gradual shift in payer framework to accountable care organizations resulting in greater reimbursement for connected healthcare solutions
- US Department of Health and Human Services launching the Health Data Initiative which provides greater amounts of health data in more usable formats

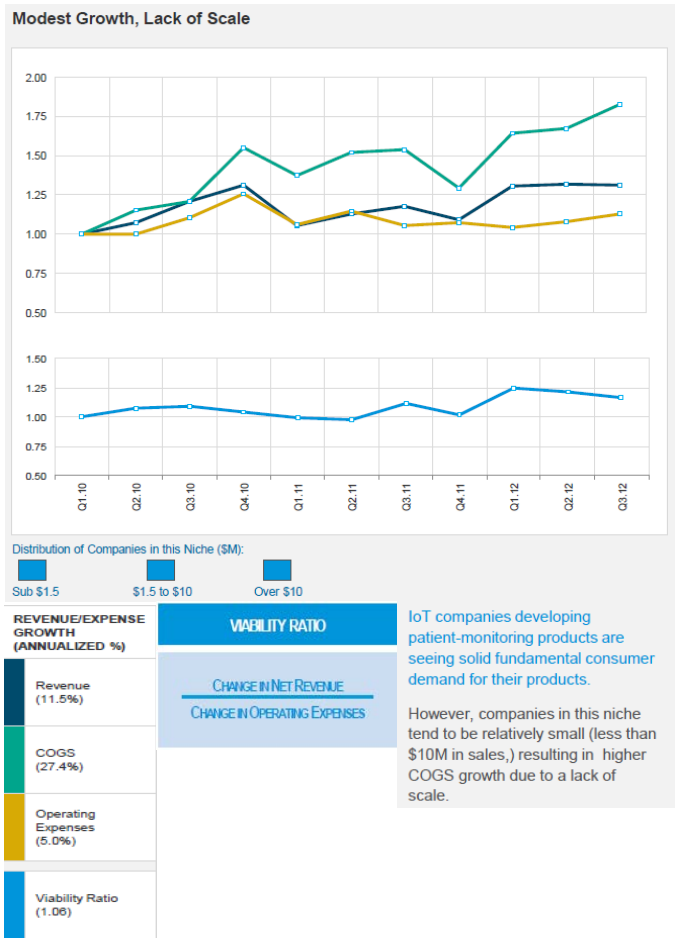


Fig. 3 Niche Analysis in Connected Health [18]

From the significant figures above of the growth of IoT we can state there is a momentum to further develop devices and services elderly people use. [18]

V. OVERVIEW SMART HOMES, CONTROLLED HOMES, AND INTERNET OF THINGS

Many terms are used in connection with smart homes such as connected home, digital home, adaptive house, and aware home. However, in order to simplify things only the smart home term is used in this context. Smart homes are based on automated and controlled homes. Controlled homes are homes that react to a deliberate user inputs such as turning on/off a stove as well as remotely closing the gates, remotely control the light with a device etc. By adding a capability to sense the environment and act upon events controlled homes are extended into automated homes. Automated homes are mostly characterized by sensors and timers. For example, passive infrared sensors which turn on the lights if people are present in a room; a floor that sense if it is dirty and automatically clean itself; receive notification on a mobile device if some appliances are detected left on and remotely be able to turn them off etc. Automated homes are more advanced than controlled homes as they are able to sense context; however they still require user inputs, i.e. they are not able to make decisions on their own. The smart homes are considered an extension of the controlled and automated home fields where they add more advanced control features and Artificial Intelligence (AI). Thus, smart homes are the most advance type. They are dynamic, Intelligent, context-aware and knowledgeable. In addition, they are able to learn user actions and predict services based on these. An un-formal definition of smart homes is provided by Alam et al [19]:

"A smart home is an application of ubiquitous computing in which the home environment is monitored by ambient intelligence to provide context-aware services and facilitate remote home control [19]"

VI. SMART HOMES SERVING THE ELDERLY

There are already various solutions from remote monitoring to robots, based on sensor networks and communication technologies used to help elderly people to retain as much of their independence as possible. Examples of projects that bridge the gap between new smart home environment and elderly people are presented below.

Social interaction

The DALIA [20] project focuses on optimizes information care in the AAL sector. It consists of a personal virtual assistant that implements a service-oriented architecture on a smart phone. This architecture is very flexible and offers functional decomposition, easy integration of new service, and reuse of existing services. In addition, it offers a high level user interface based on a virtual avatar that includes speech- and face-recognition. DALIA is an ongoing project with ten partners and a total budget of 2,8 million euro's.

The WeCare [21] project has developed online social services which enable older people, their families, friends and neighbours to communicate and coordinate activities, both online and in real life. The services include easy-to-use online calendars and activity planners, video communication, blogs and forums. The project aims to empower older people to participate in social networks, so that these social networks can empower them to participate in their community and decrease feelings of isolation.

A project that supports the vision of elderly people independent living is GIRAFF+ "Combing social interaction and long term monitoring for promoting independent living". [22] GIRAFF+ project have developed the concept to be more of an addition than a substitute for human contact. The system consists of a network of home sensors that measure e.g. blood pressure or temperature, or detect e.g. whether somebody occupies a chair, falls down or moves inside a room. There is also a telepresence robot, the Giraff, which is a mobile communication platform, equipped with video camera, display, microphone and speakers, and it helps the user to maintain his/her social contacts.

Health and home care

Technologies that monitors elderly people's health, helps them stay fit and connected with family and friends are developed and research in various EU projects with more and more focus on the AAI.

The objective of the STIMULATE [23] project is to enhance the life quality for older people. It uses ICT to offer user centric services such as: specify assistance needs, plan a trip, optimize transport means and itineraries, security advices, and local shopping recommendations and assistance. The STIMULATE project has ended. It had a total budget of 1.7 million euro's and eight companies were involved.

The AGNES [24] project provides an ICT based platform that offers timely information on activities and the subjective state of the elderly person. The objective is to improve the timely response, attention and care-giving with the benefit of reducing the healthcare costs. In addition, it contains a social element that offers the possibility to share this information with friends and family members. The AGNES project has ended. It had a total budget of 3.6 million euro's and ten companies were involved.

In the face of increasing health care costs, home-based rehabilitation will play an important role. Within this field, much research has been conducted on robot technology in practice in elder care. Below, brief overviews of a selected number of projects are presented.

REWIRE [25] project proposes to develop an innovative virtual reality based rehabilitation platform, aimed at allowing patients, discharged from the hospital, to continue intensive rehabilitation at home under remote monitoring by the hospital itself.

Another approach to in-home rehabilitation is being taken in the SCRIPT [26] project: Supervised Care & Rehabilitation Involving Personal Tele-robotics, which has developed two prototype robotic devices aimed primarily at helping people recover after a stroke. Such systems, from remote monitoring and ambient intelligence to virtual reality and robotics, can contribute to the development of 'Ambient assisted living' (AAL) environments for the elderly.

The KSERA [27] "Knowledgeable Service Robots for Aging" project has developed a socially assistive robot that helps elderly people with their daily activities, care needs and self-management of their disease.

CompanionAble [28] "Integrated Cognitive Assistive and Domotic Companion Robotic Systems for Ability & Security" project has linked intelligent home systems with a fully autonomous robot. Robot is designed to play the role of a "companion" for elderly people, to help them remain independent, secure fit and happy, through fall detection mechanisms integrated with emergency calls or remote monitoring services, personalised dialogue, interaction displaying emotional intelligence (using both visual, vocal and tactile interfaces, sensor-based movements such as "follow me" and natural language recognition of commands) to avoid feelings of loneliness, provide friendly reminders, store, bring important objects such as keys, wallet, and offer cognitive stimulation, games, as well seamless video connections to family and friends. [29]

MobiServ [30] project has developed a personal intelligent platform consisting of a social companion robot, wearable smart clothes, and a smart home environment – including smart sensors, optical recognition units, and home automation elements, to detect among others eating and drinking patterns, activity patterns, and dangerous situations. The objective of the Mobiserv project is to support independent living of older adults with a focus on health, nutrition, well-being, and safety.

DOMEO: Domestic Robot for Elderly Assistance AAL Project [31] focuses on the development of an open robotic platform for the integration and adaptation of personalized homecare services, as well as cognitive and physical assistance.

The Florence [32] Multi-Purpose Mobile Robot for Ambient Assisted Living project supports lifestyle and AAL services in the following categories: keeping in touch, lifestyle improvement service, fall handling service, agenda reminder service, home interface service, collaborative gaming.

eWall [33] for Active Long Living project - develops devices and sensors to monitor the in-house activities. Signals from networked devices and sensors are processed to extract the status of the elderly home and its occupants.

InCASA [34] project provides integrated solutions, services for health, environment monitoring to collect and analyse data in order to profile user behaviour, implement customized intelligent multilevel alerts and communication services. Home Sensor Networks and Human Monitoring Sensors (HMS) monitors elderly people lifestyle and interact, if needed, with the citizen themselves or with the Service Provider.

The "Sens Action-AAL [35] project for remote mobility monitoring technology" assist older people in maintaining independent mobility and daily life activities and prevent injuries by introducing smart body fixed sensor based technology that allow medical professionals to initiate interventions in the home environment. The Sens Action-AAL system enables: tele-rehabilitation (training & improving mobility based on augmented feedback solutions tuned on the home environment); tele-monitoring (ambulatory monitoring of physical activities) and tele-care (fall detection and alarm generation).

LONGLASTINGMEMORIES [36] and SOCIALBLE [37] projects focus on ICT assisted cognitive training and social activation for senior citizens.

Supply with daily goods and chores

The NACODEAL [38] project is an ICT-based system that provides service solutions for the ageing population. It uses a technology wizard to help elderly people to deal with the ICT society in form of offering services such as online shopping and online communication. Furthermore, it offers its services by implementing an augmented reality interface that fell confident, easy to use, and easy to understand. NACODEAL is an ongoing project with five partners and a total budget of 2.5 million euro's.

Safety

USEFIL [39] Unobtrusive Smart Environments for Independent Living project provides advanced in-home monitoring and web communication solutions. The concept of the USEFIL platform consists of the following: monitoring (low cost video cameras provide monitoring of behavioural, emotional and physiological parameters), mobility, sociability, AI (decision support system which provides the means for alarms and prognosis), personalization (applications design for the ageing population).

SafeMove [40] Safe mobility of elderly in the vicinity of their home and on journeys project develops new services which aim at supporting elderly people during their normal daily life while encouraging their normal mobility both indoor and outdoor.

The project CARE [41] provides an intelligent monitoring and alarming system for independent living of elderly persons. Specifically, this project targets the automated recognition and alarming of critical situations (like fall detection) using a stationary (and non-wearable) technology and real-time processing while preserving the privacy and taking into account system dependability issues, especially ensuring reliability, availability, security, and safety.

Presented projects have shown that a wide range of smart technologies, ICT services and applications are available to assist older people to live safely and to live independently. New ICT solutions can offer great support to the elderly within the area of social interaction, health and home care, supply with daily goods and chores, and safety.

A lot of research has been done on human monitoring sensors, home sensor network, home based rehabilitation, assistive robots that helps elderly people with their daily activities, care needs and self-management of their diseases. However, we are aware of no system providing an ICT infrastructure that exploits the entangled connections between the ambient assisted living, the smart homes, and the smart cities, therefore we believe the ISHSC infrastructure presented in the chapter IX offers a new platform for elderly-services in smart cities.

VII. ELDERLY SMART CITY SERVICES - CASE OULU

The city of Oulu considers elderly people as important group for providing services (Koistinen et al. 2012, Lehto 2012, Rouru 2013). The city has developed the following services for senior citizen:

- Vanhusneuvosto, a collaborative elderly city council with regularly meetings and within the duties they have: collect information from elderly, active communication, political statements provider as regards of elderly society, responsible for networking inside the city and outside, linking organizations with third sector and legal associations.
- OMA Oulu platform – is a collective health services platform (not only focused on elderly), which is mapping the needs of the care recipients. By visiting them to diagnostic the situation, determining what kind of supportive services they need and the frequence of visits for supporting with medicine, checking, cooking.
- Service at citizen's houses – The city provides education at citizen's house to give basic skills for using Internet, ICT equipment and provide financial facilities to acquire them.
- Oulu Open data service, aimed at increasing democracy, includes data from PanOulu and planning to be improved with more applications by 2015, e.g. data for free parking area.
- Caritas. well-being living environment with a service center, a group home, senior apartments and normal apartments, dinning services and open social activities.
- Arina. Contributing with a well-being living by partnering with Gastronauttim, a delivery service allowing consumers to order grocery online and be delivered at home.
- Oldwellactive. A wellness assessment for elderly people to be used as support for developing strategies in elderly care, focused on moving home visits from traditional way to wellness promotion of health and welfare activities of older people.

And some of the projects in Oulu benefiting elderly people are:

- EPPI-distance service project, carried out during spring 2013, aimed at collecting the information to know what kind of e-services the elderly people as result of EPPI project come the video service point, through which the remote locations connect with the central administration and service desk for guidance and service through videoconference.
- Pilot platform for nurses to access houses by opening the locks with mobile handsets.
- Pilots projects about sensors at home to detect the mobility of the elderly, to know they are having regular mobility, sensors at floor, refrigerator. Have been pilots but not in production.
- Ubi-screens provide around 20 services with potential services to develop as they also have the facility for the video guidance services which would be useful for elderly people.
- Oulu is participating in the SILVER project which looks for new technologies and solutions that can assist elderly people in everyday life, through the use of robotics or similar technologies to benefit elderly for continuing independent living at home.

Recognizing the priorities of elderly people under Smart city vision, the options for Oulu city to be applied using the resources already consolidated in the city are:

- Wellbeing, Online-physical platform integrating directory of services customized for elderly, social activities, public and private services.
- Mobility, Devices to support elderly in crowded places and providing barrier-free routes.
- Healthcare, Tele health services for monitoring and consulting from home.
- Security, Devices at home monitoring falls and a normal activity of seniors.

- Retail, e-shopping for delivery services, e-services for communal transportation to the stores.

Important element of smart city is the open data, using the real-time awareness and data analytics supporting better decision-making and further develops new business models. It is important to optimize and allocate adequate resources to strengthen the activity of senior citizens.

VIII. Future Welfare Service study in Oulu

Citizens of Oulu were engaged for the development of new public welfare services through user driven methods

- Recruitment of the elderly for online discussion and idea evaluation
- Overall 550+ participants
- 300+ postings: service ideas and in-depth insights of citizens' everyday life on online discussion forum
- 500+ citizens evaluated ideas on interactive large displays in public locations

Results: valuable information of everyday usage of services, feedback of ideas. Findings supported well the new public welfare service model of the City of Oulu

In the study conducted as a pilot project of the MAINIO project in 2012, future welfare services were evaluated and developed together with citizens and especially the elderly in the City of Oulu, Finland. In the pilot project based on action research method, Living Lab approach was applied through user driven methods. The citizen involvement tools, provided by OULLabs (Oulu Urban Living Labs) for this study were the PATIO online forum [46], and a survey on large interactive public touch screens, UBI hotspots [47]. Overall 550 citizens were involved in the study.

Online discussion on the PATIO forum was perceived as suitable method for gaining deeper insights of citizens' everyday life. Online discussion was divided into three age groups and moderated by the future welfare service specialist from the City of Oulu. UBI hotspots were used in this pilot project for evaluation of ideas. To make this possible, a new questionnaire tool UBI Poll was developed in the MAINIO project. The UBI Poll enables citizens walking by to respond spontaneously and evaluate ideas presented. In this case citizens voted ideas by choosing icon "thumb up" or "thumb down". The results of the study show that UBI poll can be perceived as easy way to involve the elderly in the development activities, i.a. future welfare services, as the user interface is very simple and no registration is needed. Guidance was provided for the use of both UBI and PATIO in this study. Compared to the PATIO online forum, where registration is needed, our experience is, although there are exceptions like an 83-year-old active PATIO user, the elderly usually need more guidance in registration and use of the online forum. Thus, it is possible to involve and engage also elderly citizens in the development activities through user driven ICT based methods.

Related Research in Oulu

Homecare systems for elderly people are becoming important due to economic reasons as well as patients' preferences. According to research conducted in the University of Oulu, expected future trend are the sensor-based surveillance technologies. Pouke & Häkkilä (2013) study of avatar-based 3D visualization system, exploiting wearable sensors and human activity simulations resulted both positive and negative impressions of the concept utilizing activity recognizion and 3D virtual world design. Perceived strengths were ability to maintain privacy of patients, check details, browse temporal content, whereas weaknesses included complexity of visualizations and intrusiveness. Pouke & Häkkilä point out that systems taking advantage of 3D virtual world visualization techniques have potential especially due to the privacy preserving and simplified information presentation style. Their study shows that simple representations and glancability should be emphasized in the design and that avatar-based 3D presentations can be helpful if they provide an overview as well as details on demand.

Pouke et al. in another study (2010) aimed to capture activity data of the elderly to use with a virtual environment and virtual human to test the services. The study shows that it is possible to recognize regular activities of the elderly using accelerometer and proximity sensors. Subject interviews and experiment space pre-examination are crucial or successful execution of the data capturing as correct sensor placement relies on the activities the subject is performing during the experiment.

Further example of related research conducted in Oulu is a study of Pulli et al. (2012) concentrated on user interaction in smart ambient environment targeted for senior citizens. Their study points out the use of smart ubiquitous technologies as solution to the challenge of rapid rising number of senior citizens: they see the technologies as a way in coping with the need of more nursing staff and the rising costs of taking care of senior citizens for the society. The study presents a wearable computing prototype: projection-based display system for elderly people with memory impairments and the proposed user interface for the system, to be used in Alzheimer's disease and its close variants in focus. For example doctor or family members are able to check and manage senior citizens calendar entries, offer personal guidance via communication tools, guide the user based on his location or activities. The prototype had novel, easy to use interface that guides and helps to improve the quality of life and enables to take more part in daily activities. The prototype was tested on elderly male in Oulu.

IX. Integrating the Smart City Concept with the Smart Homes

In smart cities the citizens activities are not limited to their homes; they live their lives in an entangled society. So, smart spaces need to address this challenge by connecting the inside and outside of the smart homes seamlessly [42] into a

cohesive context, i.e. a smart city must include a smart home concept.

Smart cities need the latest information and communication technology (ICT) and its services to create a better sustainable and cost efficient environment. Modern ICT communication infrastructure fuels sustainable economic development and a high quality of life together with a wise management of natural resources. So, using ICT in a smart city context provides personalized health care, social services and intelligent community services, among other things.

To make the smart city the engine of transformation and a generator of solutions for wicked problems, a modern ICT based infrastructure, which integrates the smart homes into a smart city, is needed. This infrastructure must be able to handle AI, Internet of Things (IoT) and Clouds of Things (CoT), because these technologies constitute the "heart" of a smart home.

The IoT technology is expected to integrate the Internet as we know it today (2014) into a multitude of things [43], [44], and hence commonly known objects such as clothes, food packing, toothbrushes, etc. will be equipped with some level of Internet-addressable AI. Thus, these IoTs will offer context awareness and communication features, and they will share some level of pseudo-intelligence depending on their processing capability and consumed power limitation [44], [45].

This development will lead to new forms of communication between people and things and between things themselves. So, the challenge is to go beyond today's state-of-the-art, making these IoTs context-aware, intelligent and able to communicate via IP, and combining them into a distributed system for the future smart homes and smart cities. They should be able to not only react to changes in the environment, but also perform AI-based reasoning to take into account the preferences of the user inhabiting the smart home. A lot of research is needed in this area [43].

The CoT is vital in the smart home and smart city contexts because IoT devices produce a huge amount of information that needs to be stored and processed. In simple terms a CoT is a pool of resources and calculation capabilities accessible through the Internet. For smart cities combining IoT and CoT is crucial, so that IoT data can be processed and stored [42].

Combining the pieces, a modern ICT based infrastructure must comprise technologies such as Iot, CoT and distributed AI. Especially, the AI part is challenging because it is embedded into the IoT context, which offers limited resources. Thus, a more Advanced AI (AAI) system is needed for handling complex IoT patterns. This AAI circuit could be implemented on the Internet as a CoT service. Such an approach offers:

- The possibility to interconnect IoTs, coordinate activities, collect big-data, and offer complex services to the community, as well as to the individual smart home user.
- Scalability, it is easy to add new smart city members in the form of smart homes, upgrade and perform service to a distributed system, i.e. it scales well.
- Compatibility with the concept of smart grids supplying resources to a smart city.
- The benefits of centralized systems such as easy access to all information and simple peripheral units can be achieved by processing the distributed pre-processed (anonymous) big-data on a cloud server.

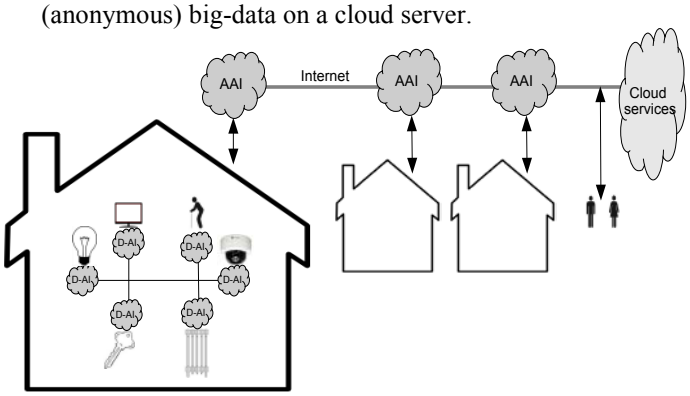


Fig. 4. Modern ICT based infrastructure for future smart cities – the suggested Integrated Smart Home and Smart City based infrastructure

The suggested modern ICT based infrastructure for future smart cities is illustrated in fig 4. It comprises a collection of smart homes, which are equipped with IoT's. They offer services such as intelligent lighting, heating, security, and entertainment systems to its users. The individual smart home is equipped with an AAI system, which controls and processes its smart home services. By combining these AAI systems, using the Internet and the CoT services, a smart city ICT based infrastructure is created. For making referencing practical the acronym Integrated Smart Home and Smart City is defined as (ISHSC).

X. SUGGESTED NEW SERVICES

To analyze new service values and opportunities in the context of using ICT embedded in Integrated Smart Home and Smart City (ISHSC) system it is useful to view the aging process in different contexts, i.e. using the three spheres of impact [48]**.** Firstly, aging at work requires integration of the elderly and the labour market by using ICT, i.e. ICT skills are necessary in today's distributed working environment. Thus, it is often possible to work from home by using ICT equipments such as a PC or an IPad. Secondly, when elderly citizens ages in a society it is vital that they stay active, creative, and they have access to public and commercial services. This improves their quality of life and reduces social isolation; especially in the rural and remote areas. Lastly, aging at home can be assisted by ICT to maintaining a high degree of independence, autonomy, and dignity. Hence, ICT can lower the barriers imposed by ages, increase opportunities for employment, and reduces social isolation. These challenging spheres of impact can be refined into four groups that classify the needs of elderly citizens in relation to their well-beings Gasner et al. [49] and fig. 2. These groups are social interaction, health and home care, supply with daily goods and chores, and safety. In the following these four groups are discussed in the light of the value added by integrating them with the ISHSC system.

Focus is on research projects performed in Finland (Oulu) and in Denmark. However, some projects performed as part of the EU based AAL program [50] are also discussed.

Social and face-to-face interaction

Social and face-to-face interaction among citizens is a very fundamental and important in general. It consists of many aspects, such as exchange of information, communication with others, and participating as an active part in the society. It is often seen that the age-specific competence losses and loss of friends give loneliness and isolation, which becomes mental barriers. To overcome these losses systems and processes are needed to maintain social networks; support time spending with family, friends and relatives; and make it possible to be an active part in the communities. Today younger citizens use services such as face-book, twitter, and sms to create and maintain their social context, however, these services requires some technical and dexterity skills, which can be very challenging for the elderly citizens. In addition, these services do not provide the type of connectivity that is needed for physical contacts in a neighbourhood.

Solutions are researched in the EU context and in the city of Oulu where projects such as Vanhusneuvosto, Oldwellactive, EPPI-distance service, and Ubi-screen provide ways to deal with the challenges. However, by using the ISHSC system more powerful solutions can be obtained. Firstly, the AAI in the smart homes control the embedded ICT in form of media devices and it is able to provide a user interface with a high degree of usability. An example could be integrating the Dalia speech and face recognition system with the ISHSC [50]. Such a combination would offer a simple user interface that is based on simple commands and replies. Hence, using AAI to interface humans and machines offers simple access to the ICT based media devices. These devices provide services such as accessing distant relatives, friends, and caregivers. Lastly, bringing this one step further the combination of AAI with CoT provided by the smart cities makes it possible to offer new services which is integrated and anchored in the nearby society. These new services could add physical elements such as arranging and participating in neighbourhood meetings and being active in different local communities such as clubs, church, hobbies and voluntary organizations. A project that supports this vision is the STIMULATE which provides a simple interface; however, it lacks integration in a smart city context [50].

Health and home care

Health care is important for citizens in general and for elderly citizens in particular. Health care contains important elements such as fitness and wellness, which are vital elements for enabling elderly to live longer at home. Additionally, it prevents and enables early detection of diseases, which reduce their impact. Especially diseases such as heart stroke, dementia, cancer, diabetes, depression, and asthma requires monitoring and early treatment. The OMA Oulu and "Managed by knowledge" platforms are examples of projects which deal with these challenges [51], [52], [53]. Regarding the fitness and wellness activities it often requires motivation such as coaching, pre-planned activities, and feedback in form of improvement in physiological health parameters. These challenges have been addressed in the Oldwellactive project [51], [52], [53]. Similarly, the Danish organization "lev-vel" has dealt with these challenges [54] in form of research projects and suggested solutions. Three of these projects and their suggested solutions will be studied in the light of ISHSC in the following.

Project 1: organizes meeting places where elderly are attracted and motivated by using a combination of play, experiences, exercise and social contact to increases the mental and physiological fitness. Firstly, they emphasize the importance of the social element where simple things such as a cup of coffee and a "ticket to talk" can be decisive elements. Secondly, they have designed a gaming platform using floor-tiles with build-in colored light. This gaming platform supports popular games such as tick-tack-toe and many other games. Their findings are that this platform provides mental training, social interaction, and physical training in an entertaining and positive manner. Actually, Gentofte municipality performs experiments with using this platform for elderly rehabilitation at home. Lastly, they have designed a social yoga-mat that detects training activities and emits messages to the yoga-team when it is in use. Additionally, it shows when other team member trains which increases awareness about the exercises and make the team members more present.

Looking at these results from the ISHSC perspective a social element can be provided by using AAI in combination with CoT and IoT to provide simple and easy access to the ICT media devices, as discussed earlier. By using these connected media's social content can be established in form of meetings and arrangements. Examples of platforms that provide some of these elements are AGNES [50] and Caritas [51], [52], [53]. These projects provide an ICT platform that offers an easy-to-use web-based social network for individual elderly persons. Hence, the projects offer contact and shared activities with caregivers, friends, family, and friends. Comparing these platforms with the ISHSC system it is obvious that it fits the objectives of linking smart homes with a smart city, i.e. they can easily be integrated into the ISHSC system. In addition, an ISHSC system offers a possible to include different home training activities similar to the gaming platform and the yoga-mat. These activities can be performed in either an interactive social context based on ICT media's linked together by the CoT network or by playing against the AAI system.

Project 2: offers preventive self-monitoring which gives access to own health state and treatment, so the elderly are able to prevent problems and take actions in time. This makes it possible to increase own life-quality, functional level, and self-reliance. For performing this study a platform named SELMA was constructed by the "lev-vel" organization. It provides a portable monitor which can measure different medical data and transfer them to a presentation device, which presents the data in an individually adapting and motivating manner. A similar system is AMICA [50]. It offers the same

functionality as SELMA but focuses more on medical self-auscultation.

Focusing on the combined ISHSC system it is able to integrate and support platforms like SELMA and AMICA with artificial intelligence and thereby provide capabilities to analyze medical data and present these in an understandable form. Furthermore, out-of-range data can be recognized and send to hospitals, doctors, and caregivers, which brings the concept of telemedicine into the homes of the elderly citizens.

Project 3: supports the elderly to take their medication by reminding and provide improved understanding of the medication. This provides increased freedom and security in taking the medicine. Their study found that elderly accept the use of new technology if there is a plausible reason and some benefits in doing this. One of their successful solutions was a reminder system that uses awareness actuators such as flashing light, voice, and phone calls [54].

A similar solution can be implemented by using the ISHSC system where its AAI part raises alarms in form of audio, light, or by using ICT devices. Alternatively, it uses CoT technology to inform close living friends, caregivers, or relatives, which then take care.

Supply with daily goods and chores

Supply with daily goods and chores are everyday activities for most citizens. However, for elderly these tasks can be burdensome since the competencies needed decrease in line with the aging processes. Consequently, there is a need for supporting these activities [49]. A project that deals with these challenges is the NACODEAL [50]. It offers a technology wizard which assists with online shopping. In addition, it offers services based on augmented reality that supports daily activities. Similarly, the Arina service [51], [52], [53] in Oulu offers ordering groceries online and get them delivered.

The ISHSC system can integrate and support these project elements by using a wizard, which is anchored in the AAI system part. Alternatively, shopping activities can be organized at the smart city level, i.e. the CoT level. Hence, creating a cloud service that organizes joint purchases of goods provides benefits in form of cheap delivery, low prices, and the possibility to share purchased items.

Safety

Safety, privacy and security are important needs for elderly citizens, as well as for citizens in general. Especially, having control and a clear visibility of whatever occurs in the home is important. Hence, privacy and reliability of assistive technologies are important for achieving thrust. These technologies must address security elements and must focus on the typical fear factors such as burglary, falling, leave the house at night, lock doors, and forgetting to switch off equipment. The city of Oulu has some pilot project that deals with these challenges by using sensors to monitor the smart home [51], [52], [53].

By addressing these challenges with the ISHSC system it is possible to supervise the smart home in an intelligent way. The AAI part in the ISHSC system is able call for help (e.g. from neighbors), police, and security companies in the case an abnormal or unwanted situations occurs.

Besides the discussed services the ISHSC system offers a multitude of other service-types such as: common information server (CoT based) that partly updates automatically based on AAI observations, AAI organizes and recommends common shopping, AAI can schedule activities such as looking after children, pets, etc., AAI is able to recommend social relationships (like LinkedIn), AAI detects unusual behavior like an elderly person has fallen, within telemedicine AAI supervises behavior and informs caregivers, calls emergency teams, etc.

This smart city ICT based infrastructure has some challenges in the form of security, privacy, costs, usability, user involvement, and the fact that the AAI does not exist. However, these are manageable with today's technological abilities.

Summing up, the suggested ISHSC based infrastructure provides new services for elderly citizens in form of providing an intelligent connected platform that is based on smart homes integrated into a smart city concept. This platform offers support for important areas such as social contacts, health and home care, supplying daily goods, and handle safety issues. Thus, it provides an efficient environment for the elderly citizens to live in, it provides a high quality of life, and it provides a high degree of independence, autonomy, and dignity. Additionally, these factors reduce the barriers provided by the aging process and they reduce social isolation.

XI. CONCLUSION

As a conclusion we can state that urban demographics require new approaches to services; therefore action must be taken on city essential elements properly addressed with a strategic vision providing the country with a shared identity, promoting the initiatives under an overall plan and communicating it.

Population aging generates many challenges not only about the future economic growth but also about healthcare and the well-being of people. Moreover the proportion of elderly people in the cities is increasing. So, it is necessary to create the cities that are aware of the specific needs of aging population to support independent elderly living. Using ICT in a smart city/home context can provide personalized health care, social services and intelligent community services.

Oulu already has different organizations and initiatives developing smart city solutions, but a unified vision and further developments are needed.

In this paper we have discussed how the recent advance in ICT, and its particular components, Internet of Things (IoT), Clouds of Things, the Advanced Artificial Intelligence, can become building blocks between elderly people, smart homes and smart cities.

We have presented a brief overview of a selected number of projects within the fields of health and home care, social interaction, supply with daily goods and chores and safety. We have showed that most initiatives are focusing on reducing healthcare costs and increasing the efficiency of

robot support, monitoring for promoting independent living, and home based rehabilitation but not necessary on the new ICT services embedded in Integrated Smart Home and Smart City system (ISHSC).

By combining smart homes with smart cities, we have been able to provide an ICT infrastructure that exploits the entangled connections between the ambient assisted living, the smart homes, and the smart cities. This ISHSC infrastructure offers many advantages. Firstly, it offers the possibility to interconnect the IoTs in the individual smart homes in an intelligent way by deploying AI. Secondly, it scales well and offers easily adaptation to new technology and services such as smart grids. Lastly, the smart city CoT element offers the advantages of centralizing the distributed data into a few big-data storages, which offer new combined smart home and smart city services.

The ISHSC infrastructure provides a new platform for elderly-services, which is based on the ambient assisted living projects performed in the EU member states with particular focus on Finland and Denmark. This platform offers services in important areas such as social contacts, health and home care, supplying daily goods, and handle safety issues.

In general it is concluded that the suggested ISHSC infrastructure provides an efficient environment for the elderly people to live in, it provides a high quality of life, and it provides a high degree of independence, autonomy, and dignity. In addition, these factors reduce the barriers provided by the aging process and they reduce the social isolation problems.

In a future perspective the ISHSC infrastructure has some challenges in the form of security, privacy, costs, usability, user involvement, and the fact that the embedded AAI does not exist. However, these are manageable with today's technological abilities.

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