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ALLIANCE FOR INTERNET OF THINGS INNOVATION

AIOTI WG5

Smart Living Environment for Ageing Well

Report

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EXECUTIVE SUMMARY

This document has been prepared by the Alliance for Internet of Things Innovation (AIOTI) Working Group 5 – Smart Living Environment for Ageing Well. The purpose of the document is to provide background information and recommendations for the Internet of Things call on *Large Scale Pilot – Smart living environments for ageing well*, part of the upcoming H2020 Work Programme 2016 – 2017.

WG5 addresses the IoT support to the continuously growing population of elderly people in living longer, staying active, undependent and out of institutional care settings, while at the same time reducing the costs for care systems and providing a better quality of life for vulnerable categories of citizens. In particular, WG5 focuses on two main issues - Elderly Care and Smart Home / Home Automation supporting technologies – that can be bridged by IoT. In fact, IoT technologies are instrumental to help older people stay in their home and live longer with a good level of safety and comfort because of their scalability that supports the increasing size of the target population. IoT also paves the way to the exploitation of genomic information to improve human health. In fact, it allows the gathering of lifestyle data that are then linked via analytics with ageing pathways in cells, organs and hormonal systems.

The report includes the points of views of the end-users and the stakeholders involved in healthcare. The analysis and recommendations are centred on the individual end-user, taking into account the physical, emotional and cultural specificities of the end-users helping to adapt and change self-perception, and shift cultural norms. The group of stakeholders that have presented their views in the report are IoT technology providers and enablers (i.e. sensor/actuators, monitoring devices, communication solutions, IoT platforms, service providers, software developers and silicon vendors), IoT applications providers, IoT integration solutions providers as well as institutions representing the end users.

Suitable policies (e.g. to handle dietary and exercise problems of the population) are essential to address the problem of unhealthy ageing and need to be adapted to the various economical, societal and cultural facets of the European citizens. Nevertheless, IoT technologies can help and foster policy implementation provided that they are very easy to use and always available and, most of all, trusted. Trust can be gained, for instance, by showing that population health data are used statistically and anonymously for the common good and deliver clear and tangible short term benefits for the

individuals.

A comprehensive analysis of the currently on-going initiatives for the aging population is a formidable task. In fact, 110 European regions have identified Active and Healthy Ageing as a smart specialization priority. Regional initiatives are then complemented by national and sectorial initiatives, including public policy actions, voluntary norms and quality labels for goods and service providers, etc. At the European Commission level, several DGs are involved in Active and Healthy Ageing policy initiatives on: "Health and social care systems' transformation" (DG SANTE, DG JRC, DG RTD), "Age-friendly environment" (DG JUST) and "Fostering jobs and growth" (DG SANTE, DG CONNECT, DG EAC). Section 2 points out some of the most significant initiatives, related either to market studies or project programs addressing prevention, care or assistance use cases.

The TechnolAGE study is presented, which focuses on business and financing models related to ICT and Ageing well.

In the area of sustainable long-term care systems and, more in general, on a life course and social aspects the CARICT (ICT for caregivers and other social actors: enhancing the sustainability of long-term care and social support) project analyses evidence from social innovation good practices across the EU.

In the area of innovation, the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) has identified a number of use cases that may also be relevant for the IoT LSP on Smart living environments for ageing well, addressing: healthcare, prevention, independent living and age-friendly environments.

The Active and Assisted Living Joint Programme (AAL JP) has recognised a set of priorities, which reflect the scope of the past calls and may be also relevant for the future IoT LSP. Besides the priorities above mentioned for EIP-AHA, the AAL-JP has also addressed: social interaction, mobility and occupation of older adults.

A wider perspective that, along with innovation, embraces new business creation and education is given by some of the Knowledge and Innovation Communities (KIC), set up under the umbrella of the European Institute of Technology (EIT), in particular the EIT DIGITAL and the EIT Health. The former, under the Action Line named *Health and Wellbeing*, supports the EU 2020 challenge to increase labour participation and independent living by two years, by focusing on primary prevention. The latter promotes activities based on three main pillars, i.e. Promote Healthy Ageing, Support Active Ageing and Improve Healthcare, addressing specific business objectives: Self-management of Health and Lifestyle intervention related to the first pillar, Workplace interventions and Overcoming functional loss, for the second, Improving healthcare systems by Treating and managing chronic diseases for the third pillar.

With respect to LSP the following expected benefits have been identified by the Benchmark Study for Large Scale Pilots in the area of Internet of Things funded by the EC:

- The LSPs will build a critical mass for specifications and standards via the implementation of open platforms
- The LSPs will allow organisations to work together to validate new ecosystems and business models and create new market opportunities via direct interaction with consumers
- The LSPs will broaden the perspective of organisations to a European context and market situation

Several past and current IoT projects, funded by the EC under FP7, ran pilots that fall within the WG5 scope. Such projects collectively contribute to the IERC (Internet of Things European Research Cluster) and they have been addressed and analysed by the IERC Activity Chain 3 - Application scenarios, Pilots and Innovation.

Finally, the AALiance2 project published an AAL Roadmap and Strategic Research Agenda, based on an in-depthanalysis of the stakeholder requirements, existing standards and implementation issues, while the UniversAAL and ReAAL projects run large scale pilots that are relevant for WG5. Beside the IoT technologies adopted, the platform's features, the use cases and services addressed, it is very interesting to observe how these last two projects address the following issues:

- How an ecosystem can be built around an IoT platform and on how impacts on various ecosystem's stakeholders can be measured
- What are the implementation issues that are key to the deployment of AAL solutions and their success in the market

Standards are essential and represent an inherent challenge for dynamic environments in which a large number of complex devices need to communicate with each other as in the case for the IoT in healthcare. Therefore Section 2, referring to the ouput of WG3 on Standardization of IoT, summarizes available guidelines and international standardization activities for healthcare and assisted living.

Section 3 focuses on four technological dimensions of an IoT ecosystem, by first describing them and giving examples on how the industry has implemented them, and then by providing recommendations on specific aspects. The following recommendations are given for each of the following four dimensions:

1. **Overall architecture**

- The LSP should ensure interoperability at network, data and rules level, demonstrating as a minimum interoperability between third party devices on the LSP platform
- The LSP platform should support subtrials testing interventions in four clusters (health, habit, house automation and safety)
- Approaches for interoperability with parts of other ecosystems outside the LSP platform should be favoured
- The LSP should include as a minimum an integrated development environment (IDE) which provides tools to developers to use the ecosystem to connect devices and to develop applications and services

2. **Communication infrastructure**

- Sensors and actuators should be able to join the ecosystem easily
- The ecosystem should provide interfaces (e.g. APIs) to authorised third parties
- The communications infrastructure should support a variety of devices and protocols:
    - Low powered / High powered
    - Short Range / Long Range
    - Low bandwidth / Higher bandwidth

  It should ensure that devices which use different communications protocols are able to request and share data
- Devices, including sensors and actuators, as well as data should be available and discoverable
- Different Quality-of-Service levels should be supported
- Strict privacy and security standards need to be available, for user authentication/verification and data encryption
- The LSP should choose data semantics and ontology schemes that support interoperability and compatibility with other ecosystems
- The communications infrastructure should support data storage required for service providers to run applications and services

3. **Smart sensors and actuators**

- Sensors of the ecosystem needs to be interoperable in order to enable "Network effects", thanks to which IoT services can use data from sensors which they may not have provided themselves

4. **User interaction interfaces**

- LSP subtrials should provide User Interfaces for Primary (person directly receiving care) and/or secondary Users (e.g. carer/relative), implemented on devices such as TVs, tablets, computers and screenfree devices
- LSP subtrials should set-out the targeted user group for each User Interface; they should then provide evidence (quantitative and qualitative) on the suitability of the User Interface for that user group for the intervention being tested. Measures of usability could include: Learnability, Efficiency, Memorability, Error-rates, satisfaction, etc.

The final part of section 3 outlines a potential architecture of LSP system composed of four clusters: health, habit, house automation and safety.

- The Health cluster monitors all necessary parameters (Physical parameters such as blood pressure, heart rate, oxygen saturation, temperature, etc.; glucose; sleep; drugs; etc.) depending on people's medical pathology and has a direct access to emergency service in case of critical situations
- The Safety cluster features fall detection; toxic gas detector; Outdoor video surveillance; Security breaches;

- The Habit cluster monitors vulnerable people's habits in a way to detect if there is an abnormal behaviour compared to usual habits related to food, hygiene, social relations, room occupancy

- The home automation cluster helps elderly people taking care of their home and people under the roof, monitoring energy consumption, Heating Ventilation Air Conditioning (HVAC), Light intensity, Main door access, etc…

Finally, section 4 focuses on business models and societal acceptance. It covers the issues that need to be taken into account when addressing business models and societal acceptance aspects:

- All stakeholders should be involved in the innovation process to improve the elderly and fragile person's autonomy in their living environment while optimizing informal and professional carers working conditions, improving sustainability of the elderly care regimes while having strong economic impact for European companies

- Pilot countries should be selected in order be representative of cross- European population diversity

- The impact of a fully regulated network business model vs. an unregulated business model on to the capability to trigger the full potentials of the IoT network effects should be carefully considered

- User and usage acceptability of the proposed solutions should be taken into account as early as possible, preferably involving users (at different levels of the value chain) in co-creating the LSP

- Solutions should be usable, accessible, simple for all users

- Privacy and security aspects should be treated early in the solution design, including organizational and economic impacts

- Ethical and legal aspects should be taken into account early

- Maturity of the solution should be proven in experimental testbeds before any deployment in real-world demonstrations and field trials

Rigorous impact assessment methodologies, involving multidisciplinary teams (sociologist, gerontologist, health economics experts) should be adopted to assess the benefits of smart living environments based on IoT.

In summary, the IoT solutions should increase the efficiency of care, promote independence and improve the quality of life of senior citizens and their carers, The LSPs will strengthen the global position of European industry in IoT developments for ageing well, allowing the use of IoT platforms and tools for creation and management of integrated IoT products and services for ageing well, personalised health and energy management in the home and on-the-move. The LSP should strengthen the potential of Europe to become a global leader in the field of IoT and ageing well, including use/development of global interoperability standards in the IoT field.

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1 Introduction

1.1 Objectives and Scope

This document provides a set of information and recommendations in the context of Smart Living Environment for Ageing Well. Its main focus is on supporting older people in staying active, independent and out of institutional care settings while reducing the costs of care systems and providing a better quality of life for vulnerable citizens.

Among the following subjects, the Workgroup has focused on the items in ***Bold Italics***:

- ***Erderly Care and Health***
- Entertainment / Leisure / Multimedia
- ***Smart Home / Home Automation***
- Educational Programs Support
- Social Interaction

After summarizing the objectives of work in these areas, and explaining why IoT and ageing and health for the Silver Economy are key priorities for the European Union, the document presents and details the main existing and on-going initiatives in Europe and sets-out a set of recommendations for the design of the upcoming H2020 2016-2017 Large Scale Pilots. The document will conclude with a set of comments and suggestions related to the business models and user acceptability.

1.2 Background summary

The population of older adults will dramatically increase over the coming decades. The population aged 70+ will increase from 64 million in 2010 to 122 million in 2060 **[1]**. As the population ages, health care expenses will inevitably increase having a knock-on impact on public expenditure. Infrastructures are required to take care of elderly people for every day assistance and monitoring. Public expenditure for long term care (LTC) is forecast to double between 2010 and 2060 for almost all EU27 countries **[1]**. Solutions are therefore needed to reduce these costs, whilst also providing benefits for both vulnerable and elderly in their everyday life and to boost the silver economy ecosystem.

As they get older, people will require more assistance and regular monitoring in most cases. People will inevitably use more hospital services or nursing homes on a long term basis with higher costs both for elderly and their families and also public authorities. Technologies available today could help older people to stay in their home for longer with a good level of safety and comfort.

1.3 Forces driving the EU priorities in IoT for ageing and health in the Silver Economy

A primary goal of the H2020 programme in health innovation is achieve two extra healthy life years, or 2 HLY, for the population. This is not a goal for greater life span, but when HLYs are increasing more rapidly than life expectancy of a population, then not only are people living longer, they are also expect to be healthy for a greater portion of their lives. Based on the 2 HLY policy ageing and living creates a sustainable ageing society via the Silver Economy. The focus deployment of H2020 for the 2 HLY goals must be to improve healthy life years, to promote a sustainable ageing society whilst at the same time to gain the people's engagement to living both a healthier & a longer life.

Independent Living as a goal - a right each citizen is entitled to expect as an equal treatment for all - is a heavy burden on the healthcare systems with rapidly ageing populations, and demands more intensive care due to the impact of chronic diseases, combined with a rapid growth in treatment costs. Analysis suggests that around 3% of the population are responsible for 50% of healthcare costs, and close to 95% of all costs are incurred for to healthcare for 1/10th of the population. Rising dementia requiring long term care is a topic high on the health system agenda, while influencing the HLY expectancy for high risk families is challenging due to poor communication on the risks involved.

Loss of HLY in an ageing population is often due to modern lifestyles, giving rise to chronic diseases, reducing social life and productivity, while ultimately shortening lifespan. The problems of modern lifestyle (for e.g. poor diet, lack of exercises, too much TV, or stress) are well documented.

The WHO gives clear recommendations when it comes to ageing well, such as reducing sugars in diets, optimized diets for hypertension, and more exercise. The condition is jointly called metabolic syndrome, and is recognized by the WHO and the EU as the problem in a "Modern" ageing population.

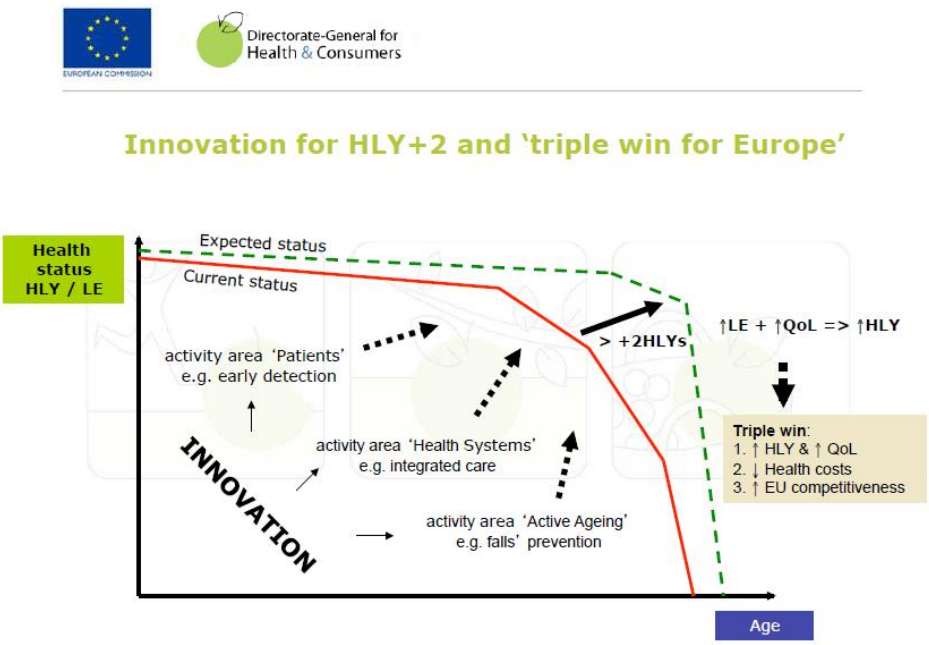

Figure 1.1: Innovation for HLY+2 and 'triple win for Europe'

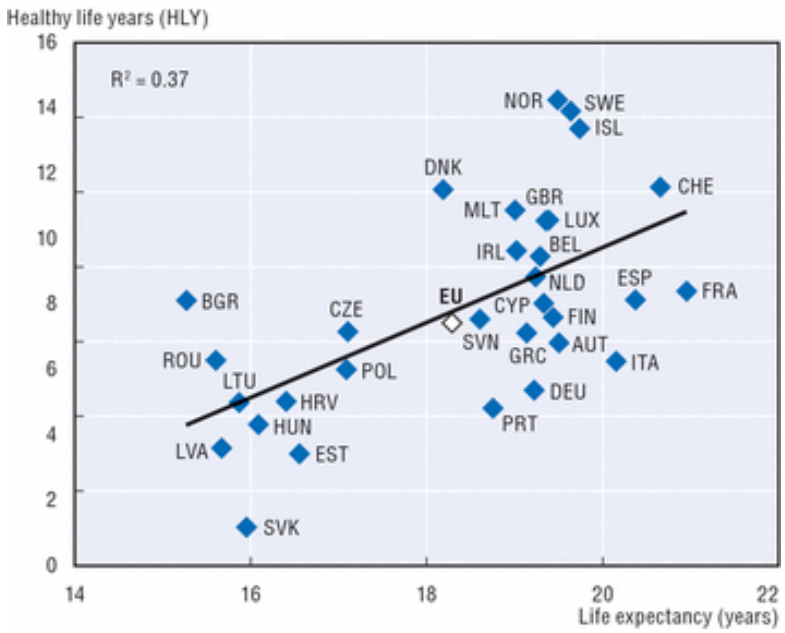

Figure 1.2: Healthy Life Years (HLY) vs. Life Expectancy

Inequality of health and lack of capability to live independently is clearly a bottleneck to the economic regeneration of the EU. The World Bank has warned that Eastern Europe must address the health of a population that wish to retire too early, due to high prevalence of CVD diseases. CVD disease is avoidable and treatable, and the dementia considered a greater burden can similarly be avoided, by measuring metabolic syndrome, (origins of CVD and dementia in the population). At this time 1 out of 3 in the population is either diagnosed with metabolic syndrome, or has a silent form of it such as undetected hypertension. Thus, the state of health in a population can be best measured by focusing on metabolic syndromes with a set of clear and staged health actions attached to it in order to fight the consequences of such modern lifestyle. If not changed, this lifestyle often results in an early progression of those diseases (as displayed in the Chronic Quadrangle below).

A policy to handle dietary and exercise problems of population is essential to address the problem of unhealthy ageing and subsequent obesity and hypertension issues.

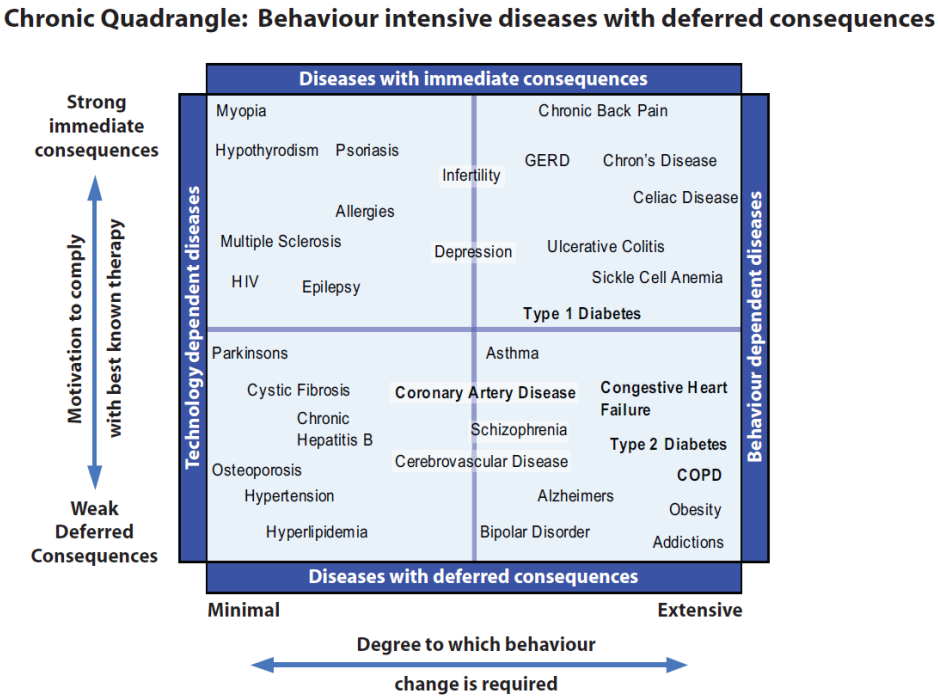

Figure 1.3: Chronic Quadrangle

1.3.1 Implication of HLY+2 for EU

Rich and well-educated populations are the spearhead of innovation in health; they live longer and are more productive due to better use of resources - such as pensions, better knowledge of how to live a healthy lifestyle, and better health services. Well-educated populations can also influence regional and national policies. The poor and unhealthy populations need effective health policy, which provide scalable solutions to their health problems and they should benefit from the trickle-down of affordable health technology. Only the IoT can provide the scaling of health services to individuals living independently at home. Regional health systems can play a major role in developing policies that motivate the population to 2 HLY via a better diet and more exercise.

1.3.2 Active Ageing Index policy instrument

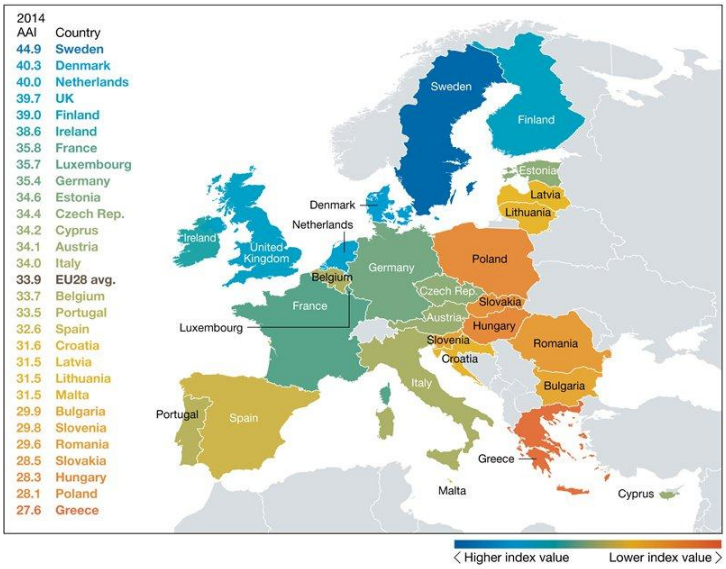

Figure 1.4: Active Ageing Index (AAI) Across Europe (2014)

It is clear from the analysis of the Active Ageing Index (AAI) that a European solution to health in ageing is possible, a European solution which is well demonstrated in North Europe. At the same time the index gives a clear example of the negative economic spiral that can engulf a region or a whole nation if the government policies fail. Even a population with strong potential for long lives can be made unhealthy in ageing, by decades-long exposure to modern

lifestyles and lack of policies to promote work and health in ageing. The AAI analysis framework should be promoted as a way to develop and evaluate new policies to deal with region-specific issues, and to coordinate use of H2020 innovation . Active Ageing Index, or a similar analytic has to be the measure of a successful ageing policy at regional level.

1.3.3 Silver economy as Innovation policy

In the regions where the influence of older adults on government policy is well established it has been effective, then the Silver Economy emerges as a natural process. Typically an analysis of the AAI index can be used to correct policy mismatch to the needs of a Silver Economy. AAI can be used to steer regions to innovations to health in ageing where the process has yet to achieve the results in economic success and the HLY windfall.

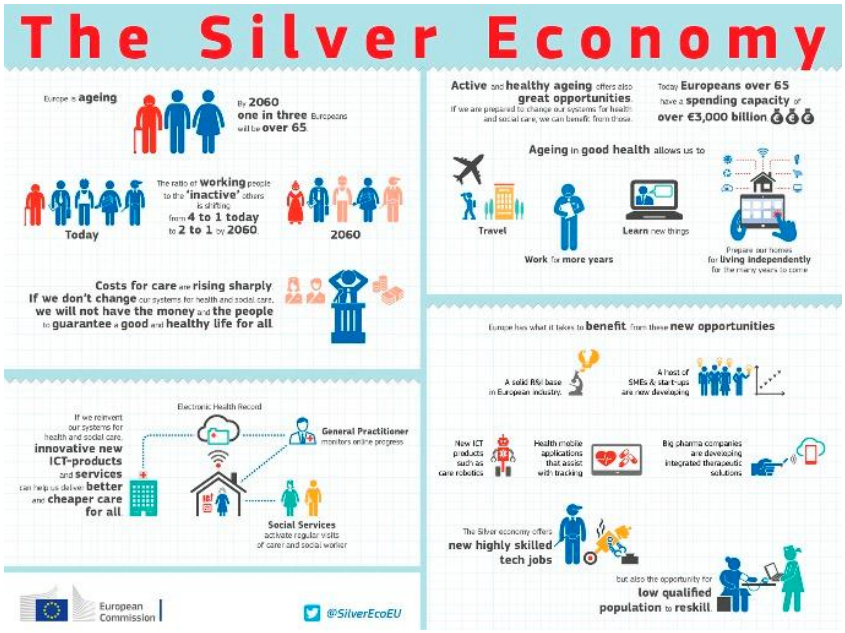

Figure 1.5: The Silver Economy

1.3.4 Role of the IoT to improve health in ageing

Analysis shows that the potential of IoT to improve health is high but IoT must be unified in its services or the potential gains will not emerge. For IoT to be used to improve health there must be a high level of trust in the technology and it must be very easy to use. Also the users must trust that the services can be used all the time, that analytics of the population's health will be used for the common good, and for clearly visible short term individual benefit. Such benefits must be in tangible health improvements, reduced pain, less frustration, better mobility, less absence from work or social life. Poor focus and delivery of IoT in the health sector has the potential to create enormous waste and discourage investment.

1.3.5 Role of IoT to improve in independent living of fragile person

Among Europe but also the US and Japan, all countries are experiencingsevere problems concerning the sustainability of their elderly care regime(s). National strategies to reduce the overall cost of eldercare include the promotion of care at home - which is intended to delay institutionalization
Care at home rather than in hospital, nursing homes or old-peoples' homes, is often related to increased 'care in the community'. Care at home is typically done by providing more support services to investing in new forms of residential care and the adoption of new technology and innovation to postpone institutionalisation. The shift to home care, and the consequent delay in institutionalisation, requires reorganisation of the entire care chain through redefinition of the services necessary to assist the elderly at home, reallocation of investment and infrastructure among hospitals, nursing homes, community services and (smart) houses, the skills required in each segment, the right mix of support services for home- and community-based care. With health services more dispersed in the community, closer coordination between home care and home nursing activities will be necessary to guarantee the continuity of care and to assist the carer by means of the various support measures. IoT solutions will be part of technical solutions to support and foster such reorganization providing more services and help coordination among dispersed carers.

1.3.6 Motivation of the regional health innovation

Regional health programmes need a clear narrative and a vision for the people based on an original regional culture that moves them away from a life style of poor diet, lack of exercise and poor social contact. Concepts such as BlueZones allow regions to focus on strengthening the concept that any society has to improve diets and return to more active lifestyle, where services to the community promote active ageing. If this is then coupled to regional centres of excellence in health care in ageing the contribution to a European solution can be created.

1.3.7 Role of Data Analytics and IoT

Since 2003, the potential for healthcare system to exploit genomic information to improve human health has risen exponentially. For example in the last five years genetic contribution to active ageing has been accepted by the medical community for the APOE and FOXO3A genes. Greater understanding of the genetics and epigenetics of ageing is driven by an exponential growth of technology for genomic and metabolomics analysis. Linking ageing pathways in cells, organs and hormonal systems via analytics of lifestyle in diet and exercise is still needed, and the 2014/5 PHC programme of H2020 intends to promote scientific excellence in applied genomics. Firstly to be able to steer policy makers to changes of lifestyle using services from IoT based health innovations, and secondly to guide research into advanced precision treatments for condition beyond lifestyle changes. A number of regions within Europe such as Iceland and England have on-going large scale population health genomics, such as a biodata bank of detailed genomic data, these can be best exploited by linking these banks to health-based IoT health state surveillance in polypharmacy and lifestyle management.

1.4 Living environment for elderly people

Care at home rather than in hospital, nursing homes, is intended to delay institutionalization and to match the preferences of the elderly person. The “Senior Living” market includes different segments and offers addressing different populations and needs. Elderly people entering in frailty will for many of them experiment different “living environment”. The expectation is to keep people independent living as much as possible, limiting and shortening the period in medicalized institutions.

The older adult population consists of a wide non homogeneous population in term of autonomy and frailty. Functional limitations are the result of interaction beteween health condition, body impairement with environmental and personal factors.

Several methods and scales have been developped by medical teams to evaluate and classify person autonomy taking into account the person’s ability of funtionning.

- Katz Activity Dayly Life (ADL) and Lawton Instrumental Activities of Daily Living Scale (iADL) are methodologies to evaluate fonctionnal autonomy of persons.
- The SMAF Functional Autonomy Measurement System was developed by a Sherbrooke Health Expertise Centre, to evaluate and quantify person’s functional autonomy which includes social aspects to take into account that Social functioning might have a substantial impact on health and functional autonomy [30].
- The clinical frailty scale which classifies the different level of depency whatever cause physical or cognitive.

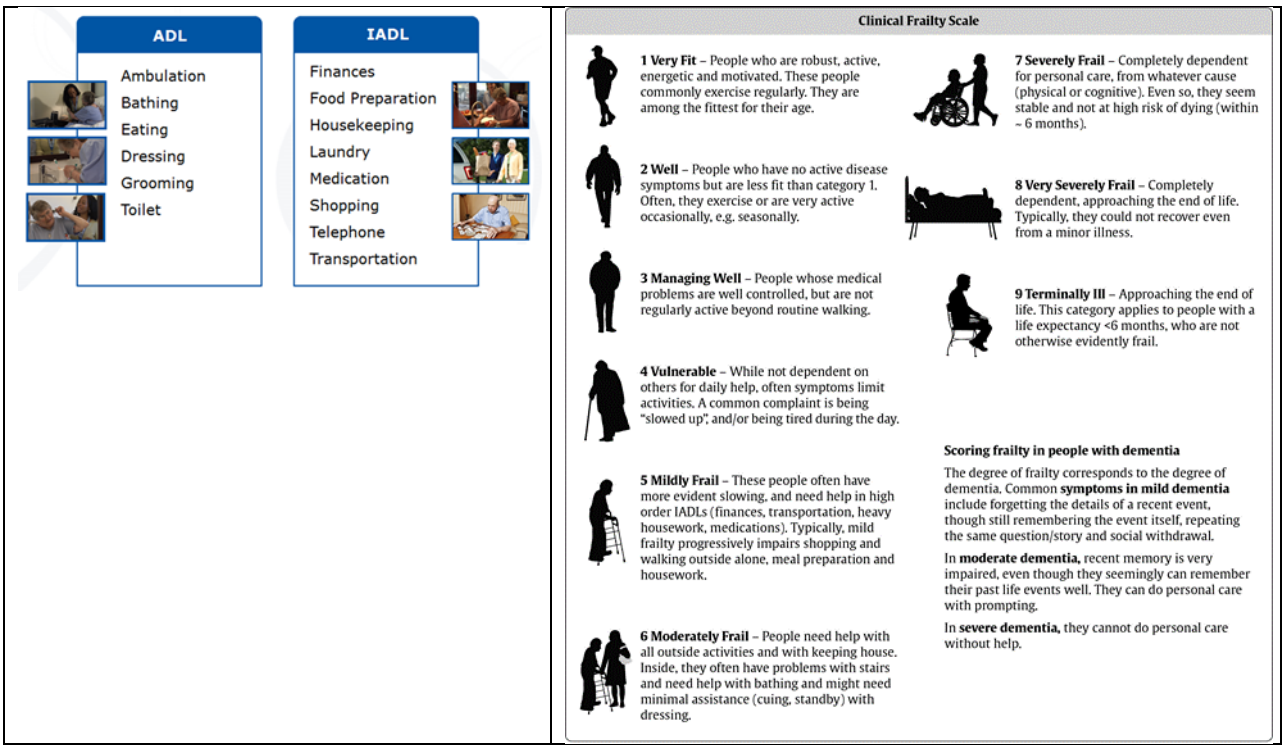

Figure 1.6: Clinical Frailty Scale

IoT solutions could help detecting before people become frail and anticipate adapted care to avoid people falling in the disability zone.

Senior Living continuum: The type of living situation for elderly is also diverse and the services to be provided through the Iot platform will depend to both factor autonomy of the persons and type of living

Independent living

- Individual Home
- Residential home for elderly or mixed population

Institutionalized living

- Nursing Home
- Hospital

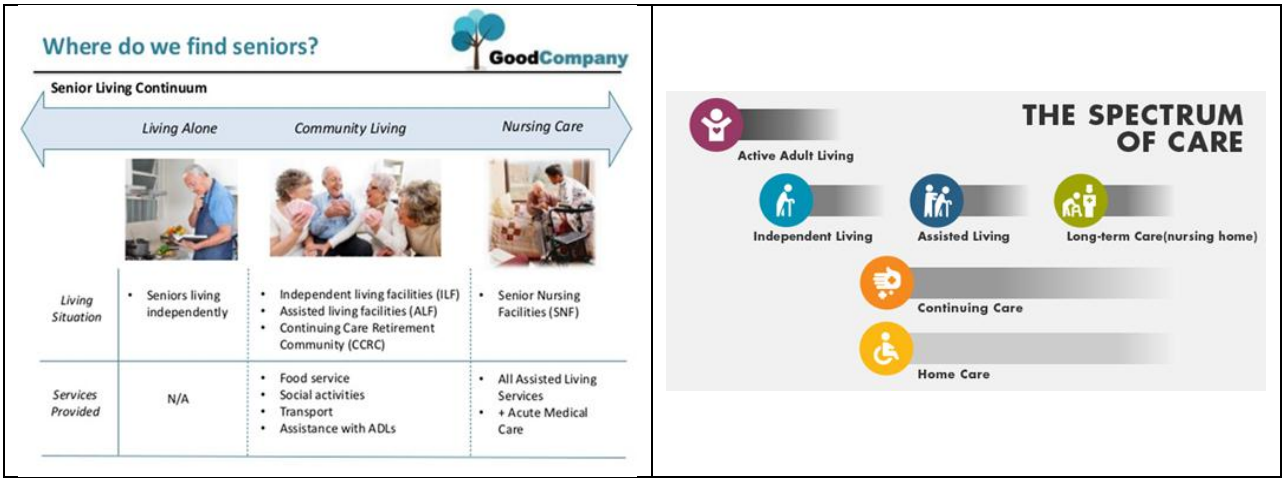

Figure 1.7: Senior Living Continuum

Deploying IoT solutions will depend on the selected use case and market segment. As illustrated in graph below showing the cost of the living solution for elderly with different level of care

http://www.seniorliving.org/infographics/senior-living-type-versus-cost/

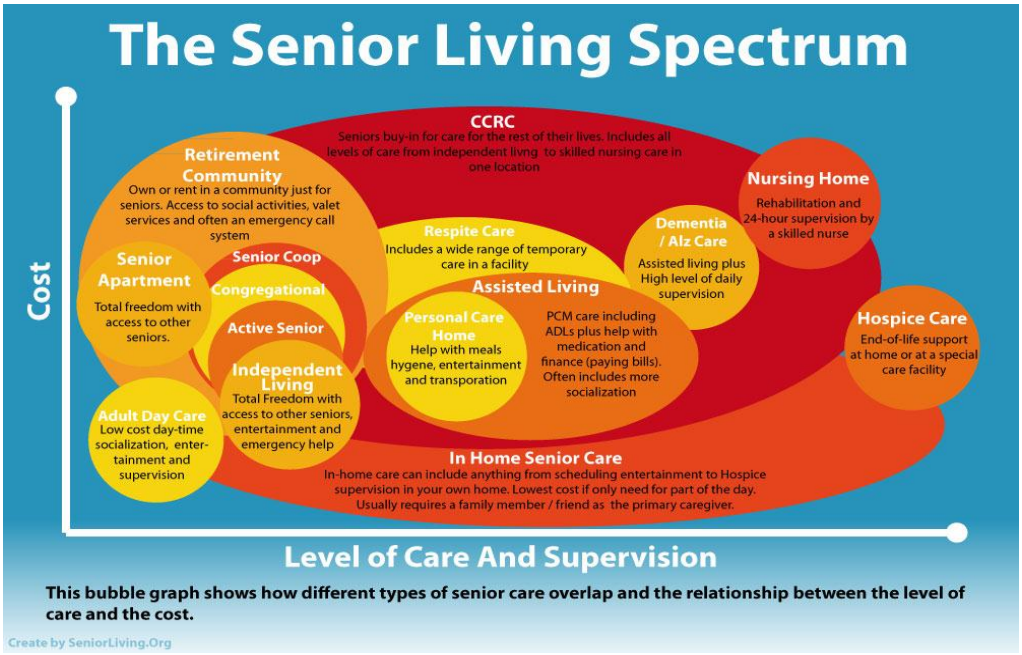

Figure 1.8: The Senior Living Spectrum

2 Mapping of existing initiatives in the relevant area of the WG5

Population ageing is a long-term trend which began several decades ago in the EU as well as in the rest of the world. This has started to impact on the sustainability of traditional health and social assistance services and it has stimulated the development of R&D programs addressing challenges, such as increasing the average healthy lifespan, prolonging the independent living and developing a Silver Economy. In Europe, where the costs of health and social care will rise substantially to about 9% of EU GDP in 2050 [7], great investments have been dedicated during last decade to support the development of innovative ICT solutions to support older adults in their daily life and addressing heterogeneous use cases. At the same time, considerable standardization efforts were carried out at different levels (e.g. communication protocols, security, user interfaces, etc.) and for different kinds of services (e.g. smart home, e-health, etc.).

The large scale project has to be based on the relevant initiatives that have been launched during the last years such as: Innovate Medicines Initiative 2 (IMI2), the Active and Assisted Living Joint Programme (AAL2), the European and Developing Countries Clinical Trials Partnership 2 (EDCTP2), the European Innovation Partnership on Active and Healthy Ageing, the new Knowledge and Innovation Community on Healthy Living and Active Ageing, and the Neurodegenerative Disease Research Joint Programme (JPND).

This chapter does not attempt to present a comprehensive description of the current initiatives relevant for the aging population, but it rather aims at proving a pointer to the most significant initiatives, related either to prevention, care or assistance use cases.

2.1 Programs and initiatives promoted by the EC

2.1.1 *Overview*

The EC is already pursuing policy initiatives relevant to the Active and Healthy Ageing of European population and to the Silver Economy, in particular on:

- New markets such as renovation of building stock for independent living, and low-season (senior) tourism;
- Sustainable long-term care systems, and, in general, on a life course and social investment approach to social protection systems and services;
- Innovation at EU-scale for active and healthy ageing through (via the European Innovation Partnership on Active and Healthy Ageing [EIP on AHA] and the Active and Assisted Living Joint Programme [AAL JP]) [8].

The development of new skills and entrepreneurship meeting the needs of an ageing population is supported by a new Knowledge and Innovation Community on Healthy Living and Active Ageing under the European Institute of Technology (EIT-Health) while also European Regional funding plays a role, since 110 European regions have identified Active and Healthy Ageing as a smart specialization priority. They are complemented by national and sectorial initiatives

that provide examples for public policy actions, including voluntary norms and quality labels for Silver Economy goods and service providers, which could contribute to competition and cross-border market exploitation a European scale.

As a matter of fact, the region of Galicia, in the northwest part of Spain, has one of the highest percentage of elderly (65 or older) in Europe and faces increasing rates of chronic disease. The importance of Galicia's healthcare public sector, whose expenditure makes up approximately **40% of the region's total public budget**, prompted regional authorities to foster innovation through two iconic programmes, Innova Saúde and H2050 [1], involving the spending of € 90 million between 2012 and 2015 [2]. The services resulting from two of the funded projects, "Digital Home" and "Hospital at Home", were aimed at improving patient-centred care supported by ICT technology, which favourably positions this region as an attractive living lab for LSPs.

Several DGs are involved in ongoing and new Active and Healthy Ageing (and silver Economy) related policy initiatives on "Health and social care systems' transformation" (DG SANTE, DG JRC, DG RTD), "Age-friendly environment" (DG JUST) and "Fostering jobs and growth" (DG SANTE, DG CONNECT, DG EAC). Some of these initiatives are described in the following parts.

2.1.2 *Study on Business financing models related to ICT for ageing well*

This Study on business and financing models related to ICT and Ageing well (i.e. the TechnolAGE study) conducted by Ernst & Young and the Danish Technological Institute for DG CONNECT, aims to show that ICT for ageing well is an area worth investing funds on, and that it is capable of generating a return on investment.
Therefore, the overall scope of the project involves the following, and the articulation of this scope into concrete project objectives is depicted in Figure 2.9 [9]:

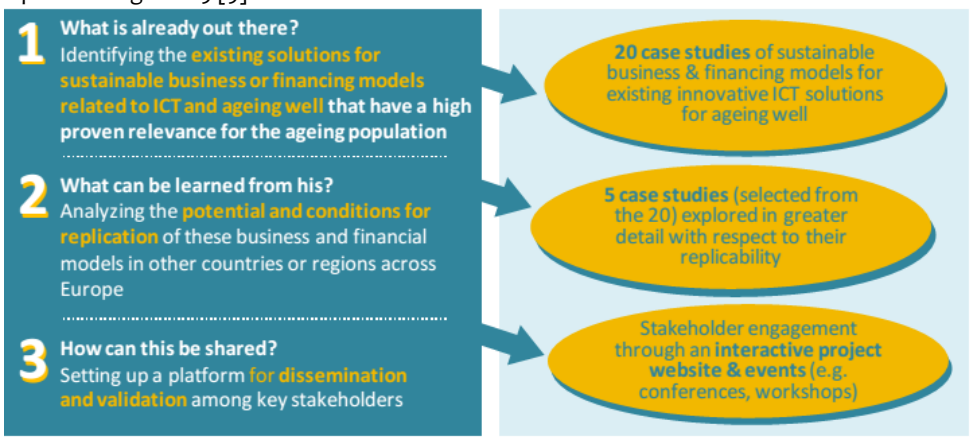

Figure 2.9 – Scope of the TechnolAGE study

- Identifying existing solutions for sustainable business or financing models related to ICT and ageing well, selected with a clear focus on support to active and independent living of older individuals and/or support to formal/informal carers (excluding institutional healthcare settings);
- Analyzing the potential and conditions for replication of these business and financial models in other countries or regions across Europe;
- Setting up a platform for dissemination and validation among key stakeholders.

2.1.3 *Analysis of Evidence from Social Innovation Good Practices across the EU: CARICT Project Summary Report*

This project summary report presents evidence-based results on the potential of ICT-enabled domiciliary care services to improve the lives and health of elderly people and of their informal carers. The report also looks at the impact of these services on other services and care systems. The final goal is to make policy recommendations as to how they could be developed, and how their scalability, replicability and transferability could be improved in the European Union (EU).

These results emerged from the study on 'ICT for caregivers and other social actors: enhancing the sustainability of long-term care and social support' (CARICT). This research project was conducted in 2011 and co-funded by the Directorate General for Communications Networks, Content and Technology (DG CNECT) and the Institute for Prospective and Technological Studies of the Joint Research Centre (JRC-IPTS) of the European Commission. [10]

2.1.4 *IoT Benchmark Study -Final Report*

This report identifies and benchmarks possible use cases for future Large-Scale Pilots (LSPs) in the domain of the Internet of Things (IoT) to be included in the next Horizon 2020 work programme. The study reports on valuable use cases for potential LSPs, identifies the key players in the value chain that could team up for deployment and makes recommendations for an LSP deployment strategy to ensure maximum impact. Based on the benchmark scores, the following top-5 use cases are proposed for the Large-Scale Pilots:

- Multi-modal mobility and smart road infrastructure
- Smart agriculture and food traceability
- Energy savings at home and in buildings
- Smart assisted living and wellbeing
- Worker safety

A relevant point about the expected benefits achievable by the deployment of LSPs in the area of the Internet of Things is also presented. They are identified as follows [11]:

- The LSPs will build a critical mass for specifications and standards via the implementation of open platforms ;
- The LSPs will allow organisations to work together to validate new ecosystems and business models and create new market opportunities via direct interaction with consumers ;
- The LSPs will broaden the perspective of organisations to a European context and market situation.

2.1.5 *IERC –Cluster Book 2015: Building the Hyperconnected Society – IoT Research and Innovation Value Chains, Ecosystem and Markets*

The book provides insights on the state-of-the-art of research and innovation in IoT and exposes to the progress towards the deployment of Internet of Things applications.

The IoT is considered as a vital instrument to interconnect devices and to act as generic enabler of the hyper-connected society, with great potential to support an ageing society, to improve the energy efficiency and to optimise all kinds of mobility and transport. In particular, the Cluster Book lists the several uses of the IoT for smart Health, Wellness and Agein Well. The IoT can be used in clinical care where hospitalized patients whose physiological status requires close attention can be constantly monitored using IoT-drive, non-invasive monitoring. In addition, the technology can be used for remote monitoring using small, wireless solutions connected through the IoT. These solutions can be used to securely capture patient health data from a variety of sensors, apply complex algorithms to analyze the data and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations.

The links between the many applications in health monitoring are:

- Gathering of data from sensors
- Support user interfaces and displays
- Network connectivity for access to infrastructural services
- Low power, robustness, durability, accuracy and reliability [12]

2.1.6 *European Innovation Partnership on Active and Healty Ageing (EIP-AHA)*

The **EIP-AHA** is a cooperation of EU, regions, industry, research institutions and healthcare professionals, aiming at increasing the average healthy lifespan by two years by 2020. Beside this global goal, the initiatives aim at:

- Enabling EU citizens to lead healthy, active and independent lives while ageing
- Improving the sustainability and efficiency of social and health care systems
- Boosting and improving the competitiveness of the markets for innovative products and services, creating new opportunities for businesses

This will be realised in the three areas of prevention and health promotion, care and cure, and active and independent living of elderly people.

EIP-AHA has defined **six thematic Action Groups**, where the partners implement, share and scale up innovative solutions that meet the needs of ageing population. These are:

- Prescription and adherence to medical plans.
- Personalised health management and falls prevention
- Prevention and early diagnosis of frailty and functional (with first action focused on malnutrition)
- Replicating and tutoring integrated care for chronic diseases, including remote monitoring at regional level
- Development of interoperable independent living solutions
- Innovation for age-friendly buildings, cities & environments

2.1.7 H2020, challenge: Health, demographic change and wellbeing

Among the challenges of Horizon 2020, the SC1 "Health, demographic change and wellbeing" is the one that is closer addressing the the ageing population issues and opportunities, as witnessed for example by the topics addressed by the call 2014-2015 [13]:

PHC 17 – 2014: Comparing the effectiveness of existing healthcare interventions in the elderly
PHC 19 – 2014: Advancing active and healthy ageing with ICT: Service robotics within assisted living environments
PHC 20 – 2014: Advancing active and healthy ageing with ICT: ICT solutions for independent living with cognitive impairment
PHC 21 – 2015: Advancing active and healthy ageing with ICT: Early risk detection and intervention
PHC 22 – 2015: Promoting mental wellbeing in the ageing population
PHC 25 – 2015: Advanced ICT systems and services for Integrated Care
PHC 26 – 2014: Self-management of health and disease: citizen engagement and mHealth
PHC 27 – 2015: Self-management of health and disease and patient empowerment supported by ICT
PHC 28 – 2015: Self-management of health and disease and decision support systems based on predictive computer modelling used by the patient him or herself
PHC 29 – 2015: Public procurement of innovative eHealth services

In addition this program has been contributing to European and international initiatives such as:

HCO-01-2014: Support for the European Innovation Partnership on Active and Healthy Ageing,
HCO-02-2014: Joint Programming Initiative "More Years, Better Lives - the Challenges and Opportunities of Demographic Change"
HCO-05-2014: Global Alliance for Chronic Diseases: prevention and treatment of type 2 diabetes
HCO-17-2015: Towards sustainability and globalisation of the the Joint Programming Initiatives on Neurodegenerative Diseases.
Among the activities not included in the 2014/15 work programme, that are part of the 'Health, demographic change and wellbeing' challenge its worth to mention the Active and Assisted Living Program [16]

The SC1 is not the only challenge related to services for the ageing population; for example in the call 2014-2015 of the LEIT - "Information and Communication Technologies", some of the topics refer to the use of IoT to develop assistive services for older adults, in particular:
ICT 1 – 2014: Smart Cyber-Physical Systems
ICT 2 – 2014: Smart System Integration
ICT 23 – 2014: Robotics
ICT 24 – 2015: Robotics
ICT 30 – 2015: Internet of Things and Platforms for Connected Smart Objects

2.1.8 AAL Join Programme (AAL-JP)

AAL Joint programme [16] includes 19 EU member states and 3 associated non-EU countries (Norway, Israel, Switzerland). The priorities of AAL-JP can be identified with the topics of the past calls:

1. Prevention and management of chronic conditions (e-health/telemonitoring)
2. Advancement of social interaction of elderly people (prevention of loneliness and isolation)
3. Advancement of older persons' independence and participation in the self serve society.
4. Advancement of older persons' mobility (orientation and navigation and assistive technology inside and outside the home)
5. Home Care (enabling older adults to live independently, and support informal carers)
6. Supporting paid or voluntary work in life of older adults

In addition AAL-JP carries out a number of Support Actions, aimed at supporting the development of the AAL market in Europ. These include for example support to the deployment, Market Observatory, communication of AAL-JP results, etc. Among these initiatives, the Action 4 about Standard and Interoperability collected about 300 use cases from the FP6 and FP7 projects and clustered them in to seven representative use cases:

- Behaviour monitoring
- Calendar service
- Social interaction with Smart TV
- Shopping and nutrition planner
- Mobility assistant
- Personal trainer
- Environmental health monitoring and alarm

The report entitled 'A Study concerning a Market Observatory in the Ambient Assisted Living field' (2014) considers, that the AAL is evolving towards an "umbrella" market, rather than a single consolidated market, assembling a wide variety of products and solutions. While this shift from a predominantly public market to a consumer-centric and private market is becoming more visible, there is still no clear shared definition of the AAL market scope as a whole and multiple taxonomies abound." Silver Economy is a cross-section market that encompasses diverse sectors like health, mobility, ICT, nutrition or housing. Broadly speaking, the AAL market includes ICT- based solutions for ageing well at home, in the community, and at work, thus increasing the quality of life, autonomy, participation to social life, skills and employability of older adults. These ICT solutions will be mainly coming from the development in the IoT technologies. The AAL market classifications include segments such as: Telecare (daily routine monitoring), telehealth (vital sign monitoring) and access to care (i.e. Health Care (doctors, nurses, *entourage*), Wellness & Lifestyle (sport/wellness…) and Social Care (social events…). An EU study (ICT enabled independent living for elderly" A status-quo analysis on products and the research landscape in the field of Ambient Assisted Living (AAL) in EU-27 - Dr. Katrin Gaßner, Michael Conrad, VDI-VDE) looking at AAL technologies produced a classification that match quite accurate the layers into the IoT generic architecture (i.e. Devices that compensate sensory impairments, Communication devices, Telemedicine and telemonitoring, Smart home and daily chores products, Medical assistive technologies, Safety and security products, consumer electronics/multimedia).

2.1.9 European Institute of Innovation & Technology

EIT (European Institute of Innovation & Technology) is a body of the European Union aimed at enhancing Europe's ability to innovate to provide solutions to rapidly emerging societal problems.

EIT Digital [17] is a KIC (Knowledge and Innovation Community) of EIT, which has been working since 2010 to foster digital technology innovation and entrepreneurial talent for economic growth and quality of life in Europe. One of its Action Lines, namely Health and Wellbeing, supports the EU 2020 challenge to increase labour participation and independent living by two years. Its focus is on primary prevention areas where regulation barriers are less strict. In 2014 this Action Line achieved results in two activities: the Cognitive Endurance and Virtual Social Gym. In 2015, in the area of Mental and Social Wellbeing, they are developing a platform that offers social health games encouraging families to stay active socially, mentally and physically, including older adults.

EIT Health [18] is a KIC (EIT Knowledge and Innovation Community) based on a strong partnership made by industry and academia and it promotes entrepreneurship and develops innovations in healthy living and active ageing. It is composed by 52 Core Partners and 92 Associated Partners, with 6 Co-location Centers and 6 InnoStars region in Wales, Portugal, Poland, Hungary, Slovenia and Coratia.

EIT Health will cover the continuum of health by a multidisciplinary and cross-sectoral set up spanning Pharma, MedTech, ICT, Imaging & Diagnostics, Consumer/Lifestyle Products, Payers. Top European Universities and research institutes (medicine, technology, engineering and business) are involved together with 37 TTOs, 39 incubators and 20 VCs / funds also investing on infrastructures, such as test beds and living labs.

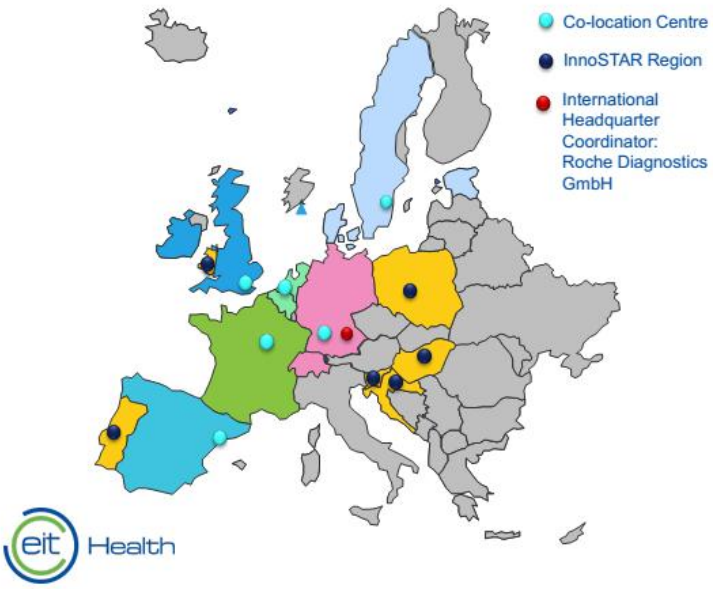

Figure 2.10 – The regional structure of EIT Health across Europe

The EIT Health is based on three main pillars, with specific business objectives:

- Promote Healthy Ageing:
  - Self-management of Health
  - Lifestyle intervention
- Support Active Ageing
  - Workplace interventions
  - Overcoming functional loss
- Improve Healthcare
  - Improving healthcare systems
  - Treating and managing chronic diseases

Figure 2.11 summarizes the challenges of Eit Health (in green boxes) and some example of project ideas (in blue boxes):

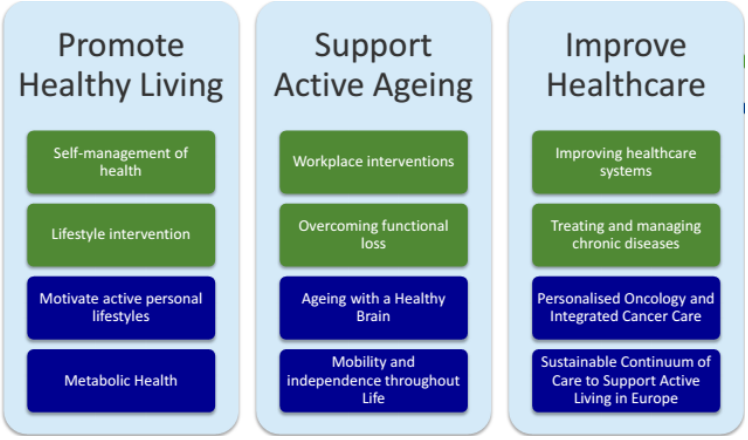

Figure 2.11 – Challenges and Projects of EIT Health

2.1.10 FP7 Projects

IERC AC3

In the context of the *European Research Cluster on the Internet of Things* [19], eight Activity Chains have been created. The aim is to foster synergies between projects dealing with IoT in order to create cooperation and a virtuous exchange of ideas on the most important research challenges.

Some of the pilots developed by FP7-funded projects have been analyzed within the IERC *Activity Chain 3 - Application scenarios, Pilots and Innovation* and are briefly described below. They address innovation in healthy living and active ageing.

Project - ClouT (status: on-going at the time of writing) [20]

Pilot - Mitaka field trial: Paw collection [21]

This application helps motivate elderly citizens to go out by providing interesting information such as event or city information provided by citizens, stores, event organizers and city. A Social Network Service (SNS) with integrated Sensor Data will motivate elderly people to go out more frequently and take longer walks, preventing them to need nursing care, by using an application called "Paw Collection". Paw is a kind of People's experience that is posted as an article with sensor data on the SNS.

Project - Butler (status: completed at the time of writing) [22]

Pilot - SmartHealth Trial [23]

It involves IoT technologies at home for health monitoring with the aim of helping people to control certain diseases. Different devices have been developed and integrated in the BUTLER platform (e.g. fall detector, emotion detector, medication intake assistant, telecare reporting service, videoconference for medical and risk prevention service)

Project: Open IoT (status: ongoing at the time of writing) [24]

Pilot - Silver Angel - IoT Enabled Living and Communication in Smart Cities

The purpose of the Silver Angel application is to help ageing citizens live independently in their own homes, and to facilitate meeting more often with friends and relatives. It offers three Silver Angel services namely Smart Meeting, Issue Reporting and Alarms.

2.1.11 Other relevant AAL projects

The UniversAAL and ReAAL projects

The interest for these two projects is related to the development of an Open Source platform to enable the development of IoT services for AAL and its deployment in an extensive piloting plan.
UniversAAL [25] developed an Open Source platform to enable developers to compose software applications which benefit from the information and capabilities available in the ambient environment.

The platform, based on IoT distributed architectures, provides a runtime environment for different type target computer, based on Android and Java, as illustrated in Figure 2.12.

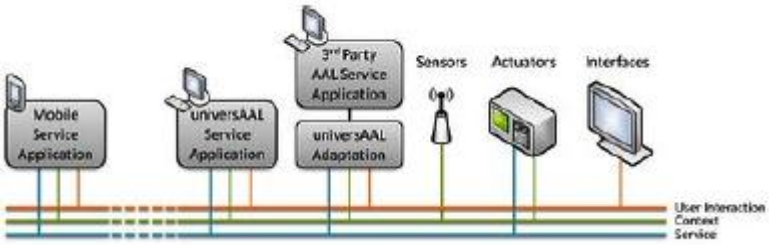

Figure 2.12 – The UniversAAL Platform High Level Architecture

The ultimate goal is to enable: semantic interoperabilities between Service Components, either on Mobile, Embedded and Cloud-based technologies; deployments of multi-vendor solutions, impeding vendor lock-in; and rule-based, intelligent system behaviour. Additionally, operation support also includes tools for the management of AAL Spaces and their components (e.g., installation, configurationand personalization tools).

In order to support the deployment of the universAAL open platform and to evaluate its impact under different points of view, the ReAAL project was set up. The ReAAL project [26] is a Large-Scale Pilot (LSP) project with 13 different pilots. Services are going to be deployed for and used by more than 5000 end-users.

The make it ReAAL project intends to kick-start the market for interoperable AAL services, applications and devices by assessing a critical mass deployment of Ambient Assisted Living services for more than 5000 users within 13 Pilot initiatives in 8 EU countries. More than 30 applications and 100 services have been adapted using the universAAL platform. To ensure such a Large-Scale Pilot (LSP), ReAAL is relying on the 13 local ecosystems with different "customers": end-users interested to the impact of the AAL applications for their daily life, but also application developers confronted to the platform usefulness. ReAAL has established an evaluation methodology (Open Platform Ecosystem Assessment framework) to measure the impact of the deployment in terms of the social, economic and health indicators.
This model is depicted in Figure 2.13.

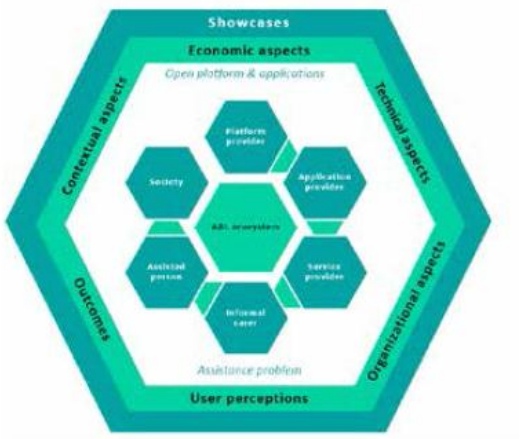

Figure 2.13 – A representation of the Open Platform Ecosystem Assessment model

The inner hexagon is the value network of stakeholders in the AAL ecosystem. Each stakeholder may expect benefits of the platform which may be specific to their usage. The layer around it depicts the main facets which are relevant for assessing the impact of open platforms on the large scale deployment of AAL services.
But each of these facets will be considered by the stakeholders from a different perspective. For instance, economic aspects are crucial for the society and the assisted person (socioeconomic benefits) and consequently the service provider is looking forward to purchase technologies using a value-best-pricing approach (business case). The underlying question is how to estimate this value-best approach for the other facets such as technical, organizational, etc? The ReAAL project answers that question by the creation of the set of showcases respectively related to: economical, organisational, technical and user perception aspects.
Details about evaluation criteria are provided in D5.2 "ReAAL multidimensional evaluation framework"

The Figure 2.14 summarizes the classes of applications considered in the ReAAL Pilot

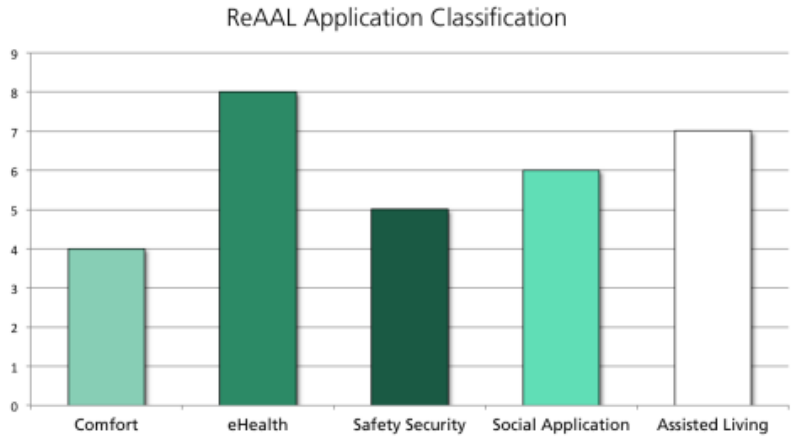

Figure 2.14 – The distribution of the usecases addressed in the ReAAL pilots

The AALiance2 Project

The AALIANCE2 Project was a Coordination Action funded in the European Union's 7th Framework Programme, focussing on Ambient Assisted Living (AAL) solutions based on advanced ICT technologies for ageing and wellbeing of elderly people in Europe. One of the project's main objectives was to build consensus upon upcoming research priorities, standardization and certification needs in the AAL sector. These were published in the AALIANCE² AAL Roadmap and Strategic Research Agenda [27].

The roadmap identified three service scenarios: prevention, independent & active aging and compensation and support. Starting from these areas, the following ten key service scenarios were defined:

- Prevention of early degeneration of cognitive abilities
- Healthy living

- Management of chronic diseases
- Age-friendly and safe environments
- Fall prevention
- Management of daily activities and keeping control over own life
- Maintaining social contacts and having fun
- Outdoor mobility (i.e. pedestrians, public transport and private cars)
- Avoiding caregiver isolation
- Senior citizens at work

Starting from the ten main service scenarios identified during the AALIANCE2 Project, the key ICT technologies, necessary to enable and implement these solutions, were studied. They are the basis for the development of AAL systems and services, that are typically comprised of sensors ("Sensing"), IT components that process the sensor data and derive conclusions ("Reasoning"), human-machine interface components ("Interacting") and actors that execute actions initiated by the system such as switching the light, or raising an alarm in case of an emergency ("Acting"). Obviously the different system components need to communicate with each other in order to provide the overall assistive service for which the system has been designed ("Communicating").
Beyond service and technological challenges, AALliance2 identified other important implementation issues related to the deployment of AAL solutions within society and their success in the business market.

Some of the main aspects that should be considered are:

- The fulfilment of legal and ethical issues, i.e. respecting autonomy, dignity and human rights
- The most appropriate methodologies to design service and technologies, involving end-users and considering the principles of acceptability and usability of the proposed solutions
- The definition of sustainable business models, support policies, certifications and standards suited to the introduction of AAL services and technologies in real care contexts and markets
- The dependability of AAL devices, i.e. increasing acceptability by users

AALliance2 also analysed needs and requirements of all AAL stakeholders:

- Primary stakeholders (older persons and caregivers)
- Secondary stakeholders (service providers)
- Tertiary stakeholders (industries, etc.)
- Quaternary stakeholders (policy makers, insurance companies, etc.)

The AALIANCE2 project has successfully consolidated and extended the previously existing network that was built during the European project AALIANCE. The current network has more than 600 people representing European stakeholders of Ambient Assisted Living (AAL): SMEs and large companies from industry and service providers, research organisations, user associations and policy makers. International associated members exist from Japan and the U.S.A. The network will offer their members periodic bulletins about AAL, maintain the website www.aaliance2.eu, keep the Wiki repository of AAL-relevant standards [28] open, and disseminate the knowledge gained during AALIANCE2, e.g. in national and international conferences and workshops.

2.2 Standardization activites

Standards are essential and represent an inherent challenge for dynamic environments in which a large number of complex devices need to communicate with each other as in the case for the IoT in healthcare.
In AIOTI the WG3 has produced three documents, which offer an extensive overview of the IoT standardisation landscape: "IoT LSP Standard Framework Concepts", "IoT High Level Architecture (HLA)", "Semantic interoperability for AIOTI LSPs" for IoT LSPs. The work is seen as a reference for the AIOTI WGs in different domains in order to address the standardisation issues and to recommend the use of standard-based solutions for the deployment of IoT solutions in the LSPs. The documents offer an extensive overview of the IoT standardisation landscape, as represented in the figure below.

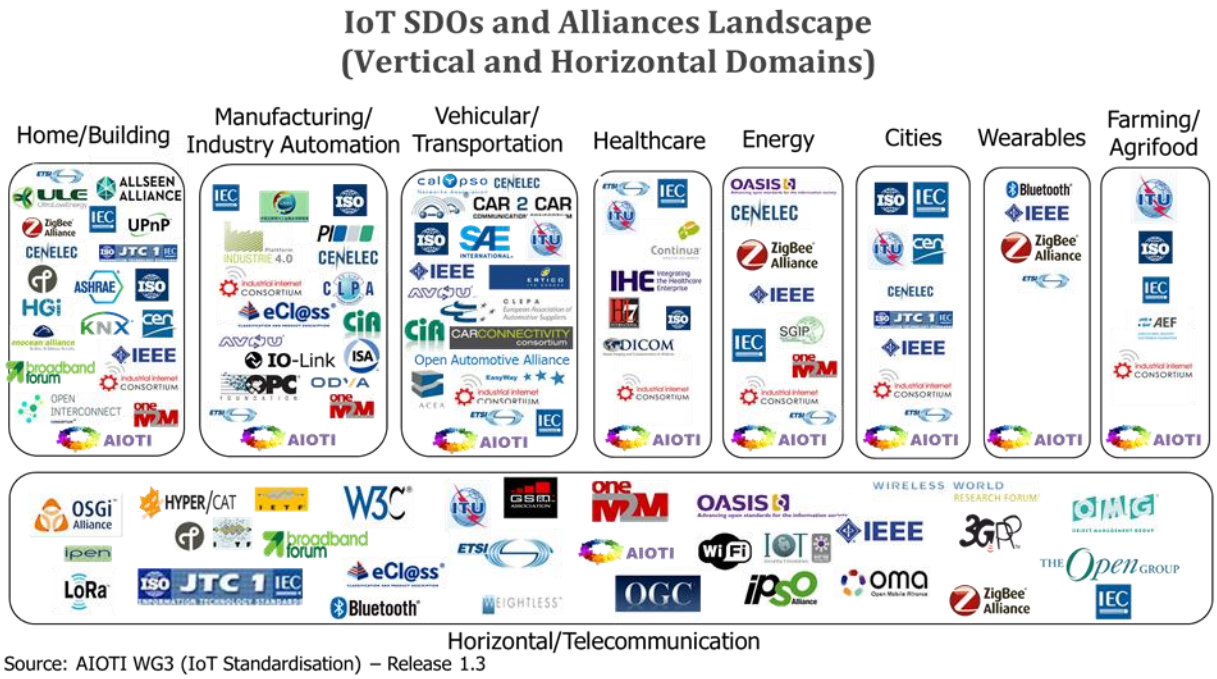

Figure 2.15 IoT SDO and Alliance Initiatives Projection on Vertical and Horizontal Domains

Therefore in this section only some references to existing guidelines and international standardization initiatives focused on healthcare. There are a number of guidelines for wireless communications between healthcare monitoring devices and with care providers. The Continua Health Alliance, formed of healthcare and technology companies was created to establish guidelines for interoperable personal health solutions. The alliance has published a set of specifications to help ensure interoperability. Companies and organizations that are using Continua-certified device will have in the future assurance that the device will connect with other certified devices in IoT-driven applications.

Continua's device standards are part of a larger standards environment that includes information technology standards established by ISO and engineering standards set by IEEE. IoT healthcare applications use as wireless technology, IEEE standards for LANs define Wi-Fi (IEEE 802.11) and ZigBee (IEEE 802.15.4), 6LoWPAN networks. Standards for PANs include Bluetooth and BLE, as well as IEEE 802.15.4j and IEEE 802.15.6, which are the IEEE standards associated with the body area network (BAN). Standards for cellular networks include GSM/UMTS, CDMA and 3G/4G. Proprietary wireless networks are still used in healthcare environments for specific IoT applications but the industry move toward standards-based architectures that require that these solutions are interoperable with the existing standards.

In the domain of healthcare for silver economy both IoT discussion on sensors that operate on traditional cellular, Wi-Fi networks and low-power wide-area networks (LPWANs) that can handle the communication needed for IoT are very relevant. The LPWAN technologies are based on specifications and protocols for low-power wide-area networks that use unlicensed wireless spectrum and can connect sensors over long distances, while offering optimal battery life and requiring minimal infrastructure. This has a series of benefits for telecom service providers, such as improved mobility, security, bi-directionality, and localization/positioning, as well as lowered costs. These improvements for telecom services will, to the products and services that are then offered to healthcare takers, healthcare providers and end-users.

International SDOs, such as IEC and ITU, have published recommendations, standards and reports which are relevant for the deployment of solutions for the aging populations.

The ITU-T's standardization activity in the e-health domain has until now produced specifications from network, interoperability, data and security perspectives. Most relevant achievements include the approval of the following ITU-T Recommendations:

- Y.2065 and Y.2075: respectively, "Service and capability requirements for e-health monitoring services" and "Capability framework for e-health monitoring services"
- H.810: Interoperability design guidelines for personal health systems
- H.820-H.859 (various Recommendations): Interoperability compliance testing of personal health systems (HRN, PAN, LAN, TAN and WAN)
- H.860: Multimedia e-health data exchange services: Data schema and supporting services

- X.1092: Integrated framework for telebiometric data protection in e-health and telemedicine

Additional studies (draft Recommendations) are ongoing, including interoperability, multimedia and application aspects, as follows:

- F.EHMMF: Multimedia framework for e-health applications
- H.HRN-IF: HRN Interface
- H.TPL-IF: TAN-PAN-LAN Interface
- H.WAN-IF (and H.WAN-IF.1/2/3/4): WAN Interface
- HSTP.EHMSI: Technical Paper: Multimedia service and interfaces for e-health
- HSTP.IPTV-MEH: Technical Paper: MAFR for e-health applications
- H.OPVQ: E-health application for on-flight and post-flight virtual quarantine

2.3 Initiatives about Smart Home

A number of initiatives aimed at developing & promoting technologies and services for the smart home, including but not limited to the energy management, home automation and home security, are very active both at the regional and EU level. A few of them are described below.

Energy@Home

Energy@home (http://www.energy-home.it) is a nonprofit association that, for the benefit of the environment, aims at developing & promoting technologies and services for energy efficiency in the home based upon device-to-device communication. Energy@home envisages a holistic approach where the house is an ecosystem of connected and interacting appliances and sub-systems that coordinate themselves in order to optimize energy consumption, increase energy efficiency and create new services for end customers.

The association's goal is to promote the development and spreading of products and services based on interoperability and collaboration of the different appliances within the household and with the energy infrastructure.

In line with its mission, Energy@home pursues the development of open international standards for products in the home through proactive contribution in relevant standardization organizations and Alliances.

AGORA

AGORA was born when several large French companies and SMEs (with an opening to international partners) joined forces to design and distribute components, products and terminals that would communicate with services to provide better «smart home» living. The idea was to jointly review all ways to enable domestic technologies to communicate, interact and cooperate. The Parties' shared goal was to provide residents of «smart homes» with more fluid, more economical, more efficient services by building a bridge linking everything together. This «bridge», this new household language, could improve the management of energy, communications, comfort, entertainment, security, home care services and e-health, while protecting personal data. What's more, it would create new opportunities and open up new ideas, for example through interaction with social networks.

EEBUS Initiative e.V.:

EEBus e.V. Initiative (www.eebus.org) is a German nonprofit association which networks the leading companies, associations and stakeholders in the German and international energy, telecommunications and electrical industry (by today: 50; http://www.eebus.org/eebus-initiative-ev/mitglieder/). The initiative is active within different standardization bodies (among others IEC TC57 WG21, CENELEC TC205 WG18, IEC/CENELEC TC59X) and defines neutral data models based on generated use cases, in the first phase mainly focused an smart energy systems. In coordination with the German institutes VDE and DKE, it cooperates with the different working groups in order to contribute to the efforts of standardizing a unified ontology. The association also has cooperation with BACnet, Echelon, Energy@home, KNX and ZigBee. The mission: increase in energy efficiency, comfort and security for the good of consumers, society, the environment and the economy.

2.4 Extra- Europe Initiatives: the Aging in Place Technology Watch

The report "Aging in Place Technology Watch" (www.ageinplacetech.com) presents a view of the technologies for aging market which is less focused on the usage domains but identifies the main products segments, as shown in Figure below. This offer an important overview for the application segments for IoT technologies.

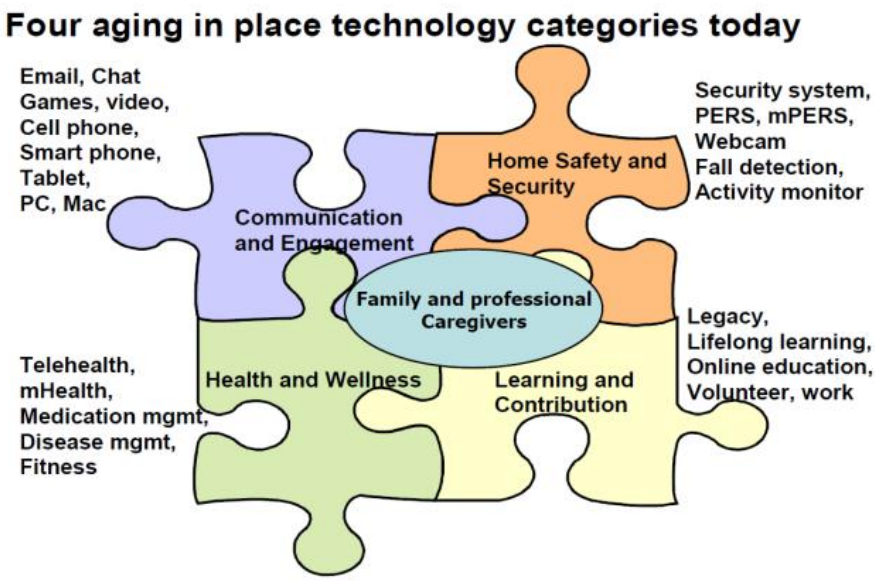

Figure 2.16 Technologies for aging market according to Aging in Place Technology whatch

One of the biggest issue that keeps more of today's technology out of the homes of seniors is the difficulty of marketing to both them ("We are not old!") and to their afraid-to-interfere adult children, while selling through knowledgeable channels, appropriate websites and pricing right for resale and white labeling. Vendors and service providers can close that gap of awareness, offering solutions for each stage of independence as presented in the Figure below.

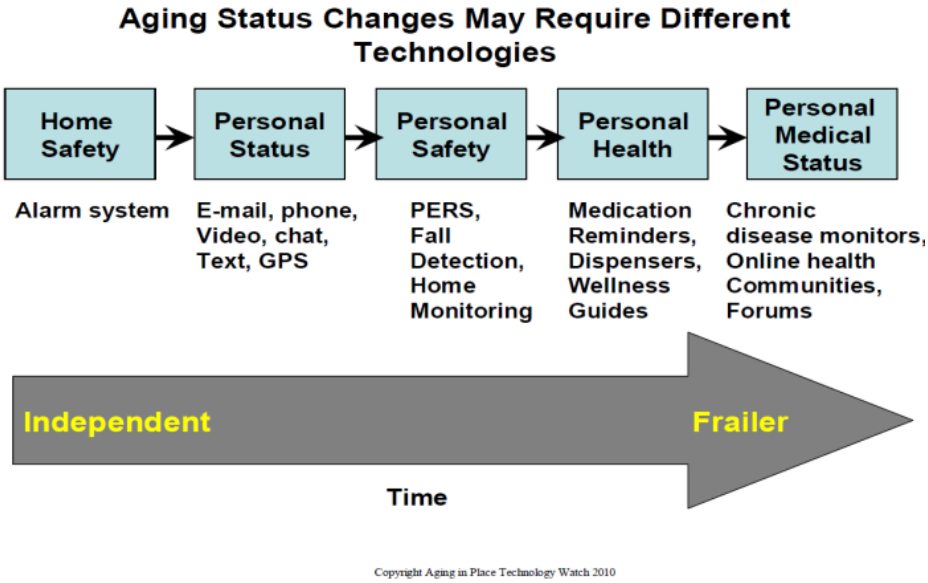

Figure 2.17 The mapping of solutions and level of independence

3 LSP's Technological Dimensions and Recommendations

3.1 Introduction

The large scale project (LSP) vision should provide a holistic solution based on citizen-centric IoT technologies integrated in the digital healthcare platform architecture and infrastructure to address the challenges and opportunities offered by the "Silver Economy" in Europe and help and support the ageing population, while prolonging the time they can live well in their own residential environment and have an active independent life. The vision will be achieved by integrating IoT solutions/services for healthcare with the overall existing or emerging IoT technologies and platforms in domains such as smart buildings, mobility, energy, wearables, cities, environment as a continuum for monitoring, collecting and analysing data in order to profile user behaviour, implement customized intelligent multilevel alerts/communication services.

By considering the European health sector dimensions, the pilot should identify common service delivery paradigms (business models), and explore how these are delivered in the selected scenarios to determine optimum clinical models.

The pilot vision should be aligned with the governmental policies, strategies, i.e. National health care priorities, and the IoT technology developments.

The LSP should propose an integrated care framework that allows data sharing between medical, support personal and elderly people using intelligent transparency mechanisms for implementing the digital services to cope with the aging population, which will require a different kind of healthcare than can be offered today. The IoT applications allow the edge devices to be connected, and patients, doctors, emergency services, healthcare facilities are interlinked and are extracting and processing the value from available, real-time data. These are important factors as the population ages, enabling preventive medicine and appropriate ongoing care. New IoT technologies that combine wearable devices and smart home devices will help the elder care by integrating health sensors that detect body vitals like temperature and heart rate, falls, and other types of incidents, allowing elderly people to age in place with dignity, improved health, and lower expenses.

Digital technologies affect the health industries, the services and the solutions about new and innovative IoT technologies that enable new drugs, therapies and diagnostic. Smart Home and welfare IoT technologies will merge in integrated services for the benefit of both residents and the municipalities. The solutions should be tailored according to individual needs and evolve as care needs increase. Health information should in future accompany the patient throughout life. IoT systems should be based on patients 'and services' needs while confidentiality and privacy are protected. Both the current and future needs for quality-assured information sharing across service levels and business boundaries in the health and care sector, and with other government agencies must implement the new systems. The large scale pilot needs to align the IoT architecture model for convergence between social and health services with the national ICT healthcare architecture.

IoT architecture needs therefore to build in a modular fashion, designed to logically isolate and untrusted critical system elements, providing standard, open integration point for cooperative system components. Real-time and batch event and health target data is obtained using highly available, flexible modules. Data used by these modules is then used further and presented through web services that produce information that local and remote staff functions and applications can use to control service / monitoring services more efficiently.

New IoT applications will allow individual user roles more effectively deliver telecommunications monitoring services via simple interfaces. Both applications and services interact on an integrated IoT platform and produce data and business logic integration including services and workflow.

The large scale pilot needs to describe and test the implementation of the functions for IoT technologies integrated into the infrastructure of health care: connectivity focuses on how the device is connected to the ecosystem; collection focuses on how data collected from the devices and patients / end users; correlation related to mapping data into a context and makes correlation to create meaningful and concise data that can be processed and used to make decisions; calculation and analysis to make decisions based on the filtered data which is processed through an algorithm; conclusion applied to make appropriate action; and cooperation used to enable collaboration between patients and health teams.
Correlations will need data from multiple systems and therefore must IoT architecture support seamless interoperability between the systems housing information. Data will include real-time data as well as historical data. Dataflow architecture focuses on data source and location and access (Relocation or federation). The establishment of common integration IoT platform(s) to integrate with common components, health administrative records and other national sector solutions is necessary.

Surroundings for "smart living" should be based on an integrated system consisting of a number of IoT-based technologies, advanced analysis and services with user-friendly configuration and control of the associated communication technologies in the home and outside. The solutions will be further built on advanced IoT technologies, as well as using and expanding available communications platforms for "open services", standardized communication protocols and open, standardized APIs.

There exist several standards in healthcare that are used in IoT applications and cover interaction between people, things, processes and applications. There is a need to focus on standardized solutions that utilize standards across technology stack and cover several classes including data standards, messaging standards, document standards and process standards. The standards to be considered may be syntax, semantic based, based on conditions, based on objective and based on classification. Development or adaptation of standards to support IoT applications in healthcare needs to be an integrated part of the work. The large scale pilot should use international standards and reusable information components that enable better reuse and sharing of information where appropriate.

3.2 The IoT ecosystem matrix

There are several layers to the development of the Internet of Things ecosystem. It is important to understand these layers before making recommendations about the technological dimensions:

- **Level 1 - Physical thing**
  - e.g panic alarm bell

- **Level 2 – addition of sensor/actuator**
  - local panic button linked to alarm;

- **Level 3 – addition of external communications infrastructure**
  - panic alarm connected to internet via a proprietary communications chip

- **Level 4 – addition of product specific platform**
  - panic alarm data provided to alarm company platform;

- **Level 5 – addition of a product specific digital consumer service**
  - e.g. 'panic alarm response service'
  - e.g 'panic alarm' alerts for relatives/friends via smartphone App, view usage info

- **Level 6 – addition of a connected data platform**
  - e.g. Panic alarm data provided on platform with data from other devices

- **Level 7 – addition of connected digital services.**
  - e.g. Outdoor light flashes when panic alarm goes off
  - e.g. Panic Alarm bell also rings when smoke detected by connected smoke detector.

The real benefits from IoT ecosystems come at level 7 where: data from all sensors; the capabilities of User Interfaces and actuators in the ecosystem become available to developers to come up with new applications and services.

IoT Ecosystems comprise a number of key components:

- Overall Architecture of Ecosystem
- Communications Infrastructure
- Smart Sensors
- Actuators
- User Interaction Interfaces

These components are summarised in the following sub-sections.

3.3 Overall Architecture of Ecosystem

In the early stages of the Internet of Things companies tended to build end-to-end infrastructures to provide services to end users. For example smart heating control companies provided sensors and actuators, communication hubs in the home, cloud platforms, installation, device management services, customer service, analytics and a user interface in the home.

As the Internet of Things has developed, it has become clear that requiring each company to build an entire E2E infrastructure to service one type of sensors, or to provide one specific automation service creates multiple architectures – increasing costs and barriers to market entry and increasing user confusion.

3.3.1 Interoperability

Three areas of interoperability are considered:

- **Network**: how devices, user interfaces and companies' systems connect and communicate;
- **Data**: how is data stored; format, labelling, data validation, quality etc;
- **Rules**: how are rules structured, stored and communicated – an example rule might be – 'if the temperature increases turn on the air conditioning';

In each of these areas ***privacy*** and ***security*** needs to be a fundamental consideration.

As a result of this there has been pressure from industry and from end users to create interoperable platforms. An interoperable platform is one where the different parts of the architecture are able to connect and communicate effectively with each other. For example a User Interface is able to display information from a variety of sensors from the ecosystem; a new device is able to be discovered and join the ecosystem, and the communications or a service provider is

able to retrieve data from a database (which is part of the communications infrastructure) to provide a service to a consumer.

To be able to know what kind of information is available, how to request and receive that information (either via a connection with a device, User Interface or database) there are two main approaches to achieve interoperability. These are not mutually exclusive approaches:

1. Create common standards and requirements for Networks, data and rules

For example an ecosystem may set requirements for the types of communications protocol which are supported, connection, privacy and security protocols, programming languages, APIs, data storage requirements and the types of rules supported.

2. Agree common semantics across different components and implementations;

Rather than try to agree or implement strict standards this approach attempts to identify common semantics across different components/parts of the architecture. So for example, rather than agree a common API, all APIs would agree common semantics (e.g. REST API) which would allow different APIs to be made interoperable. Similarly semantics could be agreed for the way in which data is structured, stored, and the way in which devices are discovered and can be connected and managed.

3.3.2 Support of legacy Systems and forward migration

An important practical aspect of implementing IoT based services on a large scale concerns the ability to integrate legacy systems and datasources already in use. There should be a gateway architecture in place to allow to integrate these in a seemless fashion, in order that a gradual migration into the future IoT based systems can be accommodated.

3.3.3 Industry examples of overall architectures

Some companies offer complete home automation ecosystems which allow device manufacturers to integrate their devices within the ecosystem. The level of control exercised by the platform varies due to a need to protect the user experience and maintain security and privacy standards.

There are a number of industry initiatives to improve interoperability in each of the three areas of networking, data and rules.

Networking initiatives include AllJoyn, Open Interconnect Consortium, Thread). There are also relevant styles which can increase interoperability such as Representational State Transfer (architectural style which can be applied to IoT systems, OAuth (open standard for autorisation), data semantics.

3.3.4 Recommendations

The LSP should set-out how it intends to ensure interoperability at each level, demonstrate as a minimum interoperability between third party devices on the LSP platform; proposals which also propose an approach to interoperate with parts of other ecosystems outside the LSP platform should be favoured.

The LSP should include as a minimum an integrated development environment (IDE) which provides tools to developers to use the ecosystem to connect devices and to develop applications and services.

3.4 Communications infrastructure

Allows new devices to join the network and allows Devices (sensors, actuators and User Interfaces) to communicate with other devices in the ecosystem (M2M) and with a wider platform where:

- Rules can be configured and stored by users or service providers, e.g. when motion is sensed, actuate the light bulb
- data from other sources can be provided
- applications can run, and
- data can be retrieved by service providers and other authorised parties (including end users)

The communications infrastructure comprises privacy and security requirements and sets the standards for all communications over all interfaces within the ecosystem.

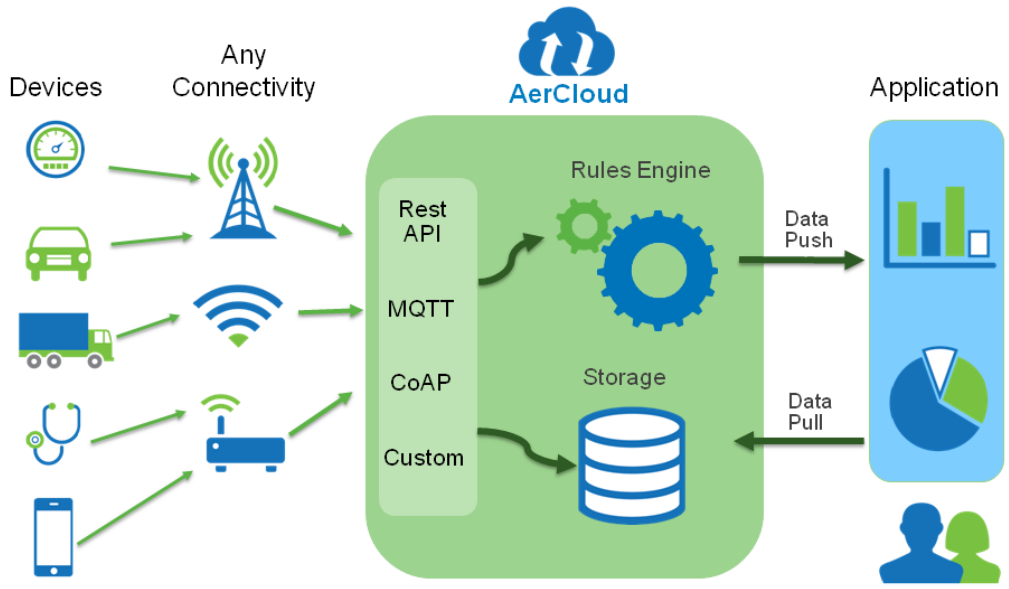

Figure 3.18: IoT Communications Infrastructure [29]

3.4.1 Networking

Bluetooth solutions include transceivers, network processors and modules supporting Bluetooth Smart (4.0 and 4.1) and Bluetooth Classic (3.0). In particular, Bluetooth Smart network processors, embedding the whole Bluetooth low-energy master and slave certified stack are featuring ultra-low power consumption. It features an excellent RF link budget as requested by accessories and wearable devices to extend operation upon battery recharge. With on-chip non-volatile memory they enable an easy and quick firmware upgrade. Most modules for Bluetooth Smart and Bluetooth Classic are based on transceivers and network processors and are equipped with antenna, Xtal and balun. They come with the embedded Bluetooth stack to provide a BQE End Product qualified solution that is also fully RF, ETSI, IC and FCC certified, thus ensuring quick integration into the final application and providing an easy-to-use solution, reducing the time to market cycle, with low development cost and very low integration risk.

ULE (Ultra-Low Energy) technology, a leading control network ecosystem for home and building use, benefits from the maturity, existing supply chain and installed-base of DECT (Digital Enhanced Cordless Telecommunications), extended with the feature enhancements needed to address IoT, smart home and other new market applications. ULE addresses Ultra-Low Energy application requirements by introducing optimized communication methods. Identified with low power consumption, low latency, long range, moderate data rate and value-added complementary voice capabilities, ULE is a formidable candidate technology representing the next evolution in smart home networking. ULE is based on DECT which is the de-facto standard for residential and business cordless phone communications worldwide. Its specification[1] is dictated by ETSI.

ZigBee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios.

Z-Wave is a wireless communications specification designed to allow devices in the home (lighting, access controls, entertainment systems and household appliances, for example) to communicate with one another for the purposes of home automation.

WiFi is a local area wireless computer networking technology that allows electronic devices to network, mainly using the 2.4 gigahertz (12 cm) UHF and 5 gigahertz (6 cm) SHF ISM radio bands.

Thread is an IPv6 based protocol for "smart" household devices to communicate on a network

[1] DECT/ULE Physical Layer (PHL): re-uses the existing DECT specification EN 300 175-2; Medium Access Control Layer (MAC): extends the existing DECT standard EN 300 175-3; Data Link Control Layer (DLC): extends the existing DECT standard; EN 300 175-4; Network Control Layer (NWK): extends the existing DECT standard EN 300 175-5; Security features: extends the existing DECT standard EN 300 175-7

3.4.2 *Recommendations*

Ease of Access of sensors to LSP ecosystem

Given the high fixed cost of establishing a communications infrastructure for a single IoT service (e.g. connected panic alarm), and the network effects of a single ecosystem, subject to the security and privacy requirements, sensors and actuators should be able to join the LSP ecosystem easily.

Ease of access to ecosystem to authorised third parties via interface with the LSP ecosystem (e.g. APIs)

Authorised third parties should be able to securely access the ecosystem to retrieve data from devices and to set configuration data to allow them to provide services to end users using available actuators.

Interoperability of devices

Different devices are more suited to different communications standards. For example battery operated sensors require a low power communications standard; devices which stream video require a higher power standard. The communications infrastructure should support a variety of device types including low powered and high powered devices and short and long range devices. The communications infrastructure should ensure that devices which use different communications protocols are able to request and share data between one another.

Device discovery; availability of data from sensors and availability of actuators to actuate

Once a sensor or actuator is joined to the ecosystem it should be discoverable to other devices and service providers. For example if a device of a specific type (e.g. a light or door sensor) joins the network, information about that device, types of sensor and its capabilities (actuators/user interfaces) should be available via the ecosystem. This means that if a heart rate monitor joins the network then other devices and services should be able to 'discover' this fact and should be able to query data on the heartrate to provide other services. For example a heartrate monitor may be provided to provide data for a specific health monitoring service, but other automated home services may use the heartrate to provide other services (e.g. setting the thermostat based on sleeping patterns). Similarly actuators should be available to do things as part of other services (e.g. the audio function of the TV should be available to a connected entry intercom).

Size, latency and availability of communications infrastructure

Different services require different levels of communications bandwidth and latency of communications. The infrastructure should permit communication between devices and provision of information via User Interfaces in near-real time.

The network should be sized to allow service providers to provide high bandwidth services;

With regard to the speed with which Service Providers are able to retrieve information via their interface with the platform, and are able to set configuration and send firmware and software updates to devices, the LSP should explain why the capabilities of the platform are suitable for the use of the platform by the subtrials.

Network availability should be at least 99.9%

Privacy

Strict security standards need to be set for the ecosystem. There must be a means of user authentication/verification to ensure that only User (or an authorised proxy) approved devices are connected to the ecosystem; similarly the interfaces between the ecosystem and any users (either User Interfaces for the primary user and secondary users (e.g. relatives, careers); or Service Provider Interfaces (e.g. care associations; SMEs etc.) must include requirements for User authentication identification.

The communications system should include the capability to encrypt data; the level of encryption required for different types of data will depend on the use case. Any subtrial bids should include a privacy impact assessment which explains the type of data being stored and transmitted over interfaces and explains the suitable level of privacy requirements with implementation plans.

Development of specific Privacy by Design approach needs to be considered as required by the LSPs, reflecting the content of the AIOTI Privacy Knowledge base developed by WG04.

Security

The ecosystem should be designed with E2E security by design; appropriate levels of security should be provided at each level of the ecosystem; Industry standard, widely implemented security protocols should be used to establish trust between devices and and between Users and the ecosystem.

Data semantics

The LSP should explain how its chosen data semantics and ontology will support interoperability and compatability with other (non LSP) ecosystems.

Data Storage

The communications infrastructure should support storage required for service providers to run applications and services. Data may be stored locally or in the cloud. Privacy and security should be taken into account when specifying the location of data storage (for example it should be considered whether very sensitive data should be kept in the home).

3.5 Smart Sensors and actuators

Sensors provide data on the environment; sensors may be local (e.g. an activity band taking heart rate) or remote – e.g. the local weather station providing weather data.

Actuators do things based on data from sensors and based on input via User Interfaces. For example a light may turn on (actuate) based on motion sensed by a motion sensor in the light, but could also turn on based on data sensed elsewhere in the ecosystem (e.g. user touching the screen on their smartphone or detection of a door opening)

3.5.1 Examples from Industry

Smart sensors and sensor hubs, UV index sensors, temperature sensors and touch sensors are among the solutions available on the market. These devices can be used to develop any IoT applications requesting sensors. Every month new solutions and products pop up on the market demonstrating a dynamic industry in evolution. Sound and voice-activated sensors are also paramount, for example for fall and epilepsy attack detection.

MEMS (Micro-electromechanical sensor) technology can address a wide range of application cases. Today, MEMS include accelerometers, gyroscopes, digital compasses, inertial modules, pressure sensors, humidity sensors and microphones. Application scope using that technology is really vast, from smartphones and tablets, drones, indoor navigation to robotics and many other applications. Micro-electromechanical technology can even be used to build actuators. For example, a microscopic insulin pump using MEMS microfluidic technology has recently been developed for the health industry. This helped implementation of an ultra-light and portable human disposable insulin system **[2]**. MEMS technology can also be used for human implantable applications with an even more recent product which is a 'Medical-Grade' Motion Sensor **[3]**.

Within Home Appliances any device in the home can be turned into an **actuator** by inclusion of connectivity to an existing device. For example a speaker or a washing machine can become an actuator if it is upgraded to have a WiFi connection and is joined to a smart home ecosystem. Similarly lights, ovens, etc can all become actuators in an IoT ecosystem.

3.5.2 Recommendations

Network effects

As explained above, much of the value from an IoT ecosystem arises from the ability of IoT services to use data from sensors which they may not have provided themselves, to activate actuators. For example if a panic alarm button is interoperable with the TV and lights, then a panic alarm service can actuate these when the button is pressed. Similarly if there is a temperature sensor in a smart thermostat then this could be used to provide other services which require temperature without needing to install a second temperature sensor. This removes the need to provide superfluous service-specific actuators and sensors; it also allows users/service providers to personalise the system to use actuators which best suit their needs.

Minimum requirements:

The LSP ecosystem should require that sensors are interoperable. Regarding interoperability the LSP should be free to design an interoperable architecture but the architecture should meet the following minimum standards:

Evaluation criteria:

- How well suited are the sensors and actuators to the proposed services in the LSP?
- How will they meet the target objectives of the subtrial ?
- Could the sensors/actuators provide externalities by providing benefits to other use cases through availability of data/actuators?
- What is the cost of the sensor/actuator?
- What is the accuracy of the senso ?
- Is the sensor/actuator accredited/safe/meets all applicable regulations?
- Have any actuators been user tested (e.g. panic alarm)?
- What is the power source of the sensor/actuator – is the power consumption within regulated levels?

3.6 User Interaction Interfaces

User Interaction Interfaces provide a way for users to interact with the ecosystem. User Interfaces allow users to:

- See/hear/monitor things (e.g. someone can see their heart rate or monitor a security camera on their mobile phone)
- Control/actuate things (e.g. user can adjust heating thermostat using TV remote control)
- Set system configuration (e.g. program the heating to come on when a sleep sensor detects that user is waking up)

Users in the ecosystem may be the person in need of care; but other users may be relatives, care-takers, community support staff, etc. who have permission to interface with the system.

A particularly important dimension is the availability of accessible and personalised user interfaces which can be easily adapted to the personal capabilities/preferences of the users. Many older adults have age related impairments, such as dexterity, vision, hearing and cognitive performance. The IoT service platforms should ideally be able to support a general user interface abstraction layer, which allows for easy personalisation independently from the services to be supported.

Note: some devices (such as a smart phone or watch) may simultaneously act as a sensor, actuator as well as user interaction interface. For example, an active smoke detector could also accept voice-activated command and as result actuate certain series of automated tasks.

3.6.1 Examples from Industry

3.6.1.1 TV Interface

The TV set is already present in almost all houses across EU27. In addition, most people are comfortable interacting with their TV as they have been using it extensively for many years. A specific and simple navigation scheme can be developed to access all sections/clusters we would like to address. The TV has the advantage of having a large screen – which may be more suitable for older people than a smaller device; it is also mains powered; this means that older people do not have to remember to recharge the device as would be the case for other User Interfaces such as smartphones. The TV can also display alerts and notifications (e.g. IoT alarms and coaching profiled messages) whilst someone is actually watching the TV set for other entertainment purposes (which the average European does around 4 hours a day on average, maybe even more so for people who have to stay home). This is important in the context of IoT as the benefits from the *smart living and ageing well* LSP will directly depend on how well people respond to relevant messages. Relevant messages include - a request to do something (time to exercise, to check blood pressure, to eat, to drink, to take medications, …); An alert (safety issue, heart frequency increase, heating or air conditioning issues, …); A coaching message (advice to do something appropriate and beneficial, including if needs be, to turn off the TV and the Hub will record the content for you to watch it later after doing some healthy exercise).

Smart TVs are internet-enabled and therefore are capable of allowing service providers to develop services and applications which use the TV to allow the user to view and input information, and to display alerts and notifications. TVs with connected cameras also allow applications using video calling capabilities (such as remote doctor appointments). Smart TVs with microphones can also support voice activation commands which could be useful for older groups. Given the functionality of the TV, the LSPs should explain how they can best use that functionality to achieve the benefits set-out in this document. This could include consideration of:

- How the TV can display messages and notifications in a seamless and user-friendly way such that the older person is more likely to respond to the alert:
- How to design the user interface on the TV to ensure that the navigation menu and display of alerts is best suited to the subgroup of users (this should include proposals for user testing)
- Compatibility between the TV and tablets and smartphones (for example alerts are displayed in different ways on all devices; and relatives are able to send videos of an older person's grandchildren to their relative's TV

3.6.1.2 Voice activated Interfaces

Intuitive voice-oriented, and in general sound-oriented, sensing and automatic detection for Smart living environments for ageing well could deliver significant benefits. As the range of stakeholders involved in health care and assisted living increases, healthcare and assisted living solutions will need to provide integrated solutions for formal and informal medical care, rehabilitation, carers, nursing, training, social and family circles. The solutions must all contribute to quality of life, quality of care and quality of medical support.

Notable examples of related voice and sound oriented capabilities include automatic detection of falls and epilepsy attacks, calling for help, voice-activated commands, voice announcements by the system and 2-way communications, for example with community-assistance or emergency services. This corresponds for example with extended home monitoring, quantified-self, geofencing, behaviour monitoring, contact with caregiver and community-

support circles, e-health, smart health appliances and leisure / family contact.

The importance of devices designed for voice to Smart Living stem from the devices' inherent voice-processing, high-quality HD-Voice codecs, integrated microphone and speaker connectivity and ability to identify the vulnerable individual, whether elderly or child, through support for voice and video verification.

Furthermore, emerging ULE devices provide also built-in support for simple, low-res video (1Mbit data bandwidth, pp to 30FPS@VGA / 10FPS@720p), which is sufficient for elderly status monitoring and/or incident analysis or improved remote assistance / guidance.

Universal capabilities, no-less important to Smart Living, include:

- low-cost
- simple silver-age-friendly user interface
- low-energy long-lasting battery-operation
- adaptability to external living environments which may become danger zones, such as the elderly's home garden, courtyard, stairs, etc.
- real-time interaction between relevant stakeholders
- interference-free resilience
- Foolproof reliability
- mobility of devices
- super-high range: guaranteed full home (and office) coverage
- remote OTA (over the air) equipment upgradability, ensuring 100% reliability through continuous bug-fixing and important continuous anti-hacking security enhancements, and for future-proofing
- secure link
- one wireless link that covers all
- ubiquity, which will prove valuable for the upcoming trials and large-scale pilot, facilitated by the wide availability of devices on the market and ample Telecom operators' support

3.6.1.3 Computer interfaces

Laptops and desktop computers are still used by many of the aging population for internet access. Computer operating systems and web browsers offer a development environment in which service and application providers can use.

3.6.1.4 Smart Phones and tablets

Smart phones and tablets also offer App platforms and web connectivity allowing service developers to provide apps and services via the smartphone/tablet. Given that the majority of people now carry a smartphone for most of the day, the smartphone could provide the User Interface for users when they are outside the home. Given that the majority of an elderly person's friends and relatives will have a smartphone and the relatively low cost of developing simple applications, this could provide the user interface for friends and family to receive alerts via the ecosystem.

3.6.1.5 Wearables and Pendants

Smart watches offer smaller interfaces, but are always worn – and could therefore offer effective interfaces to provide alerts – and provide the user interface inside and outside the home. Smart watches do not currently have high penetration amongst older people and initial adoption barriers would have to be overcome.

3.6.2 Recommendations

Subtrials should provide User Interfaces for Primary (person directly receiving care) and/or secondary Users (e.g. carer/relative). User interfaces that could be suitable for different trials include: TVs, tablets, computers, screenfree.

A subtrial should set-out the targeted user group for each User Interface; they should then provide evidence (quantitative and qualitative) on the suitability of the User Interface for that user group for the intervention being tested. Measures of usability could include: Learnability, Efficiency, Memorability, Error-rates, satisfaction, etc.

3.6.2.1 Evaluation criteria and KSFs (Key Success Factors):

How well suited are the User Interfaces to the proposed services in the LSP:

- How easy is it to personalise the user interface, including meeting the accessibility and usability features required?
- How will they meet the target objectives of the subtrial;
- Does the device with the User Interface offer a software platform which allows developers from third party companies/associations to develop web and native applications?
- Could the User Interfaces provide externalities by providing benefits to other use cases through availability of the User Interface?
- What is the cost of the User Interface;
- Does the User Interface meets all applicable regulations;
- What is the power source of the User Interface? Is the power consumption within regulated levels?
- How adaptable is the User Interface platform to any new coming technology which may be massively adopted as a user interface in the coming years;
- Can the User Interface make its capabilities available to other interfaces? For example could a TV be controlled by laser pointer or smartphone where an older person is not able to use a remote control?

3.7 LSP Research Clusters

Based on subjects highlighted in IoT Benchmark study [4], we recommend that the large scale pilot act as an ecosystem (or Hub) composed of four clusters: health, habit, house automation, safety. As explained above this modular approach will avoid cost duplication and will allow cross-cluster sharing of data and sensor/user interface capabilities. The role of each cluster is to provide data from sensors to users and for authorised third party analysis, allow rules to be implemented controlling actuators and providing alerts and notifications to user interfaces, and to provide user interfaces to allow users to interact with the ecosystem. For example if health related sensors provide data which indicates a high risk of an imminent health problem, an alert may be generated to the user to see a doctor, or shared (with permission) with a specialist in order to be analyzed remotely or locally.

The number of clusters can be increased if required in the future using the same LSP ecosystem.

There are real challenges to find interesting added values for the end user to improve system acceptance. The LSP proposed here must not be seen as a "big brother" system but as a system improving the quality of life for vulnerable people and elderly staying home. It must avoid any invasive behavior towards the people using it.

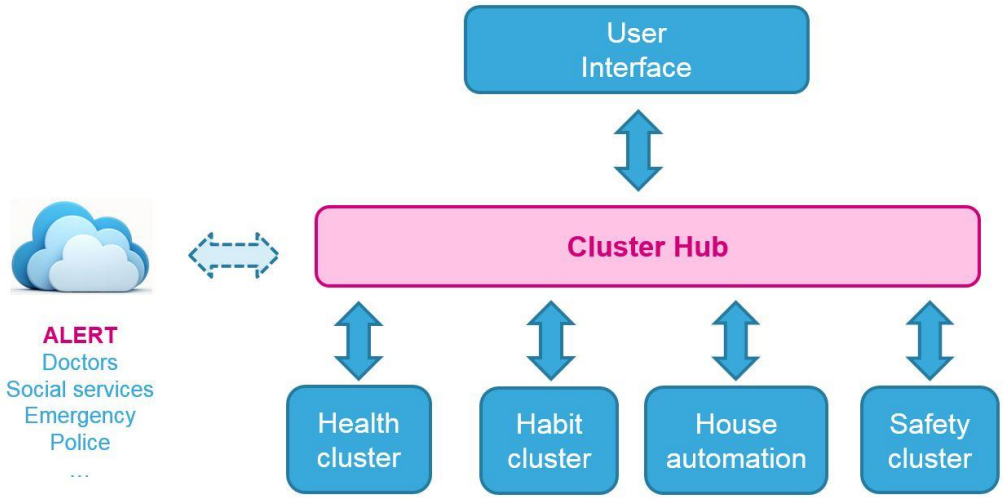

Figure 3.19: LSP Research Clusters

Let's detail every LSP research cluster and its unique features.

3.7.1 Health cluster

Health cluster must be capable of monitoring 24 hours a day all necessary parameters depending on people's medical pathology. A modular approach can be used to reduce the cost of unnecessary items. The following modules can be

activated for instance:

- **Physical parameters:** all information on blood pressure, heart rate, oxygen saturation, temperature, Auscultation and any other parameters are sent to Health cluster. Many sensors are available to perform an extensive health monitoring. New sensors can also be developed to reach higher level of health tracking if it does not exist today. Data can be shared upon request to any medical team or partially shared automatically upon predefined automatic alerts. All information like statistical, average data, alerts can be visible by the main users so there is a real interaction between the user and its health monitoring system.
- **Glucose metering:** modern countries have growing problems with diabetes. Light portable systems can really simplify people's life when affected. Based on a real time glucose measurement, new technology can optimize the amount of insulin delivered. Today, micro pumps and valves can be produce using MEMS technology, reducing then size and weight. The target is clearly to improve safety, reducing under or over dosage accident. Optimizing this way should reduce drug cost. Information on insulin consumption and glucose metering can be added to the local database. One can even think about an automated insulin delivery at home based on average consumption during a week / month. In addition monitoring of blood sugar levels, combined with better data on sugar consumption and targeted alerts/dietary training could be used to prevent cases of prediabetes developing into Type 2 diabetes and a range of other conditions with the heart, eyes, kidneys and blood vessels.
- **Sleep monitoring:** this module intends to monitor the quality of our sleep. It can help to optimize the wake up at the right time as many wrist and smartphones proposed to do nowadays. Moreover, it can greatly help in a less famous medical area: apnea while sleeping. Many people suffer apnea during the night, generating abnormal tiredness after the night. System available today can detect apnea and inject pressured air to force ventilation to restart. MEMS pressure sensors and/or MEMS MICs can be used here. These can also provide data on heart rate, sleeping hours, and data which can be used as an indicator of stress levels. This data can be connected to the health cluster as part of general health monitoring. Users can then directly see, as the medical expert if necessary, the quality of the sleep they had with advice on how to improve their sleep, or recommendations to see a health professional where the data indicates a high risk of a health issue (e.g. irregular heartbeat, poor sleeping patterns).
- **Drug dispenser:** target if this module is to optimize drugs used and act as a reminder for people having memory troubles. For long term drug usage, we can think in the same way as the glucose metering to automate the drug delivery home based on average consumption. This module may use several user interface (TV set, smartphone) at the same time upon user's request to ensure that medication is taken at the right time.
- **Activity monitoring:** this module can use wearable sensors and motion sensors in the home, including data from energy monitors or smart meters to provide data on the level of activity of an older person. Analysis of this data could be used to provide hints and tips to increase activity levels where necessary, and data analysis could be used to spot changes in activity levels which could indicate a high risk of a health-related problem.
- **Other modules:** many modules could be developed based on medical requirements which we do not currently know. Technologies exist and allow many different types of medical investigation and monitoring. Sensors can be developed if they do not exist to enhance human quality of life. As per the IoT benchmark study recommendations, we should be concerned about Alzheimer's, Epilepsy, Chronic Obstructive Pulmonary Disease, Cardiovascular Diseases, Obesity and Congestive Heart Failure. For some most of those diseases, we need to know what parameters we have to monitor in order to detect them as early as possible.

The health cluster must have a direct access to emergency service in case a critical parameter is detected.

3.7.2 Safety Cluster

The same module approach can be used for this cluster on safety to reduce final cost of the system.

- **Fall detection:** It is vital to detect a fall when people involved are vulnerable. People may be in a bad position, unable to move, unable to stand up on their own or injured and need immediate assistance. Capability to allow the use to call for the Emergency services should be provided. If the person is unable to use this capability, a system could use data and algorithms to generate an 'everything-OK' check (e.g. voice call or video) to see if the person really needs assistance or not. Data could directly (e.g. Motion MEMS on a wearable device can be used here to detect a shock or an abnormal acceleration due to a fall) or indirectly (e.g. abnormal electricity use for a

period of time; or the sound of a fall picked up by a microphone) detect a fall. . Users and their family/relatives can see direct benefits here as this could provide an increased level of safety/comfort whilst allowing vulnerable people to live independently for longer.

- **Air quality detector:** Carbon monoxide detection is about to become a legal obligation in most modern countries. This gas is responsible for many deaths as it becomes lethal beyond a threshold level. Carbon monoxide is the most common and dangerous gas to detect as it is the most commonly generated. Incomplete combustion in heating systems is a major cause of this. Air quality systems could also detect other aspects of air quality such as CO_2, NOX, VOCs involved in outside air pollution for instance. Vulnerable people may then be proposed stay home in case of peak air pollution, or advised on how to reduce levels of other air pollutants (for example by aerating the property or keeping windows closed. All this information can be monitored by users on the TV set or any user interface accessing safety cluster, giving them an overview of the current situation; alerts can be generated to other users (e.g. relatives) and to the local authorities where there is a high risk situation.

- **Outdoor video:** This segment can be an option for people seeking for increased safety while living remotely. It is then possible to see via the user interface all outside video cameras. It can be simply a way to see who is ringing the bell at the front door and open it. There is then a link between safety cluster and home automation (§ 3.4.4). This module can be also connected to private companies proposing remote safety service and assistance. Data from cameras could be stored locally until an incident is detected subject to privacy requirements.

- **Security breach:** Sensors can be placed in some specific places to detect intrusion. This module can be also connected to private companies proposing remote safety service and assistance or directly to emergency service.

Outdoor video and Security breach modules can fulfill the need of increased security mostly required by elderly. Other modules can be developed and added to that cluster if necessary.

3.7.3 Habit cluster

The main idea is to monitor vulnerable people's habits in a way to detect if there is an abnormal behavior compared to usual habits. This can start with an adaptation period while the system is learning what normal habits are. Machine learning/predictive analytics can be used to detect when something has happened, or where a risk has risen above a set threshold (e.g. given the changes in data on activity around the house there is an increased risk of a health-related incident). Direct monitoring and real time detection should be avoided as surveillance systems may not be accepted by users. This could be avoided by use of be non-intrusive systems using data generated from uses that are of direct benefit to the user (for example electricity use is of benefit to the older person, but analysis of the use could be used to detect a fall or health problem.

- **Food:** Usage of Oven, Fridge, cooking hob, coffee machine and many more items can be monitored using smart appliances. The major idea is to detect if there is a big trend (usually a drop) in those appliance usage demonstrating something is going wrong with the vulnerable person supposed to use them. A link with health cluster is highly recommended here.

- **Hygiene:** Water metering is a good information to check if the water consumption is in the average or not. A drop in the usage can demonstrate something is going wrong with the vulnerable person. This can be linked and cross checked with other parameters like food sub-cluster and of course the most important one: the health cluster.

- **Social relations:** Most people are living alone while aging and need to maintain social relation with distant relatives and friends. This is a very important point to keep a good level of self-appreciation. Vulnerable people may be not in the physical condition to travel even short distances. Social isolation can also be addressed by allowing older people who have previously been digitally excluded to access digital social networks via the LSP ecosystem. For example, relatives could send video clips of a child's first steps, older people can have video calls with friends, play brain games with friends and family to increase awareness; receive remote video support for any issues with their house, heating, systems; watch TV programmes simultaneously with friends and comment and chat about the programmes in real-time. This can allow more social relations for persons living remotely. Social dining is no longer a utopic idea. TV set is then the perfect interface as it is the biggest screen of the house and it is easy to use.

- **Room occupancy:** this section is able to check the habits of the person under care. It is not recommended to perform a direct detection by video as it can be considered as an intrusion in private life. MEMS MICs can detect noise without voice analysis and determine which room is occupied for instance. It can be used for lighting control and/or HVAC adjustments for instance.

3.7.4 Home automation cluster

There is a big industry push to develop home automation. Big players like Google and Apple are already in the game pushing their own solution for widest public adoption as a standard. Home automation can be a real help for elderly, taking care of homes and their occupants.

- **Metering:** The trend to have smart metering with communication features in every home across Europe. Electricity, water and potentially gas are concerned. Users may be very interested to see as often as they want the real consumption and an estimation of the amount they are about to pay at the end on the month. Moreover, abnormal consumption may be highlighted demonstrating a leakage (gas, water) that may be potentially harmful.
- **Heating Ventilation Air Conditioning (HVAC):** Elderly and particularly those over 85 years old, are much more vulnerable to extreme heat and cold temperature compared to younger people **[5]**. HVAC is thus critical for those vulnerable persons. Some dramatic events have already occurred in the past years (2003, 2006, 2007 for instance) **[6]** concerning this subject. It can be easily avoided using an accurate temperature regulation in houses. It can also lead to energy consumption decrease as a regulation is most of the time more efficient that manual settings requiring regular updates and checks.
- **Light intensity:** Different settings can be used and light sensors can greatly help to adjust light intensity in any room for the house. Light intensity may vary a lot depending on the time of the day, seasons and outside luminosity for instance. Room occupancy sub-cluster information can be used to determine whether there is someone in the room or not. Light can be switched off when people leave the room and after some period of inactivity in that room. Different settings can be used upon request.
- **Main door access:** Quick and easy systems already exist. They are able to show the house holder who is ringing the bell at the front door by using a video camera. This can be integrated to the home automation cluster to have it available as all other system.
- **Other subjects:** Many other items in home automation can be addressed and not only for vulnerable persons or elderly but for everybody. This can be a vast and opened subject of discussions.

3.8 A use case pattern leveraging the Consumer Electronics dynamics and Standards

3.8.1 From IoTs towards Machine-to-Machine

As of today, sensors - whether being fixed or portable - collect data which are then processed in the Cloud, and rendered back in the most compelling and intuitive possible manner through a Smartphone or a Tablet. This App centric ecosystem is very much a trend in the Industry. However, even when mapping API and shaping websites into finger-touch friendly navigation schemes, the fundamentals of the Internet remain unchanged. App developers still leverage the mainstream IP Standards being HTML, TCP-IP, HTTP, CSS, Javascrypt, etc.

Moving forward, the still very individual nature of IoTs - where Smartphones are the preferred screen of choice to interact with them and render cloud generated dashboards - is going to fundamentally change. As tens of billions IoTs are expected to be in circulation by 2020, we'll then enter into the true Machine-2-Machine (M2M) age where devices will interact with one another at the edge, and then automatically, even offline, create sets of alerts and actions, thus enabling some sort of artificial intelligence to emerge at the edge, including our homes. As time goes on, we have to figure out scenarios where IoT information dashboards could be rendered and displayed on multiple types of screens surrounding our lives, not exclusively individual devices such as Smartphones and Tablets.

Indeed, Smartphones specifically remain the most compelling way of interacting with personal wearables, but also as a remote control when people are outside their homes. But whenever they are back in, like it will often be the case when it comes to ageing well at home rather than in hospitals, then other means of interacting with multiple edgier IoTs may very much arise.

3.9 AIOTI Reference documents about IoT general subjects

AIOTI has extensively addressed common issues faced by the IoT market and the results of these works are endorsed by WG5, because they are relevant also for the smart living and they should be taken into account in the definition of LSP pilots.

Workgroup #3

The work in the AIOTI WG05 is reflecting the views in "IoT LSP Standard Framework Concepts", "IoT High Level Architecture (HLA)", "Semantic interoperability for AIOTI LSPs" for IoT LSPs provided by WG03.

The AIOTI W03 has provided their views on the IoT standardisation that are covered in 3 documents (**) : "IoT Landscape and IoT LSP Standard Framework Concepts", "IoT High Level Architecture (HLA)", "IoT Semantic interoperability" recommendations for IoT LSPs.

The documents delivered describe and summarise the outcomes of the discussions within the AIOTI WG03 and reflect the interaction with the other AIOTI WGs.

The work is seen as a reference for the AIOTI WGs in different domains in order to address the standardisation issues and to recommend the use of standard-based solutions for the deployment of IoT solutions in future projects. The documents offer an extensive overview of the IoT standardisation landscape and do not prescribe methods to achieve the implementation of the IoT solutions in different domains. This allows the stakeholders involved future projects to be flexible and innovative in their use of the information, while assuring that they provide standard-based and interoperable IoT implementations.

These documents could be used as a checklist for stakeholders and include information about the IoT Standardisation Landscape, how each SDO and Open Source initiative maps its activities. This is extremely useful information for stakeholders that will work to develop standard-based, interoperable IoT solutions that can demonstrate compliance with specific standards or other standard-based IoT solutions.

(**) AIOTI WG03 documents approved by 16 Oct AIOTI Steering Board meeting will be available at https://docbox.etsi.org/SmartM2M/Open/AIOTI/

Workgroup #4

Development of specific 'Privacy and Security by Design' approach needs to be considered as required by the LSPs, reflecting the content of the AIOTI Privacy Knowledge base developed by WG04.
The scope of Working Group 4 (WG04), as per the AIOTI terms of reference, is to identify existing or potential market barriers that prevent the take-up of the Internet of Things in the context of the Digital Single Market, as well as from an Internal Market perspective, with a particular focus on trust, security, liability, privacy and net neutrality. In its policy document, WG4 highlights a number of key issues related to each of these areas. In so doing, WG04 also makes a number of recommendations to further inform both the policy debate and the activities of the Large Scale Pilots due to commence in 2016. WG4 also makes reference to other relevant stakeholders that are carrying out important activity in this field and which need to be linked to the work of WG04.

4 Business models and of user acceptability

4.1 The Silver economy ecosystems and eldercare regimes across Europe

European Silver Economy ecosystem is complex with different dimensions and multidisciplinary stakholders. All these dimensions should be taken into account for relevant assessment of IoT Large Scale Pilot focusing on "Smart living for Aging Well".

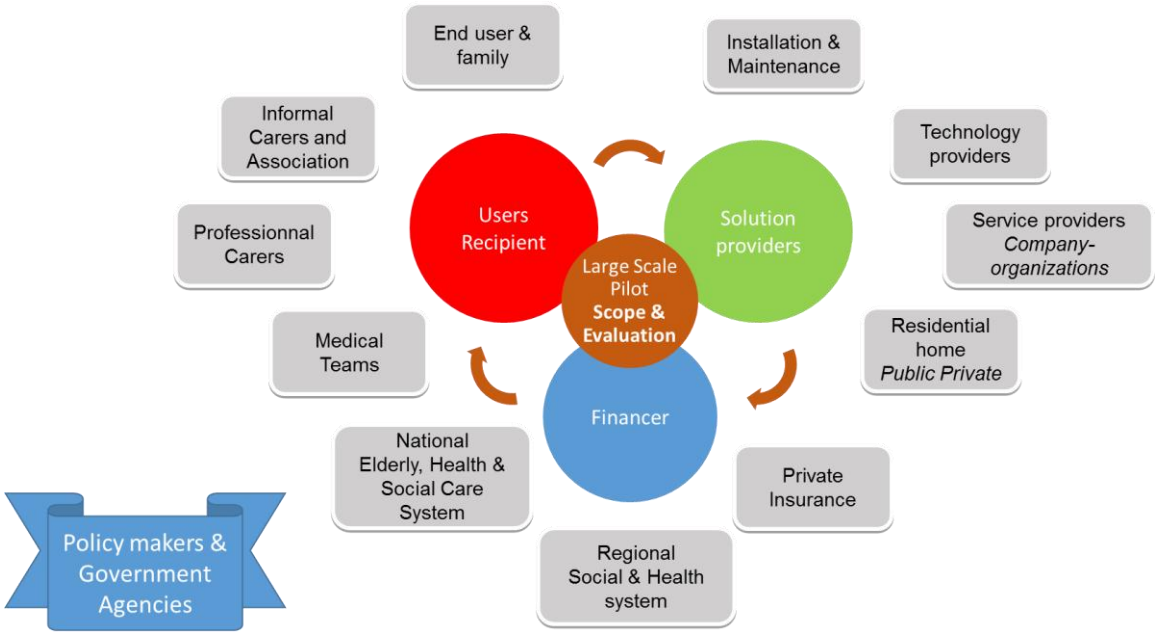

Figure 4.20: Silver Economy: "Smart living for Aging well" multi dimension eco-system

All stakeholders should be involved in the innovation process to improve the elderly and fragile person's autonomy in their living environment while optimizing informal and professional carers working conditions, improving sustainability of the elderly care regimes while having strong economical impact for European companies.

Furthermore, the development of the European eldercare funding system has taken place in different ways across Europe, leading to different eco-system for Silver economy.

A recent study "TechnolAGE" as identified five geographic regions of Europe with their own characteristic for eldercare funding regimes (Anglo-Saxon, Scandinavian, Continental, Mediterranean and Eastern European) having direct impact on the business model. These models should be taken into account when choosing the 4 pilot countries in order be representative of European diversity.

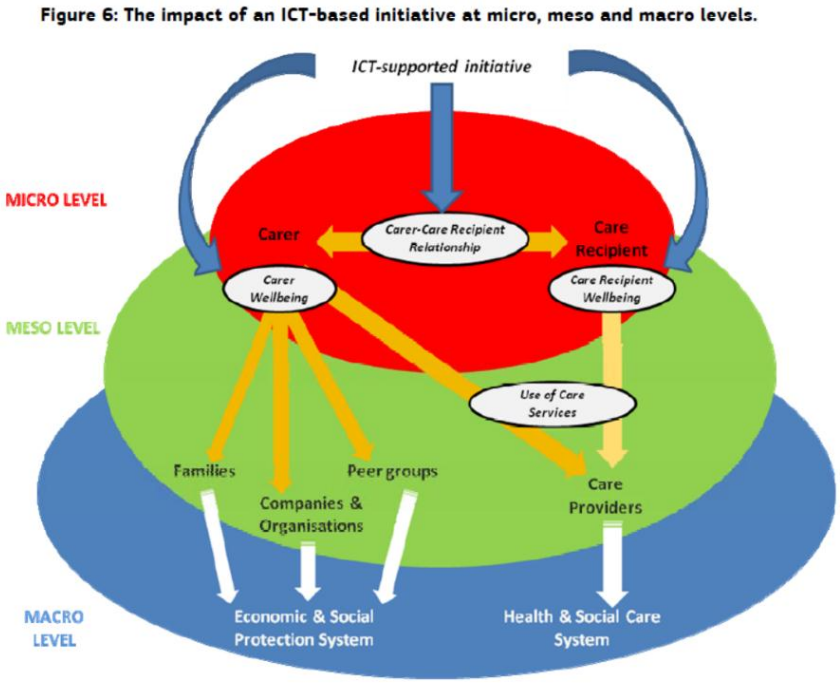

Figure 4.21: The Impact of ICT-based Initiatives

Source: "Can Technology-based Services support Long-term Care Challenges in Home Care?" Report EUR 25695 CARICT Project Summary Report, Joint Research Centre Institute for Prospective Technological Studies

Table 4-1 Summary disposition of actor roles across the five European geographic regions

Geographic regions	Funders	Providers	Direct carers
Anglo Saxon	Strong state funding role (the largest in Europe), with some commercial funding	Mainly commercial sector and the state, with some civil and informal providers	Mainly informals and civil society carers
Scandinavian	Strong state funding role, also insurers, informals and commercials	Mainly commercial providers with some informals and state	Informals, the state and commercial sector carers
Continental	Mixed funding model: state and insurers, also informals and some commercials	Mainly commercial provision and some civil society and informals	Mainly civil society and informal, with some state, carers
Mediterranean	Mixed funding model: state, commercial and civil society, and small informals role	Commercial sector by far the largest provider with others having small role	Mainly informal and civil society carers, with smaller commercial and state roles
Eastern Europe	Mostly only state and commercial funding roles	Mainly commercial with some state providers	Important informal and civil society carers, with some commercial and state role
Europe as a whole	Mainly state funding but all other actors involved	Mainly commercial provision but all other actors involved except insurers	Mainly informals and civil society carers, with some role for commercial and state actors

Source: "Study on business and financing models related to ICT and Ageing well" i.e. the TechnolAGE study conducted by Ernst & Young and the Danish Technological Institute for DG CONNECT

4.2 The IoT ecosystem

As stated above, due to the network effects of an IoT ecosystem, there are efficiencies from having a single ecosystem and allowing devices and users to join the ecosystem to provide services (sensor providers, Analytics companies, Application providers). The business model for provision of the IoT network infrastructure therefore needs to be carefully considered.

A fully regulated network business model would involve setting up charging regimes for access to the IoT ecosystem. The ecosystem provider would be permitted to recoup its costs plus a profit margin in return for providing the infrastructure; and users (sensor and service providers) would be charged for joinging their devices to the ecosystem and for using the communications infrastructure and platform. Charging could be based on traffic volumes and number of connected devices;

An unregulated model would rely on commercial initiatives to set-up IoT ecosystems. Given the positive network effects there are strong commercial incentives on consortia to set-up ecosystems and to allow access to these ecosystems. Under this model, however, there is a risk that some parties could be excluded from the ecosystem, or that, once established the ecosystem provider could increase/introduce charges to parties using the infrastructure.

An intermediate approach could ensure open access to commercially built ecosystems by taking steps - if and where there is evidence that certain parties are being given unequal terms for access to a commercial ecosystem. This will allow the continued development of commercially driven ecosystems; the European Commission could also drive and encourage the adoption of open standards for both device interoperability and open access to IoT ecosystems.

With regard to the provision of sensors, user interfaces and services there are two main business models. The first is to offer sensor and UI hardware and software and allow users to use these capabilities to receive a range of services offered by service providers. Device providers make money from device sales and competitive advantage is maintained by Research and Development to improve existing sensors and user interfaces and to develop new technologies. Under this business model generally users will buy a device via a one-off payment; consumers could also pay for software updates (e.g. windows computers).

The second core business model is to use the ecosystem to offer services to consumers. For example a provider may offer basic free services, but then paid 'premium' subscription services. This business model either relies on collaboration with a company who provides hardware and software, or the availability of an open ecosystem which allows access to data from sensor, capabilities of actuators and User Interfaces required to offer the service.

In any case, two aspects should be addressed:

- the affordability of IT solutions for e-health and assisted living solutions
- the integration among application domains that are still separated, such as e-health and AAL on one side and building automation, home security, light control, energy management, possible entertainment, social media etc. on the other side.

4.3 Testing User acceptability

As seen in previous chapters, existing experiments have been already launched with different maturity and deployment scale in Europe. Based on feedback from these, the LSP "Smart living for Aging Well" should propose a clear methodology to build the user acceptability assessment. This evaluation should address all the different aspects innovated through the pilot:

- Usage acceptability from all stakeholders of the proposed solution and services
- User adhesion promotion and evaluation in the long term (coaching, formation, perceived individual advantage…)
- User context adaptability (tailored and individualization, evolving situations…)
- Respect of privacy and ethical concerns
- Effectiveness of the proposed model to prolonge independent and safe living of older adults at home with good quality of life
- Ability of the proposed model for wider scale deployment
- Adaptability to the different elderlycare National organizations.

User and usage acceptability concerns should not be seen as a final step in the LSP process, but should be taken into account from the early definition of the Pilots objectives, specifications in a Usage Driven Specification process.

- **Usages driven Pilots specifications and co-conception methodology:**

It is important as well to involve during the usages requirements and specifications, the different types of stakeholders: end-users (elderly, patient organizations, family, professional and non-professional carers), installation and maintenance professionals, exploitation (service providers, housing providers..), financers (public , private) The involvement of users can also be relevant, not just in the early stages of service development but in the continuous improvement and renewal of services.

- **Usability, accessibility, simplicity designed solutions for all users**

Co-designed methodologies with multidisciplinary teams including ergonomist, designers, engineers, economists and sociologists should be proposed in order to optimize the adhesion of all stakeholders to the LSP.

- **Privacy and ethical concerns**

Privacy and security aspects should be treated early in the solution design, including organizational and economic impacts.

Ethical and legal aspects should be taken into account early

- Affordability

Affordability of high quality solutions should be addressed, to guarantee the availability at reasonable prices of services for keeping the senior citizens, safe, healthy and connected in the digital continuum.

- **Testing, deployment, and assessment**

Future deployment in real environments and larger scale, should be taken into account early in the specification of the solution, including all the necessary actors involved in home installation and maintenance, as well as caregivers.

Maturity of the solution should be proven in experimental testbeds before any deployment in real-world demonstrations and field trials. Such testbeds should be used to validate the functionality, robustness and durability of the solutions in realistic environments before launching usages assessment in real world.

- **Impact assessment methodology**

Usage evaluation protocol and criteria should be built with together with multidisciplinary teams: sociologist, gerontologist, health economics experts, to assess the benefits of smart living environments based on IoT in terms of prolonged independent and safe living of older adults at home with good quality of life. The assessment methodology could include: panel selection, reference panel, financial condition for the testing, evaluation criteria for the various dimensions, evaluation mode (quantitative and qualitative) and geographic region comparison.

4.4 Usages driven Pilots specification

It is important as well to involve during the usage requirements and specifications, the different types of users : end-users (elderly, professional and non professional carers), installations and maintenances professionals, exploitation (service providers, home Usability, accessibility, simplicity designed solutions for all users, co-designed solution with multidisciplinary teams including ergonomist – designers – engineers – economist- sociologist, privacy and security aspects should be treated including organizational economical impacts. Ethical and legal aspects should be taken into account at early stage.

Deployment, testing and assessment

Future deployment in real environment should be taken into account early in the architecture, including all the necessary actors involved in home installation.

Maturity of the solution should be proven in experimental testbeds before any deployment in real-world demonstrations and field trials, in order to test and validate the functionality, robustness and durability of the solutions in realistic environments before launching usages assessment in real world.

Usage evaluation protocol and criteria should be built with together with socio-medical teams (sociologist, gerontologist,…) to assess the benefits of smart living environments based on IoT in terms of prolonged independent and safe living of older adults at home with good quality of life.

As stated above, due to the network effects of an IoT ecosystem, there are efficiencies from having a single ecosystem and allowing devices and users to join the ecosystem to provide services (sensor providers, Analytics companies, Application providers). The business model for provision of the IoT network infrastructure therefore needs to be carefully considered.

A fully regulated network business model would involve setting up charging regimes for access to the IoT ecosystem. The ecosystem provider would be permitted to recoup its costs plus a profit margin in return for providing the infrastructure; and users (sensor and service providers) would be charged for joinging their devices to the ecosystem and for using the communications infrastructure and platform. Charging could be based on traffic volumes and number of connected devices;

An unregulated model would rely on commercial initiatives to set-up IoT ecosystems. Given the positive network effects there are strong commercial incentives on consortia to set-up ecosystems and to allow access to these ecosystems. Under this model, however, there is a risk that some parties could be excluded from the ecosystem, or that, once established the ecosystem provider could increase/introduce charges to parties using the infrastructure.

An intermediate approach could ensure open access to commercially built ecosystems by taking steps - if and where there is evidence that certain parties are being given unequal terms for access to a commercial ecosystem. This will allow the continued development of commercially driven ecosystems; the European Commission could also drive and encourage the adoption of open standards for both device interoperability and open access to IoT ecosystems.

4.5 Business Models

The actual lack of Business model is one of the bottleneck limiting the "Silver economy" market takeoff that should be address taking into account the specificity of "Independent living at home for older adults" market segment and its strategical socio-economical impacts. The choice made by Euroepan care system for Care at home rather than in hospital, will supposes new forms of organisations of long-term care services ICT and IoT will surely be facilitators for such evolution. The conventional organisation of formal care services (predominantly local, focused on management of people) may be challenged by the economics of ICT-based services (which may operate from platforms and be economically viable on a much larger scale). Furthermore, each EU country has specific national care systems organisation that will aswell strongly impacts the potential business models of the IoT solutions.

The proposed business model for the LSP should involve intergaction with national care systems and when necessary propose innovation at the organizational level to obtain efficiency gains from capital technology and lead to economical viability. Innovating business and financing models should be studied in the Pilots to propose and assess the solvability of the proposed solutions and services to rationalisation and efficiency gains.

Different actors of the socio-economical eco-system should be involved in the analysis and assessment of the models: national/regional financers, private/ public health insurance, national / private service providers / National – private promotors.

Ethical and privacy issues are critical aspect to be taken into account in the business model and organization. Different national models should be compared and tested, proving that the proposed IoT pilot will be adaptable to different organization and business models.

Investigation aspects of the operational dimension for an LSP (Large-Scale Pilot)

- Which governance should be adopted by the consortia
- What kind of IP rules for collaboration / Which incentives for companies to continue cooperation after the end of the funding period / How to translate the pilot into more commercialisation / etc

The operational dimension may also look at potential market barriers for future deployment.

5 Acknowledgements

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6 References

[1] The 2012 Ageing Report: Economic and budgetary projections for the 27 EU Member States (2010-2060) published by European Commission.

[2] Disposable insulin system using microfluidic technology: http://www.st.com/web/en/press/jp/t3037

[3] 'Medical-Grade' Human implantable Motion Sensor: http://www.st.com/web/en/press/en/p3722

[4] SC78DI07171 – *D4 Final study report:* IoT Benchmark Study - Final Report published by European Commission.

[5] Health Effects of Climate Change in the UK 2012 V13 published by Health protection Agency / UK.

[6] Over mortality during European heat wave: http://ec.europa.eu/health/climate_change/indicators/index_en.htm

[7] http://ec.europa.eu/digital-agenda/en/ehealth-and-ageing

[8] "Growing The European Silver Economy" - Background Paper European Commission - 23 February 2015

[9] "Study on Business financing models related to ICT for ageing well" - European Union, 2013.

[10] "Can Technology-based Services support Long-term Care Challenges in Home Care?" - Analysis of Evidence from Social Innovation Good Practices across the EU: CARICT Project Summary Report – JRC Scientific and Policy Reports – 2012

[11] "Benchmark study for Large Scale Pilots in the area of the Internet of Things - Final study report" – European Commission 2015

[12] http://www.internet-of-things-research.eu/pdf/Building_the_Hyperconnected_Society_IERC_2015_Cluster_eBook_978-87-93237-98-8_P_Web.pdf

[13] http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-health_en.pdf

[14] http://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/home_ws_intro.pdf#view=fit&pagemode=none

[15] http://ec.europa.eu/research/innovation-union/index_en.cfm?section=active-healthy-ageing&pg=about.

[16] http://www.aal-europe.eu/

[17] https://www.eitdigital.eu/

[18] https://eithealth.eu/

[19] http://www.internet-of-things-research.eu/index.html

[20] http://clout-project.eu/

[21] http://clout-project.eu/field-trials/mitaka-city-paw-collection-field-trial-2/

[22] http://www.iot-butler.eu/

[23] http://www.iot-butler.eu/domains/smart-healthcarewellness

[24] http://open-platforms.eu/library/openiot-the-open-source-internet-of-things/

[25] http://universaal.org/index.php/en/

[26] http://cip-reaal.eu

[27] http://www.aaliance2.eu/newaalroadmap

[28] http://nero.offis.de/projects/aaliance2/start%2520

[29] http://www.aeris.com/technology/aercloud/

[30] Archives of Gerontology and Geriatrics 48 (2009) 40–44, "Validation study of a social functioning scale: The social-SMAF (social-Functional Autonomy Measurement System) Eugenie Pinsonnault et Al.