DOI: 10.1561/9781680838251.ch9

Chapter 9

SIS-based eHealth Application: The Tellu Use Case

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9.1 From Chronic to Pro-active Care

To date, an average of 80% of public health care resources in Europe are spent to respond to chronic diseases that are exacerbated in the last three years of people's lives, against a low investment of resources in the field of prevention, which can be pursued by changing lifestyles. Public health expenditure is among the largest and fastest growing spending items for governments. In 2015, public expenditure on health was 7.8% of GDP in the EU as a whole, with more than 70% of expenditure funded by the public sector in two thirds of Member States (EC 2017). In 2013, premature deaths due to major NCDs (cardiovascular diseases, cancers, respiratory diseases and diabetes) cost EU economies 0.8% of GDP (OECD/ EC 2016), with further losses incurred due to the lower productivity and employments rates of people living with chronic health problems. Due to population aging, chronic diseases and the diffusion of new diagnostic and therapeutic technologies, the share of GDP spending on health is projected to increase in the coming years (EC 2015, OECD/ EC 2016). In most high and middle-income countries, non-communicable diseases are responsible for the biggest share of such healthcare costs (EC 2014). Furthermore the ongoing pandemic situation has boosted the demand of online telecare, eHealth solutions. General practitioners and nurses have improved the remote physical parameters gathering, almost regarding oxygen saturation and body temperature. Due to these kind of increasing use of technology, care provider organizations has improved and scaled up their organizational models also in terms of digital employees' digital skills and care workflows.

This panorama indicates that institutions and care providers adopt a pro-active care approach aimed at significantly influencing individual, collective and organisational behaviour so that people can consciously plan lifestyles in which the preventive role played by the behavioural determinants of longevity is valued: nutrition, physical activity, cognitive stimulation and sociality.

This last aspect, in particular, has a decisive role as a health protection factor. It has been shown that perceived loneliness has an impact in terms of mortality comparable to smoking fifteen cigarettes a day. Furthermore, it is frequently associated with anxiety, depression and reduced movement, which can lead to hypertension and metabolic disorders with chronic degenerative effects. In this sense, living, lifestyle and technological support are integrating into a unicum that characterises the ecosystem in which the health design of the future is embedded. Within this new perspective, the process of longevity requires social and health services to overcome the dichotomous logic of intervention structured on antitheses such as health vs. disease, autonomy vs. dependence, placing rather their offer within a continuum that contemplates paths of reversibility, compensation, homeostasis, and new dynamic adaptations to the needs of the subject.

It is therefore necessary to imagine a model of person-services relationship based on the concept of co-production of health. In such a framework, the intervention of technology is inserted in support of care in a co-decided way with the person: at one extreme, ICT assumes a role of support to the fitness and well-being (i.e. prevention) of autonomous and still healthy citizens, to reach at the opposite extreme the apex of the technological complexity connected to an increase in the intensity of health care, passing through moments in which it becomes possible to set up an "intermediate" action of technological support, for example in the management of chronicity at home and in the transitions between the services used by the subject. eHealth solutions have increased their presence, and their perceived usefulness, following the development of the Covid pandemic19. In the global context, and in the European context in particular, there has been a proliferation of state-sponsored applications that provide information on the disease, ensure contact tracing, and create an informed dialogue with one's doctor and the Covid19 emergency management team in one's territory. The applications have also made it possible to remove much of the bureaucracy involved in the relationship between citizens and the health system, since many of the activities relating to the booking of diagnostic examinations, their payment and their reporting have moved online. Lastly, one of the most interesting aspects of the increase in the use of wearable technologies for measuring certain health parameters is the growing possibility of acquiring data capable of feeding machine learning and data processing systems capable of activating artificial intelligence systems capable of making diagnostic forecasts and providing useful information for personalising care in increasing numbers.

At the centre of this paradigm is the decision-making process involving experts and the person: it is based on the personalisation and timing of the use of technologies, and on the personalised design of the integrated care process structured in collaboration with the family (where present) and the social and health services, public and private, which may be activated.

9.2 e-Health and m-Health for the Digital Evolution of Services

The European Commission defines eHealth and Digital health and care as: "Digital health and care refers to tools and services that use information and communication technologies (ICT) to improve prevention, diagnosis, treatment, monitoring and management of health and lifestyle. Digital health and care has the potential to innovate and improve access to care, the quality of care and to increase the overall efficiency of the health sector".

In the field of care for the elderly, tele-assistance is one of the answers that best translates the above statement into concrete terms. It must be understood as the person's ability to communicate remotely with home care providers and their social surroundings through the use of devices such as tablets and smartphones. These devices, equipped with integrated adapted video communication applications, are often placed in dialogue with wearable devices capable of automatically acquiring information about certain significant critical parameters, such as blood pressure and blood sugar in the case of fragile people suffering from chronic diseases such as hypertension and diabetes. They are therefore able to signal the exceeding of individual critical thresholds, activating the subject and starting a pre-set alarm chain.

In this sense, in 2017 the European Commission launched the initiative "Blueprint strategy for a digital transformation of health and care in an ageing society" proposing a structured path that links four distinct but fundamental worlds in advancing care innovation alongside technology: universities, companies, public authorities and citizens. The objective pursued is to transform social challenges into opportunities for economic growth associated with an increase in citizens' wellbeing. This initiative foresees a "multiplier effect" to boost the digital transformation of the entire health care secotr. For companies, research organisations and care providers operating in the social and health sectors, the indications contained in the

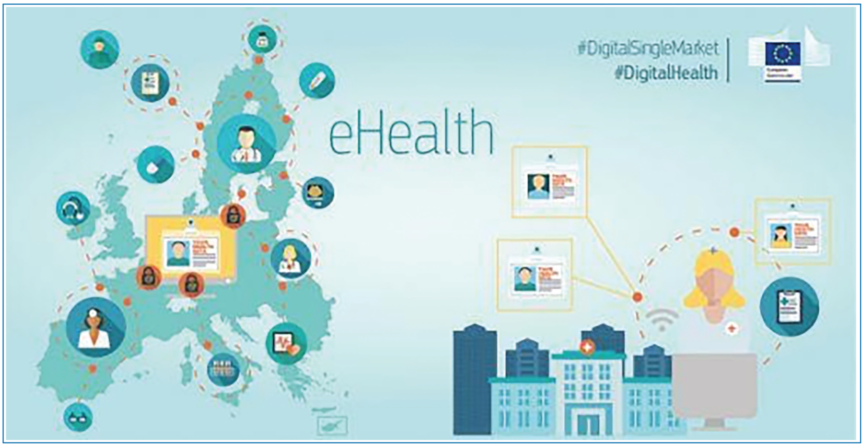

Figure 9.1. Evidence of the positive results produced by the implementation of this approach, defined as “quadruple helix”, is the success of numerous experiences mapped by the study of European excellence in the sites selected by the European Innovation Partnership for Active and Healthy Ageing.

“Blueprint strategy” represent a fundamental reference point for structuring digital innovation paths in care. This document directs corporate efforts towards the adoption of a perspective in which people and their needs are placed at the centre, aiming at their empowerment to achieve independent living in their own context. The elements connected to the participatory co-design of technological solutions, as well as the creation of sustainable business models capable of making care systems more efficient, represent the drivers to be followed for the digital transformation of services supporting frail persons.

A virtuous example is represented by the recent HoCare2.0 Project, done in the Interreg Central Europe Programme (https://www.interreg-central.eu/Content.Node/HoCare2.0.html) that is going to codesign and provide customer-centered home care by co-creation with citizens. The Project foresee the creation and the devices adaptation to the user needs in combination with the SMEs knowledge to come up with technological solutions that could be relevant and usable in the daily life.

Another experience is The “Electronic Health Care Record and Integrated Information Systems” that has been implemented by the Valencian Health Agency to improve the integration and interoperability of systems and guarantee their sustainability, with greater efficiency and quality of service and according to a citizen-centred approach.

Below are some examples of the impact of the programme:

- In the context of the Integrated Home Care Programme, approximately 7,000 patients were treated with an overall satisfaction index of 92.7%; 154

were saved for each stay in hospital, which was 30% less than the Spanish national average duration;

- the Electronic Dossier is accessible to 50,000 health professionals and 373 pharmacies. There are 5.1 million clinical pictures of patients, 43 million clinical documents are registered, 150,000 visits are conducted daily online. This information, integrated with each other, has enabled better control of treatment interactions and drug administration and increased quality support for professionals' decision-making;
- system development has created a boost for the IT industry in the region: 1,320 IT specialists and 107 companies have been involved at full capacity.

9.3 H2020 ENACT Project Pilot Testing Experience

This framework includes the experimentation conducted in ISRAA (ISTITUTO PER SERVIZI DI RICOVERO E ASSISTENZA AGLI ANZIANI) that is a Public care provider organization for older people, based in Treviso (Italy) concerning the investigation, and subsequent experimentation, of some technological solutions for the remote assistance of fragile people living in the residential context of "Borgo Mazzini Smart Cohousing" foreseen within the Horizon 2020 ENACT DevOps project on DevOps of trustworthy smart IoT systems.

The residential complex in which the elderly people who participated in the pilot reside is located in the historic centre of Treviso. It consists of 46 flats with a total surface area of 5,589 m2 in which elderly people live alone or in pairs with an average age of 75 years.

9.3.1 ENACT Pilot Scenarios on Smart Building and eHealth Impact

As the first step to the e-health IoT system design, in order to understand the attitudes and needs of the elderly residents in Cohousing towards technological innovations for the improvement of quality of life, a set of questions were defined to be asked to the residents in the form of an interview. Then, a focus group followed where eight residents representative of the elderly population used the designed technologies for environmental comfort and independent health management.

Below are some of the most significant elements taken from the survey conducted in August 2020:

The study showed a general inclination towards the adoption of technologies useful for monitoring both one's own health and the living environment for the benefit of one's comfort and safety.

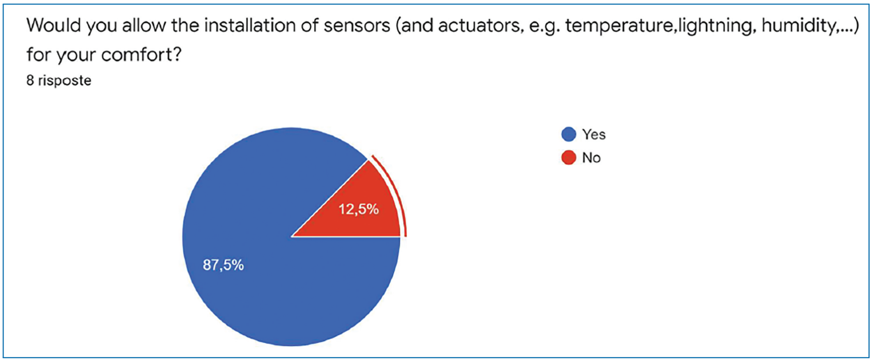

Figure 9.2. Percentage of users who agree to sensors installation for environmental comfort.

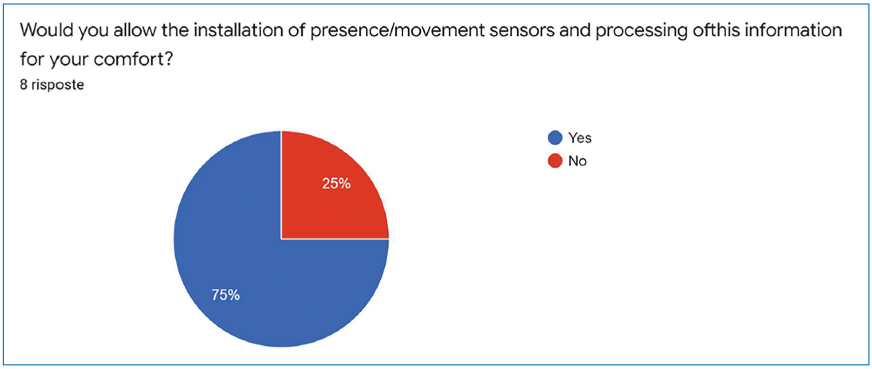

Figure 9.3. Percentage of users who agree to presence and movement sensors.

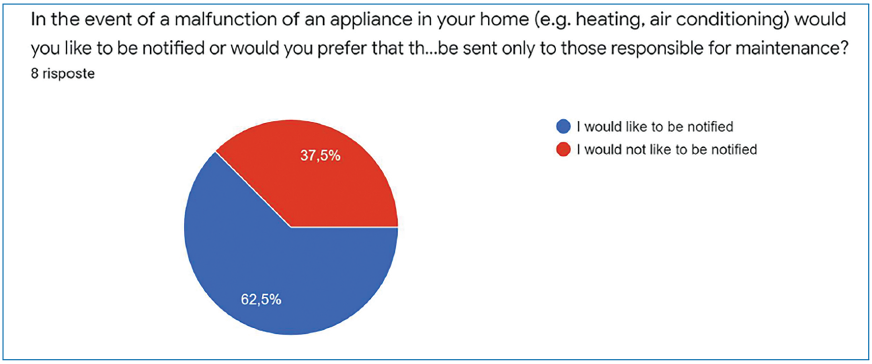

Figure 9.4. Percentage of users who want to get notifications of devices' malfunctioning.

On the basis of this attitude, some residents with conserved cognitive resources and a discreet functional autonomy were involved in order to test the devices provided by the Norwegian Company TellU that provide eHealth solutions in health care such as: thermometer, saturator, Oxymeter, sphygmomanometer capable of

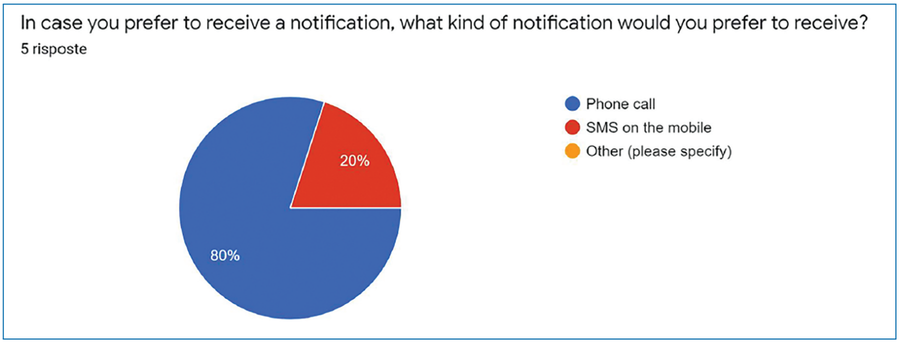

Figure 9.5. Percentage of notification modalities preferred from users in case of malfunctioning.

detecting and transmitting the parameters detected via Bluetooth in real time to the ISRAA care manager. In this way, on the basis of a personalised care plan, innovative teleprotection paths have been activated based on the detection of critical alarm thresholds, for each parameter, over which the care manager was able to act in a timely manner by innovating the care processes.

The experience was favourably in the eyes of the elderly people testing the solution, who were able to experience the benefits of these health support tools, highlighting the high usability of the devices throughout the trial.

With regard to the organisational impact, determined by the experimentation, it should be noted that the nurses and care management staff involved appreciated the time savings, the accuracy of information and the possibility of acting proactively, guaranteeing better health conditions for the people assisted.

9.3.2 Technical Overview of the eHealth Case Study

The industrial-based use case from TellU that was developed in ENACT is a Digital health system for supporting and helping various patients staying at home or in residencies such as cohousing to the extent possible during treatment and care, as well as to have tight interaction with health personnel through digital means in addition to adequate physical meeting points. This makes the patient more independent and it enables support for extensive self care. One type of "patients" supported by the provided digital services is elderly people, for whom the Digital health system will feature elderly care to allow the elderly to live safe at home. Another type of patients are people with chronic diseases such as Diabetes, Kidney diseases, Chronic obstructive pulmonary disease (COPD) and people with temporary diseases such as Covid-19 and cancer. These are patients that need to be regularly followed up and that would benefit from sensor based health status monitoring and digital self care services. For example, Diabetes patients apply sensors and devices to follow

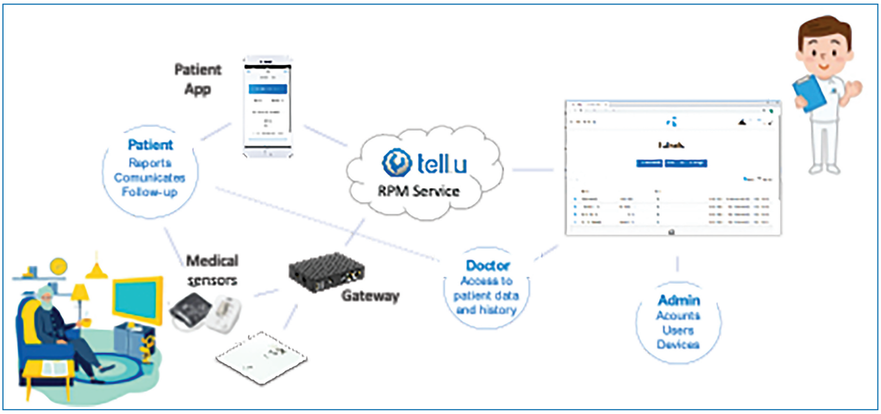

Figure 9.6. The general set up of the ENACT eHealth case study.

their glucose level and regularly provide measurements and questionnaire reports that can be followed up by health personnel. The general set up of the Tellu eHealth case study for medical telecare services is illustrated in Figure 9.6.

The digital health system controls both equipment that are deployed for remote supervision (such as bed sensors, motion sensors, sensors for indoor and out-door location, video based supervision, etc.) and various types of medical devices and specific sensors supporting the care and wellness for the specific patient (e.g., blood pressure meter, sphygmomanometer, Oxymeter, glucose meter, medicine reminder, etc.). In addition, the system can integrate with other systems, for instance to provide information or alarms to response centers, caregivers, physicians, family, etc., and to feed information to medical systems such as electronic health record systems.

In terms of managing the extensive distribution of devices, sensors and software across the IoT and edge space we exploit what we denote "the Personal Health Gateway" (PHG) which integrates the sensors and devices and that controls the edge and ensures the right data are provided to the various stakeholders and to the cloud based system. Thus, the handling of large numbers of largely distributed personal health gateways and their connected sensors has been a main focus in this case study for the validation and exploitation of the ENACT technologies. In particular, we have explored the potential of ENACT for the IoT, edge and cloud services, by having smooth integration of heterogeneous devices, DevOps process for the development of the edge components, as well as secure and trustworthy connections and data transfers. This case study is set up with a local/edge infrastructure consisting of a set of devices and a home gateway (GW). A set of such local infrastructures are then connected and aggregated into a cloud-based infrastructure. The overall technical architecture of the use case including the PHG are depicted in Figure 9.7.

The Personal Health Gateway architecture is the one depicted in the lower part of the figure, and is the element that is controlling the edge and connecting devices

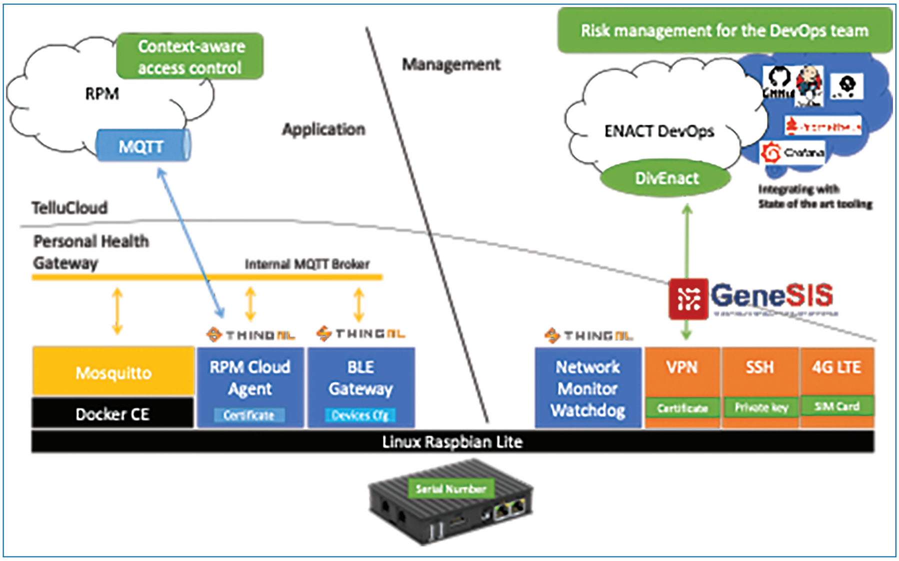

Figure 9.7. Overall architecture with the GW architectural components.

and sensors in the IoT and edge space, while the TelluCloud eHealth system resides in the cloud. The total system encompasses a complex ecosystem spanning IoT, edge and cloud. The Personal Health Gateway consists of a set of microservices to manage the various interactions with the devices and cloud services. The application level interaction and the management is completely separated. This is partly to ensure strict security and privacy requirements. The BLE gateway component manages Bluetooth Low Energy (BLE) enabled devices, for example blood pressure meter, scale, glucose meter, etc. The RPM cloud agent includes the application logic that resides at the edge level and interacts with the cloud level service. A set of microservices supports the management and DevOps process, providing access to system level operations of the Personal Health Gateway through secure channels. Moreover, it includes the monitoring component providing system and application level monitoring required for the continuous operation of the service. The Gateway includes an MQTT broker and support for standard internet communication protocols. The components run on docker containers. The application of the ENACT enablers is indicated in the overall architecture of Figure 9.7:

- The context aware access control is explored to provide more advanced application-level functionality in order to dynamically provide access to different stakeholders based on the context. Context can for example imply an escalated state or a crisis situation. For example, in case of a fire alarm in the patient's house, it may be important to provide further access to the installed camera for example to provide access to firefighters for them to better assess the current situation, while in the normal state the camera will only be possible to be accessed by authorised health personnel;

- ThingML is fully exploited for the efficient coding and DevOps support of the Personal Health Gateway;
- GeneSIS together with DivENACT is explored for the efficient management and continuous deployment of potentially large scale deployments of our telecare service, where large amounts of IoT and edge devices such as welfare sensors and medical devices are managed through the deployed Personal Health Gateways (PHG) residing in people's homes. Note that the PHG is the software stack as depicted in the overall architecture figure above, thus, it may also be deployed on mobile gateways (e.g., smart phones) and we are currently releasing a new version of our PHG that can be deployed on Android and iOS based smart phones, enabling the patient to do medical measurements on travel.
- The ENACT Risk Driven Decision Support tool is explored as part of our DevOps process that needs to be compliant with standards such as ISO 27001, where risk analysis and risk management is required to be an integral part of the DevOps process.

Reference

[1] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Addison-Wesley, Reading, Massachusetts, 1993.