inCASA project – Smart telemonitoring

Andrea Prestileo, Raffaele di Fiore

Abstract — **Telemonitoring services represent an added value both for patients, who are assisted better and are more sheltered at home, and for institutions that provide care, as this can reduce the number of accesses to their facilities and therefore the costs. The generation of alarms and their management by a service centre that can involve the most appropriate structures are a prerequisite for this type of service. Generally, Telecare and Telehealth services belong to different application domains and have few points of convergence. This paper presents the inCASA project in which has been realized a solution, applied to the telemonitoring of the elderly people, where Telecare and Telehealth data are processed jointly by a smart system capable of generating alarms based on the deviation of measurements from the habits and physical profile of the patient.**

Keywords — **Telemonitoring, Telecare, Telehealth, Standards, Interoperability.**

I. Introduction

inCASA is a project funded by the European Commission under the CIP - ICT PSP program (Competitiveness Innovation Programme - ICT Policy Support Programme) which aims to encourage and accelerate the use of innovative technologies and digital content by citizens, public administrations and companies. In fact, using the latest technologies the inCASA project, which involves 13 partners from 8 European countries, aims to improve the quality of life of self-sufficient elderly people by reducing the periods of hospitalization. This goal is pursued through the integration of already existing services and solutions (hardware and software) which allow the profiling of the normal behaviour of patients through the collection and analysis of a substantial amount of data related to environmental monitoring (Telecare) and vital signs (Telehealth).

The "real" innovation brought by the inCASA project is the integration at service level of the two different domains of measurement (Telecare/Telehealth) and the design of specific integrated scenarios.

The pilot sites where the trial has taken place are distributed in 5 European countries: Institut National de la Sante et de la Recherche Medicale (Paris, France), Fundacion Hospital Calahorra (Calahorra, Spain), Chorleywood Health Centre (London, UK), Konstantopouleio General Hospital of Nea Ionia Agia Olga (Athens, Greece), Agenzia Territoriale per la Casa della Provincia di Torino (Turin, Italy).

A. Italian pilot: ATC Torino (Agenzia Territoriale per la Casa della Provincia di Torino)

In Italy the trial started with a pilot group of 20 elderly residents in social housing flats in charge to the Social Services of the city of Turin; the initiative aims to create a new welfare model focused on the collaboration between Social Services and social housing enterprises.

The sensors, installed in the elder's home, monitor his/her habits: as soon as the system detects a significant deviation from the "normal" habits an alarm is triggered which is immediately handled by the call centre of ATC Turin. Operators call the elder, check the situation and if necessary alert the Social Services. An innovation, compared to home care, whose benefits extend to the family network of the elderly and to community services.

II. Telemonitoring services

The platform developed in the inCASA project aims, through the use of technology and provision of a specific set of services, to extend the time in which elderly people can just "live well" at home, surrounded by their own comforts and their loved ones. In this way the seniors will both improve the self-confidence and the ability to cope with everyday life thus increasing their independence and minimizing the need for hospitalization.

One of the main functional requirements implemented by the inCASA platform is the integration at service level of data collected through the monitoring of clinical parameters (Telehealth) and habits (Telecare) of the senior. The combined analysis of the two different kinds of data is used to assess more accurately the impact that the deviations from habits, together with the change of some clinical parameters, may have on the elder; this may help to prevent possible problems by planning actions targeted by the Social Services and/or general practitioners (GPs).

Figure 1 Factors enabling the Socio-Medical integration

Specifically, the inCASA project aims to:

- provide patients with special needs a non-intrusive solution of habits profiling that monitors their health conditions outside traditional healthcare facilities;
- provide physicians, health professionals and Social Services more comprehensive telemonitoring measures in order to remotely analyse the user's physical/behavioural conditions;
- ensure continuity of care through greater interaction between elderly patients and health workers;
- ensure the integration of the home automation in a system which allows the remote control of electronic devices.

A. Telecare

The Telecare service is useful to provide physicians, health professionals and Social Services an indication on the social/physical state of the remotely monitored patient.

Specifically, using environmental sensors, the following parameters are monitored: movement inside the home, chair and bed permanence, opening/closing of the front door, turning on/off of the television set, wrist movement during the night (actigraphy).

The innovation comes from the idea to combine the sensors with the "smart" platform, developed by Reply, able to capture the behaviour of the elderly and generate alarms in case of deviation from the normal profile.

One of the most interesting scenarios implemented in ATC pilot is about the combined use of the sensor of permanence on the chair and the one which detects the turning on/off of the television set. Capturing data for a predefined period of time the system learns the average time the user spends sitting at home and how long he/she keeps the television turned on. When it detects a deviation greater than 70% compared to the normal profile, it generates an alarm which is displayed on the monitors of ATC Torino call centre's operators who take care to call the senior patient and in case to alert Social Services. These data, crossed with those acquired by the sensor of opening/closing of the front door, may help to prevent problems of depression. For example, the Social Services could plan some actions in favour of the senior who previously used to leave the house on a regular basis and now spends more time sitting in front of the television.

B. Telehealth

The inCASA solution integrates Telehealth services covering aspects of prevention, treatment and care.

The platform, using appropriate sensors, allows remote monitoring of the following physiological parameters: heart rate, pulse oximetry, blood pressure, body weight and blood glucose.

The inCASA platform, collecting measurements for a certain time period, is able to create the clinical profile of the elderly and then to evaluate the deviation of the parameters not only from the clinical reference thresholds but with respect to the patient's specific ones. For example, the alarm thresholds of two elderly people who suffer respectively high and low pressure will be different.

The physician has available on a graphical user interface the patient's profile, the clinical measurements' trend and the alarms generated by the system: these data are supportive to the evaluation of the health of the elderly and the decision to start therapy or not. Once checked and ascertained the real state of health of the elderly, the doctor may change the reference values of some parameters and thus the relative alarm thresholds.

III. Functional Architecture of the inCASA Platform

The functional architecture of the inCASA platform includes 4 levels of communication (Figure 2):

- **primary communication** between sensors and gateway, at home level;
- **secondary communication** for local monitoring of data and events;
- **tertiary communication** between the gateway at home and the central platform accessed by the service centre;
- **quaternary communication** between the service centre and external actors.

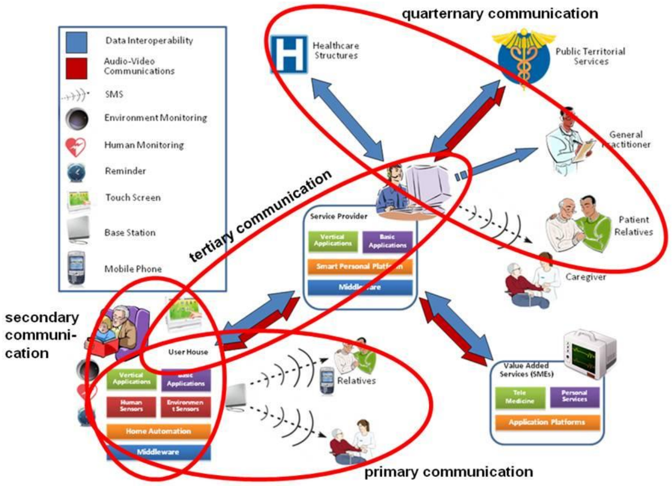

Figure 2 Functional architecture of the inCASA platform

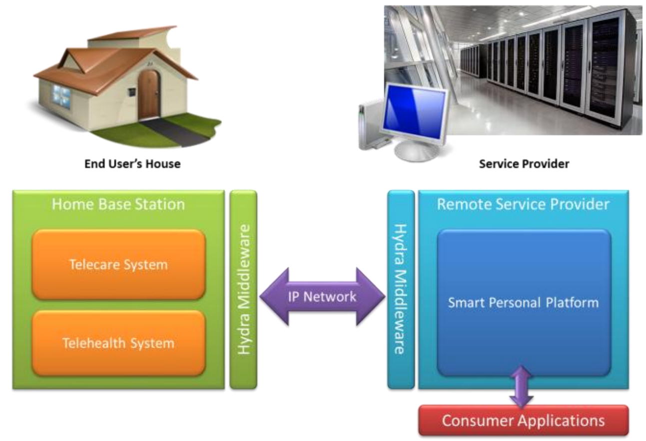

Figure 3 Technological architecture of the inCASA platform

The primary communication takes place locally, at the home of the elderly or in appropriate healthcare facilities, between the sensors and the gateway that collects the measures by them transmitted.

The secondary communication provides the collected measures back to a graphical user interface installed at the patient's home so that he/she can directly monitor his/her clinical parameters.

The tertiary communication takes place between the gateway installed at the home of the elderly and the "smart" platform which processes the measurements and, if needed, generates the alarms to be sent to the service centre.

The quaternary communications occurs whenever the service centre has to contact, depending on the nature and severity of the alarms, the external actors who take care of the senior patient (Social Services, caregivers, relatives).

IV. TECHNOLOGICAL ARCHITECTURE OF THE INCASA PLATFORM

The inCASA platform architecture is made of some components installed at the patient’s home premises (Home Base Station) and a central system dedicated to the collection and elaboration of data (Remote Service Provided) which are consumed through graphical user interfaces (Consumer Applications). Data transmission from the Home Base Station to the Remote Service Provider is performed via the GPRS network.

Figure 3 summarizes the architecture and shows its composing modules, described below.

A. Telecare and Telehealth Gateways

Inside the Home Base Station are placed the Telecare and Telehealth systems.

The Telecare gateway receives the measurements collected from environmental sensors connected via ZigBee network. The elderly patient is monitored in a non-intrusive way.

The Telehealth system (SARA) integrated by Telefonica (project’s partner) into the inCASA platform requires the interaction with the patient who, guided by a graphical touch screen interface, performs the clinical measurements using devices connected via Bluetooth.

B. Integration Middleware

The communication between the Home Base Station and Remote Service Provider is realized through the LinkSmart (alias Hydra) integration middleware, which is the outcome of another project funded by the European Commission.

Inside the Home Base Station the client component of LinkSmart acts as a collector of the Telecare and Telehealth data flows and takes care of transmitting them in a normalized and homogeneous way to the server side of LinkSmart, placed into the Remote Service Provider.

The architecture of LinkSmart, which allows the communication between many home networks and the server side of the platform, is based on P2P technology.

C. Smart Personal Platform (SPP)

The Smart Personal Platform (SPP), developed by Reply, is placed inside the Remote Service Provider and has the task to collect and process telemonitoring measurements, to generate alarm events and report them to the Consumer Applications.

The brain of the SPP is the Reasoner, a context-aware module that makes use of Semantic Web standards (OWL, SWRL, SPARQL) to create the model of the user habits and clinical profile of the elderly patients and to evaluate against it their alterations. The life cycle of the alarms is managed by the Reasoner, automatically or interacting with a service centre operator depending on the nature and evolution of the alerts, by implementing the Alarm Communication Management (ACM) integration profile, defined by IHE.

The measurements received, together with data and alarms generated by the Reasoner, are stored in a patient-centric clinical repository that acts as Electronic Patient Record (EPR).

D. Consumer Applications

A graphical user interface has been developed specifically for the inCASA project as an example of a possible Consumer Application that can be integrated to the system.

This interface is used by the service centre operators to monitor elderly patients and manage the alarm conditions reported by the SPP. In addition to the alarms it is possible to display the Telecare and Telehealth measurements in a tabular or graphical form in order to evaluate their trend.

An alarm can have many levels of severity, shown differently by the user interface; in the Italian pilot, in order to handle some scenarios such as that of the front door left open, the alarm is sent via email to an ATC's software, which in turn sends an SMS to the elderly. Afterwards the inCASA platform keeps monitoring the evolution of the scenario and if the problem persists raises the alarm severity; in the previous example, if after a given time the door is still open, the alarm's escalation will cause the call centre operator to call the elderly by phone.

V. INTEROPERABILITY

As well as the inCASA platform modules have been developed making use of standard technologies, so the communication between them is based on standard protocols and coding systems.

The communication between the main blocks of the architecture is realized implementing the transactions defined by the IHE Patient Care Device integration profile.

As shown in the figure below, measurements' transmission from the Home Base Station to the Remote Service Provider is realized implementing the PCD-01 (Communicate PCD Data) transaction, as prescribed by Continua for the WAN interface, while the integration between the Consumer Applications and the Remote Service Provider is performed implementing the PCD-02 (Subscribe to PCD Data) and PCD-04 (Report Alarm) transactions.

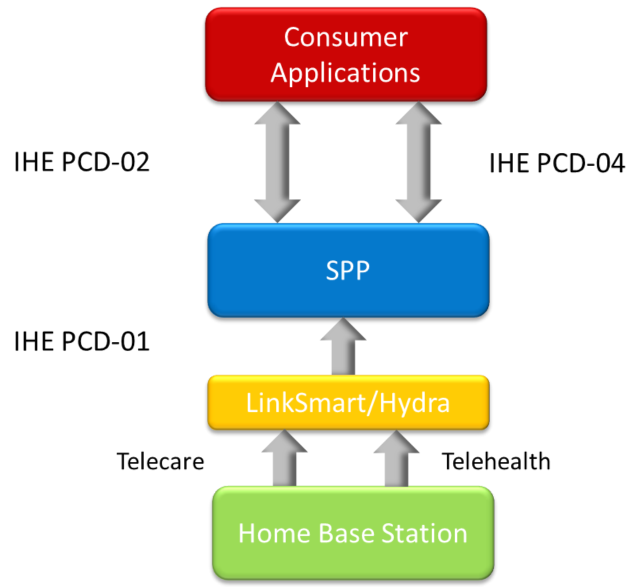

Figure 4 Integration between the inCASA platform components

All data, measurements and alarms, are transmitted using HL7 (version 2) messages exchanged through Web Services whose interface (WSDL) is defined by IHE.

The coding system adopted for measurements and alarm events is IEEE 11073. IEEE 11073-10101 nomenclature defines the terms and the data model which are subsequently specialized, depending on the kind of telemonitoring device, by the IEEE 11073-104xx documents (Device specialization). Some examples are: IEEE 11073-10471 (Independent living activity hub), IEEE 11073-10407 (Blood pressure monitor).

The main benefit coming from this kind of approach is that inside the inCASA platform Telecare and Telehealth measurements are transmitted in a homogeneous way, even if in the origin they might have been coded using proprietary coding systems. The integration of other medical or environmental devices is made transparent by the fact that collected data can be transmitted without affecting the communication interfaces: it is sufficient to code the measurements according to the rules defined by the appropriate nomenclature.

Of course integrating Continua compliant devices (sensors and gateways) is more straightforward but, thanks to the middleware layer (LinkSmart), it is potentially possible to connect any device or pre-existing application.

The adoption of standard interfaces and coding systems has guaranteed the realization of an open and interoperable platform inside which it is possible to easily integrate new components. The figure below shows the inCASA platform broken up in its main blocks: inside each of them it is possible to add new modules or replace the existing ones with others providing the same functionalities.

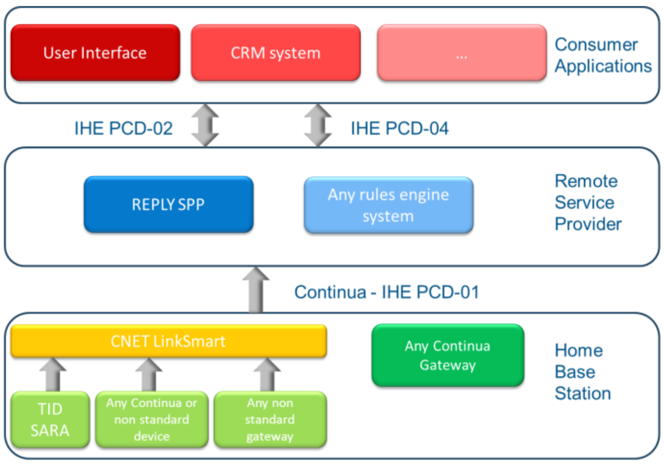

Figure 5 Interoperability of the inCASA architecture

VI. Conclusion

This paper has presented the architecture of the inCASA platform and the telemonitoring services which it can provide to the frail elderly people. The outcome of the inCASA project is a modular platform which connects in a standard way Telecare and Telehealth sensors and that, thanks to its open architecture, allows the re-use of its modules and the integration of other platforms and devices.

On the market there are different telemonitoring systems as well as in literature may be found consolidated integration specification (Continua guidelines): on this foundation the inCASA project has built a solution that, given for granted the connectivity technologies, has focused on the elaboration and interpretation of data. The main innovation of the inCASA project, in fact, is the presence of a module (SPP) that creates the physical and behavioural profile of elderly patients by combining measures of Telecare and Telehealth. The intelligence introduced in the platform allows the generation of alarms resulting from the comparison of clinical and environmental measurements with the user habits profile; these alarms of new generation come alongside to more traditional ones (e.g. detection of water leaks, ambient temperature and humidity out of range) and can potentially be employed in functional scenarios increasingly complex.

Acknowledgement

We thank all the inCASA project partners listed below in alphabetical order which, coordinated by Reply, have contributed to the accomplishment of this solution:

- **ATC** – Azienda Territoriale per la Casa di Torino, Italy
- **BU** – Brunel University, London, UK
- **CHC** – Chorleywood Health Centre, London, UK
- **CNET** – Cnet Svenska AB, Sweden
- **FHC** – Fundacion Hospital Calahorra, Spain
- **IN-JET** – IN-JET APS, Denmark
- **INSERM** – Institut National de la Sante Et de la Recherche Medicale, Paris, France
- **INVENT** – INVENT SAS, Italy
- **KGHNI** - Konstantopouleio General Hospital of Nea Ionia Agia Olga, Greece
- **NTUA** – National Technical University of Athens, Greece
- **SIG** - Steinbeis Innovation gGmbH, Germany
- **TID** - Telefonica Investigacion y Desarrollo SA, Spain

References

[1] inCASA project official site: http://incasa-project.eu
[2] AA.VV. (REPLY, INVENT, NTUA, inCASA pilots), D2.4 Requirements Consolidation and Prioritisation Iteration 2, inCASA Project – 250505, Report 06-05-2012
[3] AA.VV (TID, REPLY, SIG, NTUA, CNET), D3.3 Reference Architecture iteration 2, inCASA Project – 250505, Report 07-03-2012
[4] AA.VV. (REPLY, CNET, TID, NTUA), D5.3 Integrated Home Sensor Network and Healthcare Provider Platform, inCASA Project – 250505, Report 09-05-2012
[5] IHE Patient Care Device (PCD) Technical Framework Volume 1 Revision 1.0 Final Text August 12, 2011 (IHE_PCD_TF_Vol1_FT_2011-08-12.pdf)
[6] IHE Patient Care Device (PCD) Technical Framework Volume 2 (PCD TF-2) Revision 1.2 Final Text August 12, 2011 (IHE_PCD_TF_Vol2_FT_2011-08-12.pdf)
[7] HL7 Messaging Standard Version 2.6
[8] ISO/IEEE 11073-10101 Health informatics - Point-of-care medical device communication – Nomenclature
[9] ISO/IEEE 11073-10471 Device specialization – Independent living activity hub
[10] Continua Design Guidelines – Version 2010 – April 20, 2011
[11] C. Barbero, P. Dal Zovo, B. Gobbi, A flexible context aware reasoning approach for IoT applications, 12th International Conference on Mobile Data Management, 2011 12th IEEE International Conference on Mobile Data Management
[12] F. Levi, A Arbaud, G. Dispersyn, J. R. Simon, P. F. Innominato, R. Bossevot, M. Mocquery, V. Plessis, J. Fursse, M. Caprino, The European inCASA telecare-telehealth electronic platform (PSP-CIP) for the daily assessment of symptoms, weight and activity in cancer patient on chemotherapy at home, Annual Meeting 2012 of ASCO (American Society of Clinical Oncology)