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Integrated Network for Completely Assisted Senior citizen's Autonomy

D4.2 Remote Monitoring Device Implementation

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Executive summary

This document represents the Remote Monitoring Device implementation for the inCASA project. The content of that system comprises the inCASA gateway and the relevant subsystems (i.e. Activity Hub, SARA Client and proprietary solutions) connecting to it, the communication between the gateway and subsystems. The document also describes the two subsystems and their sensor types, low level features and communication in order to give full insight in how the Remote Monitoring Device implementation is most properly conducted. Here also the feature of Hydra as home automation system is anchored as optional implementation by any specific Consumer application. A development and test plan is continued from D4.1 that iteratively runs over WP4 deliverables and for this deliverable a secondary set of test notations are given, analysed and reasoned upon.

1 Introduction

1.1 Background

This deliverable is the second in order for WP4 which strives for fulfilling the EU e-inclusion targets[1]. As stated in D4.1 the market for products and services for ICT and ageing is still in its infancy whereby the inCASA platform implementation plays a role in solving the problem of ageing independently [1].

The ever more growing percentage of elderly persons in the general population is indicative of the pressing need for developing various tools and technologies to support these individuals in maintaining their own physical and mental health. A focus on the demographics and social development as of primary importance guides the inCASA solution to be designed to make real difference and provide real impact when the service is deployed. For this reason, the inCASA solution aims at integrating a number of services that empower elderly persons to contribute and play an active role in modern society. Another crucial point is the solution compatibility with the wide range of devices already available on the market. Multiple device types and communication protocols need therefore to be supported through the Remote Monitoring device implementation or made possible by descriptions or tools.

Another argument for developing integrated health information networks based on remote monitoring is that by the end of 2009 a large part of European health organisations are able to provide online services such as Teleconsultation (second medical opinion), e-prescriptions, e-referral, Telemonitoring and Telecare (remote monitoring of patients in their own homes). In cohesion with this, the work of this deliverable and the overall work package will contribute to the definition of a socio-economic foundation for sustainable implementation of the inCASA remote monitoring services across Europe. Besides the arguments above, another major reason for doing this relies on earlier studies of remote patient monitoring showing that a 37% intervention level led to therapeutic and care changes resulting in significant shifts in risk of future levels of morbidity [2].

The objectives of the inCASA project will be gradually reached by realising and testing in specific pilots efficient integrated care systems that combine innovative technological platforms for ubiquitous communication, advanced healthcare monitoring and state of the art domotic systems. This will be based by the inCASA subsystems that jointly will collect and manage data unobtrusively and non-invasively on behaviour, using wireless detection of movement. This data is collected by the implemented Remote Monitoring Devices. Its architecture combines multiple types of sensors and will base their potentiation by integrating further input and/or resource data as to increase profiling accuracy and achieve the medical target. As such, the inCASA platform needs to be open for extensions but also scalable to meet future device and communications specific demands.

1.2 Purpose and Content of this Deliverable

WP4 efforts will primarily be directed at presenting the various aspects of the inCASA solution implementation. Moreover, it deals with the iterative implementation of all the parts of the inCASA system as well as the technical testing of its functionality. These iterative processes involve a development plan that describes how the different software modules, subsystems and systems developed in inCASA will be integrated in order to easily interoperate while the test plan will be the actual basis for the testing process. This deliverable formalises an extension of the set of actions introduced in deliverable D4.1. It also details the description of procedures, processes, equipments, materials, activities or systems. These sets will be further revised in order to help

[1] http://ec.europa.eu/information_society/activities/einclusion/index_en.htm

understand whether the system performances meet both old and refined required specifications and quality attributes set forth in WP2.

The results will be validated according to pre-established criteria while the addressing of adjustments to the project user requirements specifications and design specifications will be approached using the previous deliverable as a reference. The overall WP4 development work is divided into the following implementation tasks that focus on specific components in the inCASA framework (those estimated to be directly or in-directly relevant for D4.2 is presented in *italic* and with extended description in chapter 2.1):

- *Task 4.1 – Hydra Customization and Sensor network Set up*
- Task 4.2 - Remote Monitoring gateway implementation
- Task 4.3 - EPR and Application Customization
- Task 4.4 - Reasoning and Learning System
- *Task 4.5 – Service Delivery Platform*
- *Task 4.6 - Telehealth Applications*

The purpose of this deliverable is to describe the iterative implementation of inCASA's Remote Monitoring Devices. It will mainly concern the first step of sensor measurements performed locally by front subsystems and components in inCASA and the way these process sensor data. The implementation of Remote Monitoring Devices will also reinforce those aspects, already stated in D4.1, to affect the modifications necessary on the Hydra Middleware in order to provide sufficient adoptability in the inCASA Core Monitoring functionalities. For the inCASA platform, the Activity Hub and SARA client both play a crucial role on how data is managed at an early stage. The purpose of this deliverable is also to present the second iteration on development and testing plans which may be further modified to fit the technological scopes and requirements set by related tasks T4.1 and T4.3.

1.3 Outline of this Deliverable

In order to establish a reasonable approach to the development activities, the expected prerequisites and issues regarding the Remote Monitoring device implementation and uses are related to the complementary WP4 tasks, in Chapter 2. Chapter 3 continues the iterative work where D4.1 left implying that the renewal of the WP4 development and test plans possibly involves a new set of actions for the remote monitoring subsystems and components relevant for this deliverable. Chapter 4 details these subsystems' features highlighting the Activity Hub and the SARA Client. Chapter 5 describes the implementation of a storage model for the generated data by these subsystems and also details the Web Services and WSDL interfaces required for the development of the Data Collection Repository. Chapter 6 reviews how home automation of elderly's devices and appliances could enhance self-confidence and independency; to further support this argument it lists the features provided by the already Hydra-enabled devices. Chapter 7 describes the iterative tests conducted during integrating the Remote Monitoring device implementation and compiles the experiences gathered so far. Finally, Chapter 8 summarizes the validation results and critically evaluates the proposed iterative development model.

2 Description of the Remote Monitoring Device Implementation

The technical platform of inCASA will allow a flexible combination of components and services, to meet the “end user” needs (independent living sensors, home automation, emergency alert systems, remote monitoring as well as home security and energy management), by employing a “checklist” approach. This checklist compiles key points from the WP2 outcomes and the iterative development plan detailed in D3.1 [3]. These points are further specialized to address the requirements arisen by the implementation of a common features set distinct to the Remote Monitoring Devices.

In inCASA there will be a Body Sensor Network (BSN) and a Home Sensor Network (HSN) that will be able to self-organize and connect to a wireless interface in order to communicate data to the inCASA gateway. This gateway ultimately communicates gathered data to the remote inCASA back-end servers that are hosting more intelligent functionalities.

Various clinical sensors are used to address the different monitoring requirements for the patients and the environment. These sensors are made available by various vendors and employ different wireless protocols and technologies, each operating in a different part of the wireless spectrum. The inCASA Core Monitoring architecture already allows remote adaptation and reconfiguration thus enabling sensors to work together in a single BSN/HSN. D4.1 has also addressed implementation issues related to reliability, security and timely delivery of data from the gateway middleware to the back-end middleware side.

The inCASA gateway, installed on the base station will periodically monitor various clinical sensors to aggregate vital body signs and uploads important health information to the provider servers using, as described in D4.1, a secure P2P tunnel to communicate. There are two tested devices and applications in D4.1 and these are organised in two types of inCASA Remote Monitoring device subsystems: Telecare and Telehealth.

The Telecare solution is provided by Steinbeis and is simply called the Activity Hub. It acts as a generic low-cost bidirectional gateway interconnecting the input from the wireless Telecare sensors to the inCASA base station (i.e. Hydra middleware).

Besides the outcomes of previous development and test plans, the main contributions to the implementation of the Remote Monitoring Devices address the WP4 objectives described in the inCASA DoW: further development of the base station application, the integration of components into a prototype platform and ensure interoperability between them and of course testing of their functionality and usability.

As such, the inCASA Remote Monitoring Device implementation constitutes the next required step in the platform development, i.e. sensor measurements. It ensures that data is enquired properly through the Remote Monitoring Devices (sensors/inputs using BlueTooth, Wi-Fi, ZigBee and many more), is correctly gathered and is finally made available to the Core Monitoring System.

Telecare data is collected from the environment monitoring system installed in the senior’s home and composed by the following sensor types: temperature, humidity, motion, tampering, flooding, door, sitting, light, presence, distance, fall and activity (wireless motion/contact sensors). Also, collected medical data related to pre existing monitoring system (e.g. SARA client) will be channelled and managed through the base station.

Furthermore, the data collected by the base station should be continuously and/or periodically sent to the service provider in order to create a strived behaviour model of the person (via the learning system) and to generate reports and/or alerts in case of anomalies. Therefore, it is important that the Remote Monitoring Device implementation allows for flexibility in the way devices, components and subsystems can be configured and controlled.

Summarizing, the Remote Monitoring Devices, irrespectively to the communication standard or messaging format they employ, should encompass to the Telecare and Telehealth features that in turn are governed by the inCASA gateway and/or base station.

2.1 Task Related Work

For each WP4 deliverable there is a set of work tasks that more or less relate to each deliverable's content and intention. Major contributions to D4.2 are expected to be derived from Task 4.1, Task 4.2, Task 4.5 and Task 4.6. The following list describes the high level relationship of these tasks to the implementation work planned in task T4.2:

- SIG Activity Hub needs to be able to send event data to the Hydra client module (Task 4.2).
- SARA Client will send medical data to either the Hydra client module or directly to the SPP (Task 4.2).
- Create automation and allow for distributed and remote control of domestic applications by integrating technologies (Tasks 4.1, 4.5 & 4.6).

Task 4.1: Hydra Customization and Sensor network Set up (*Data survey Center implementation*); here data survey will better refer to automatic data collection, storage and its implementation using the inCASA gateway and base station. This task will cover the customization of the Hydra Middleware in order to manage the remote monitoring of inCASA subsystems and components. It will mainly take care of the following:

1. Customization of the hydra middleware on the remote healthcare provider platform.

Task 4.2: Remote Monitoring gateway implementation. This task will cover the implementation of the base station applications to be able of the following:

1. Automatically collect data, via Bluetooth or Wi-Fi, from the health monitoring system and the environment monitoring system,
2. Perform basic checks on the collected data to advise (via SMS/Email/Web notification), in case of anomalies, a group of people and/or the headquarters based on the escalation procedure,
3. Periodically send (via email or internet file transfer) collected data to the headquarters for the analysis and populate the behaviour model of the person, and
4. Manage the socio-medical calendar (appointment audio alert, appointment creation, modification, removal and remote synchronization).

Task 4.5: As this task will cover the implementation of the operating central in term of remote healthcare provider platform services finalization, the work for D4.2 will be based on the extension for the service exploitation defined in D4.1.

Task 4.6: Telehealth applications involve the use of SARA, a telemedicine platform, provided by Telefonica that allows carers take care of their chronic disease patients remotely. The patients can do most of the common tasks related with their chronic conditions from their home, with the remote assistance of the health professionals. As such, the Remote Monitoring device implementations need to incorporate the SARA client.

2.2 Draft Remote Monitoring Device Architecture

The draft of the Core Monitoring System described in D4.1 relied on the original abstract view the consortium had on developing the inCASA platform and the implementation description highlighted the core monitoring mechanisms. In D4.2 the Telecare and Telehealth subsystems are instead placed in focus.

What the Remote Monitoring Device architecture aims to do here is to present the involved SMEs and academic institutes for their innovative approaches and resources of platform subsystems and components designated for the inCASA Remote Monitoring Devices and further lead the way for the work to be conducted for D4.3.

While the D4.1 Core Monitoring System architecture demonstrated how to implement middleware mechanisms for the inCASA gateway and server side, Figure 1 points at the current work of implementation for this deliverable, i.e. the Remote Monitoring Devices and their underlying processes. It mainly involves an overhead positioned inCASA gateway (or base station) which should now implement the Hydra Middleware on the Patient Side Layer comprising the Telecare and Telehealth services provided by the Activity Hub and the SARA client.

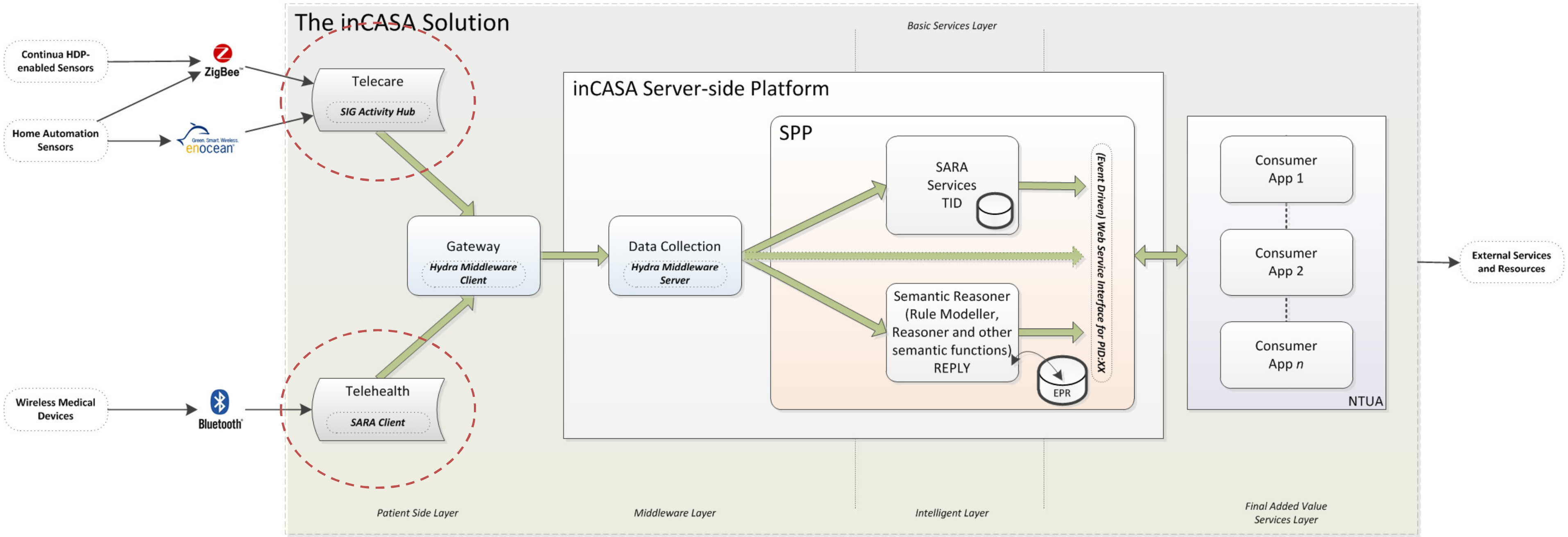

Figure 1 - Current draft of Remote Monitoring Device implementation where subsystem specific consortium partners involved are marked.

3 Project Development and Test Plans

WP4 does not only deal with the iterative implementation of the inCASA system parts but, as stated in D4.1, also with the technical testing of system functionality in order to ensure that these are performed in accordance to a well-defined quality management procedure. The second iteration of the implementation and test planning process will take place in this deliverable. The development plan describes how the different software modules, subsystems and components, relevant to the Remote Monitoring functionality of the inCASA platform, will be integrated so that they can easily interoperate with the base station. Also similar to the approach in D4.1, the test plan will become the basis for the testing process and the results will be presented in Chapter 7, where any needs for adjustments of the project user requirements and design specifications will be determined in the summary (Chapter 8).

The work here is divided into the implementation tasks presented in Section 3.1. These tasks greatly simplify the description of the Remote Monitoring Device implementation procedure by focusing in turns on a specific component in the inCASA framework.

3.1 Quality attributes and set of actions for subsystems and components

The inCASA work plan is an implementation of iterative methodology ensuring a tight cohesion and continuous communication between all the different phases of the process so as to minimize risks. Testing the D4.2 implementation in a new environment (e.g. pre-pilots) will increase the customization that will be required to meet local requirements (e.g. pilots) by updating a set of quality attributes and set of actions for subsystems and components available for D4.1 refinement and D4.3 creation. These set of actions should involve any procedure, process, equipment, material, activity or system that will help the consortium partners to understand whether the system performances do meet the required specifications and quality attributes. These set of actions are deliverable specific, i.e. they relate to the matter of topic (i.e. here the implementation of the Remote Monitoring Devices).

The Remote Monitoring Device implementation involves the initial communications that are expected by a structured network approach in inCASA which allow the local monitoring of data and events to be transparent to the server side and the primary communication between a local sensor or actuator and a gateway (i.e. inCASA Client). It is also partly affected by the secondary communication allowing the local monitoring of data and events on the End User's side where the first alternative of two is the direct communication. This approach allows direct access to the data collected at the local node. The display is connected to a gateway or middleware node. Major benefits are: local access to unfiltered data, no online connectivity to the backend system required, and real-time observation of signals supported. Major drawbacks are: access rights must be managed locally, data filtering and processing must be performed locally

The Remote Monitoring Device implementation should preferably have the following quality attributes that can be reclaimed through D3.2 Reference Architecture Iteration 1 [4] as well as D4.1 and matched against the cohesion of D4.2. These are transparent throughout of this deliverable and all contribute to fulfil the stated quality attributes above and are further anticipated to reveal separate subsystem's needs of counteractive actions to be set. Some quality attributes are the following:

1. continuous transmission of data to the inCASA platform frequency customizable by the remote end operator,
2. acceptance of extemporary measurements provided by the user/patient,
3. customizable event triggered alarms,
4. wireless sensors to detect movement of the user inside the house, detect presence of the user on the bed, detect presence of the user on a chair, detect opening/closing of the front door, detect temp/moisture variations and to detect emergency events, and

5. continuous monitoring of the technical emergency sensors, forwarding the emergency signal in seconds after the event is detected.
6. user interface for end users (elderly people, patients) in terms of presentation of data that is separated from system logic. But also where this user interface provides different access levels both to data and functionality, according to user's profile and role within the system.

3.2 Deploying an iterative process for the plans

The actual executions of subsystem and component actions are performed by an iterative process throughout the WP4 deliverables. D4.1 started off including those arguments posed in WP3 deliverables and especially the D3.2. The submission of this deliverable will consequently contain additional outcomes of the subsystem and component validation that may conduce altered quality attributes to accomplish as well as a register of set of actions to be executed in forthcoming WP4 deliverable. As such, the WP4 implementation declares an iterative process for the parted but still collective development and test plans which will be separately and implicitly tested throughout the WP6 and WP5 as to generate reformed development plans.

4 Remote Subsystem Features and Physical Installation of the inCASA Platform

The inCASA platform and its remote subsystems have features that resemble most applications for home-assistance (not only Healthcare) and cover many areas (e.g. private homes, social housing, etc.). It also provides a complete solution that with its modular design allows installation to scale from a few unobtrusive devices to complete health monitoring setting. inCASA will both monitor biometric data and track environment and lifestyle parameters of elderly users in their own home, integrating related data into a new lifestyle model. The inCASA solution will use the central Service Provider to integrate social and healthcare Services through their local authorities (i.e. by regional policies) but the real and closest performance occurs within the patient's layer of the platform. Consequently the device interoperability will be a key success factor for the project. It will also be of major importance to include existing products into the installations, but also to ensure that future products can be fully integrated.

4.1 SARA Client

The SARA Client is the branch within the architecture that permits the inCASA solution to gather all information related to healthcare. Many different kinds of sensors can be installed in this side, e.g. blood pressure sensor, weight device, heart rate sensor, etc… and it is has been decided to use Bluetooth in order to make patient's home wireless, not having cables everywhere, and thus, improving the user experience and making the system more user-friendly. Also, because Bluetooth is so popular, all sensors can be found with this technology.

The Health client is able to read different incoming data rates and make the extrapolation of the information in order to serve useful information onto the platform. The implementation of this client-agent is currently done over Windows platform, although there will be soon a new version for Android in order to provide a wider-market solution. Communication through the platform (Hydra Client Side) is done using a conventional Internet broadband connection, i.e. cable, 3G, etc… The next figure shows how the SARA client fits into the general architecture:

Final implementation of SARA client for inCASA has involved mainly the next decisions:

- Only a Bluetooth connector will be implemented although there are other wireless possible connectors such as ZigBee, RFID. This has been decided because all the pilots will use Bluetooth devices, so it was a good choice in order to keep it as simple as possible.
- Because we know what devices are going to be used during the pilots, parsing the datagrams coming from the sensors has been embedded into the client. Therefore, adding a new device would imply new programming (supported devices are described in D3.1).
- The rules engine has been implemented in order to create alerts when some sensors values exceed some limits.
- The inferring engine showed in D3.2 section 3.4.3.3 [4] hasn't been implemented because that role is taken by the SPP in the platform.
- A layer of Web Services Clients has been implemented in order to send sensor data and alerts to the platform.
    - These WS Clients are integrated into the platform through the Hydra middleware.

Everything has been developed using C++. The next figure shows a picture of the SARA implementation for the inCASA project:

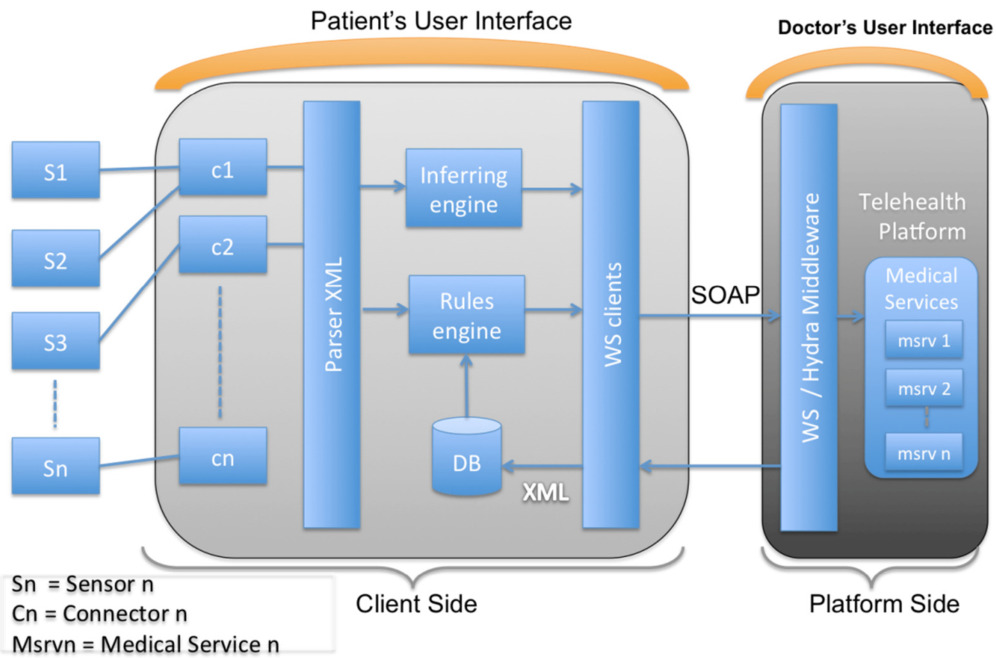

Figure 2 - Implementation of SARA client for inCASA.

From the patient's point of view (Figure 3), the health client is a portable touchable screen, which is in fact a PC with Windows platform that runs the SARA agent. Implementation of this client has been done in order for the application stay in foreground all the time. Patient will not see this device as a PC, but as a medical assisting device.

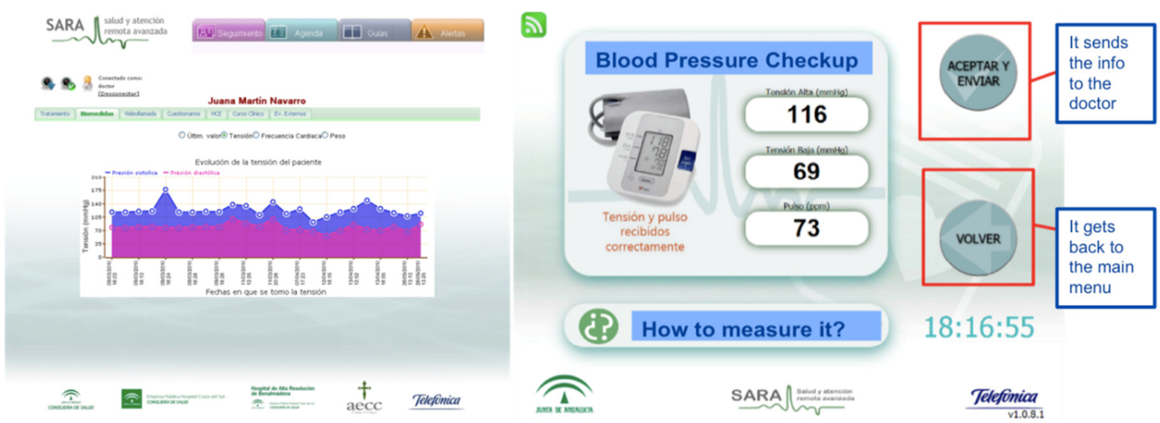

Figure 3 - User Interface of the patient's medical device.

4.2 SIG activity hub

It is anticipated in the inCASA architecture to have one SIG activity hub for each apartment. For the physical installation of the SIG activity hub, the following conditions must be met:

- For the easiest deployment mode, the activity hub will be mains powered. Therefore, an access to the electricity network must be available.
- The SIG activity hub must communicate with the wireless sensors in the apartment. This leads to a possibly central positioning in the apartment, so that a possibly direct communication can be supported. In case of a ZigBee enabled network, this criterion is of low importance as ZigBee network layer supports mesh networking. In this case, intermediate other sensor nodes could possibly forward the data to the activity hub.

However, using the inCASA basic sensor set, all sensors are run as ZigBee Reduced Function Devices (RFD) only, which do not come with routing capabilities. For this purpose, other mains-powered router would be required.

- On the other side, the SIG activity hub shall forward the monitored data to the Hydra middleware platform. For this communication, an IP-based communication channel must be accessible. For the lower network interface layer, the SIG activity hub supports the following options: Ethernet (IEEE802.3), Wireless LAN (IEEE802.11), mobile communication (GPRS), or legacy Public Switched Telephone Network (PSTN) modems (configuration example is shown in Figure 4).
- For the installation, this network must be physically accessible. In dependence of the layout of the apartment, this requirement can contradict the second condition (central dislocation) of the SIG activity hub. As at least for the ATC pilot, the apartments are of reduced size, the SIG activity hubs can also be placed in the staircase.

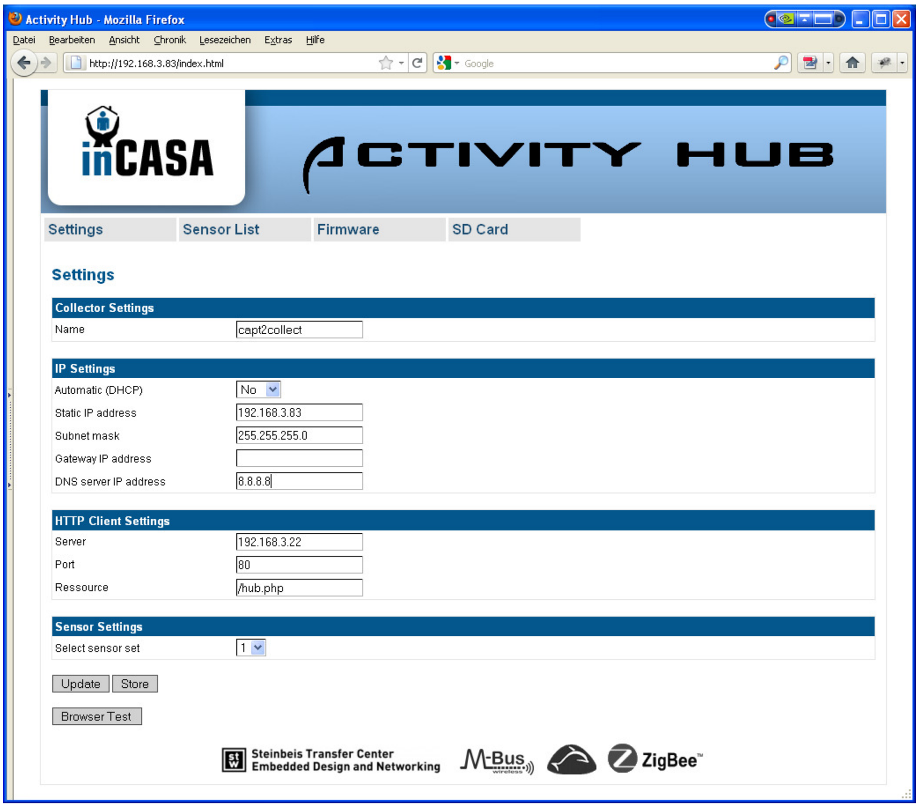

Figure 4 - Configuration Interface of the Activity hub.

4.2.1 System requirements

For the physical installation of the inCASA Telecare devices, the different elements must be regarded separately.

4.2.2 Sensor installation

The sensors must be dislocated with respect to their sensing task. This means that:

- occupancy sensors must be installed at premises walls so that they can cover the largest possible area,
- environmental sensors, like those for temperature or humidity, must be installed in areas, where there is enough air flow, so that the measured data is representative for the complete premise, and
- Telecare sensors, i.e. bed or chair sensors must be installed directly in the respective objects.

All sensors must be easily accessible, so that local monitoring and periodical battery exchange can be supported.

4.2.3 Hydra middleware

It is anticipated in the inCASA architecture, one physical entity of the Hydra middleware processes the input data from several apartments. Therefore, it is assumed that the Hydra middleware platform won't be operated on-site, but in a different location. The settings to contact the Hydra middleware are defined for each activity hub individually. Once connected, the settings can also be automatically downloaded from the Hydra platform.

4.3 Pilot sites and available technical resources and specifications

The following conditions must be met at the pilot sites from communication point of view:

- The frequency bands of the wireless sensors must be legally allowed. As all pilot sites are dislocated in countries of the European Union, the anticipated ISM-bands, i.e. 868 MHz and 2.4 GHz, fulfil this criterion.
- The frequency bands of the wireless sensors must be available. Availability means that there shouldn't be other networks with extremely high duty cycle in the same frequency bands in the direct vicinity of the inCASA installations.
- The premises should be relatively RF-friendly. Walls should attenuate the RF-waves in the expected factor. No harmful materials (concrete walls with high metal density, wallpaper with metal shielding) should be used.

During the installation phase, the correct operation of the devices should be verified.

4.4 Installing the sensors

The sensors are easy to install as most of them can be battery-powered. The chair sensor is even autarkic, which makes the system even more flexible. The following subchapters highlight the necessary steps to include each sensor. The registration with the Activity Hub is performed automatically, as the registration data are loaded from the backend.

4.4.1 Z-B01x Motion Device

To delete former binding information, the motion sensor is manipulated by the power when the binding key is pressed. Fast LED flashes (~ 5 Hz) show the correct reset. After another power-cycle and physical installation, the sensor is ready to use. The light sensitivity can be adjusted as shown in Figure 5.

Figure 5 - Motion Device.

4.4.2 Z-302A Door Device

To reset the door sensor to factory default settings the auxiliary key is to press for at least one second, before additionally pressing the binding key until the device LED flashes fast. Afterwards, the Magnetic contact and the sensor can be installed. To save the battery, the sensor powers down automatically.

Figure 6 - Door Contact Device.

4.4.3 Z-71x Temperature/Humidity Device

As for the motion sensor, power-cycling with the binding key pressed resets the combined temperature and humidity sensor, shown by quick LED flashes. Another power-cycle causes the device to register in the network. The sensor is powered by 2 AA batteries.

Figure 7 - Temperature/Humidity Device.

4.4.4 Z-801 WLS Water/Wet Device

Resetting the flood sensor is performed as for the other sensors (power-cycling with binding key pressed). The special requirement for this sensor is to determine the warning logic.

- Those of the five connectors that are open when applying power cause an alarm when connected to ground. This happens when the plates become wet.
- The connectors that are connected to ground when powering cause an alarm when becoming dry (contact open).

As the sensor is not mains-powered but powered by 2 AAA batteries, there is no risk to the user when parts of the sensor become wet.

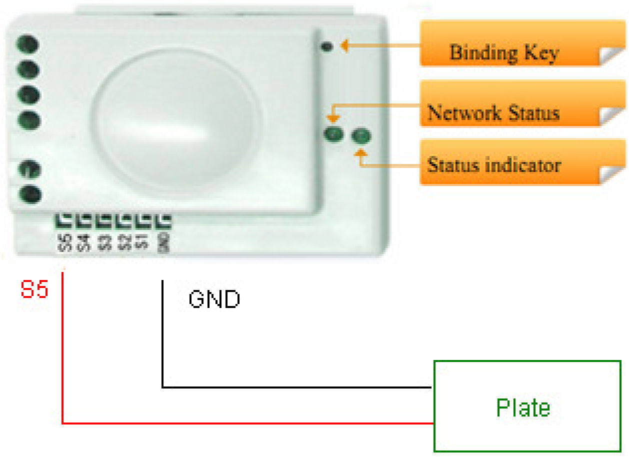

Figure 8 - Plate connection example.

4.4.5 Z-A01A Smoke Detector Device

The smoke detector is not only a sensor but also a ZigBee router. Therefore, the device is mains-powered, which results in a different reset procedure. The binding key and testing key are to press simultaneously until the red LED flashes for 10 times. After a power-cycle, the sensor will enrol in the network. The router functionality extends the other sensors' range, which permits the Activity Hub to be placed in the stairway. As the smoke detector is mains-powered, it needs to be installed by an electrician.

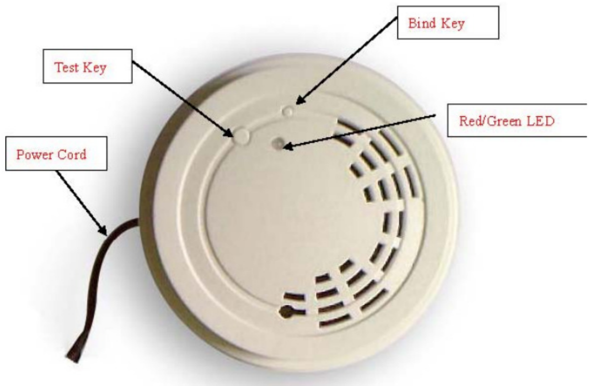

Figure 9 - Smoke Detector Device.

4.4.6 Chair and Bed Sensor

Those sensors have a unique hardware ID, which the backend communicates to the Activity Hub. As the sensors are unidirectional, they do not need any installation process.

5 Automatic Collection and Data Storage

Task 4.2 concerns the automatic collection of data via Blue Tooth or Wi-Fi, from the health monitoring system and the environment monitoring system. It also performs basic checks on the collected data in order to advise in case of anomalies. Therefore this task will permeate through this chapter.

Collected data related to pre-existing monitoring system (e.g. domotic and health related) will be managed via the dedicated inCASA base station. Collected data from the monitoring system related to user behaviour will be stored in the base station data repository (here described in terms of a database).

Moreover, the inCASA solution aims to reduce duplication of information collection and assessment activity especially as patients are expected to move from one part of the service to another. The solution will also try to reduce the proliferation of record systems and unnecessary duplication of information which would help professionals across the services to be familiar with the system and enable easier retrieval of information ensuring patient data source reliability. This objective will be achieved thanks to the unique technologies behind the inCASA platform that unifies process workflows and enables relevant information to be shared between the health and social care records systems (more described in D4.3).

Though for this deliverable, the proposed solution integrates automatic monitoring of the movements of the user in the home together with monitoring of the physical environment and the definition of the behaviour profile to create customised care services. The solution incorporates the augmentation of inCASA base station development and integration, exploiting results emerging from existing subsystems (i.e. Hydra, Activity Hub and SARA). Conclusively, this automatic monitoring will be stored in the inCASA client data repository (i.e. the Hydra Middleware database constituting the base station).

5.1 Data value assemblies and basic check functions

The inCASA remote monitoring system provides alerts related to significant changes in activities of daily living. For example, someone has had a significant change in sleeping, eating or toileting, will start evaluation workflows that lead to multiple actions (like alerts or automated calls). These early indicators could be used by caregivers for early interventions, and by social and healthcare professionals for care-plan purposes or direct interventions.

5.1.1 Habits monitoring-based data collection

The inCASA platform will operate on two sides where for this deliverable the End User's house, where sensors, devices and specific interfaces are in focus. As stated earlier, this side will collect habits and health conditions in order to provide services through communication with a remote Service Provider. As such, collected data are habits and health conditions related to the End Users. Such data are further transmitted from home environment to Service Provider permanently stored in order to be analysed and allow dedicated subsystems to generate alerts and notifications to proper endpoints. The Data Repository has to guarantee the appropriate operating level with respect to issues like data retention and security while satisfying end users need of a transparent and unobtrusive way to profile habits while they are at home and to monitor their health conditions outside traditional healthcare environments.

The process implemented in the Habits Monitoring Use Cases described in D2.2 profiles user habits in order to automatically identify anomalous situations and send alert to the user, carers and to the Service Provider [5]. As such, the initial decision making will here be performed by raising events on data value anomalies. In order to do so, the collected data will be assembled according to commonly specified sensor data types individually based on the inCASA subsystem sensor definitions and mapped to what the inCASA platform will initially monitor. The habits monitoring-based sensor types are:

- the state of the door (open/closed),
- indoor movement (real-time information about user conditions), and
- bed permanence (in bed or not).

The Remote Monitoring system will also be implemented as to provide reminder prompts to individuals or professionals. Using this feature a model of the behaviour being monitored or the reminder being given can be created, extended with additional sensor types as well as updated.

Unlike Telecare here (where the initial data collection for habits monitoring occurs), additional requirements that concern the Telehealth subsystems are to be defined in D4.3 as these are mainly propagated when deploying the SOAP tunnelling and hence not stored or managed at patient layer.

5.1.2 Event-driven notifications

The basic check functions are implemented by simple event handling. One of the requirements in D2.2 is the provision of continuous monitoring of the technical emergency sensors and the forwarding of the emergency signal in seconds after an event has been detected [5].

For this reason, the Activity Hub demonstrably triggers an event when the state of any of the habits monitoring-based sensor types is changed. This is though what makes the Activity Hub send data in first place and can be considered as event-driven in its embedded form.

Alternatively, the Hydra Middleware residing on the base station may provide its own Event Handling mechanisms spanning over both Telecare and Telehealth domains. This was technically described in D3.2 [4] but will here shortly be retailed. To create Hydra events the inCASA developer needs to access for that specific Telecare or Telehealth device created Web Service in order to listen to its inCASA events. This Web Service should also follow the EventSubscriber WSDL provided through Hydra. Optionally, it could be implemented such that the inCASA developer can interface the Web Service's anticipatory functionalities giving him access to define event rules, e.g. what should be the upper or lower value limit to trigger an event. These events would then be transparent to upper layers of the inCASA platform.

5.2 Storage specifications

During D4.2 implementation and the initialisation of the different inCASA pilots the database for development trials is located within the premises of CNet's office in Stockholm, Sweden but could easily be repositioned to fit local conditions.

What is crucial is to let the data repository retain and give access to the different clinical data of the End User and to allow the extension of its internal data model in order to provide further environmental data definitions (e.g. temperature; water or gas leakage) as well as habits models.

In inCASA it is provided some interfaces to access the data. This is commonly most suitable implemented and exposed as services. Using for example Web Services internally in the inCASA platform would divest any storage module provided GUI and instead allow for a global network access according to profiled security options. That is, all access levels must be granted on a user role basis, allowing different actors having different privileges while accessing the personal and clinical data. Sensitive data must be encrypted.

Data incoming from Home Base Station must be collected and persistently retained within the Data Collection's Data Repository. Furthermore, the incoming new measure should be sent to the Mediator where this module may mediate its content to correctly receiving part. For example, the

SPP Reasoner can receive this data from the EPR where the Mediator has stored the new data. The Reasoner can then take actions based on a comparison between two measures; the new against the old data and for example, push this data back as feedback to the end user.

Data regarding habits models (i.e. user behaviour profiles) are maintained by the SPP and stored in the EPR. For that End User identification (more detailed in D4.3) becomes handy. It should provide for data configuration stored in the Data Repository, since they are "patient's related" from an EPR point of view. Even though data regarding house and devices are not directly related to a user's profile, configuration data for these may be stored in the Data repository although most appropriately managed and stored by the Hydra Device Ontology. All of these data are fundamental for the correct recognition of the source of measurements and alerts associated to an individual and will be used within messages exchanged between the different SPP modules, the Hydra Middleware as well as other inCASA subsystems and therefore must be equally configured on End Users premises.

As stated in chapter 6.3 "Composite Web Services at inCASA Server Side" in D4.1, data to the external applications are provided through (secure) Web Service interfaces neither too simple nor too complex. These interfaces should not be too basic allowing low levels of single data but instead provide consuming applications with a broad and general perspective on retrieved sets of data, e.g. various segments in HL7 messages. This allows for enhanced querying performance and thereby also reinforced business.

5.2.1 Database language and table definitions

In order to provide both internal and external access to the Data Collection's Repository, Web Services will be made available. These will enable for queries in a created Microsoft SQL database that holds the incoming sensor data in a certain table simply called postdata in Figure 10. Overall, the table definitions for the inCASA Data Collection Repository are 1) some kind of ID identifying the row number, 2) postdata containing the collected data, 3) a URI describing the posting identifier from the network or Internet, 4) a creation date, 5) header descriptions, 6) original IP address of the sender, and 7) the HTTP method of choice (POST vs. GET). A query in the MS SQL Server Management Studio for the top 1000 rows is shown in Figure 10:

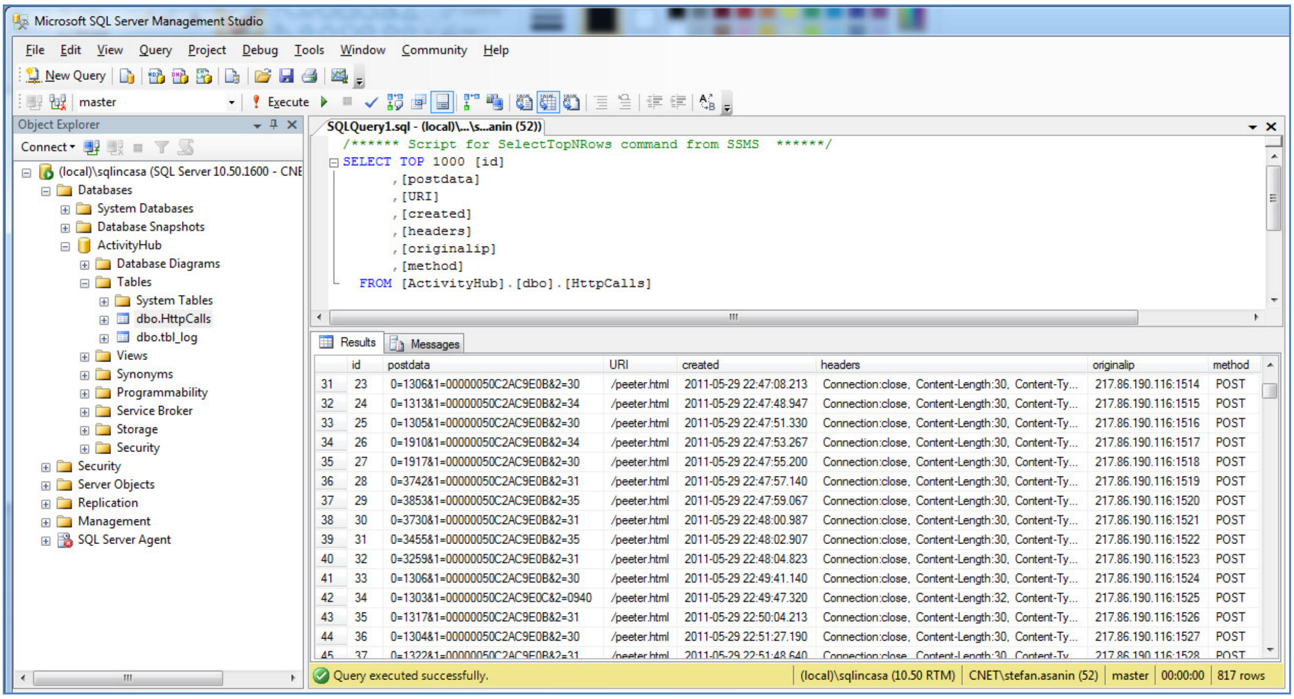

Figure 10 – MS SQL view of inCASA Data Collection Repository.

5.2.2 How to query the database

For development purposes in inCASA, a SQLManagerDevice is up and running as a Web Service. It announces eight methods that are found in its WSDL description and that can be viewed through this URL: http://192.168.9.15:8080/SQLManagerDevice/SQLService?wsdl. In short it includes methods that enable the developer to set the SQL connection for the Activity Hub database, open it, and search it by any formal SQL query which has a standard set as described in the SetSQLConnection method visible in Figure 11.

To develop with the SQLManagerDevice as Web Service: include a new Web Service into your project called something appropriate such as "SQLService" in the C# code below and refer it to http://192.168.9.15:8080/SQLManagerDevice/SQLService. Strictly follow the outline of methods as shown in the code here. This ensures that the SQLManagerDevice handles the initiation of methods by the correct order.

```
SQLService.SQLServiceWS sqlws = new SQLService.SQLServiceWS();

sqlws.SetSQLConnection("sig", For password please contact CNet, "burken", "ActivityHub");
sqlws.OpenConnection();

setquery = ("SELECT TOP 1 [id], [postdata], [created], [method] FROM
[ActivityHub].[dbo].[HttpCalls] ORDER BY id DESC");
sqlws.SetSQLQuery(setquery);

sqlws.RunSQLCommand();

string postData = sqlws.GetSQLQuery();

sqlws.CloseConnection();
```

This contains the collected sensor data.

Figure 11 – C# code for using the inCASA SQLManagerDevice.

Most methods found in this Web Service are either declared as strings or Booleans in order to maintain simplicity in the development. The string named postData here will contain the Activity Hub data for specific sensory type. Mind that the SQLManagerDevice methods may be altered over the WP4 deliverables and iterations to fit coming customizations.

5.3 Data Collection Framework

The inCASA project goals will be attained through achieving some specific objectives where one of five is to provide for automatic data-collection and behaviour models for a validated decision system. This will lead in generating alerts and control escalation as well as identifying preventive actions. As such, this subchapter deals with the implementation of a data collection framework for decision support in inCASA. Most suitable for inCASA is a logical framework that involves three layers of data repositories: MicroSD storage at the Activity Hub, Data Collection Data Repository and the internal data storage in SPP. The framework also incorporates bidirectional data flow as described in the text above where Web Service calls are the most appropriate communication method in order to ease the platform integration even though not all storage access will be made public as necessity.

6 Home-wide Automation and Appliances Communication

Besides the project aim and objective to enable continuity of care through a wider interaction between elderly people or patients and caregivers, the project aims on integrating home automation into the system to support remote control of electronic devices in the immediate surroundings and provide for the special needs of the elderly to make active ageing a reality.

The term of Home Automation means to enable home-wide automation and communication for appliances. That is, various types of equipment enable distributed and remote control of domestic applications, from both inside and outside the home. Automation, communication and shared use of appliances in a home environment are the real challenge to imagination and life style and especially worth reconsidering for the care of elderly and their quality of life.

inCASA will build on common home automation architecture, and exploit the wide experience of Telefonica and CNet, to implement integrated solutions including automation of the whole home aimed at assistive functionality, which features flexibility and expandability, low cost and openness with respect to different devices and technologies. The result of an open architecture as in inCASA would support “ageing in place” policies and may help to improve life quality of elderly people, as well as of their families and caregivers.

The inCASA solution will be based on a set of common specifications for technology and services agreed by all the actors in the complete value chain. It will include healthcare devices and home appliances which are relevant for the e-health and associated care services. The technical platform based on the Hydra Middleware will allow a flexible combination of components and services, to meet the “end user” needs (independent living sensors, home automation, emergency alert systems, remote monitoring as well as home security and energy management). The inCASA project will therefore be able to result in a scalable service platform.

The expected impact of implementing support for home automation in inCASA is to achieve a major role in the quality of life of elderly people such as preserved physical health, psychological status and social relations by an integrated care plan. This plan could further include improved diet, hygiene and social lifestyle, as a result of a focused profiling activity and social services.

6.1 Centralised and local control

Remembering the distribution of platform stakeholders by the layered implementation figure presented in Figure 1 (patient vs. added value (*read: service provider side*)) it is easy to logically map the centralised and local control to be part of the patient side layer.

Centralised and local control of devices and sensors in the home is fairly straight forward to explain. The control could either be embedded in the device the end user is using or communicated through a laptop or other processing unit. The point is that the control is never used outside of the premises of the sensor or actuator. It is though governed by the elderly themselves.

This could add value on the patient side layer with general feedback on appliances and sensors as well as enhance the self-confidence and subsequently an improved quality of life.

As means to achieve this, the inCASA platform already charters the functionalities given by the Activity Hub and the SARA Client but for actually automating the elderly’s homes the Hydra Middleware could assist in supplementing the requisites. The Hydra Middleware adopts a certain sensor kit called PlugWise and Hydra-enables these into the middleware. Using ZigBee technology Hydra is then able to control any coupled electronic appliance by its generic Hydra Device Ontology, e.g. turn on/off, energy consumption, etc. [6].

Except the PlugWise abilities in Hydra, the Hydra Device Ontology support far more enabled devices and sensors (Table 1). These would allow for expanding the variety of home automated services for the inCASA platform where end users (i.e. the elderly) would appreciate a gained knowledge of their home appliances' functionality and security.

	Device type/name		Device type/name
1	Bloodpressure Monitor : UA-767 BPM, A&D Medical	21	RF-power switch, Nexa (Discoball, Fan. Light, Train)
2	Weightscale: BT Weightscale, A&D Medical	22	RF-power dimmer-switch, Nexa
3	Bloodpressure Monitor, Siemens	23	Navigator, Nuvi 610, Garmin
4	GlucoseMeter, SmartGenie	24	WebCam, Axis 206
5	DLNA Media Renderer: Noxon, TerraTec	25	Router, D624, D-Link
6	DLNA Media Renderer: Streamium SL 400i, Philips	26	SunSpot Thermometer, IEEE 802.15.4
7	DLNA Media Renderer: AV Renderer, Intel	27	SunSpot Accelerometer, IEEE 802.15.4
8	DLNA Media Server: AV Server, Intel	28	RFIDSec, Sigma, RFID Tag.
9	ZigBee Coordinator, Labor S.r.L	29	Phidget Sensors- movement, light, vibration, temperature
10	ZigBee Transceiver, MaxStream	30	LonWorks switches
11	ZigBee Temperature Sensor Sensirion (SHT11)	31	Z-Wave Sensors
12	ZigBee Pressure Sensor VTI (SCP 1000D01)	32	ePatch Sensors
13	ZigBee Accelerometer, ST Microelectronics	33	VarioPort
14	Wireless Thermometer, Heavyweather	34	WII Balance Board
15	Wireless Windmeter, HeavyWeather	35	PlugWise Smart Plugs
16	Wireless Rainsensor, HeavyWeather	36	Ploggs Smart Plugs
17	Wireless Airpressure, HeavyWeather	37	Lynx Motion Ala5 Robotic Arm
18	Mobile Phone, Sony Ericsson, Z600	38	Phidget Servos
19	Smartphone, HTC	39	Phidget RFID Reader and Tags
20	SmartPhone/GPS Device, HTC	40	SQL Manager Device

Table 1 – List of Hydra-enabled devices.

6.2 Distributed and remote control

Chapter 6.1 described a local control of home automated devices and sensors while this chapter will describe how these are made available through remote control in a distributed network such as inCASA.

Also it has already been described in D4.1 how Hydra uses a SOA-based architecture framework that combines Web Services and UPnP with P2P networking. This technology enables the Hydra-enabled devices and sensors to be remotely controlled by a feature in the Hydra IDE. This remote connection feature enables the inCASA developer to develop software without having a Hydra installation running locally while connecting to a remote working Hydra installation. It further allows the developer to run Hydra user applications on a device without having Hydra middleware installed or running on it. The only prerequisite is that the remote connection has both *HydraMiddlewareAPI* and *HydraMiddlewareClients* bundles running in the system. When connecting remotely, a set of functions provided by the *GlobalHydraIDEUtils* class included at the package *com.eu.hydra.main.global* of the Hydra IDE bundle are initiated [7]. As such, the Hydra IDE provides two means to remotely connect to a Hydra installation: R-OSGi and through the Hydra NetworkManager already part of the inCASA platform subsystems Gateway and Data Collection.

A distributed and remote control of home automated devices and sensors by the inCASA solution enables the service provider to, for example monitor TV consumption in the elderly's homes in order to prevent loss of physical activity.

6.3 In-house technology integration to increase elderly household functionality and security

The integrated care plan described in the beginning of this chapter may for inCASA help to increase the level of independence through two aspects:

1. a remote monitoring system in the home environment to increase individual self-confidence,
2. home automation to act as facilitator to everyday home needs, so reducing home-help and increasing security.

Moreover, environmental features could be streamlined by home automation, which can automate routines and give the best home scenario for each profiled activity (going away from home, going to bed, waking in the morning, etc.). These features could help realising the objective of inCASA by reducing voluntary or premature hospitalization because elderly people living home alone will have increased self-confidence and trust in the deployed services through the continuous monitoring in their own home with unobtrusive technologies and customized day-by-day planning.

7 Test Notations

D4.2 has had the aim on delivering descriptions on the implementation of remote monitoring devices. For the concerned device types, the field trials in inCASA will highlight possible priorities and needs that are estimated to have an impact on the final inCASA service model especially when it comes to remote monitoring appliances and services.

This approach will, likewise as for D4.1, enhance the inCASA project objectives by realising and testing in specific pilots efficient integrated care systems that combine innovative technological platforms for ubiquitous communication, advanced healthcare monitoring and state of the art domotic systems.

Integrating various types of sensors, services and appliances with the inCASA Gateway sets a course of actions to be taken. It involves the procedures of Hydra-enabling these types into the inCASA platform where they can serve to their functional services. The process to do so is exemplified by this document and the procedure found by each specific subsystem described for inCASA. These actions will help the inCASA project consortium as well as future proprietary vendors, developers and end users at the patient side layer understand how the system performances met for the project stated required specifications and quality attributes and map this knowledge to future implementations. For now, these results are presented here for later validation according to the criteria and needs for adjustments of the project user requirements specifications and design specifications found in chapter 8.

7.1 Aspects of Data Flow

It is already known by D4.1 that the data flow occurring throughout the inCASA platform requires service related control by parallel bidirectional communication. Whether this is valid for the Remote Monitoring Devices is optional for an inCASA developer that may let communication feed back to the device or sensor if this is supported at their technical level. The point is that any device or appliance connecting to the inCASA Gateway just needs to be able to communicate with it. That is the only obstacle to pass to integrate with the inCASA platform.

7.1.1 Tested Devices and Applications

D4.2 contributes to the Pilot Scheme Set Up phase by addressing the issue on developing integrated health information networks with a major effort done in this document on establishing a health information network on existing subsystems, i.e. the Activity Hub, the SARA Client and the Hydra Middleware.

Still, the focus should be given on the interoperability required on Middleware level, i.e. providing support to various types of communication and data. The experience on working with the Hydra Middleware has postulated the expected outcome of plausible Remote Monitoring Device implementation in inCASA. And so has it been confirmed here. This fact together with the already tested devices and applications in D4.1 show that the iterative processes over WP4 deliverables impose implementations that increasingly become easier to facilitate.

7.1.2 Communication and Formats

The inCASA Gateway postulated by the Hydra Middleware, will periodically monitor various clinical sensors to aggregate vital body signs and uploads important health information to the provider servers using a secure wireless communication channel (i.e. P2P tunnelling). The Hydra middleware can also manage communication in the inCASA network, route data, provide session management in the communication and synchronise the different entities in the network. The technology is termed proxy and controls the specifics of the communication and data exchange with the device (low level communication such as Bluetooth, ZigBee, Z-wave, etc.). For this reason, it is foremost important that despite the choice of communication protocol or message format, the inCASA Gateway implementation must encapsulate a synoptic support. The Hydra Middleware can easily accommodate any communication or format by superintend itself as a surpassing development platform available for the inCASA Remote Monitoring Device developers. The Activity Hub and SARA Client are then externally examples of good implementations.

7.2 Integration Risk Analysis

Because health information, products, and services have the potential both to improve health and to do harm, organisations and individuals that receive and provide health information remotely have obligations to be trustworthy, provide high quality content, protect users' privacy, and adhere to standards of best practice for online professional services in healthcare.

Based on this, the main risk integrating the inCASA Remote Monitoring Devices is the diverse support for devices and applications. It may sound contradictory but the need to support these also impose an increased risk of market expectancy, i.e. the more inCASA is said to support the more it risks to fail.

As such, there are no risks at stake for the subsystems already involved in the inCASA project as their implementation are described here but for the market value for the inCASA platform highly depends on its device and sensor serviceability.

7.3 Re-designed specification

A re-designed solution implementation specification is regarded as not necessary.

8 Summary and Validation of Subsystems and Components in inCASA

We began with chapter 2 that described the expected prerequisites and issues regarding the Remote Monitoring device implementation and the chosen approach confirmed as reliable. The related WP4 tasks are shown to be well suitable for this deliverable and its intention which has been to describe the implementation of Remote Monitoring Devices based on the structured network approach and a SOA model found in D4.1. A number of significant driving requirements (in this document seen as quality attributes) from WP3 has been considered and established with respect to the contents of this document. The main quality attributes have been realised through the features found in the inCASA subsystems. These are:

- SIG Activity Hub is able to send event data to the Hydra client module.
- SARA Client sends medical data to either the Hydra client module
- Hydra assists in the creation of home automation and allows for distributed and remote control of domestic applications.

The referred work tasks for WP4 are considered to coordinate with the content of this deliverable. D4.2 has managed to incorporate Task 4.1 and Task 4.2 where data is automatically collected and stored by the Hydra Middleware as well as at the Activity Hub level. Task 4.5 suffices for the Remote Monitoring Device implementation to stand basis for remote healthcare provider platform service exploitation down to sensor data level. Finally, Task 4.6 will by using various types of subsystems or proprietary sensors, devices or appliances the like, let the Remote Monitoring device implementation to be able to unambiguously communicate and handle various communication protocols and formats.

The test conducted throughout the Remote Monitoring Device implementation will hereafter feed knowledge and implemented technology to WP5 and WP6. This will give expected return in terms of refined or re-designed implementation specification.

With the notation that the inCASA end users truly need home automation permitting remote control of electronic devices in the immediate surroundings justifies the adoption of distributed intelligence in home management and monitoring which will provide a safer environment and help daily living activities. This chapter calls the attention on how to exploit random devices available in elderly's household to increase exploitation of the inCASA platform and so integrating home automation into the inCASA platform to support remote control of electronic devices in the immediate surroundings will provide for the special needs of the elderly to make active ageing a reality.

Moreover, it is also clear that the data flow in the inCASA platform is ongoing versatile and requires stable control of its services where the communication is done over parallel bidirectional directions. For this reason, the Remote Monitoring Devices need to fulfil some basic prerequisites otherwise hard to exclude. These are to provide one or a set of functionalities (e.g. on/off, value) and a way to communicate its data to the inCASA Gateway. The market is though filled with these types of devices and appliances and therefore it should not be any problem extending the inCASA service model in the future.

9 Glossary

SQL	Structured Query Language
OSGi	Open Services Gateway initiative framework
WP	Work Package
ICT	Information Communication Technologies
SPP	Smart Personal Platform
WS	Web Service
P2P	Peer-To-Peer
HID	Hydra ID
HSN	Home Sensor Network
HMS	Human Monitoring Sensors

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