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CAALYX-MV

Complete Ambient Assisted Living Experiment – Market Validation

D2.1 CAALYX-MV Services Description

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Executive summary

This document describes all the potential e-health services that CAALYX-MV could provide to health care organisations, both public health care systems and private hospitals. The main idea of D2.1 is to describe the system and its services and to be used as an input for D2.2, where the most suitable services will be chosen for commercialisation. Before listing the potential e-health services provided by CAALYX-MV, the system is explained in detail by providing an overview of the platform, showing its architecture and its potential users. This explanation shows the basic services or functions of CAALYX-MV that will be tested throughout the project in the different established pilots-sites. Finally, this document defines how the final e-health services should be launched onto the market. Thus, the main outcome of this deliverable is to propose a set of services, the CAALYX-MV service portfolio, that will be looked at in more detail in D2.2 through the application of a market analysis to be ultimately refined in WP5.

CAALYX-MV is a TeleHealth platform that provides a web tool interface for clinical professionals so to enable the follow-up of their patients. On the patient side, at home, CAALYX-MV provides a way of taking different kinds of measurements (i.e. weight, blood pressure, pulse, and oxygen saturation), filling out questionnaires, checking the medical agenda (e.g. appointments, times for drugs) and even having videoconferences with doctors. Furthermore, patients' homes are set up for being Smart-Homes (e.g. sensors at beds, doors) in order to provide doctors with more information about their patients' activity. Apart from that, patients might wear a special t-shirt with different kinds of sensors (i.e. respiratory and heart rate, temperature) to provide continuous monitoring. It is intended for patients that need constant care and observation.

The CAALYX-MV architecture comprises a platform (i.e. caretaker server) where all data is collected and processed. On the client side there are two main elements: coming from the t-shirt (i.e. mobile system) and also coming from the sensors in patient's home (i.e. home system). Because the first element must send data continuously, a permanent Internet data connection is needed. This is why a mobile phone is used as a gateway, to deliver information to the platform. At the patient's home, a Set-Top Box (STB) is used to collect all the different data coming from the sensors. The main interface for the patient in this case is the television, because most people already have one in their home. However, CAALYX-MV is also set up to work with other supports such as PCs, mobile phones or tablets.

The system is intended for use by clinical professionals (e.g. doctors, nurses, carers), patients' relatives and friends, and of course, the patients. Each user will have different roles within the system, able to access specific data. For instance, doctors will be able to access all the patient's information, but relatives and friends will only be able to access the public part of this information. Also, both patients and relatives will receive data from clinical professionals and patients will be able to send feedback to them by using questionnaires and the videoconference service.

Main basic services provided by CAALYX-MV can be classified in three main categories: Emergency, Ambulatory and Social Care services. This grouping of services is practical from a technical point of view since it groups all the different functions that the system provides. These functions and general features will be tested and adapted in WP3 during the pilot phase. The second stage, however, follows a market approach, using a new categorisation that considers levels of severity for chronic disease and economic efficiency. This idea provides us with the potential service portfolio for the project and the different clinical flows followed by these services in both ambulatory and emergency situations.

1 Introduction

The goal of this WP is to analyse pioneering trends in European and global markets in relation to already existing systems of independent living platforms as well as developments. By studying market requirements and comparing them with existing solutions, the consortium will be able to understand current opportunities for selling CAALYX-MV services in the Healthcare market. Therefore, WP2 has the following objectives:

- To conduct a technical analysis of our solution
- To describe the CAALYX-MV functions/features/services that will be validated at the different pilot sites throughout the project
- To propose a commercial service portfolio to feed D2.2
- To study and analyse the CAALYX-MV market
- To define market needs and ascertain which diseases CAALYX-MV would best serve
- To provide preliminary marketing strategies to give input to WP5

1.1 Purpose and content of this deliverable

D2.1 defines and describes in a fully functional way the features and functions provided by CAALYX-MV that will eventually be validated at a number of pilot sites in WP3 and WP4. The CAALYX-MV solution has not yet been validated for the European market and re-engineering of the services process is, therefore, needed [1] [2]. This document will also study and describe links between the different CAALYX-MV users (doctors, elderly people, caretakers, relatives, etc.). Finally, a list of potential marketable e-health services will be provided.

1.2 Methodology

This deliverable will provide a technical analysis of the CAALYX-MV solution, which will be used in D2.3 to complement the market analysis. Furthermore, D2.1 intends to provide a preliminary list of commercial services that will feed D2.2 and the marketing strategies. These services will be refined, from a market point of view, in WP5. Also, the different functions of these services will be tested and adapted by WP3 during the pilot phase.

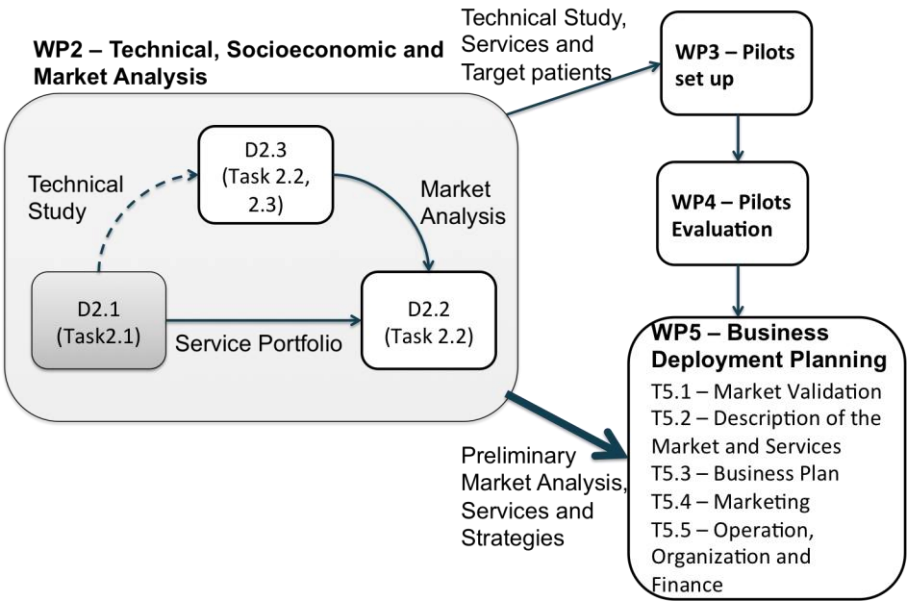

Figure 1 - WP2 methodology focused in D2.1

1.3 Outline of this deliverable

In chapter two an overview of the system is given as well as an explanation about its architecture. In chapter three the platform users' roles are listed. Chapter four describes the basic services and functions provided by CAALYX-MV. Chapter five describes the proposed service portfolio for the project and a conclusion is provided in chapter six.

2 Description of the CAALYX-MV System

2.1 Mission and Vision

Mission: Strengthening public and private collaboration to create a reliable social and health care service, which gives elderly people greater autonomy, prolonging the time they can live in an independent way at home

Vision: Easy to handle, easy to install, reliable, affordable, standardised, health and social care.

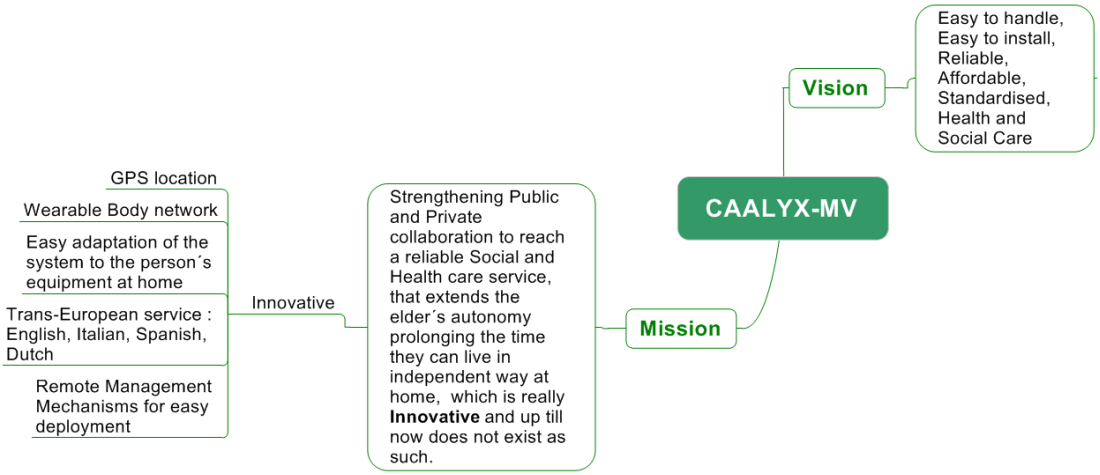

Figure 2 - CAALYX-MV mission and vision

2.2 Product Description

CAALYX-MV will provide a distributed and scalable system to allow monitoring of patients by multiple professionals (e.g. doctors and caretakers) simultaneously and will enable the provision of meaningful coordinated actions under the concept of a health agenda for prevention and self-management of their multiple chronic conditions. CAALYX-MV consists of a caretaker website, a home and a mobile system. Both systems have associated different kinds of sensors that transmit their information either through a mobile gateway or a TV STB as depicted in Figure **3**.

The CAALYX-MV product aims at offering a set of innovative and user customisable elder and patient care services. Two levels are envisioned:

- Basic service – mobile and home monitoring of a user using the standard equipment
- Extended services – on top of the basic service one can add more sensors, both at home and to the garment. A TV STB at home improves user monitoring and other added value services for users without their own PC.

In both services the system should be used by a user without any advanced technological knowledge, thus the need for the full remote configuration of the mobile and home systems. The

system monitoring functionalities should be easily expanded by the seamless addition of new sensors both at home and the mobile system (not included in the garment).

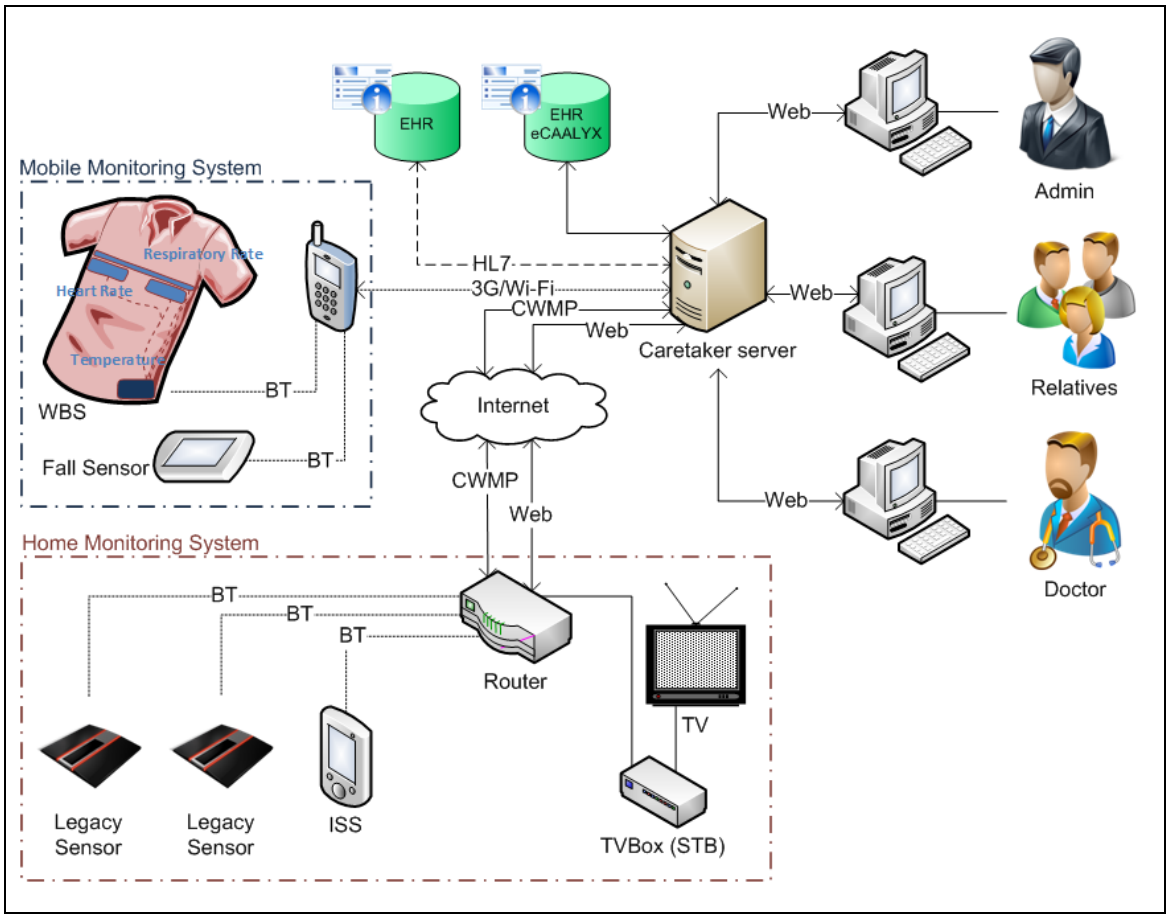

Figure 3 - System overview of the CAALYX-MV

2.3 CAALYX-MV Architecture

The available technology of CAALYX-MV consists of three main components:

- The caretaker system
- The mobile monitoring system (Mobile System – MS)
- The home monitoring system (Home System – HS)

The overall system architecture is depicted in Figure 4. The proposed architecture will be revised also later on, but no major change is expected.

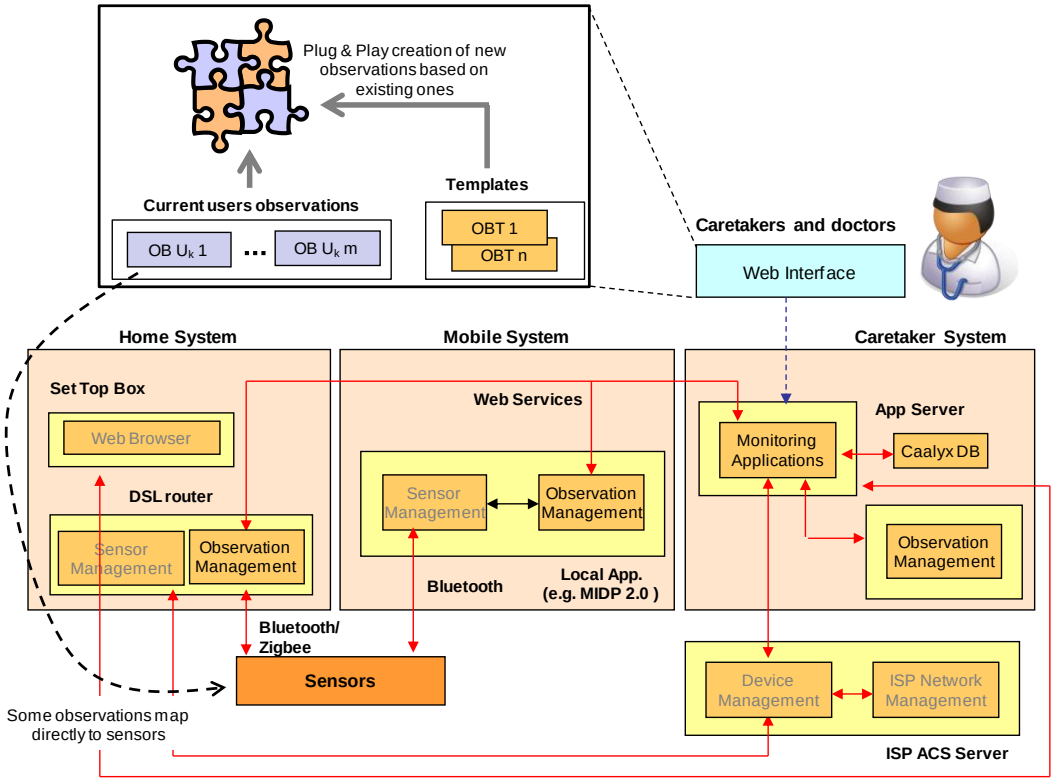

Figure 4 - CAALYX-MV Architecture

Caretaker System

Family/Caretaker/Doctor system

Family members, caretakers and doctors may access the system through any standard Internet enabled device, such as personal computers or mobile phone. Additionally, to be able to contact the patient through videoconference, a camera and microphone will be needed.

The way the family members, caretakers and doctors will see the web site presented by the caretaker server will depend on the role with which they are subscribed. Also, the caretaker server includes an ACS as a module, providing the devices with auto-configuration capabilities.

Mobile System

The mobile platform's purpose is to continuously monitor an older person while outside the home and report when medical attention is needed.

For that purpose, the mobile platform is connected with sensor devices that can measure older people's vital signs. These sensors constitute a sensor network, associated with a single individual's body, which are related between them directly or indirectly, following a networked architecture, where the only common point to all its nodes is the mobile system. In CAALYX-MV application context this network is denominated Body Area Network (BAN).

In the BAN there may be several kinds of sensors with different purposes, such as fall sensors, ECG sensors, thermal sensors, or even GPS devices. The criterion is that the provided data is useful to make a better assessment of the user's condition, in order to improve alarm situation reporting. A minimum set of sensors required for general monitoring will be integrated in a wearable garment, thus improving system usability.

The mobile platform is also capable of storing readings coming from the BAN's sensors, analyse medical data and report alarm situations to other CAALYX-MV components, namely the home system and caretaker site.

The **Wearable Body Sensor (WBS)** system is composed by a set of important biomedical signal sensors including heart rate monitor, respiratory rate monitor and temperature. The system continuously monitors the parameters during the daily life activities of the patients, at home and also outside. The word "wearable" means that the system is directly integrated in the garment, making it easy and comfortable to wear and its use nearly transparent to the patient. The WBS is able to continuously monitor the health status and communicate it to the mobile phone using wireless technology.

Home Monitoring System

The home system is composed by the following components (also depicted in figure 3):

- Home Gateway (HG): Bluetooth USB Adaptor (to enable Bluetooth communication) and USB flash disk (to store measurements and system debugging logs)
- Set-top box (STB): TV (to display the interface) Web-cam and Microphone (for video-conference)
- Home Sensors: Set of sensors that are wirelessly connected to the router.

DSL residential routers and STB's are cheap devices present in consumers' houses to enable broadband access and for TV viewing, respectively. Therefore, reusing these devices to implement the CAALYX-MV system functionalities allows the service providers to distribute the investment cost in equipment among different services.

The **Home Gateway (HG)** includes USB expansion slots in order to make it possible to add a Bluetooth USB adaptor and a USB flash disk. The Bluetooth adaptor enables the router to communicate with the health sensors. In order to allow the local storage of medical measurements as well as, a continuous system monitoring it is necessary to plug a USB flash disk into the HG. In addition, the HG includes a remote management module that enables auto-configuration of the system at home, releasing the user from system configuration tasks as well as reducing the need for on-site technical support.

The **STB** provides the user interface of the system. It acts as a renderer, connected to the TV, where the user is given the opportunity to follow his health condition, manage the health agenda (consultations, medication, etc.), and communicate with doctors and family as well as providing input to the system through questionnaires prepared by the doctors.

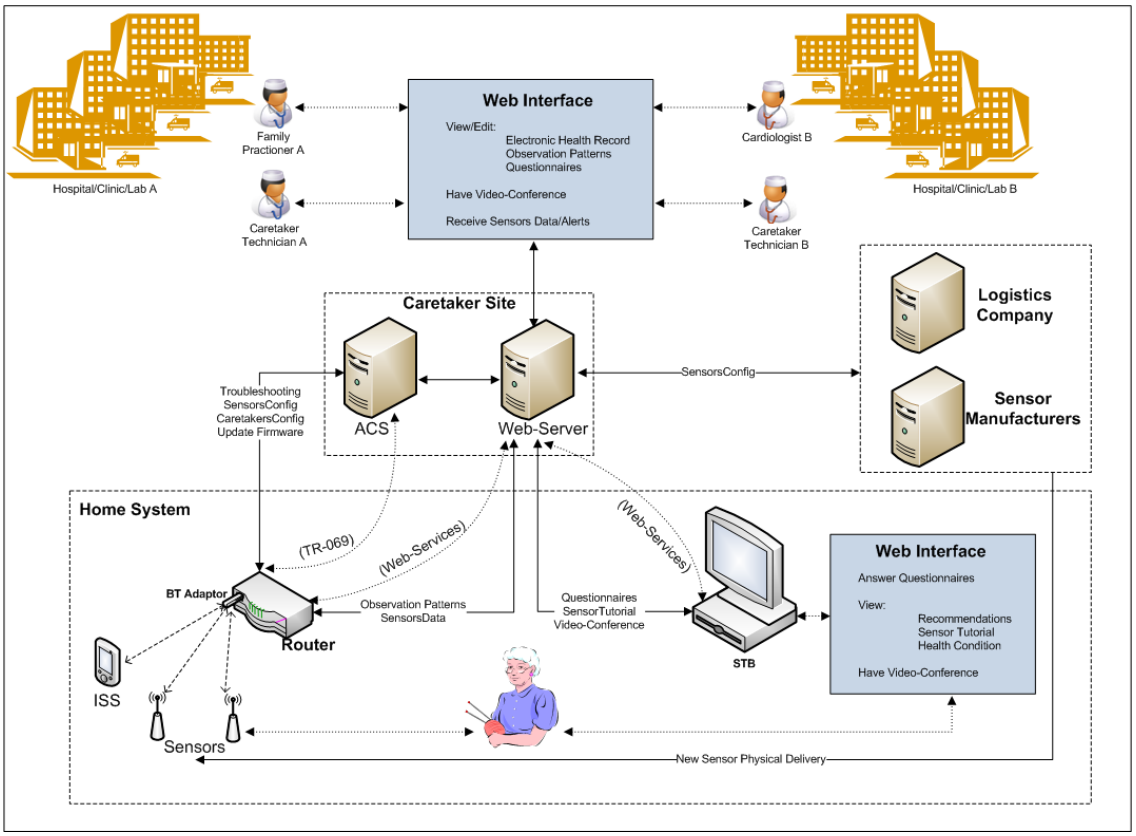

Figure 5 - Home System components

The **Home Sensors** used in CAALYX-MV can be classified into two groups:

- Vital Sign Sensors: Collect patients' e-health data
- Smart Home Sensors: Detect patients' activity

2.4 CAALYX-MV Interfaces

This section gives an overview of the interfaces between the components.

Home Monitoring System

List of Interfaces

HG ←→ Caretaker Server

STB←→Caretaker Server

HG←→ ACS

STB←→ACS

Home Sensors ←→ Router

The home monitoring system consists of 2 IT-infrastructure components (the HG (router and the STB) and 3 vital parameter sensors (the ISS, the scale and the NIBP-device). The home gateway (HG) is the middle point of the home monitoring system. It interfaces with the health sensors present at home, with the caretaker Web-Server and the Auto-Configuration Server. The STB can be seen as both the interface of the system to the user and as another sensor for collecting data

that is either more difficult to measure or even subjective (e.g. tiredness, pain...). The ISS, the scale and the NIBP-device enables the collection of the vital signs of the user.

One of the main requirements of the home system is auto-configuration. Auto-configuration is enabled by the creation of an interface between the home router and the caretaker Auto Configuration Server (ACS). This interface enables the ACS to share information with the router that enables the router to setup communication both with the home sensors and the caretaker Web Server automatically. This interface is based on the CPE WAN Management Protocol (CWMP) defined by the Broadband Forum's Technical Report 69 (TR-069). This protocol is already used by telecom operators to manage communication equipment such as routers and STBs. If desired by the CAALYX-MV service provider, this design choice will enable the provider to make use of the management infrastructure already deployed by telecom operators, reducing the initial investment in infrastructure. During this project, extensions to the CWMP protocol will be defined that enable the management of the health devices present at home. Such extensions, that will be part of the vendor-specific extensions allowed by CWMP, mainly include the definition of the parameters required for sensor communication (e.g. RFCOMM channel used, PIN code, driver software, etc.).

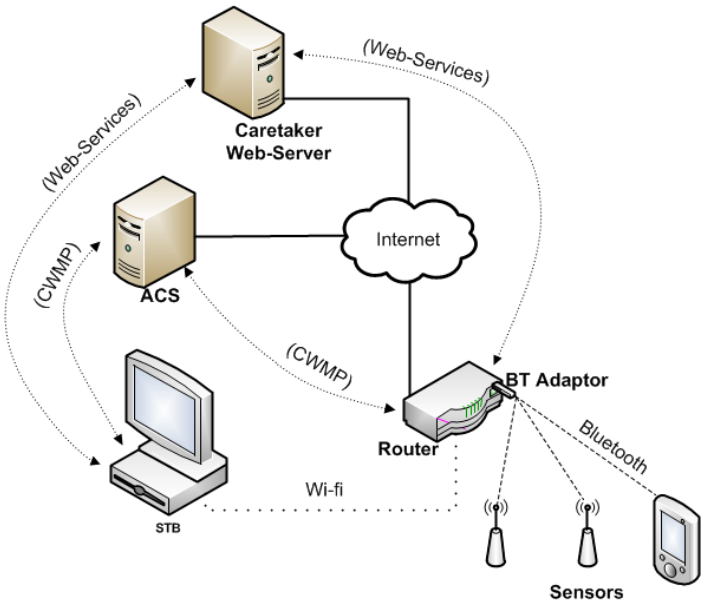

Figure 6 - Home Monitoring System interfaces

The router is responsible for collecting data from the sensors and sending it to the caretaker Web Server. The frequency with which the data is collected is defined by the observation patterns specified by the doctors. In addition, the router may apply some pre-processing to the data collected in order to raise alarms in the system. The pre-processing is also defined in the observation patterns. The router obtains the observation patterns dynamically through a set of web-service primitives supported by the caretaker Web Server.

The flow of data between the router, caretaker Web Server, ACS and the home sensors is the following:

- the home router performs the initial setup using the standard mechanisms defined by CWMP;
- after the initial configuration is established, the router receives the configuration parameters of the home sensors and the URL of the caretaker Web Server;
- the router uses this information to setup communication with the sensors automatically and also to establish a session with the caretaker Web Server;

- the router retrieves the observation patterns specified by the doctors from the caretaker Web Server and starts processing data from the sensors and sending the data/alerts to the caretaker Web Server as defined in the observation patterns.

Mobile Monitoring System

List of Interfaces
Mobile Phone ←→ WBS
WBS←→Fall Sensor
Mobile Phone ←→ Caretaker Server

The mobile system, as depicted in figure 1, connects only to the caretaker server either using the public 3G networks or the Wi-Fi network at the user's home. There are also two inner interfaces, one between the mobile phone and the WBS and another between the WBS and the fall sensor.

3 CAALYX-MV User's Roles

The CAALYX-MV system works with the following users' roles:

Administrator

A person will play this role for configurations, such as adding, modifying, removing and linking elders, family members, caretakers and/or doctors. This role may be partially played by caretakers, family members and/or doctors. Elders may not play this role due to their lack of technological skill.

Doctor

Family practitioners or specialists play this role. They are allowed to access to their elder's electronic health record stored in the caretaker site so that they can identify medical conditions and require due attention for their patients. They can modify normal values for clinical parameters monitored and medical treatments.

Patients

Patients who are supported and monitored by the CAALYX-MV system play this role. It is assumed that the person has little technological skills but can perform simple technical tasks regarding the common use of a mobile phone, a TV and sensor devices (e.g. automatic blood pressure meter, weight scale, etc.).

Caretakers

System operators play this role with a human-oriented profile providing caring tele-services from the caretaker site. S/he attends alerts received and produced by the caretaker site; contacts elders to kindly show concern for their health state or remind activities.

Emergency Services

This role will be played by the responsible emergency system at the elder's location. The emergency service will provide help to the elderly person in case of an emergency.

Relatives

Family members providing a caring contribution according to their own circumstances from their own home/place play this role.

The next picture shows what each role's associated functions are:

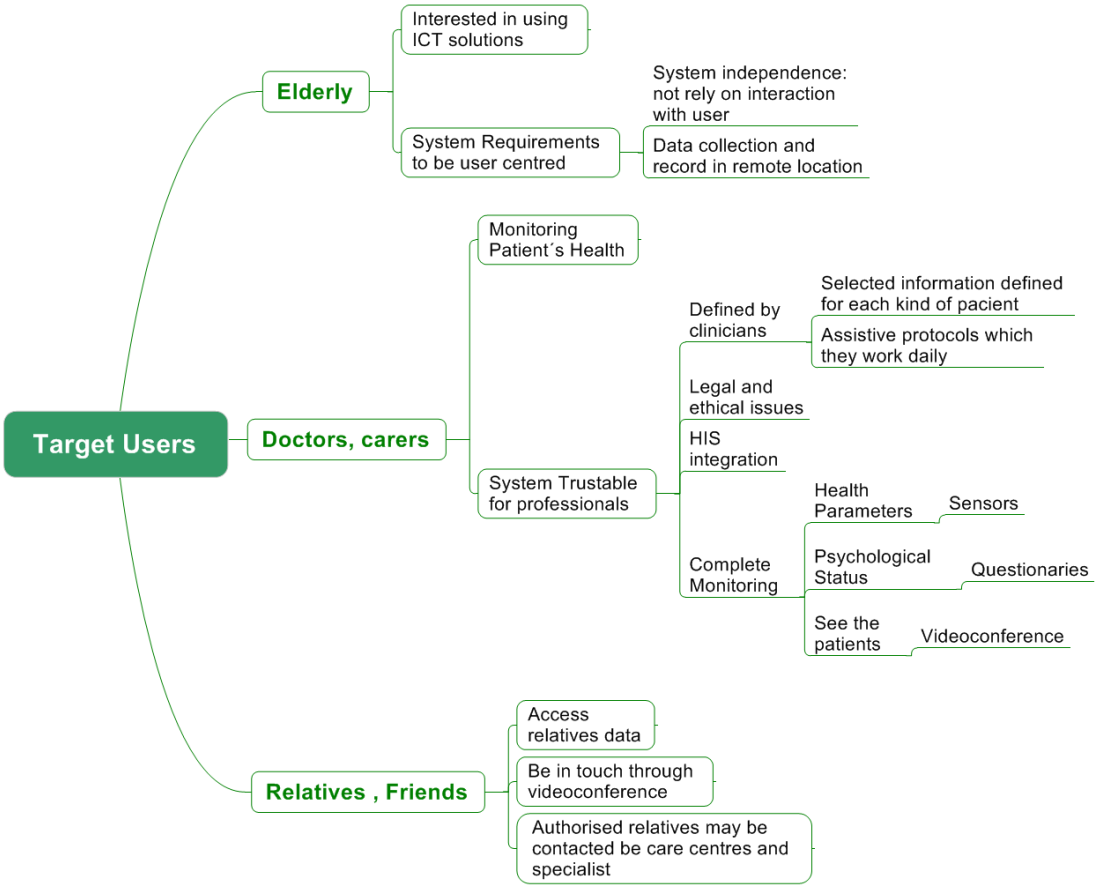

Figure 7 - Users' roles

4 CAALYX-MV Basic Services and Functions

The CAALYX-MV services can be divided in three main categories of basic services:

1. Emergency care: patient falls, geo-localization when there is an emergency, flood detector, bed occupancy sensor, etc.
2. Ambulatory care:
   a. Remote vital sign monitoring: temperature, breath, possible heart failure or chronic respiratory disease exacerbation (the two last currently in developing).
   b. Specific questionnaires: depression screening, functional status monitoring.
3. Social care: live connections, calendar, history clinical access, and videoconference.

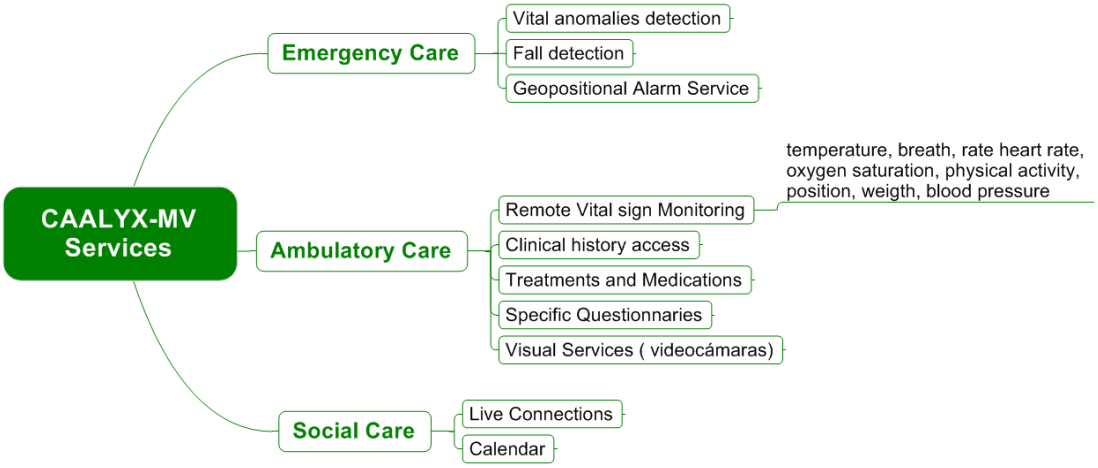

Figure 8 - CAALYX-MV basic services

The services that can be implemented with a central server will be described that receives medical data from the home and the mobile monitoring system, that offers a web interface accessible by every PC connected to the internet, where data display, configuration and other services are provided.

As innovators in health care services we want to identify best services, from a business point of view, to be Emergency Care Services offered in CAALYX-MV pilots.

Vital Anomalies Detection

The Home Gateway is able to communicate with the Caretaker Server through a set of web services methods, allowing the HG to obtain the treatments assigned to the patient. For each treatment, there are measurement scheduling and rules. Each rule allows validating a measurement by comparing values with a threshold defined by the doctors. If a measurement means value overpasses the threshold an alarm is raised on the caretaker server. Currently only simple comparison operators are supported, such as greater than > or lower than < for comparing the mean value of a set of measurement values.

Fall Detection

The system consists on a highly sensitive fall detector [3] incorporating an accelerometer and a specific fall detection algorithm, which performs a complex analysis of the inertial signal, combined with posture detection. This is complemented by a telecommunications layer involving wireless technologies, able to send alarms when the falls are produced both inside and outside the home via 3G or GPRS protocol. The system is designed to be worn all day except during sleeping hours,

during this time the battery is recharged. A standard commercial Li-ion battery powers the system with a capacity of 650-700 mAh.

The fall detector device involves tri-axial accelerometry [4] and incorporates a microcontroller (µC) that manages the different measuring components and therefore guarantees computation capacity in order to manage the specific online algorithms. This µC acquires orders, performs calculations and transmits the sensor data. The size of the complete device with battery, communications and plastic box is 58 x 93 x 17 mm and its weight is 52 g.

The device is worn near waist level and beneath clothing in a comfortable customized neoprene belt in direct contact with the skin. The sensor is water-resistant so it can also be worn in the bathroom, where the risk of falls is particularly high. A panic button may be optionally included in order to allow user sending a help requirement voluntarily. Additionally, a reset button can be included.

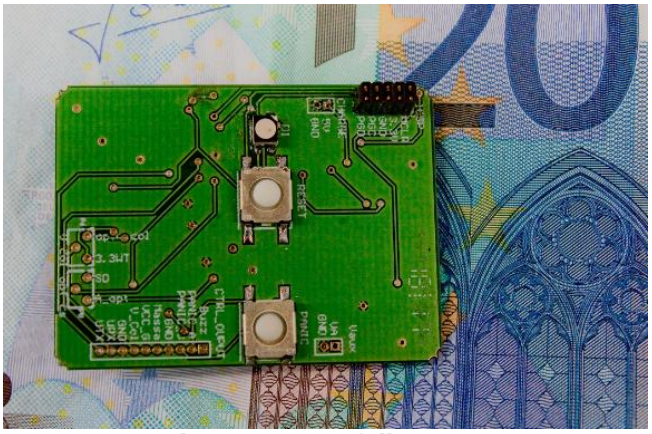

Figure 9 - PCB fall sensor

These fall detector will be included into the smart shirt developed by CETEMMSA, with some changes (it is not necessary to include the communications layer and the battery). Thus, only the PCB is needed, whose size is 43,7 x 32,5 x 5 mm and its weight is 8 g.

Whenever fall detection occurs, the alarm will be transmitted from the sensor to the smart shirt processor through a UART serial communication, in the same way that the previous sensor performed.

Geo-positional Alarm Service

The geo-position of the user is paramount for context awareness. In most situations, the exact position may not be needed, but only simpler information like being outside/inside, walking or travelling on a vehicle, etc. The context is then used by the observation pattern reasoning mechanism to use the suitable observations. For example, if the user is walking on an uphill road is quite natural an increase in the heart rate, thus the alert threshold must be higher than the rest one.

The mobile phone's geo-positioning capabilities will also be used to implement a simple geo-positional alarm service to help users with memory lapses or prone to get lost in their neighbourhood. The use of computational intensive reasoning mechanism and heavy GPS usage would lead to a huge increase in power consumption in the mobile phone, dangerously reducing its power autonomy. Thus, the monitoring will be applied only to walking users, relying whenever possible on the intermittent use of assisted GPS (A-GPS) and switching to full GPS only occasionally to increase the accuracy.

The geo-positional alarm service is based on the definition of "safe" areas the user usually uses when leaves home walking (to go shopping, etc.). The areas are polygons defined by the caretaker on a map (caretaker server). When the user leaves the area an alarm is sent to the caretaker server so that the caretaker can phone the user and assess the situation.

Emergency Smart Services

These services are intended to control patients' activity and create a behavioural pattern that is complemented by the e-health information sent by the tele-health part. The information combined provides a more complete picture of the patient condition. The next bullet points describe the different sensors that CAALYX-MV will use to create smart-homes on patients' homes:

- The flood detector provides home safety to a person who is likely to be at risk from leaving taps turned on.
- The bed/chair occupancy sensor can automatically raise an alarm whenever a person is getting out of bed before a predefined time, is not going to bed before a predefined time or does not return to bed during the night within a predefined time period.
- The Personal Trigger, which is worn round the neck, on the wrist or attached to an item of clothing (Figure 1: 6). It can enable a call for help anywhere in the home or garden within a 50m range of the Lifeline home unit. Both operate on the 173MHz frequency.
- The fall detector detects both the impact and angle of a fall and can automatically raise an alert after a fall.

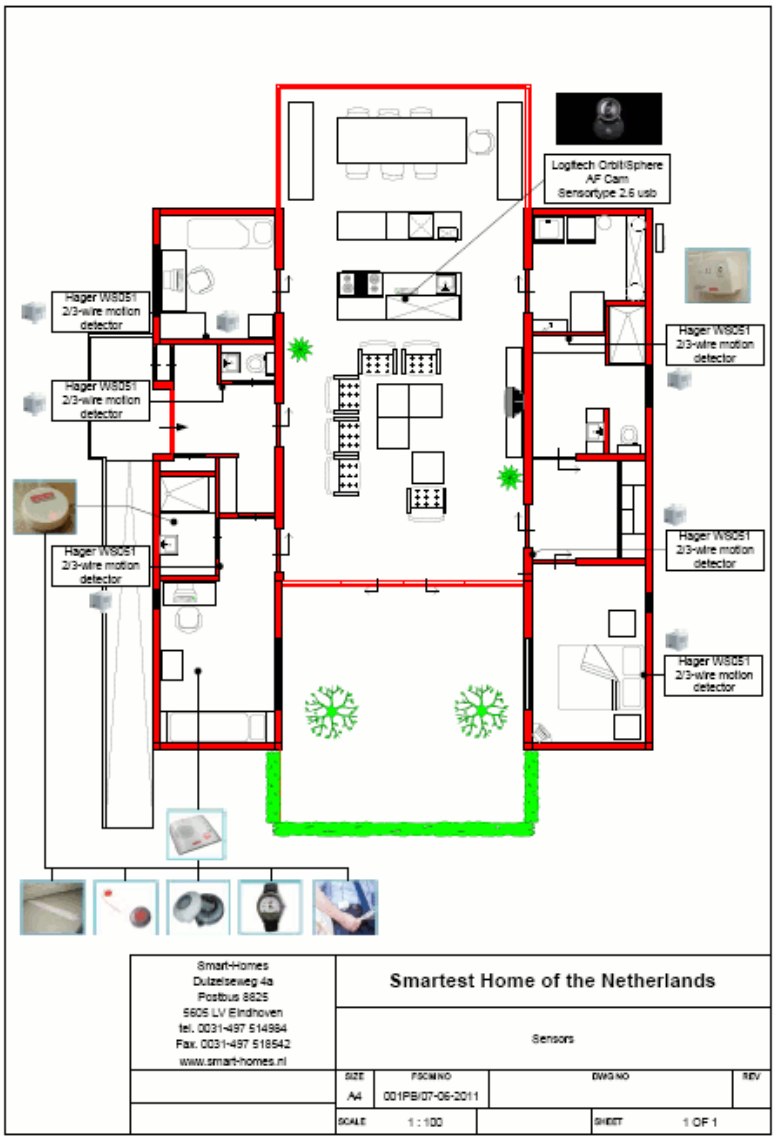

Figure 10 - Smart home

4.1 Ambulatory Care Service

Remote Vital Sign Monitoring

1. The clinical parameters which may be controlled by the system are the following: heart rate, respiratory rate, temperature, blood pressure, weight, oxygen saturation, electrocardiogram, glucose levels, physical activity, functional status and affective status.
2. Monitoring is performed according to “Observation Patterns”. So, the system have absolute values for normality and abnormality for each clinical parameter evaluated:
   - **a.** When the clinical parameter evaluated is into “normal” range, the system doesn’t send any alarm nor other parameters are evaluated (Observation Patterns don’t work).
   - **b.** When the clinical parameter is into “abnormal” range, the system sends an alarm to caretaker centre even if other clinical parameters are in normal range.
   - **c.** When the clinical parameter is into “grey zone” (not normal, not abnormal), the Observation Patterns are performed. It means other clinical parameters are taken in account and then the system takes a decision:
     - **i.** Send an alarm to caretaker centre.
     - **ii.** To repeat the measures some time after (15 minutes, 30 minutes, etc.)
     - **iii.** The measure is rejected.

In addition to other clinical parameters evaluated, the system takes in account the activity level of patient and the duration of measure alteration.
The objective of using Observation Patterns is to avoid sending “false alarms” or alerting from clinical measures without clinical significance.

EXAMPLE
Below, clinical parameters of a patient at rest in different clinical situations are described and interpreted according to system configuration.
Values for normality and abnormality for these parameters are shown in the following figure:

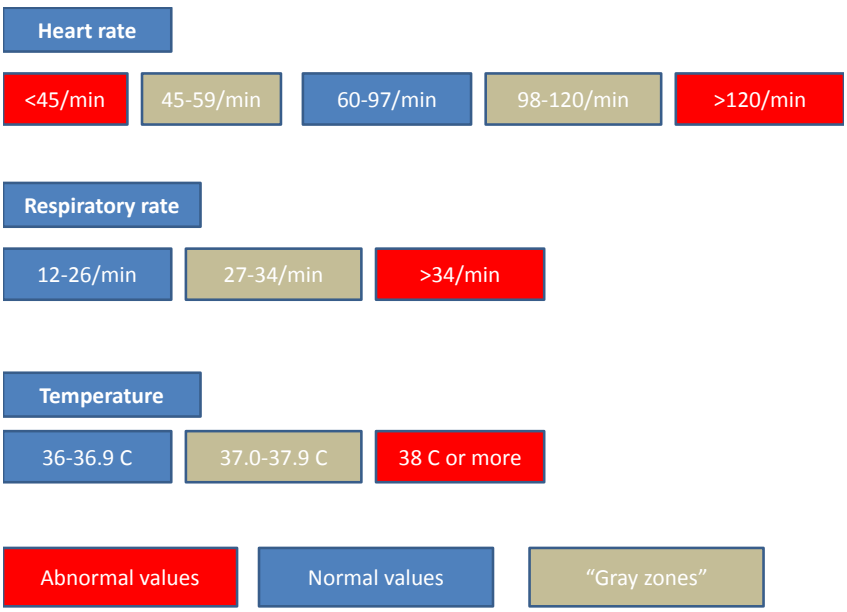

Figure 11 - Vital sign monitoring example

Clinical situation 1:
Heart rate: 140/min (at rest)
Respiratory rate: 16/min
Temperature: 36,5 C
In this situation heart rate is into abnormal range, then the system send an alarm to caretaker site regardless of the values for other clinical parameters. The diagnostic is tachycardia.

Clinical situation 2:
Heart rate: 80/min
Respiratory rate: 16/min
Temperature: 37,6 C.

In this situation temperature is neither normal nor abnormal ("gray zone"). That is why observation patterns are applied (other clinical parameters are considered to define a diagnostic or decision). The observation pattern for this situation is the following:

Combination of findings with clinical sense			System sequential responses		
Temperature (C)	Hear Ratio (bpm)	Respiratory Rate (rpm)	Action 1	Action 2	Action 3
Normal	Normal	Normal	No alarm necessary		
37.5-37.9	Normal	Normal	repeat in 10 minutes	repeat in 30 minutes	alarm: FEVER
37.5-37.9	97-119	Normal	Alarm: FEVER		
37.5-37.9	Normal	27-34	Alarm: FEVER		
37.5-37.9	97-119	27-34	Alarm: FEVER		

Table 1: Observation pattern

As we can see in according to this Observation Pattern, the clinical decision from the system is to repeat the measurements in 10 min. At the other hand, if heart rate and/or respiratory rate are elevated (for example 110/min and 29/min, respectively) the system will send an alarm with diagnostic as FEVER.

Currently, the system has Observation Patterns for evaluation of temperature, heart ratio, oxygen saturation and respiratory rate. Observation Patterns for heart failure, chronic obstructive pulmonary disease and other diseases are in progress (these will consider other clinical parameters like weight, reaction from heart rate and respiratory rate to effort, and others.

3. The most important diseases for monitoring (because functional impact, hospitalizations, mortality and institutionalization caused by them) in elderly people with comorbidity are the following:
    a. Heart failure
    b. Chronic respiratory disease, mainly COPD.
    c. Osteoarticular diseases.
    d. Cardiovascular risk factors: mainly hypertension and diabetes mellitus

e. Stroke

The diseases or clinical situations that may be controlled by the system are the following:

a. Heart failure.
b. Chronic respiratory disease:
    a. Chronic obstructive pulmonary disease (COPD).
    b. Asthma
c. Cardiovascular risk factors:
    - Hypertension,
    - Diabetes mellitus,
    - Obesity.
d. Stroke (secondary prevention): functional status and cardiovascular risk factors monitoring.
e. Hipoxemia situations [5]
f. Depression
g. Osteoarticular disease: pain, functional impact.
h. Geriatric syndromes:
    a. Falls
    b. Constipation
    c. Urinary incontinence
    d. Cognitive impairment (geographic monitoring)

4. Videoconference

The physicians can contact to patients by videoconference through the system. Videoconference sessions may be performed in according to physicians or caretaker demand. The system sends an alert to patient (or relatives) when the physician or caretaker asks to contact with them.

Treatment and Medications

Give physicians the ability to prescribe medications, order exams, change charts, on mobile devices.

Specific Questionnaires

1. For monitoring elderly people with comorbidity, the physicians need information about physiological parameters (heart rate, respiratory rate, etc.) and information about functional status, symptoms intensity, mood status, which cannot be measured by medical sensors but by other instruments like clinical scales, medical questionnaires (often used in clinical practice). These may be applied by remote way by CAALYX-MV system (home system).

2. Physicians can apply the medical questionnaires and they have the following capabilities:

    a. Physicians can choose medical questionnaires for patients from a list of them.
    b. The questionnaire has a threshold level for alarm (example: alarm if the index [6] decreases 30% from last measure). Physicians may modify this threshold values.

3. Medical questionnaire currently available:
    a. Functional status:
        i. Basic activities: Barthel index.
        ii. Instrumental activities: Lawton index.
    b. Affective status or depression screening:
        i. Yesavage questionnaire [7] (5 items version).

Visual Services

The videoconference feature in the STB allows the user to call his doctor(s) and make a live consultation while staying at his home. The user is prompted with a list featuring the doctors that are following the patient and their specialty. The connection may also be in the reverse way, i.e. it can be the doctor to contact the patient. In CAALYX-MV, doctors are who call patients for videoconference. Patients will not call the caretaker.

Clinical History and Access

The system organizes clinical data collected from patients in five sections:

- Pathological background
- Basal situation: functional, mental and social status when the patient is stable.
- Clinical course: medical annotations introduced by physicians.
- Medical treatment.
- Assessments performed by the system trough medical questionnaires (about functional or mental status, depression screening, etc.).

Physicians can access to clinical history from personal computer or mobile phone with connection to the Internet (website system).

4.2 Social Care Services

Live Connections

Depending on the caretaker service policies, the user may also select between a list of friendly contacts and establish a video call with any of them. If the remote end doesn't support video, at least an audio call is started. The user may also use this service to contact a doctor out of the pre-scheduled appointments.

Calendar

The user is able to check his medical agenda through the STB user interface. He can check all his forthcoming appointments, as well as all information regarding his medical prescriptions and vital sign measurements using the provided sensors. A reminder service is also available, which will immediately warn the user when a new medical appointment is assigned and when the time of the next appointment, medication or measurement is approaching.

Social Smart Services

Smart Home components are already available and affordable. Older people could benefit from the integration of Smart Home components. User requirements analysis and evaluations, in situ, should shed light on the components that suit the users' needs (i.e. integration of webcam, KNX).

5 Potential CAALYX-MV's Service Portfolio

Once the CAALYX-MV system has been explained and its basic services described, the time has come to further develop how these services will be presented in the real Healthcare market. To do this, we need to further develop how these basic services (i.e. emergency, ambulatory, social care services) will be combined to create a portfolio of marketable e-Health services. D2.1 is not intended to provide for how these services will fit in the market, which is the task of D2.2 and D2.3. However, the main outcome of D2.1 is to propose a portfolio of e-Health services that will ultimately be adapted to meet the expectations of the selected market segments.

In order to create this portfolio, a nested list of services packages is presented according to the severity of patients' care needs. The same kinds of diseases can be developed in different stages for different patients. While some patients will need on-going monitoring and care, other patients in earlier stages of the disease will only need a soft care system, enabling them to give feedback to the doctors about their condition. This distinction is remarkably important when considering monetary savings and customisation of the system for patients' needs. For example, wearing monitoring t-shirts is not necessary if a patient's clinical status is not severe. The next table describes what this portfolio looks like:

Commercial Service Name	Service Description	Rationale	Outcome
Soft care service (A mild combination of ambulatory care and social care services)	Patient agenda (i.e. appointments, drugs,) questionnaires, videoconferencing	For patients that only need to be followed-up and reminded to take their drugs	All these services are the result of a particular combination of **ambulatory care** and **social care services**. This new categorisation of services is more convenient to target different chronic conditions. It gives us the flexibility to provide a different service depending on the level of severity. It also provides a means of customising the service for each patient.
Primary care service (A combination of ambulatory care and social care services)	**Home monitoring** Patient agenda (i.e. appointments, drugs,) questionnaires, videoconferencing	For patients that constantly need to attend the hospital for check-ups	
Extra primary care service (A combination of ambulatory care, social care and emergency services)	**Smart home services** ***Home monitoring*** Patient agenda (i.e. appointments, drugs,) questionnaires, videoconferencing	For more fragile patients. They need more monitoring in order to live independently and reduce GP visits	
Continuous care service (A combination of ambulatory care, social care and emergency services)	**T-shirt: Constant monitoring** ***Smart home services*** ***Home monitoring*** Patient agenda (i.e. appointments, drugs,) questionnaires, videoconferencing	For more severe cases when patients need very frequent care and monitoring to avoid clinical exacerbations (heart failure, respiratory diseases, etc.). They must wear the T-Shirt in order to gain autonomy	

Table 2 - Services Portfolio

This categorisation of services is broad enough to be adjusted to specific situations related to different kinds of disease. It is essential to have a service portfolio that can offer a range of different solutions depending on the severity of the patient. The next picture shows a different way of representing this services portfolio.

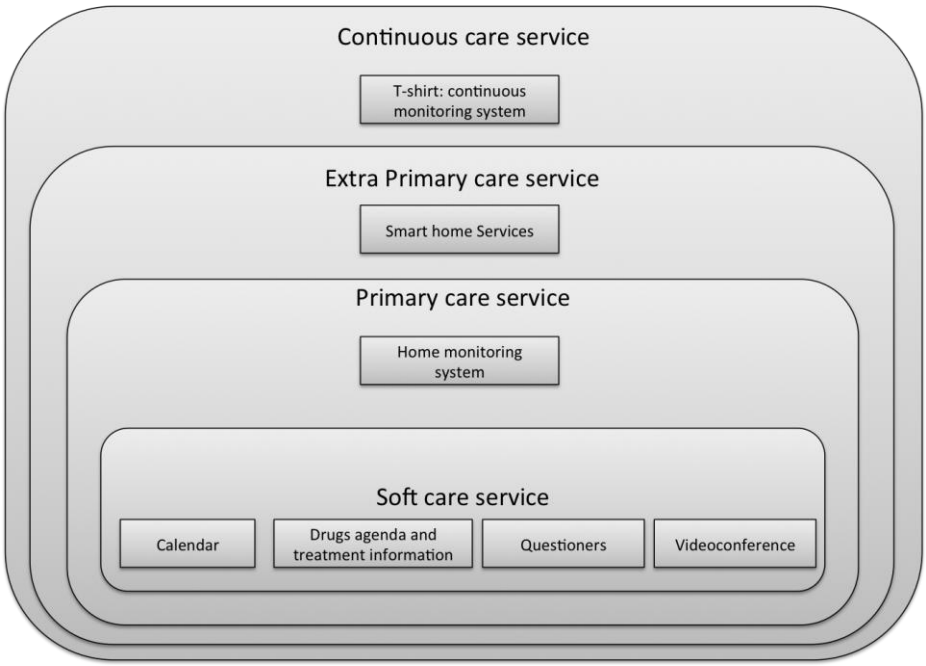

Figure 12 - CAALYX-MV services portfolio

5.1 Clinical Service Flows

In this section, the main clinical service flows such as ambulatory care and emergencies are presented and compared with the impact that a system such as CAALYX-MV would have on the services. These services flow through the different tiers of care, i.e. Primary Care, Specialists, Urgencies, Hospitals, etc.

5.1.1 Traditional versus CAALYX-MV in Ambulatory Care Service

When we look at elderly people with a chronic condition is quite likely that they have developed some level of comorbidity, which means that there is more than one disease affecting them. This is the typical scenario. The traditional ambulatory care service is represented in Figure 13. Normally, the process begins when a patient goes to their GP because of a particular problem. To diagnose a chronic condition the patient is forwarded to a specialist to for initial treatment. Then, the GP does the follow-up and talks to the patient about health education. Due to a lack of monitoring, things might get worse for the patient who then might have a series of acute episodes, taking that patient to emergency services. The same patient might also have to return to the specialist to be re-evaluated.

For patients with a mild condition, Figure 14 – Soft Care Service, CAALYX-MV is an invaluable tool for both patients and GPs, providing constant feedback through questionnaires and videoconference meetings. This constant two-fold flow of information improves treatment adherence, reduces visits and increases social contact with the patient. Thus, the patient improves, as they are motivated to take their medication, follow a healthier diet or sports programme, etc.

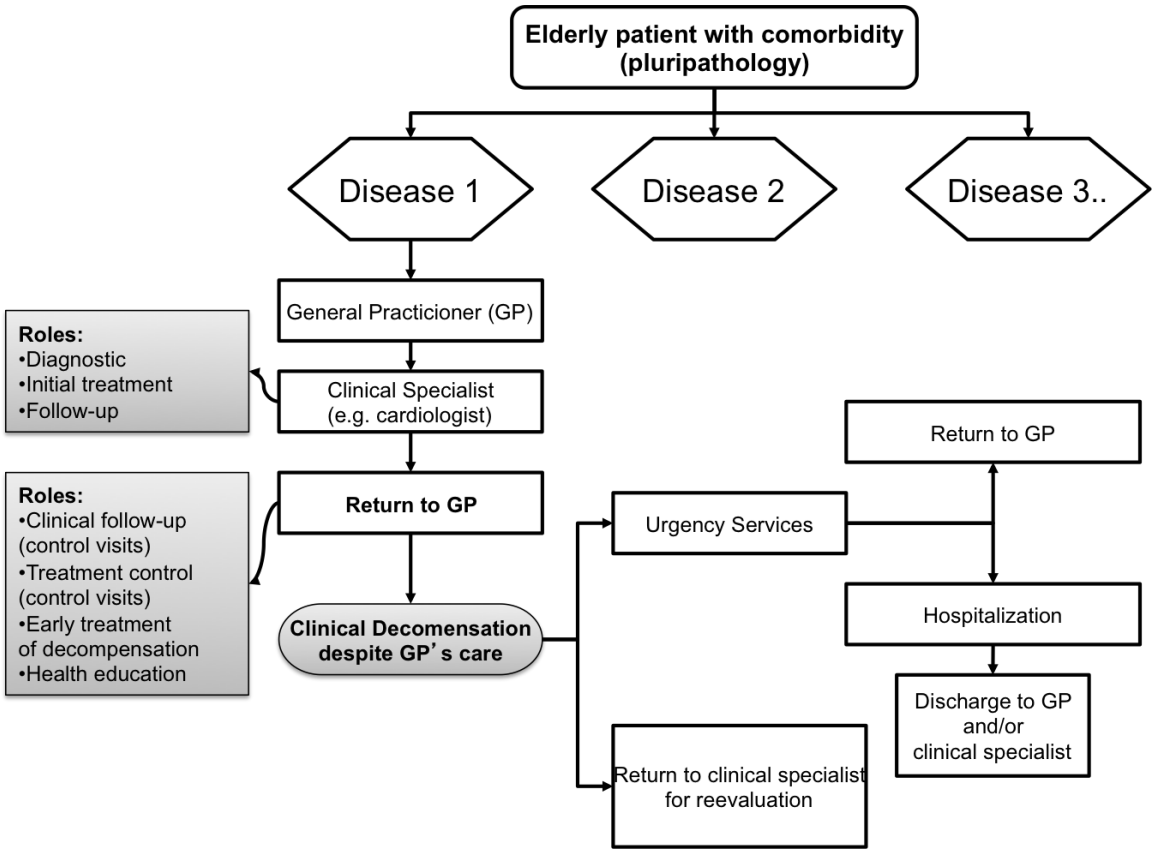

Figure 13 - Usual medical services flow in Spain for older people

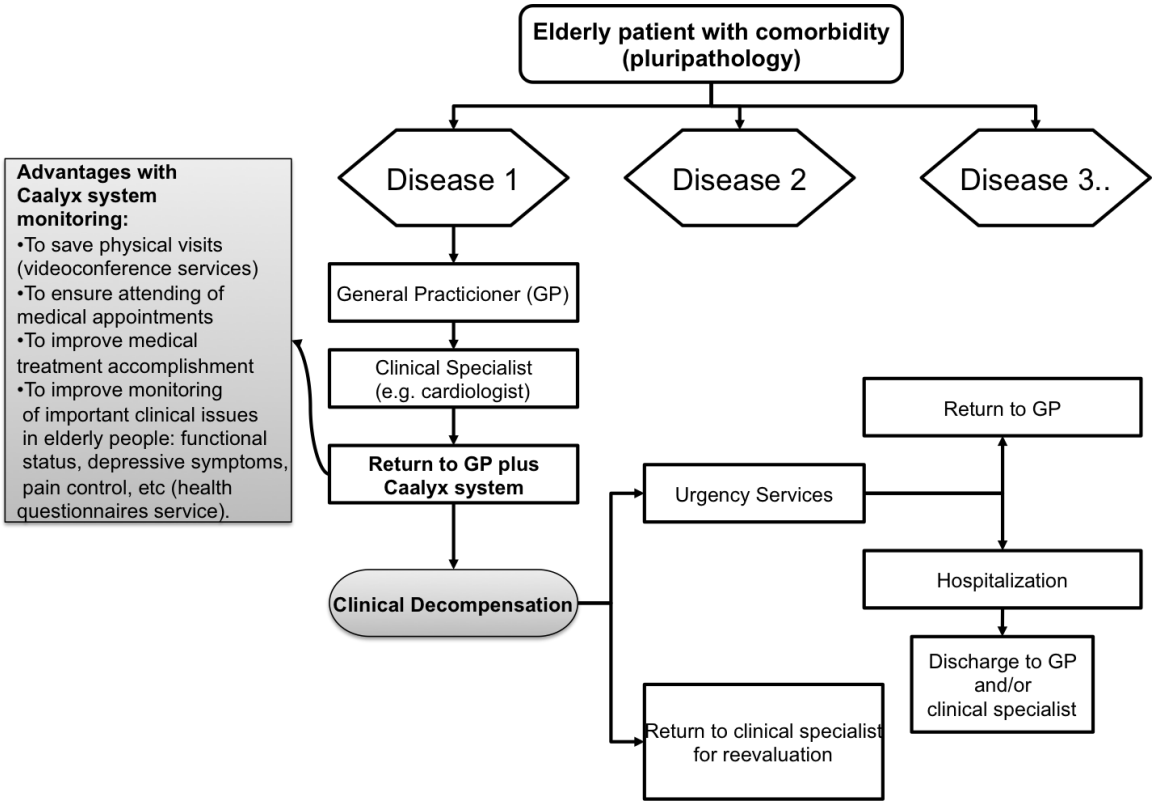

Figure 14 - Service flow for elderly people using CAALYX-MV system – Soft Care Service

For patients with a mild condition, Primary and Extra Primary Care Service – see figure below, the system gives more inputs for doctors, providing them with regular biometric and activity measurements. This enables patients in more acute states to advance and avoids patients ending up in emergency services.

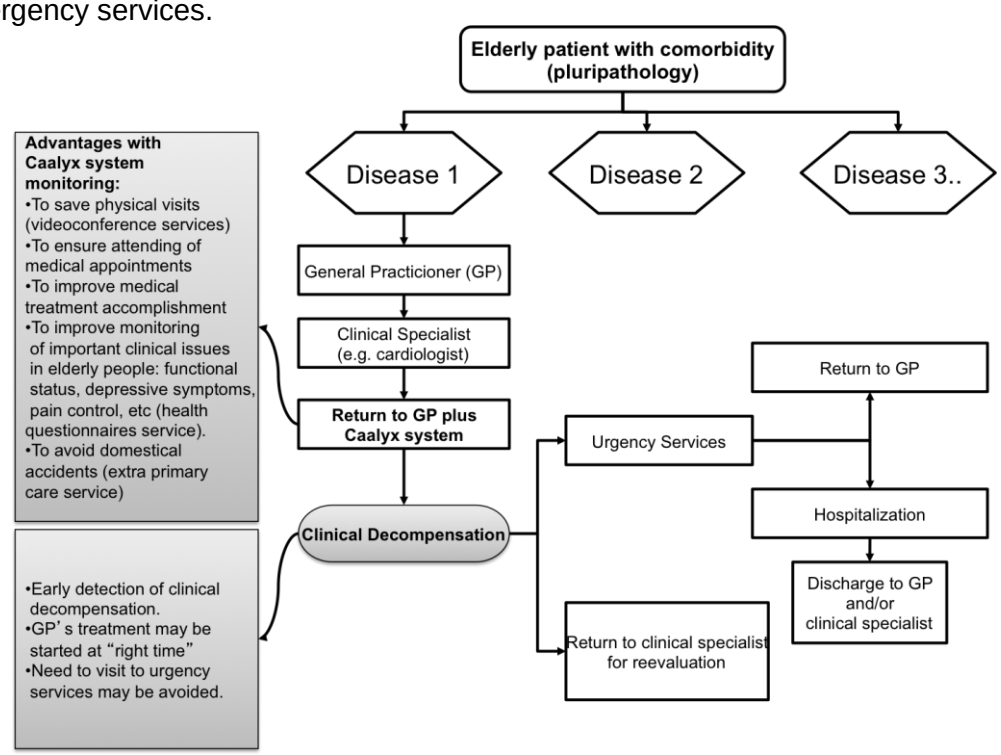

Figure 15 - Service flow for elderly people using CAALYX-MV system – Extra/Primary Care Service

Finally, for severe patients, the Continuous Care Service -see figure below- is a system that provides constant monitoring. This allows patients with more serious conditions to live autonomously anticipating health problems before an accident/urgency occurs.

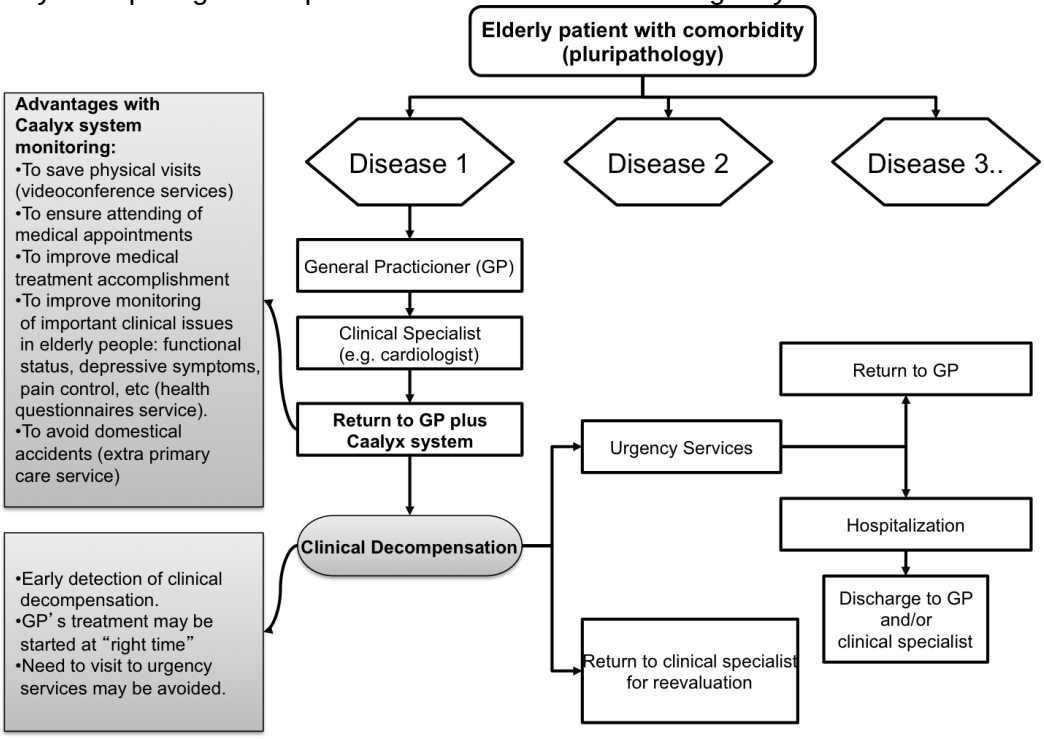

Figure 16 - Service flow for elderly people using CAALYX-MV system – Continuous Care Service

5.1.2 Traditional versus CAALYX-MV in Emergency Services

When someone feels ill, people normally use Emergency Services that can lead to further visits at the GP or even hospitalisation, especially for elderly patients with severe chronic conditions. Figure 17 shows all the different pathways patients can take throughout the different tiers of care. For those patients with severe chronic conditions, CAALYX-MV provides the Continuous Care Service, Figure 18, which allows clinicians to anticipate this type of information thanks to 'intelligent' alarms based on a function called 'Observation Patterns'. This would mean that most emergency situations could be avoided since clinicians would be able to anticipate the patient's prognosis.

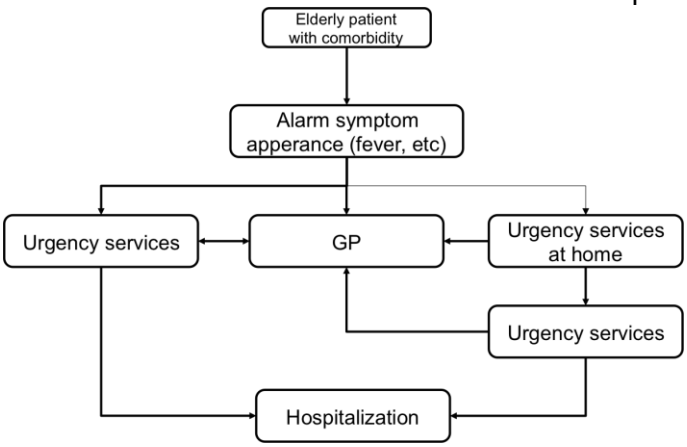

Figure 17 - Usual medical service flow for elderly people in cases of emergencies

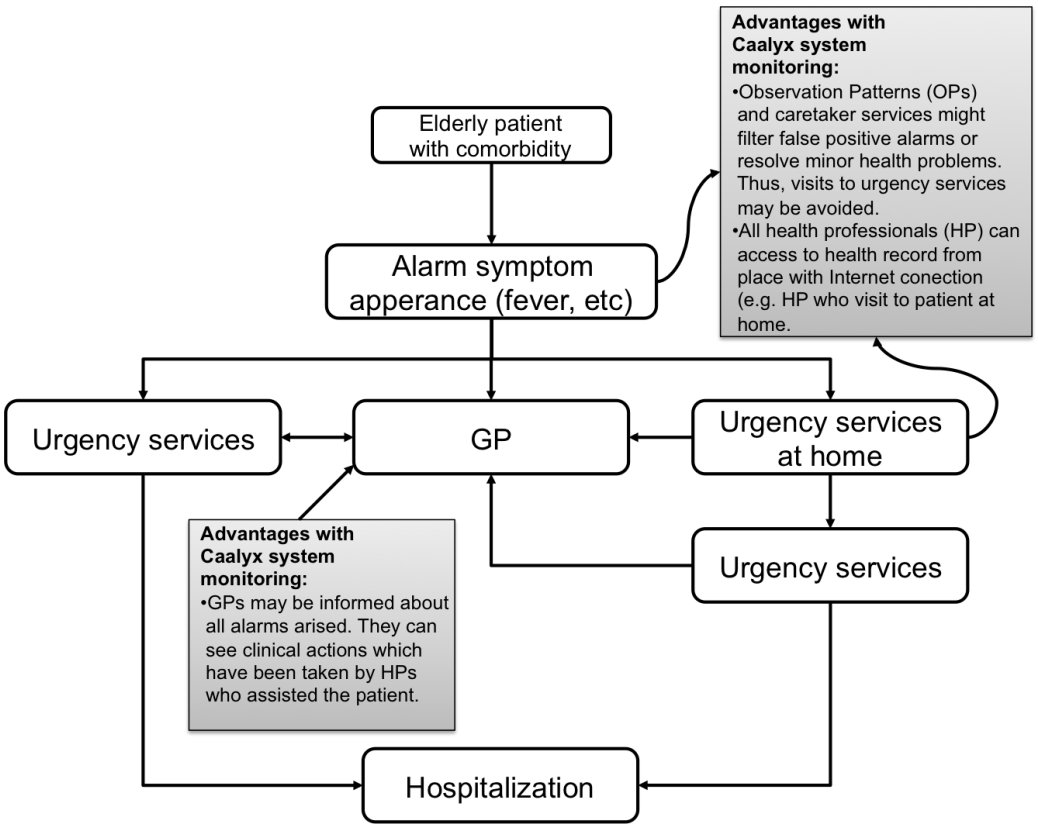

Figure 18 - Usual medical services flow for older people in cases of emergencies using CAALYX-MV

6 Conclusions

This deliverable has presented a technical analysis of the CAALYX-MV solution. This information will be used in D2.3 in order to complement the market research and the competition analysis. Furthermore, D2.1 has proposed a service portfolio for the project. These services have been listed and their flows have been compared with traditional ambulatory care and emergency services. The proposed service will be reinforced and complemented with marketing strategies. This work will be implemented in D2.2.

The next steps to be effected in deliverables D2.3 and D2.2 are as follows:

1- CAALYX-MV market study and analysis
2- Benchmarking to know our competition
    a. The technical analysis in this deliverable will feed the competition analysis in D2.3 where features among the different solutions will be compared
3- SWOT
4- Business models to understand how to commercialise services and how the companies forming CAALYX-MV could make a sustainable and profitable business
5- Marketing strategies
6- Final list of marketable services
    a. This will be the direct input for WP5

7 References

[1] eCAALYX project; funded by the European Commission under the Ambient Assisted Living (AAL) Joint Programme, “Deliverable D3-M15 -Scenario description”
[2] eCAALYX project; funded by the European Commission under the Ambient Assisted Living (AAL) Joint Programme, “Deliverable D4-M27 Requirement Specification”
[3] Noury N, Rumeaua P, Bourke AK, ÓLaighin GM, Lundy JE. A proposal for the classification and evaluation of fall detectors. IRBM doi:10.1016/j.irbm.2008.08.002 2008.
[4] Lyons GM, Culhane KM, Hilton D, Grace PA, Lyons D. A description of an accelerometer-based mobility monitoring technique. Med Eng Phys 27(6): 497-504, 2005.
[5] Internation Liaison Committee on Resucitation (1997). Special resuscitation situations, 34:129-149
[6] Tibaek, S. (2011). Is Barther index a relevant measure for measuring prevalence of urinary incontinence in stroke patients? PubliMed.gov, PMID: 22038557
[7] Counselling Resource Research Staff (2011). Geriatric Depression Rating Scale, A screening test for depression. Counsellingresource.com

8 Glossary

AAL: Ambient Assisted Living
ACS: Auto-Configuration-Server
ADL: activities of daily living
BAN: Body Area Network
BP: Blood pressure
BPM: Beats Per Minute
BT: Bluetooth
COPD: chronic obstructive pulmonary disease
CPE: Customer Premises Equipment
CV: cardiovascular
DSL: Digital Subscriber Line
eCAALYX: Enhanced Complete Ambient Assisted Living Experiment
ECG : Electrocardiogram
EHR: Electronic health Record
GPS: Global Positioning System
HR: Heart Rate
HSS: Home Sensor System
ISS: Intelligent Sensor System
NIBP: Non-invasive blood pressure
OTS: Off-the-shelf
PPG: Photoplethysmograph
PTT: Pulse Transit Time
RR: Respiration Rate
SpO2: (Peripheral) Blood Oxygen Saturation
STB: Set-top box
SWOT: Strengths Weaknesses Opportunities and Threats
USB: Universal Serial Bus
WBS: Wearable Body Sensor
WP: Work package