COMPETITIVENESS AND INNOVATION FRAMEWORK PROGRAMME

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Abstract

This deliverable presents the final service operational and technical specifications and design for the integration of the three components of LLM (Intelligent Living Component – ILC, Cognitive TrainingComponent – CTC and Physical Training Component – PTC), thus delivering innovative ageing well / independent-living support services for elders.

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[1] Please use a new number for each new version of the deliverable. Add the date when this version was issued and list the items that have been added or changed. The 'what's new' column will help the reader in identifying the relevant changes. Don't forget to update the version number and date on the front page and the header.

[2] A deliverable can be in either of these stages: "draft" or "final". For each stage, several versions of a document can be issued. *Draft:* Work is being done on the contents. *Final*: All chapters have been completed.

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Executive Summary

The integration of the currently existing prototype solutions towards the construction of the LLM service will be based on the trivial interconnection linking the Cognitive Training Component – CTC, and the Physical Training Component – PTC, to the eHome solution as the Intelligent Living Component. Thus, we aim to deliver innovative ageing well / independent-living support services for elders.

This deliverable describes the definition of all operational and technical requirements, specifications and design of the LLM service. Operational requirements are strongly correlated with the cognitive and physical training process and the personal training programme scheduling. The operational specifications and the technical requirements affect the integration process design, also presented here. LLM service properly addresses interoperability and standardization issues, as the proposed architecture is not limited either by a specific CT or PT component. In this respect, alterations, extensions and even replacements may lead to improved service features, especially in the case where trial results contradict previous assignments and work hypotheses. Finally, this deliverable also includes the required steps towards the localization and the configuration of the service.

1 Introduction

The integration of two existing ICT solutions with physical training equipment, thus delivering innovative ageing well / independent-living support services for elders is the first of the main objectives of the project. The related task of this deliverable, aims to provide the final service operational and technical specifications and design for the integration of the three components of LLM (Intelligent Living Component – ILC, Cognitive Training Component – CTC and Physical Training Component – PTC). The result of this task will lead to the actual tasks of integration, testing, validating and adapting the service to adhere to the afore-mentioned specifications. Further, the service will be localized to the regions where pilots will be held and where the LLM system that will be used for pilots will be delivered.

This deliverable describes the definition of all operational and technical requirements, and specifications and design of the LLM service. According to the overall specifications and design the LLM system consists of:

- ILC, namely the e-Home system, that will be responsible for assisting seniors living an independent life by monitoring their daily activity and responding by initiating alarms where emergency cases are identified.
- CTC that will serve as a tool in order to help elderly people to improve their cognitive capacity or mental health, by means of a set of computerised exercises that target to enhance several functionalities of the human brain.
- And PTCs, to ameliorate elderly people physical condition by motivate them to exercise themselves in a more convenient and enjoyable way.

The service adaptation is divided into two directions: the first one concerns integration of the three aforementioned components and the second deals with the localization of the service to the countries where it will be piloted. Preliminary work on the merging process indicates that the components can be integrated within required time limitations.

The deliverable comprises six chapters. More specifically:

Chapter 2 gives an overall description of the LLM service to be deployed at the trials and within the system, with respect to hardware and software components selected.

Chapter 3 begins by detailing the current trends, evaluation, selection and the unique characteristics of the selected LLM components. It then continues by presenting the LLM technical and operational requirements.

Chapter 4 consists of the LLM technical specification. This covers hardware and software specifications of the Server and client application, inclusion characteristics addressed and interoperability and standardisation.

Chapter 5 includes LLM operational specification with a set of use cases presenting a clear view of the LLM system overall functionality.

Finally, chapter 6 concludes with the Integration design of all three components.

2 Overall services & system description

2.1 LLM service

The LLM service is designed to comprise of three existing interoperable components which perform complementary and interactive tasks to provide the system's services:

- The **Independent Living Component (ILC)** is based on the eHome system, which is a network of distributed, wirelessly-operating sensors connected to an embedded system (the e-Home central unit). It includes features, such as intelligent learning of normal and exceptional patterns of behaviour (dangerous situations or indicators for emerging health problems), and relevant alarms. e-Home is a project funded by the Austrian Research Promotion Agency (FFG).
- The **Cognitive Training Component (CTC)** is designed to support cognitive exercises provided by specialised software. A variety of software can be used for this process; a careful selection and evaluation has been performed by the LLM partnership to identify the appropriate software for testing during the project and for completing customization and localization of this software as needed for the initial deployment and the pilot testing of the LLM system.
- The **Physical Training Component (PTC)** comprises custom training equipment, which is geared to meet the specialised needs of the elderly. The only prerequisite for the equipment selected for integration is that it is able to provide exercise performance output. This output will be forwarded to the central LLM system for monitoring and processing.

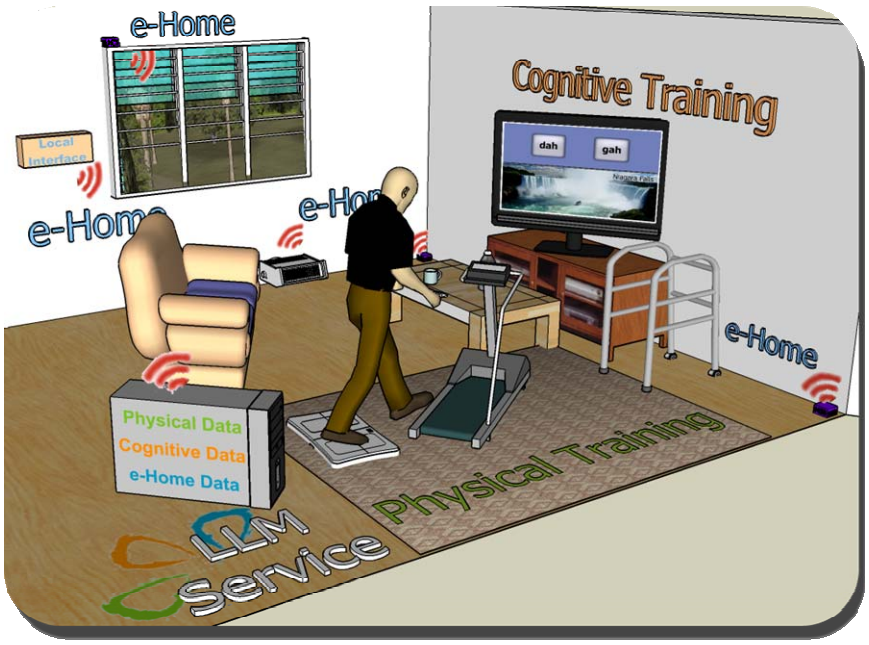

Figure 1: LLM service

2.2 LLM system

LLM system, as an innovative ICT solution for ageing well, features typical AAL solution characteristics, such as accident detection, support in daily activities and third party notification in case of emergency. LLM combines these with pre-emptive measures, such as training. The LLM system utilizes state-of-the-art hardware and software technology. It comprises of:

- User Interfaces: touch screens or simple screens for interaction with the users. All system functionalities, including home environment management, cognitive training and physical exercising performance monitoring, are displayed and set from the Local User Interface, which is a touch screen. Remote User Interfaces facilitate communication with the relatives, care takers or authorities in the case of an emergency.
- Sensors: to monitor movements inside the house. They are deployed as a distributed network of wirelessly connected sensors that identify moving patterns. Importantly, these detect deviations from those patterns, for example, as caused by a fall. In these cases they notify the user's relatives or caretakers via the Remote User Interface.
- Facility to connect Instrumented Power Outlets: These sensors detect situations where the user has forgotten to switch on electrical appliances.
- Both aforementioned sensor components guarantee the safe living of the elderly inside their home environments without the need for exclusive intensive care.
- Facility to connect Actuators: which facilitate acts, such as opening windows, doors and blinds and are remotely operated using the Local User Interface. These provide the daily activity supporting feature of the LLM service.
- Processing units: an embedded processor and a general purpose PC which are used for coordinating and management of the AAL environment, for executing the cognitive training software and for storing and processing the physical training performance information.
- The cognitive training software that will be used initially will form the BrainFitness of PositScience. Subsequently, different cognitive training software packets will be used.
- Various training equipment, such as recumbent bikes and/or ergometers and/or treadmills, which offer a variety of physical exercising possibilities according to the special needs and disabilities of each user. Recumbent bikes are the most suitable apparatuses for elder users with moderate disabilities. For people in a more serious condition ergometers might be used, as they require minimum physical exertion and can be used in a normal sitting position. On the other hand, elders in better physical condition or of a younger age may use treadmills to simulate, within the eHome framework, a walk they would do outside.

3 LLM technical and operational requirements

3.1 Current trends, evaluation and selection of LLM components

3.1.1 Physical training component

3.1.1.1 Current state of the art

The Physical Training Component (PTC) is one of the three components that constitute the LLM system and is responsible for providing senior users the possibility of training themselves and maintains their overall well being. More specifically, the supplied equipment compromising the PTC should provide several types of exercises that target the following:

- slow mental decline
- improve physical function
- improve general cardiovascular health
- reduce the risk of falls
- lift mood, ease stress, and add calm
- pass time in an enjoyable way

Currently there is a great variety of training equipment in the market that can be utilised by seniors in order to improve their physical condition. Physical training equipment varies from custom training equipment, such as recumbent bikes, ergometer bikes and treadmills, to Wii console games and several other exercise and gaming facilities (ConnectAndPlay, Touchdown, Positive Gaming, etc.) offered by companies specialised in the field of the fitness and gaming industry.

3.1.1.2 Evaluation and selection

Therefore, research was conducted in terms of selecting the most appropriate kind of training equipment for integration into and supported by the final LLM system. A number of criteria were formed in order to evaluate the suitability of training equipment according to end users' special needs. The criteria formed concerned both the hardware accommodation and corresponding software packages. Below there is a list of these criteria, firstly for the selection of hardware devices and next for the software packages.

Hardware	Software
Cost	Cost of use
Ease of integration	Ease of integration
Efficacy of improvement of physical function	Appropriate data output format
User satisfaction and approval	Open source
Diversity of physical activity	Scalability / Flexibility
Adaptation to special needs (accessibility)	Storage (local /remote database)
Safety of usage	Web access
Compatibility with standard communication protocols	Compatibility with standard communication protocols
Support of multiple concurrent users	Control of training procedure
Performance output	User performance progress monitoring
Motivation provision	Range of performance indicators
Difficulty level adjustment according to performance progress	User Interface attractiveness
Additional accessories / equipment / peripherals	
Appropriate accompanied software	
Possible use with certain fitness tests or exercise protocols	

Table 1: PT Components software and hardware criteria

After defining the above criteria, two cross-sectional tables were designed. These combined, in the first case, both candidate equipment and selection criteria, and in the second case, candidate software packages and selection criteria. A score, between 1 to 5,

was assigned to each component (hw and/or sw) to quantify the level of criteria satisfaction.

Finally, the subcomponents that will compromise the final Physical Training Component (PTC) were selected and are listed in the table below with their costs.

PT Components	Cost
Ergoline ergometer bikes: ergo 100K	2700 €
Medical treadmill Marathon Heavy Duty 2HP	2200 €
Nintendo Wii Remote	33,5 €
Nintendo Wii Balance Board	79 €
Nintendo Wii Dance Mat	19,9 €
Total cost	5032,4 €

Table 2: Physical Training Component s selected and their costs

3.1.1.3 The unique characteristics of the selected component

The main reason for selecting this kind of equipment is, first of all, that they satisfy the one and only prerequisite for their integration into the LLM system, which is the provision of exercise output and performance data. Both ergometer bike Ergo 100K and Marathon Heavy Duty support data transfer to PC via serial communication protocols, such as Ergoline RS232 and Trackmaster communication protocols. In addition, Wii peripherals, such as Wii Remote and Wii Balance Board, use Bluetooth wireless communication protocol in order to send raw data captured by their sensors (acceleration data, infrared data and pressure data).

Moreover, the selected equipment have great potential for supporting a wide variety of different types of physical exercise targeting to specific outcomes, e.g. endurance, strength, balance (static and/or dynamic) and flexibility. Cycling, for example using an ergometer bike, could improve the cardiorespiratory system, which shall be monitored during warm up. Walking or running using a treadmill targets also can improving aerobic endurance of the patient during the warm-up phase. Static balance exercises could be accomplished using a Wii Balance Board. For example, using this, participants should try

to hold the same position for a short period of time (30 seconds to 1 minute). Last but not least, dynamic balance exercises target improvement of agility and dynamic balance, by prompting participants to try to remain in different positions over short periods of time.

Finally we note that a great advantage of the selected equipment over other candidates is the combination of user satisfaction and approval. User satisfaction was determined through users' reactions, for example, when using Wii accessories during physical training, and the extent and ease with which it enabled them to complete their intervention successfully. Satisfaction and approval also derived from the low cost of Wii accessories. The latter is a crucial characteristic of the final LLM system, since it is a prerequisite for successfully entering the business market. This aspect will be further described in the Business Plan.

3.1.2 Cognitive training component

3.1.2.1 Current state of the art

The widely-documented age-related cognitive decline (e.g. [1-2]) and the demographic trends which reveal that the earth's population is growing and is expected to age further in the next decades [3-4] highlight the pressing social need for the design and evaluation of effective cognitive training programs that will maintain and improve older adults' cognitive functions. To this end, several approaches have been used, including strategy-training, multimodal-interventions and process-based training [1-2].

During strategy training interventions, seniors are directly taught putatively useful strategies in various cognitive processes (e.g. memory, reasoning, etc). A major disadvantage of this approach is that there is limited transfer beyond the directly trained skills. For example, Ball and colleagues [1] showed that seniors receiving this type of cognitive intervention were able to perform better on multiple measures of the specific cognitive ability for which they were trained, but did not generalize this learning to everyday performance.

In typical multimodal intervention programs, adults are engaged in enjoyable, cognitively demanding and social meaningful activities (e.g. bridge playing, participation in volunteer work, video games, etc). For example, Basak and colleagues [2] demonstrated that after a 23.5 hr training in a popular strategy video game, older adults improved significantly in their use of the executive control functions, such as task switching, working memory and reasoning.

In process-based training approaches, participants are trained in tasks which are designed to target critical brain areas and neuromodulatory systems associated with learning and memory. This type of intervention was used in the recent study by Smith and colleagues [6]. Their study was the first double-blind large-scale clinical trial that demonstrated marked improvement, not only in the trained task, but also in several generalized measures. Specifically, the study demonstrated improvements in memory and perception of cognitive performance in everyday life, relative to an active control group that received a frequency and intensity-matched cognitive stimulation program.

In sum, different cognitive intervention approaches have demonstrated plasticity and learning effects in the aging brain. There is also strong evidence that process-based methods can promote generalization of learning to untrained tasks and everyday activities [6].

3.1.2.2 Evaluation and selection

The selection process for the cognitive training program was as follows:

First, a list of criteria was identified by consortium partners, and their relative importance was estimated with regard to the desirable properties of the cognitive training component. A number of software packages were proposed by several partners, and a small number of

them, noted for their potential to fulfil multiple criteria, were shortlisted for further comparative evaluation. Each of these programs was then evaluated against every criterion.

Criteria for the cognitive training program included the cost and ease of integration and customization, the range of cognitive functions affected, evidence for efficacy in cognitive functions, the cognitive exercise structure and the duration and intensity of training, user acceptance and satisfaction, protection of privacy, whether it is a web-based application, whether there is a specific scientific theory underlying the training structure and content, and other technical criteria. The software candidate short list included the BrainFitness program (Posit Science), CogniFit Personal Coach (CogniFit) and GRADIOR (INTRAS). The complete list of criteria and software is shown in Appendix A.1. Software packages not selected for comparative evaluation are listed in A.2.

BrainFitness was selected at this stage as it fulfilled all criteria, especially in its latest version which is modular and web-based, facilitating customization and integration. BrainFitness is considered a state-of-the-art product in the United States, and has already been translated into German by partner UKON in German, which is a first step to a wider deployment of the software in Europe. PositScience, the company developing and marketing BrainFitness, has expressed an interest in actively supporting LLM, by providing access to BrainFitness internals, as a stepping stone to accessing the European market, thus foreshadowing strong exploitation prospects. Most importantly, there is strong scientific evidence [6] that this program can lead to generalized improvement in memory and attention in everyday life.

3.1.2.3 The unique characteristics of the selected component

The Brain Fitness Program is designed to speed up auditory processing, improve working memory, and encourage the brain to produce more of the chemicals that help it remember. Having already acquired the endorsement of PositScience and following a cooperation formula that will be further elaborated during proposal implementation; our consortium will organize and hold the pilots using the BrainFitness software. Cognitive exercises provided by it are divided into six categories, delivering different cognitive impacts to the service's users.

- High or low: In this exercise, subjects hear sweep sounds and have to identify whether these sounds are rising or falling in their frequency (purpose: training basic sensory temporal discrimination)
- Frequency discrimination: Two pairs of sounds are presented. 3 sounds are identical; one sound is deviant in frequency. The subjects have to decide on which pair the deviant sound occurred. (purpose: training basic frequency discrimination)
- Tell us apart: In this exercise, subjects have to tell apart two similar phonemes, which might be difficult to understand because they are specially synthesized. (purpose: training speech relevant sounds by using specifically processed challenging speech sounds).

- Sound replay: The subjects hear several syllables and have to remember them. They have to repeat them in the right order by pressing the corresponding buttons. (purpose: trains longer syllables and auditory short-term memory)
- Match it: In this exercise, subjects have to press on rectangular buttons to hear syllables. The goal is to find two buttons that represent the same syllables and click on them one after the other so that they disappear (purpose: uses longer syllables and trains auditory memory with visual components).
- Storyteller: Subjects hear segments of stories and are asked to answer a set of questions concerning the details of the respective segment. (purpose: uses whole words/sentences and trains story comprehension and memory)

3.1.2.4 Potential of using Gradior

Gradior is a program which offers a structured evaluation and neuropsychological rehabilitation system. This system permits cognitive training and the recovery of higher cognitive functions in people who show cognitive deficit / deterioration, with few technical requirements for the therapist or the professional that supervises the performance of the senior.

The Gradior cognitive evaluation and rehabilitation program is aimed at people with dementia, brain trauma, neuropsychiatric disorders, brain damage, mental impairment, mental illness, and any other type of loss of cognitive skills.

Gradior works on a large number of areas of cognitive ability: attention, perception, memory, working memory, orientation, calculus, learning, language, and executive functions. It is comprised of four modules: clinical management, treatment management, reports management and rehabilitation sessions. The clinical management module collects data on the patient's clinical history, sociodemographic details, diagnosis, medication and clinical evaluations. The treatment management module allows the therapist to establish an individual treatment regime for the patient, using the reports management module, which presents the performance results data of the patient in the form of lists or graphs. The final module is that which provides the exercises in a specialised session for the patient.

Gradior has more than 35,000 cognitive exercises specifically developed to not only improve cognitive performance, but to act as rehabilitation exercises, with evaluation of the patient's progress and adaptation to his or her needs. This is one of the unique characteristics of the program; it is a truly personalised clinical treatment program which gathers data and information on the clinical history of the patient and on their performance in the exercises, to allow for constant adaptation to meet their needs. It has been developed by professional neuro-psychologists and specialists in Research and Development specifically as a tool for cognitive rehabilitation treatment, always with a user-centred perspective.

With this in mind, the program has been developed for ease of use, both for the patient and for the professional therapist, and has a Client Relationship Management service which offers technical and clinical support.

The high potential for future application of the Gradior program is due to its great flexibility and ability to incorporate new advances and updates. From the point of view of its technological components, it can be easily updated or customised for different target users, due to its large number of independent components which can be easily and cheaply changed or added to. Furthermore, as the program adapts and is personalised to the concrete needs of each individual user, it can be used for many different people with different cognitive problems, or even without any cognitive deficiencies.

Various short-term studies have proven the effectiveness of the Gradior program for improving all aspects of cognitive ability and there are already over 300 centres worldwide using the program.

3.1.3 Independent living component

3.1.3.1 Current state of the art

Driven by the ageing of the European population, a recent focus on the smart home market is taking place. Also in EC funded initiatives, such as FP6, FP7, and AAL, a lot of effort is being put into making homes smarter, more assistive and more enabling for the elderly. The current smart homes can serve as a real shelter for fragile older people: they feel protected by the monitoring and surveillance systems and care is provided when needed; they also feel protected against intrusion and fire; and feelings of isolation are reduces, since, for example, they can watch TV and talk to individuals in the world beyond the boundaries of their home.

Some examples of current home monitoring solutions are as follows: The American Telecare Monitoring Station is placed at the patient's home to offer assistance with patient compliance and vital signs monitoring by collecting and transmitting health data to a doctor's office. A two-way audio/video station combined with medical peripherals is also available to provide a real-time picture of the patient health status. Philips' Motiva system, works around a patient's television, in order to measure autonomy levels as well as vital signs, glucose management, etc. ADT's WellHealth product suite, is designed to monitor health regimens and medication through the use of digital devices and networks that connect patients to ADT's Customer Monitoring Centres and, if necessary, a medical professional. The Living Independently Group offers the QuietCare product, which works using presence sensors. Based on the recognition of events, this early detection and warning system lets caregivers and family members know that a loved one is safe. It recognizes emerging problems before they become emergencies.

3.1.3.2 The unique characteristics of the selected component

For the LLM service, the eHome system has been selected as the component for an independent living. The eHome system has been developed within an Austrian consortium (CEIT RALTEC, University of technology Vienna, Treventus GmbH and Kapsch CarrierCom AG). This project is funded by the Austrian department of traffic, innovation and Technology (BMVIT) within the program FIT-IT.

The eHome system is comprised of a network of distributed wirelessly operating sensor units connected to an embedded PC. It includes features such as intelligent learning of normal and exceptional patterns of behaviour (dangerous situations or indicators for emerging health problems), raising of alarms and as an option an intelligent power outlet (IPO) for controlling. One of the main features of eHome is the detection of a person's downfall. The main advantage, compared with other solutions, is that the elderly person using eHome does not need to wear any device on his/her body, as the monitoring is done by sensors placed in the end user's home. These sensors are connected to a central unit through a wireless network. For privacy reasons, no cameras or microphones are used as part of the monitoring process and – except in alarms - no monitoring data is transferred outside the elderly person's home.

eHome can be easily installed in an elderly person's home, at a day care centre or at a formal institution, since the wireless sensors are battery fed and no cabling is required.

The sensors are placed in the MSB (Multi-Sensor-Box), which contains different sensors for monitoring environmental data, movements and activities of a person living alone. These MSBs are connected through a wireless network to the eHome home control unit HCU. The HCU collects the data delivered from the sensor boxes, it processes and analyzes this data and detects abnormal or dangerous situations. In case of a dangerous situation (such as a detected fall of the person) it informs the local user interface LUI and generates an alarm in case of a detected dangerous situation. This alarm is (preselectable) routed as a VoIP telephone call to a relative, care taker or an emergency call centre. Preselectable intelligent routing of a VoIP telephony alarm call is performed by the Alarm & Routing server A&RS, which is a centralized telecommunication server, based on state of the art VoIP and IMS (IP multimedia subsystem) technology.

The eHome Local User Interface LUI offers to the end user a local interface, based on touch screen technology, as a simple to use intuitive graphical interface based on simple icons for system input and output, e.g. for signalling a detected alarm and offering an alarm cancelling facility to the end user in case of a false alarm. In addition to this functionality, eHome's LUI offers the elderly end user a Voice and Video telephony option: originating calls can easily be performed by simply touching icons showing the picture of the person to be called.

The eHome remote interface RUI gives access to care takers, relatives and technical support. It is a web-based interface for remote access via the internet. For care or medical experts it offers remote access to certain user data and to configuration of the system.

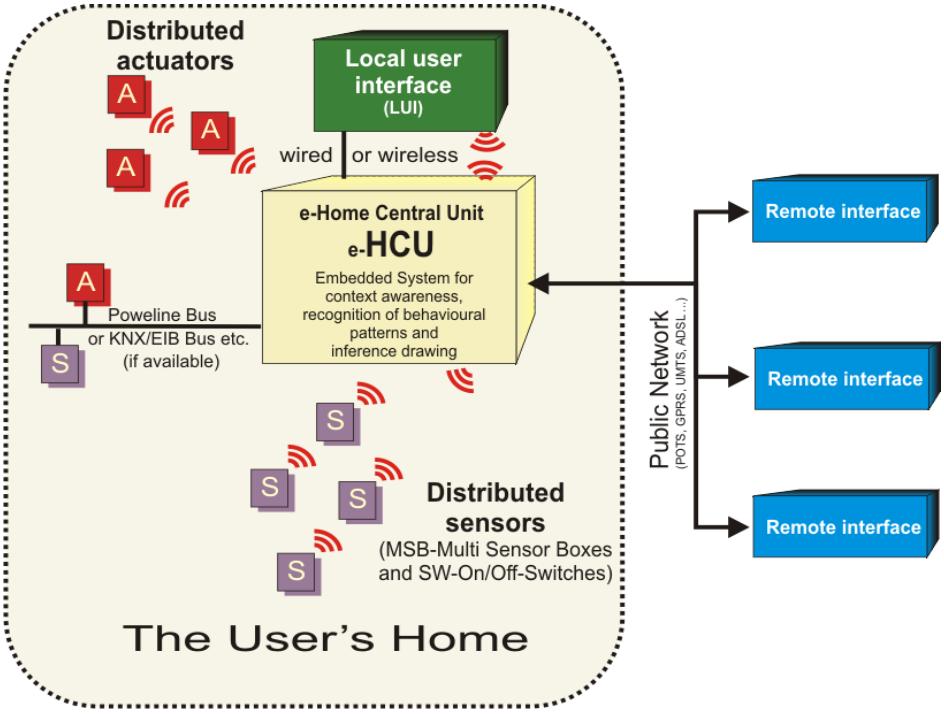

Figure 2: eHome system

3.2 LLM Technical requirements

In order to target a specific group with many specialties, the LLM system will be designed according to usability, accessibility and ability to be easy customised. Although the LLM system will be based on complex functionalities, the users, and especially the seniors, must face a user-friendly system. Moreover the seniors must face it as an easy facility that makes their daily living more entertaining while contemporaneously they get themselves physical and cognitive trained.

A PC screen is the main interface for most of the components. The opportunities for interacting with this interface are restricted to:

- Touch screen
- Mouse Keyboard
- Wii remote controller (optional for the user)
- Simple voice recognition (optional for the user)

The touch screen is the most appropriate input device for systems familiar to the LLM. It is widely used today, especially for user groups who lack computer experience. Its functionality is simple, user-friendly and easily understandable.

The mouse and keyboard are more difficult to be understood. They should be avoided as an interaction form for the LLM system because they are considered as interaction inputs for people with some kind of experience in using personal computers.

Nowadays, more appropriate input devices are being introduced. The Wii remote controller, for example, seems very promising for new designs, especially for special target groups. In particular, arguably, the remote controlling (Wii remote) can be comprehended more easily than any other input device. A remote control, such as the Wii, will be useful, also through its buttons only, without requiring a user to move it as a pointer, such as a mouse. This is advantageous to accommodate also elderly people who have motoric problems (like Parkinson), especially when using a small size screen.

Last but not least, as an option for user, simple voice recognition provides the opportunity for replacing complex input devices with simple instructions. Simple voice recognition can be used to facilitate control via simple spoken answers to prompts, such as “Yes”, “No”, “Later”. In particular, by using a text-to-speech engine by means of an avatar accompanying the user, the LLM system is able to “communicate” with the senior by voice.

Moreover, one the most problematic interactions (for users without computer usage experience) is the “Login” procedure. An optional ID card will facilitate this procedure by providing to the system the user’s credentials. Thus, seniors may avoid using the keyboard, which is arguably the most complex input device.

On the other hand, as the LLM system tries to be personalized, the selected input devices that will be used must depend on user’s needs. Thus, the LLM system will provide the facility for parameterization based on user’s needs and preferences.

This customisation facility shall be provided for every component of the LLM system. Moreover, the customisation shall also cover the installed devices and components per site. For example, a LLM home installation system may use only PTC and CTC without ILC component depending on the seniors' needs. The LLM system has to be able to function under all possible circumstances.

Finally, special attention needs to be taken concerning localisation and customisation needs of the LLM system. Menus and content of the LLM service should be translated into all four languages that will be used during the LLM trials. Therefore a multilingual package will be developed allowing seniors to choose their native speaking language as the one used to communicate with LLM service.

3.3 LLM Operational requirements

Operational requirements in general should be designed such that a very large percentage of the population gets the chance to use the full functionality of the system. Within the LLM Project we develop a training system for the population of elderly people in the EU that might already suffer from a variety of handicaps or sensory and cognitive impairments. This is understood as one of the major challenges here.

As there is a wide variety of impairments, needs are very diverse and likewise a great variety of solutions is needed. As shown in the figure below, there are many barriers to ICT usage, and consequently many ICT-enabled products and services may pose accessibility challenges to persons with disabilities, as well as many potential solutions.

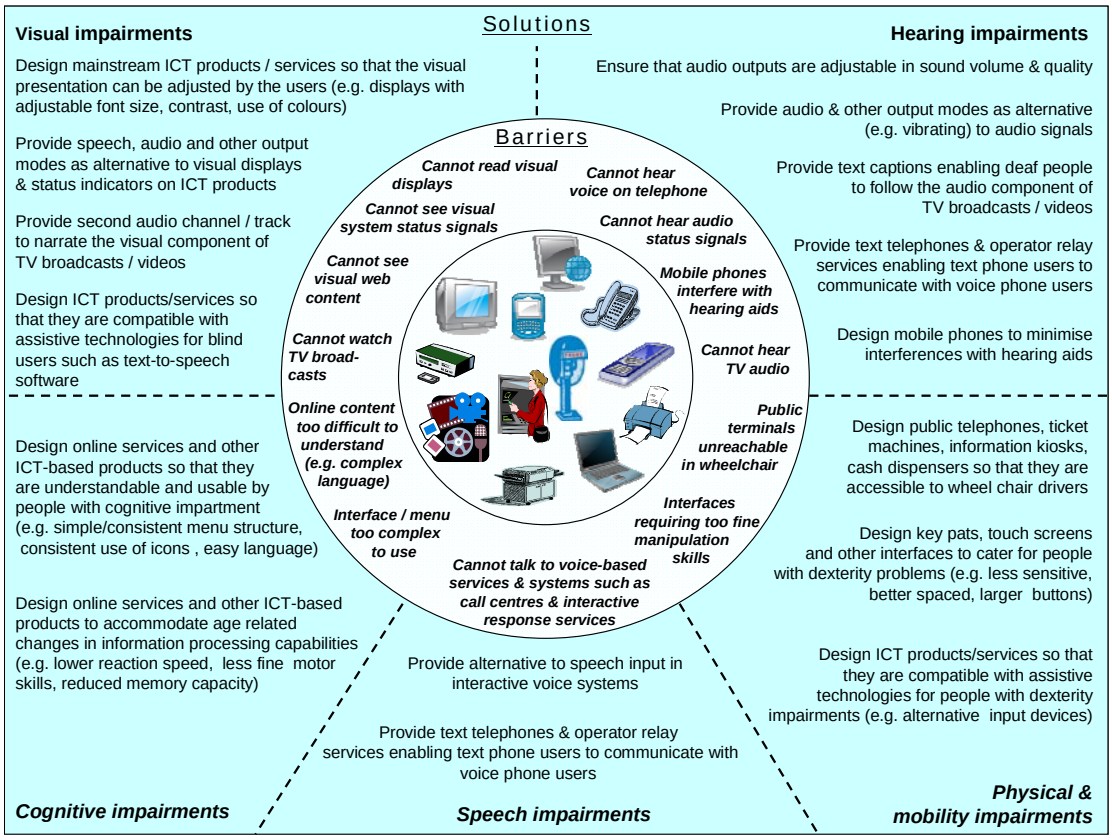

Figure 3: Barriers to e-accessibility and solutions [3]

[3] Staff working paper on e-accessibility: Status and challenges of e-accessibility in Europe: http://ec.europa.eu/information_society/activities/einclusion/docs/access/comm_2008/staffwp.doc

Thus, we are currently designing the LLM system such that only a minimum of skills are required to use the system in an effective way:

- Touch screens are simple and easy to use screens for the interaction with the users. They allow navigation through the system by simply touching the buttons that are displayed on the screen. Touch screens are the most suited interfaces for the interaction with senior users since they require a minimum of cognitive and motor skills. The current development of the LLM system aims for one single Touch screen for interactions by the user with all three technical (ILC, PTC, CTC) components.
- Wii remote will be incorporated as a simple-to-use remote device for elderly with mobility impairments to interact with LLM system and access LLM training programs content.
- Alternative multimedia content will be provided for a specific object (text, speech, image)
- Text at the Touch screens will be easily structured and illustrated with images and icons to allow readability with minimum effort.
- Loudness of the auditory signals and size of the letters can be adjusted by the user to for compatibility with their individual hearing and visual skills. Also a set of headphones will be available for the seniors to wear during cognitive training and interaction with LLM components in general, and an adjustment menu concerning the visual presentation will be provided so that each individual may configure the presentation layer of the system according to his/her individual needs.
- Descriptions of the training components and help menus can be accessed at any time.
- Seniors will be reminded by the system when and how to carry out the cognitive and physical training with respect to their individual training schedule.
- Avatar-based guidance throughout the training program will notify seniors about their progress, motivate them and encourage them, thus engaging senior's attention and interest.
- LLM services and multilingual support will be localised.

The LLM system is designed to be used by a very broad senior population. However, in accordance with objective 2 of the Grant Agreement, we want to "demonstrate the significant impact potential of the LLM system in five different countries".

To perform a serious scientific study, rigid inclusion and exclusion criteria are needed to allow confident judgements of the outcome results. The inclusion and exclusion criteria of the pilot tests are displayed in the table below. These criteria apply only for the pilot tests, while the final LLM system will be accessible for a high percentage of the elderly people.

Inclusion Criteria:
• Participants of any gender or ethnicity 65 years or older at the time of consent • Written consent for participating in the LLM intervention program • Participants must be a native speaker of the respective local language (English, French, German, Greek or Spanish) or having attended a school in the local language from latest the age of 15 • Willing to commit to the 6-month time requirement of the entire study period with an emphasis on availability for the 8-10 week computer based training and the additional time required for pre/post tests • For the Group of Healthy Participants: Mini-Mental State Examination (MMSE) >= 26 • For the Group of Alzheimer's Disease Patients: mild diagnosis of AD
Exclusion Criteria:
• Participant is not capable of giving informed consent or is unable to comprehend and/or follow instructions • Major cardiovascular event, stroke, transient ischemic attack (TIA), or traumatic brain injury within the past 5 months • Participant is enrolled in a concurrent clinical study that could affect the outcome of this study. • Participant is unable to use the technical devices (CTC, PTC) or perform the pre/post tests • Major neurodegenerative disease or condition, e.g. multiple sclerosis, amyotrophic lateral sclerosis, or Parkinson's Disease • Current diagnosis of psychiatric illness, e.g. major depressive disorder, bipolar disorder, schizophrenia, post traumatic stress disorder • Current use, or use within the past 3 months, of medications with substantial central nervous system (CNS) effects, including acetylcholinesterase inhibitors and medications with either anticholinergic or antidepressant properties. • Current substance abuse, including alcoholism

Table 3: Inclusion and Exclusion Criteria – User profile

As has been already mentioned, the LLM system is designed to be used by very broad senior population. One requirement that stems from this is for a multilingual and multi-localised facility. Each component of the whole LLM system must be multilingual in order to find great acceptance by the different nations. Also, targeting elderly people, the multilanguage support is considered vital for successive results. It is particularly important that the CTC training component should be designed to accommodate localisation.. Thus, partners of the project will provide to the LLM system useful information and material according to their regional habits and characteristics.

4 LLM technical specifications

The server has a distributed application architecture that partitions tasks or work load between service providers (servers) and service requesters (clients), the server – client architecture, since we believe this to be the most appropriate for the LLM system. Client-server describes the relationship between two computer programs in which one program, the client program, makes a service request to another, the server program. The layer supporting this architecture for the LLM service is the web services.

The heart of the LLM service is an integrated ICT platform which combines state-of-the-art cognitive exercises against cognitive decline with physical activity in the framework of an advanced ambient assisted living environment.

Thus, the main service is comprised of three independent components:

- CTC, Cognitive Training Component
- PTC, Physical Training Component
- ILC, Independent Living Component

These three independent components will meet the proposed service by means of a server side system, which comprises a database, a web service and a decision making system. On the user side, the client will provide access to the three independent components. The user's performance on each component will be manipulated by the server. Thus, the responsibilities of the server and client are:

Server

- Data manipulation and database management
- Web service hosting
- User authorisation
- Data integrity

Client

- Independent components installation
- Central Management System as main interface
- Call to the web service to add and get user's activities information
- Exchanging of the current selected user interface according to the current activity

4.1 Server application specifications

As described above, the LLM system is designed according to server-client architecture principles, as this architecture is widely used nowadays. The main advantage of such a system is that the server provides its computing functionalities to the clients. Consequently, the requirements for the clients are not so obligated in terms of computing power. On the other hand, the computer that will service all the requests must fulfil demanding requirements. These requirements affect not only the hardware but also the software part of the server. The former must be fast and able to support volume client requests. The latter must manage the requests in the most appropriate way.

The server functionalities are:

- Database hosting and management
- Web Service hosting
- Addressing of clients' requests
- Security, authorisation and integrity of the LLM data
- Hosting of an interface for administration management

4.1.1 Hardware specifications

The server's hardware is the foundation of its performance. The computing power must be able to support all the clients' requests. Moreover, the connection layer between server and clients is the Internet. Consequently, the server must have a fast internet connection.

One of the major concerns is the number of servers that will be used. The options that are more dominant, taking into account the factors of work load and maintenance efficiency, are:

- One server per country
- One server for the LLM system

By using one server per country, where trials are performed, the work load of each server is reduced. The number of clients that must be served by each server is also reduced. Each server is responsible for its own data and functionality. One of the disadvantages of this architecture is the maintenance overhead. When an alteration to the server's functionality is needed, the same procedure must be followed for all of the servers. Besides this, the data of all the seniors will be distributed to different geographical locations. As a result, statistical analysis will provide results per country and not for the LLM system.

Of course, one subject that will be considered during the pilot phase but also for the service deployment, is regarding the concerns or even objections against a cross-border transfer of personal data, especially for UK and Austria.

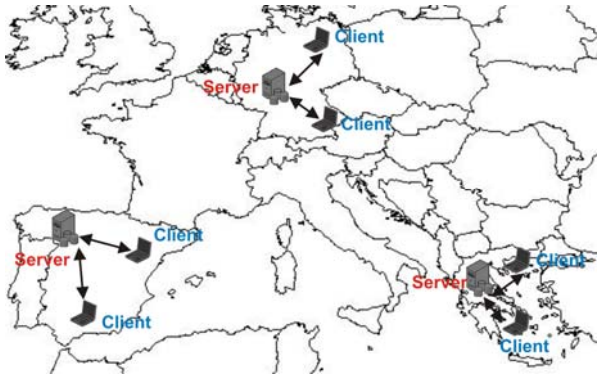

Figure 4: One server per country

On the other hand, by using one server for the LLM system, its critical role within the system is increased. All clients will make calls to the same server machine. Additionally, the internet connection's bandwidth will have to support data transfer among the server and clients from different countries. The advantages of this architecture include the ease of maintenance. Moreover, all LLM's data are located in the same computer.

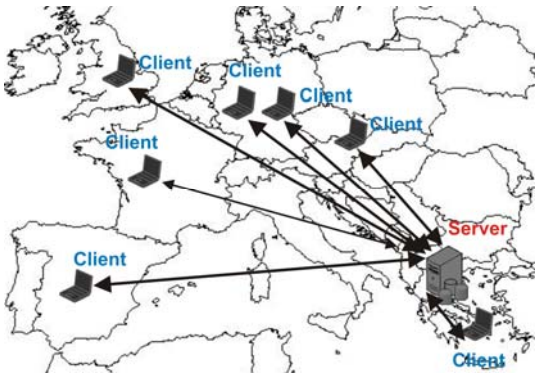

Figure 5: One Server for the LLM system

4.1.2 Software specifications

In order for the server to support all the required services, different software must be installed. First of all the Operating System (OS) has to be a "server" version one. The server's OS that is selected for this purpose is Windows Server 2003. The selection is based on the development tools that will be used, namely .Net Framework, C# Programming Language, etc. Most of the potentially available services rely on the OS. Moreover, the software will provide the required functionalities for the database, the web service, security and privileges and finally the web administration panel/interface.

4.1.2.1 Database

One of the main components of the LLM Server is the database. This component is responsible for data storage, manipulation and serving. The database engine that will be used for this purpose is the open source MySQL. This engine will support the LLM Database (LLMDB) and its functionality. The database supports users, seniors, the 3 components' related attributes and the senior's activity while interacting with the components. For safety issues, the database is accessible only by the web service.

4.1.2.2 Web Server

As will be detailed in the next section, the protocol layer for communication via web services is the http protocol. In order to deliver the LLM services via the web, the server's primary functionality is to deliver web pages (HTML/XML documents) and associated content to clients. A client makes a request for a specific resource using HTTP and, if all goes well, the server responds with the content of that resource.

While the primary function is to serve content, a full implementation of HTTP also includes a way of receiving content from clients. This feature is used for submitting seniors' data activity. To this end, the web server will utilise the IIS, which is included in the windows server 2003 installation.

4.1.2.3 Security - Privileges

Security, authorisation and integrity are some of the main issues that shall be addressed by the LLM service. Sensitive data, such as a senior's physical and cognitive status must be delivered only to authorised users, based on their privileges. The authorised access will be addressed by the web service according to the database's registered users. The security of sensitive data stored in the database will be ensured, using the DBMS security mechanisms, with use access determined according to each user's role and credential. The security of the sensitive data which is exchanged between the server and a client will be addressed by SSL encryption. Consequently, the server will be enhanced with SSL encryption functionalities.

4.1.2.4 Web service

The LLMWS will be the main heart of the system. It is responsible for management of clients' levels of authorisation and also for providing all methods and functions in order to support the three independent components' functions. Moreover, the web service is responsible for the authentication of the system's users according to their role. A database accompanies and supports the web service's procedures

Each of the three components accomplishes different scope of application and provides heterogeneous data and semantic sources. According to these requirements the proposed architecture must support the integration of the data and the co-ordination of the components' functionalities.

One of the major features that the proposed architecture should accomplish is flexibility. The web service's architecture and functionality will be open in order to allow new developments to be integrated and supported by the proposed service. Consequently, the main scope of the web service architecture is to provide a way to integrate future developed components (CTC, PTC, ILC). The only prerequisite for the candidate applications to be integrated into the proposed service is to be compatible with the general framework of the service.

The Web Service provides programmatic access to the system's features and services. Developers can build custom applications, tools, and services that correspond to the same services. Typical applications include add/edit and searching for registered seniors, add data tracking a senior's progress relating to cognitive or physical training and add information about negative events, such as a senior falling and other alarm situations. The Web Service includes the Simple Object Access Protocol (SOAP), Web Services Definition Language (WSDL), and the XML Schema Definition language (XSD). These standards are supported by a wide range of development tools on a variety of platforms.

```
<s:complexType name="senior">
   <s:sequence>
      <s:element minOccurs="1" maxOccurs="1" name="senior_id" type="s:int"/>
      <s:element minOccurs="0" maxOccurs="1" name="lname" type="s:string"/>
      <s:element minOccurs="1" maxOccurs="1" name="birthdate" type="s:dateTime"/>
……..
   </s:sequence>
</s:complexType>
```

Figure 6: A Web service paradigm

The web service provides structures (an example is given in Figure 6) as inputs and outputs to all supported methods. All structures and methods are well described by a human readable document which is publicly available. Moreover, each structure is accompanied by an "error" structure in order to facilitate appropriate message exchange with the components.

4.1.2.5 Interface

A user interface will be hosted by the server. The interface will provide simple information on senior's physical and cognitive progress. Moreover, this interface will act as the administration control panel that will provide access to the control features of the LLM service. The information presented to this interface will be visible and accessible according to the user's privileges determined during the log in procedure. Finally, the remote interface should be multilingual in order to offer access to all therapists and seniors across the nations taking part in the pilots

4.2 Client application specifications

The client side of the LLM system comprises of four subcomponents. These are the following:

- Independent Living Component (ILC)
- Cognitive Training Component (CTC)
- Physical Training Component (PTC) and
- Central Management System (CMS)

ILC, namely the e-Home system, will be responsible for assisting seniors living an independent life by monitoring their daily activity and responding by generating alarms when emergency cases are detected. CTC will serve as a tool in order to help elderly people to improve their cognitive capacity or mental health, by means of a set of computerised exercises that target to enhance several functionalities of the human brain. PTC's primitive cause of usage is to ameliorate elderly people's physical condition by motivate them to exercise themselves in more convenient and enjoyable ways. Finally, CMS will be the core element of the LLM system on the client side and its main responsibilities will be to successively alternate the User Interfaces of the three subcomponents (ILC, CTC, PTC) and to authenticate end users.

4.2.1 Hardware specifications

The hardware that needs to be incorporated into the LLM system should include the appropriate equipment that shall accompany seniors during their physical training exercises. This comprises of ergometer bikes, treadmills and exergaming facilities such as Wii accessories. Additionally, variable number of sensor boxes and Home Control Unit - HCU (embedded PC) shall be installed and configured in an appropriate way, so as to support the recording of seniors' activity. Finally, a touch screen PC will be used to present properly the Local User Interface of the ILC, CTC and PTC.

4.2.1.1 Central management system

The Central Management System consists of a touch screen PC (for example: ASUS EeeTop PC) and / or a remote controller that will also host and execute the software of the CMS and the other three subcomponents (ILC, CTC, PTC). At this point it has to be stressed, that the touch screen PC will be the central access point, acting also as the PTC, ILC and CTC user communication interface.

4.2.1.2 Physical training component

PTC is comprised of the selected training equipment suggested at section 3.1.1:

- Ergometer bike (e.g. Ergo 100K)

- Treadmill (e.g. Marathon Heavy Duty 2 HP)
- Wii accessories (Wii Remote, Wii Balance Board, Wii Dance Mat)

Performance data output from the treadmill and ergometer bike are available through their hardwiring with the central PC that hosts the LLM service components, including the PTC software which monitors the physical training. In more detail, both types of training equipment offer a serial communication port (RS232 port) and support communication interfaces. PTC software package supports several well established communication protocols, discussed in section 4.2.2. Furthermore several peripherals are integrated into the training equipment, such as, for example, blood pressure cuffs, ergospirometers and ECG in order to measure vital bio signals, including blood pressure, heart rate and maximum uptake of VO2. Additionally, Wii peripherals could be connected to the host PC wirelessly using the well known Bluetooth wireless communication protocol. The only prerequisite is to connect a Bluetooth adapter to the host PC in order to act as the receiver of the raw data sent by Wii devices.

4.2.1.3 Cognitive training component

BRAINFITNESS

In order to use the CTC effectively there is a need to acquire appropriate equipment which will support the CTC software functionalities. Therefore what is needed is a regular low-cost PC close to the minimal running requirements of BrainFitness and with a touch screen. The latter is required to display the content of exercises and to provide the end user with the possibility to interact by a simple touch on the correct answer..

BrainFitness is running on systems with the following minimum requirements:

- At least 256MB RAM (512MB for Windows Vista)
- 1GHz or faster processor
- X24 CD-ROM or DVD drive
- 500MB free disk space
- Headphone jack
- Internet access

Additionally, a set of headphones are needed to accompany user during training process, as most of the exercises of the training protocol use auditory stimuli to excite brain functionality.

GRADIOR

Minimal hardware requirements to run GRADIOR on Windows XP/Vista are:

- Processor 1GHz or an advanced version
- RAM 1024 MB

- 1,2 GB free at the HD
- Touch screen recommended for elderly users
- Mouse
- Speakers
- Internet access
- Sound card

4.2.1.4 Independent living component

eHome Sensor network

The Independent Living Component ILC, which is based on the eHome system (see also 3.1.3), is based on a sensor network which consists of modules which contain a whole set of sensors connected to an embedded processor and a wireless communication unit. The sensors that are working together in a "Multi-Sensor-Box" (MSB) are:

- Temperature sensors
- Accelerometers
- PIR
- Reed-Switches
- Light detector

Every MSB-unit, each of which contains an embedded microprocessor, collects the sensor readings, performs a low level signal analysis and data compression and transmits the coded and time-stamped results via the wireless network. The MSB-units are primarily battery powered. A synchronisation with the system clock is dynamically carried out to ensure millisecond-accurate time-stamps.

Falls constitute one of the major safety and health risks to older people. For this reason the detection of possible falls plays an essential role in the concept of the sensor technology to be used. Feasibility tests with state-of-the-art accelerometers have shown that already a small number of accelerometers placed on the floor have the potential to detect the impact of a body to the floor and to relay this event whenever the signal shows certain characteristics in the combination of signal amplitude, event-duration and frequencies.

Sensor boxes HW-specification:			
General Characteristics			
	Power requirement:	Battery (2 AA) or mains (via external adaptor)	
	Size:	max. 145x45x45mm	

	Temperature range:	0 to 45°C	
Sensors			
	Accelerometer	Measurement Range	-1G to +1G
		Detection Threshold	40mG
	PIR	Viewing Angle	-45° to +45°
		Detection Range	3m
	Temperature	Measurement Range	0 to 45°C
		Measurement Accuracy	<2°C
	Light	Measurement Range	1 to 16000lux
		Measurement Resolution	<1lux
	IIR	Viewing Angle	+45° to -45°
		Measurement Accuracy	<2°C
	REED-Contact		
Interfaces			
	Zigbee (IEEE® 802.15.4)	Range indoor	10m
		Range free space	20m
		Transfer Rate	256kb/s
		Frequency	2,4Ghz
	Serial	USB-Jack	57600 baud

Table 4: ILC Sensor boxes HW-specification

eHome home control unit HCU:
The HCU consists of an embedded PC and the wireless network coordinator, which is based on the MSB (see above) without containing any sensor.

Home control unit HCU HW specification		
(any) embedded PC	minimum requirements	
	Atom CPU	
	Memory	Minimum 512 MB DDR RAM recommended
	Mass Storage	Any hard disk
Interfaces	ZigBee (IEEE® 802.15.4)	
	LAN 10/100/1000 Mbps	
	USB	

Table 5: ILC Sensor boxes HW-specification

eHome Local User Interface LUI

This can be any touch screen PC which fulfils the following minimum requirements.

Local User Interface LUI HW specification		
Standard PC compatible	*Minimum Requirements*	
	Screen	Any; recommended: LCD 15.6" 16:9, Touch Screen Single Touch
	Operating system	Windows® XP Home
	CPU	CPU + Chipset Intel Atom N270 + 945 GSE
	Memory	2? GB
	Mass storage	160G
	Interfaces	LAN 10/100/1000? Mbps
		Wireless 802.11 n
		USB 2.0 * 2
	Camera	Built-in 1.3M pixel Web camera
	Microphone	Built-in stereo
	Speakers	Built-in stereo

Table 6: ILC Local User Interface LUI HW specification

eHome Alarm & Routing server A&RS:

The AR&S is a centralized telecommunication server based on standard state of the art server technology and is (at least for the pilot trials of LLM project) placed at one of the Austrian eHome partner's site (Kapsch CarrierCom).

Additional HW requirements

LAN / WLAN router	
Interfaces	LAN 10/100/1000; Wireless 802.11 (optional, if separate LUI)
Broadband Access	
Data rate	Min. 512 up&down for VOIP w/ video/ 1024
IP-address	Static
Internet connection	Stable, not interrupted
Ports to be supported	

Protocols	SIP
Power	UPS / external battery package (optional if needed)

Table 7: ILC Additional HW requirements

4.2.2 Software specifications

4.2.2.1 Central management system

The Central Management System CMS is the core element of the LLM service:

It is a PC-based application, running under MS Windows XP. It is resident on the PC which offers the LLM-service to the end-user together with the other 3 subcomponents CTC, PTC and ILC.

Functionalities of the CMS

- User Interface to the LLM Service
- Control of LLM-components, -services and –training
- User administration
- Communication with remote LLM database

The CMS offers to the LLM users a common user interface, which enables end user access to the independent components PTC, CTC and ILC.

In order to offer the end users, who are belonging to users groups not familiar with computers and PC-interfaces, a friendly and easy accessible interface, a central touch screen is used as the global access point.

This central UI serves as the general presentation layer of the LLM service, offering welcoming reception

User Interface to LLM-Service

- Local User Interface to LLM-Service (LLM-LUI)
    - Login Screen: The Login screen is accessible to all kind of users. This UI shows the end user an easy accessible login window; it prompts for user-id and password. After logging in to the CMS, and depending on user's category and role, the systems offers the user, different modes of user interfaces which differ both in UI presentation and in access rights relating to data manipulation. The user roles supported are:
        - end user GUI
        - expert UI
        - technical administrator UI

    - administrator UI
  - End user GUI: CMS GUI offers the end-user of the LLM-service the facility of simple switching to the different components PTC, CTC or ILC via icon selection, thus and intuitive touch-screen based control of the 3 components. Only one of these applications is accessible to the end user at the same time. Alternation between component's UIs is performed by simple switching back from the currently used component to the CMS UI via simple icons, and thence to the required LLM-LUI. CMS GUI is realized as a simple to use intuitive graphical UI, dedicated to the special focus group of elderly people. It offers only access to the LLM service. In order to maximise user friendliness, this UI does not display artefacts relating to accessing other interface facilities of the PC.
  - Expert UI: Gives the expert users of the LLM-system (care taker, trainer, therapist) access for retrieval and modification of end user specific data and training specific data of CMS, CTC and PTC.
  - Technical administrator UI: Gives the technical administrator access to retrieve and modify technical configuration data of CMS, CTC, PTC and ILC
  - Admin UI: Gives the system admin unrestricted access to all data. The data interfaces from CMS-LUI to the UIs of the other components are the specific interfaces of the other components PTC, CTC, ILC.
- Localization
  - End user interfaces: Localization and language adoption is provided for the interfaces which are accessible to the end users:
    - Login screen and end user interface are multilingual (output and inputs). System outputs and user inputs / commands are realized in the language of the country where the service is running.
    - Provisioning of different European languages is provisioned by table entries.
    - For the pilot trials the following languages are implemented: English, French, German, Greek and Spanish.
  - Expert, technical and admin UI: These interfaces are implemented in the English language
- Access options for LLM LUI
  - Basic solution: The basic user access to LLM LUI is a senior-specific intuitive graphical user interface.
  - Additional options: As additional options for attractive and simple to use access modes to the LLM LUI the usage of a Wii remote and user guidance by an Avatar will be investigated.

- Wii Remote: As an alternative to a touch screen a Wii remote controller will be used as an input device to LLM LUI. Wii remote will act as a navigation tool through LUI and among components UIs and handle general scope functions, such as a pointing device in order to choose correct answer in CTC tasks
- Avatar guide: Avatars can be used in order to welcome end users to the system and guiding them through the selection of different components using text to speech and voice recognition technology. Text to speech Avatar can be additional to text or graphical output text to speech as an output option. Simple Inputs, such as "yes" or "no", can be input via a speech recognition system

Control of LLM-components, -services and –training

CMS serves as the supervisor of the operation of the three subcomponents CTC, PTC, ILC. Manual control of the LLM-components by the end-user is performed via the LLM-LUI (-> ref), CTC or PTC can be started alternatively by manually accessing them via the LLM-LUI. ILC is permanently active as a background application; by manually accessing it via the LLM-LUI the end user gains direct access to the ILC-LUI.

- Control of the exercise programmes performed by PTC or CTC
  - Validation of Training data: The CMS retrieves and stores key data from individual training programs and individual training results of physical training performed by PTC and CTC. A smart decision making system based end user data (-> ref), look up tables and rules uses these retrieved data and performs a classification of the actual physical and/or cognitive condition level of the elderly end user in a few levels (e.g. good, very good, excellent).
  - Daily Scheduling: As an option, CMS will offer a scheduling of training sessions: LLM-LUI (expert access) offers high level control commands concerning daily scheduling of physical and cognitive training sessions, e.g. start/stop PTC/CTC, time slot for each training session, etc.
- ILC interaction: ILC is permanently active as a background process in order to permanently monitor the end user's activities and movements. If ILC (eHome-system) generates an alarm, ILC automatically becomes the foreground application, so as to present the alarm-message via the eHome LUI.
- Communication with remote LLM database: CMS exchanges data with remote LLM database via a SOAP protocol (defined in LLMWS-description)

User Administration System – UAS

- User groups (categories): UAS of CMS manages user data for different LLM user groups which are classified according to different categories. The different categories define different roles and access rights for the users. According to these categories the access right policy is handled by the LLM-LUI. Login/Authentication to CMS is provided on the Login-Screen of the LLM-LUI by asking for User ID and Password.

- Types of user categories:
  - End user of LLM-Service
    - This is the elderly person using LLM local user interface
    - Data of end user: (User ID, Password, Prename, Surname, Address, Date of birth / age, Additional data (medical condition)
  - Expert User
    - This is the care taker, trainer, therapist, or physician supporting the end user
    - Data of expert user: (User ID, Password, Additional date)
  - Technical Administrator
    - This is the technician having access to configuration of the LLM-components
    - Data of technician. Administrator (User ID, Password, Additional date)
  - Admin
    - Admin is the "super user" having unrestricted access to the LLM system
    - Data of super user. Administrator (User ID, Password, Additional date)
- User database

CMS hosts locally the complete user database, which contains all user data (as described in 3.1) and end user related training result data (-> 2.1.1). The central LLM database retrieves end user related personal data and training data. For privacy reasons only anonymized user data is transmitted to the central LLM database. CMS handles this anonymizing process. Interface to central LLM database is via a SOAP protocol (defined in LLMWS-description)

PC operation

CMS will operate locally as a separate module in the same PC, where CTC or PTC SW will run alternatively and ILC runs permanently. As an option a CMS standalone solution is foreseen.

4.2.2.2 Physical training component

The software package that will support the integration of several items of training equipment within the overall PTC subcomponent will be custom developed software that will support a flexible architecture in order to offer the possibility to numerous commercial products to be supported by its functionalities.

As already mentioned ergometers can transfer performance data and training details to a PC through a serial communication interface. This can be accomplished with the development of several protocols that support serial communication and are widely supported by most ergometers' providers on the market.

Communication protocols - widely used in the market - to be incorporated into the PTC application that will accompany physical training equipment (ergometer bikes and treadmills) will be:

- Ergoline ergoselect protocol
- Trackmaster (mostly for treadmills)
- H/p cosmos coscom protocol
- CSAFE (Communications Specification for Fitness Equipment)

PTC software will also make use of selected open source libraries that provide methods for communicating with Wii devices, such as WiiUse (http://www.wiiuse.net/) and WiimoteLib (http://www.codeplex.com/WiimoteLib). These can be used for developing applications that allow easy access to high-resolution data from Wii™ Remote and Balance Board input devices by connecting them to a computer equipped with Bluetooth stack. Therefore, the development of simple game-like interactions will give the patients visual feedback and provide them with a sense of competitiveness.

The PTC software is the core management system of the PTC, thus being responsible for the overall management of the physical training procedure. In addition to communicating with peripheral devices, it shall also undertake the task of storing analytical performance data into an internal database. Therefore, PCMS (PTC Core Management System) should keep track of the performance history of each user, thus making smart decisions concerning:

- Kind of exercise equipment to be used and specific tasks to be fulfilled by individuals
- Time to be spent for each task and number of iterations
- Difficulty level adapted to individual's physical condition according to biomarkers and performance statistics

User Interface

The UI of PTC is the front-end application that will enable interaction between end-user and PCMS. It shall combine and integrate user interfaces of all available training devices, such as ergometers and Wii. Each type of physical training equipment shall be accompanied by its own user interface, thus enabling visualization of any particular features, e.g. game environment affected by Wii motion data. Therefore, PCMS shall be responsible for the correct response to external events, such as, for example, a correct movement towards a target. Finally, the PCMS shall rotate different UIs according to in response to the current needs of physical training scenarios.

Last but not least, great effort will be put into creating a user–friendly presentation layer for the end users and clinicians to get feedback concerning:

- current performance data, e.g. kms already run, success rates, etc. and
- biosignal indicators

and to present them in a numerical or graphical way. In addition, a separate interface will be available for therapists to enter new tasks to be done and extra metrics to be evaluated during training. The user interface of PTC shall support a multilingual option for presenting menus, tasks and help advice.

4.2.2.3 Cognitive training component

CTC software package should be ***localised*** and ***multilingual.*** This means that the content to be included in the training tasks should be transformed into an appropriate form, taking into consideration the diversity and the special characteristics of end users, such as linguistic features, cultural morals, etc. Furthermore, translation of different kinds of material, such as text and speech advice, is needed to support different nationalities participating in LLM trials.

BRAINFITNESS

The CTC software package will consist of a number of commercial products, such as PositScience BrainFitness and Gradior software. Brain Fitness supports six different tasks of cognitive training which contain several multimedia materials, such as text, sounds and pictures. BrainFitness stores results of each exercise task within a central server. Consequently, it has to be extended in order to support LLMWS methods for storing performance data to the LLMDB.

Furthermore, translation is needed concerning text content such as guidelines, the general presentation layer, etc. Localisation of each training task is crucial to the final product, in order to adapt the scope of each task to the special linguistic and cultural characteristics of the different population groups participating in the trials.

GRADIOR

The GRADIOR program offers a structured evaluation and neuropsychological rehabilitation system. This system enables cognitive training and recovery of higher cognitive functions for people showing signs of cognitive deficit / deterioration, with minimal technical requirements for the therapist or the professional who supervises the performance of the elderly person. Nowadays, GRADIOR is composed of more than 35.000 cognitive exercises, belonging to several cognitive modalities: attention, perception, memory, language, calculus, orientation and reasoning.

It is a local desktop application developed in Visual and involves webservices - SOAP protocols to interact with other applications.

Database employed: Access

GRADIOR has more than 35,000 cognitive exercises specifically developed not only for the purpose of improving cognitive performance, but also to perform the function of rehabilitation exercises with evaluation of the patient's progress and adaptation to his needs.

4.2.2.4 Independent living component

Multi Sensor boxes:
The SW running on the MSBs is proprietary to the eHome consortium. Interface within the wireless sensor network is based on the Zigbee® protocol according to IEEE 802.15.4.
eHome home control unit HCU:

- Operating system: Ubuntu Linux.
- The application SW is proprietary to the eHome consortium.
- Communication protocols supported are:
    - Zigbee® protocol according to IEEE 802.15.4.
    - TCP, ssh, SOAP / XML

eHome Local User Interface LUI

- Operating system: MS Windows XP.
- The application SW is proprietary to the eHome consortium.
- Communication protocols supported are: TCP, Ssh, SOAP / XML and SIP

eHome Alarm and Routing Server A&RS
Alarming and Routing Server (A&RS) implements flexible coupling of home appliances producing different alarms, translating these alarms into communication requests, and then routing them to different recipients according to individually defined alarming plans. Communication between home appliances and A&RS is based on Web services standards with support for SOAP messaging over HTTP protocol. Basing the A&RS concept on Web services provides a technologically modern way for home appliances to send alarm notifications to fixed or mobile appliances of caretaking personnel using infrastructure of telecommunication service providers.
A&RS is conceived to support a broad spectrum of telecommunication infrastructures. The design concept of A&RS allows for flexible additions of different implementation options, depending on the technology used for accessing telecommunication services. The currently implemented option uses the concept of open APIs provided by telecommunication providers, and the implementation targets usage of the Samurai API provided by Sipgate.
Processing of received alarms in A&RS depends on alarm plans which can be flexibly defined for every household. Alarm processing possibilities include converting alarms to 3rd party initiated calls, SMS or email notifications. Alarm plans include several addresses of family members, friends, caretaker institutions, and emergency centres to which call, SMS or email should be initiated, as well as different criteria for choosing one of the contact persons.
The A&RS concept targets will use State of the Art IT technology to achieve the following:

- SIP based communication for VoIP and messaging
- Carrier Grade service availability
- Open interfaces

- Security
- Scalability

4.3 E-inclusion characteristics addressed

The LLM service will distinguish itself with characteristics, such as usability, accessibility, understandability by end users. Moreover, it will take into consideration all the e-accessibility barriers senior citizens face, such as ability restrictions concerning cognition, vision, hearing and mobility dexterities. In order to address these problems, attention is paid concerning the design of the central LUI and PTC UI. Several aspects to be taken into deep consideration during the development process are: conformance with international e-accessibility guidelines (WCAG) for content development, e.g. big buttons, and provision of alternative multimedia content for a specific object.

The terminal devices that will be used, such as touch screens, are widely considered to be an easy to use communication means by elderly people who have no prior computer experience. These, in combination with user-friendly remote controllers, such as Nintendo Wii Remote, constitute a set of input devices particularly popular to seniors that can be used on a daily basis and contribute to the ease of accessibility to the services offered by LLM system to end users.

Additionally the LLM system will enforce e-accessibility to the information offered by LLM services, importing avatar technology as mentioned in the description of the CMS. Thus computer use will be transformed from just a simple tool into an emotional assistant or a companion during daily activities. Avatars can make use of new technologies, such as text – to – speech system (TTS) and voice recognition, in order to accompany elderly people in their daily activities, thus encouraging, motivating them and providing them with some sort of social interaction.

Finally, the creation of a daily schedule by a decision support system supported by the LLM system according to seniors' performance in several kind of training, will help seniors to focus on the exercises to be performed and to avoid possible confusion.

4.4 Interoperability and standardisation

The LLM solution will be based on integration of existing ICT components. Hence, the interoperability features of the final service depend on:

- standardized interfaces of the existing components
- retaining these features after the merging of the components
- defining the integration design on an open architecture which will facilitate the extension of the delivered service with products and services from different sources

The eHome solution is based on a wide range of standardized interfaces or industry standards, like LAN, WLAN, TCP/IP, SIP, XML, GSM/GPRS/UMTS, Bluetooth, Zigbee, MS Windows and uCLinux. Therefore interconnection and interoperability with other services and to the outer world is guaranteed. On the other hand, the cognitive and physical training components use the Central Management System (CMS) for the processing of the service, which is actually based on a regular (low-cost) personal computer. This results in being able to execute any software written for its operating system and hence the capability of providing cognitive training through various different software packages.

One of the major features of the followed architecture is its flexibility. The web service's architecture and functionality will be open in order to allow new developments to be integrated and supported by the LLM service. The main scope of the web service architecture is to provide a way to integrate future developed components (CTC, PTC, ILC). Thus, the web service methods are not developed to be dedicated to the selected components for the first trials. Contrarily, these methods are designed to support the general functionality of physical, cognitive and independent living components. In addition, the "open" web service's structures and methods are well described by a human readable document (LLM Developer Reference - LLMDR) which is publicly available. Thus, any new or existing product (commercial or not) has the potential to be supported by the LLM system. The only prerequisite for the candidate applications to be integrated into the LLM service is its compatibility with the general framework (LLMDR) of the service. Consequently, the LLM framework will act as a standardized model compatibility with which could be targeted by relevant components manufactures. On the other hand, acting as the integration layer, the web service provides the admirable interoperability among different systems (hardware and software). As described above, the web service is platform independent. As a result, the LLM data can be hosted by different hardware systems, including mobile, PDA or computer training software. In addition, the LLM data can be hosted by different operating system, such as windows, linux and web based.

Overall, our work will make a particular effort to simplify our designs and clearly document our integration work. Thus, we aim to attract the attention of technical providers who will be motivated to complement and building upon our service. This is

one of the main dissemination policies and initiatives, i.e., to insight private interest and create a market around the LLM service.

5 LLM operational specifications

The LLM environment is an innovative health-related technology that, among others, is used for aiding the elderly people in their everyday life and helping them improve their overall well being. LLM is a system that builds on the idea of protecting the elderly against development of dementia and other memory-related illness, through cognitive and physical exercises.

LLM system is used by three types of users: the elderly people, their therapist and the relatives of the elderly people who mainly access the system in order to keep track on the progress of their older relatives. The LLM system, installed at the user's home, monitors all their movement activities. The user can access the system through touch-screens placed at preferred locations around the house.

All types of users are provided with a single account which they use in order to log into the LLM system. After they log into the system, they are assigned a unique role that has certain action rights on certain system objects. The user can select an activity type, like raising the blinds of the window, turning the TV on, etc. The user can also select a training program, which can be of a cognitive or physical kind, and after that initiate the training program. Moreover, the user can perform the exercises. The therapists also have access to the LLM system and can query the system to print reports on the (elderly) users' activities. The therapists and the system itself can create a daily schedule of all the activities to be carried out by the elderly users. Apart from the training activities, the system can recognize any emergency case that elderly users may face during their training and notify therapists or relatives through alerts. The alerts can be of an emergency kind, such as falling down of the elderly user or the overheating of an electrical appliance, at which point the system can call an ambulance, and/or notify by SMS or emergency phone call the therapists and the relatives. Finally, the relatives can have a constant update on the progress of the elderly users through notifications (e.g. on their mobile phones) and through reports (e.g. daily, weekly, monthly).

In order to describe the requirements of the LLM, concerning user interaction with the overall system, a set of use cases will be delivered, thus presenting a clear view of the LLM system overall functionality and providing assistance for testing purposes later on.

5.1 LLM service scenarios example

5.1.1 LLM for elderly remaining at home

Mrs B. is an old lady who has recently been widowed and is now living in the same town as her daughter. Nevertheless the distance between them is such that it is not possible for her child to constantly visiting her to see if everything is alright. While this distant arrangement has successfully worked while Mr. B was alive, after his death, Mrs B's daughter finds herself worrying more intensely about her mother, afraid that she might fall at any time, without having someone to help her. She is thinking about hiring a personal caretaker, but knows that her mother will not accept full time care. Finally, her mother is already showing some signs of memory loss, a definite sign of cognitive decline.

LLM is used in such or a similar scenario very effectively. First of all, it is easier for Mrs B. to accept having the LLM installation in her home, since it is less obtrusive than a home personal caretaker. Meanwhile, the eHome environment monitors the movements of Mrs B. and notifies her daughter at home or at her mobile if anything goes wrong. Thirdly, it creates a training programme for Mrs B. following the pattern for an aged person in moderate condition and motivates her to work out mentally with the cognitive training software of the CTC and on the physical training equipment connected to LLM.

The usage of the service progresses in the following way: Mrs B. wakes up. After washing, she approaches the touch screen of the LUI of eHome and calls her daughter using the intuitive telephony interface. The video connection allows her daughter to see her mother face to face and to recognize her condition Afterwards Mrs. B sits on her armchair and clicks on the touch screen to initiate the cognitive training procedure. A number of exercises appear on the touch screen and Mrs B. clicks on the correct answer by putting her finger on the corresponding button-image on the screen. At any time she can stop the procedure by clicking on the corresponding button; otherwise the procedure will eventually finish for this day, asking her to return tomorrow. During the evening the system suggests that she sits on the ergometer and follows the training program according to the displays on the screen. Since Mrs B. has improved during the last two weeks the program will set a slightly more challenging physical program and monitor her performance. If she can keep up with the pace, then after two weeks a more intense work out will be proposed. Otherwise, the system will return to the previous pace and will display related messages accordingly.

The effects on the lives of Mrs B. and her daughter are various. First of all Mrs B. herself feels more self-reliant and independent, not only because she can move freely around the house without any worries, but also because she is feeling physically and mentally fitter. Furthermore, her daughter is not afraid about her mother being helpless, since she knows that in the case of an emergency the system will immediately notify her.

5.1.2 LLM in a day care centre

Normal physical training session

Mrs. Smith enters the training room and takes a seat on the ergometer of the LLM service. Using the LUI in front of her she establishes a voice & video connection to the care taking trainer by simply pushing an icon on the touch screen; the trainer welcomes her and gives her some special advices for today's physical training program. When Mrs. Smith starts the training program a sensor of the ILC recognizes the begin of the training and the ILC starts internally a timer for a reminder function; after 10 minutes of training Mrs. Smith gets a reminder by the LUI to take a sip of water. During her training, sensors of the ILC are measuring the activity level of her training session and are reporting it to the LLM-service for further processing and analyzing.

Emergency situation during a training session

The next day, Mrs Smith starts training again but after a few minutes she feels sickish; so she pushes the emergency icon on the LUI. An emergency call is generated directly to the care taking trainer, who immediately talks to Mrs. Smith and initiates personal help for her. In parallel, the ergometer is switched off for safety reasons by a remote powering switch via ILC's network.

5.1.3 LLM in a clinical institution for elderly

An elderly person enters a medical institution (such as a hospital or an assisted living facility) when he or she needs intensive care. Once hospitalised, this person might be allowed to move freely around the facilities, depending upon specific medical conditions. Much as at the day care centres, constant monitoring of the movement of the patients within the facility is not possible. And though most institutions provide physiotherapy sessions, they lack any methods for cognitive training.

LLM can be used in elderly clinics, with special rooms equipped for cognitive training exercises. The physical training equipment can be used in a fashion that is complementary to the normal physiotherapy sessions of the patients. For maximum effect, the clinic can have a specially trained neuropsychologist to evaluate each patient's progress using the LLM service and provide further feedback in the form of personal interviews. Finally, patients can be encouraged by the hospital's staff to use the physical training equipment, above and beyond their normal physiotherapy work, if their medical condition allows. Such complementary training can further increase the mobility skills and improve the physical well-being of the patients. The LLM service can also assist the hospital's staff to know whether any of their patients has an accident while performing physical training using a physical training component of LLM, enabling a quick response. Taking into account that hospitalized persons suffer either from a cognitive and/or a physical problem, LLM can have a significant effect. Its cognitive training component can be used by every patient, excepting those with severe cognitive issues. The physical training equipment can be used by all physically able patients, thus improving their physical condition and sense of well-being.

5.2 Use cases scenarios

Title: Login user to LLM system	
Brief Description	One of the users that use LLM system enters the system and is assigned a specific role with specific action rights.
Actors	Senior, Therapist, Relative
Pre-conditions	The actor should be a already registered user to the LLM system, assigned with a valid username and password
Post-conditions	• A senior's profile exists and he/she is assigned a senior role by the system. • A therapist's profile exists and he/she is assigned a Therapist role by the system. • A relative's profile exists and he/she is assigned a Relative role by the system.
Trigger event	User (Senior, Therapist, Relative) enters room
Basic flow of events	1. System recognizes user presence in the room and prompts user to enter his/her credentials 2. User enters his/her credentials 3. System checks the submitted data and allows the access to LLM service
Alternative flows	3a Invalid credentials: 1. System prints error and rejects the entry
Security requirements	None

Title: Senior performing a training session	
Brief Description	It describes the process of senior training using LLM training programs (physical and/or cognitive).
Actors	Senior
Pre-conditions	• The actor is already logged into the system.

	• A daily schedule is already fixed and assigned to senior by therapist or system.
Post-conditions	Senior's performance data are stored by the system, which in turn notifies senior for his/her progress based on previous session data.
Trigger event	Senior starts a training program either by accepting system's proposal according to daily schedule or by selecting another training program by simply touching the appropriate button on the touch screen
Basic flow of events	1. System suggests senior to interact with specific training program according to already developed daily schedule 2. Senior accepts system's proposal 3. System depicts training program content on the central screen of the room 4. Senior provides response 5. System draws content according to user response Senior repeats steps 4-5 until training session ends 6. System stores training session performance data 7. System gets performance history 8. System makes decision based upon history data and shows message to senior concerning his/her progress
Alternative flows	2a Senior chooses to perform an activity other than the one proposed by the system: 1. System provides senior with a list of the available training programs included in the LLM service 2. Senior chooses the training program he/she wishes to use
Security requirements	None

Title: Alarm setting	
Brief Description	It describes the case that a senior has an accident like falling down during a training session and the system sets an alarm
Actors	System, Relative, Therapist
Pre-conditions	None
Post-conditions	Relatives and therapist are informed about the emergency
Trigger event	Senior while training falls down and LLM system recognizes the emergency situation
Basic flow of events	1. System recognizes senior's fall and stops training program 2. System prints message on the screen asking senior if he is fine and can continue the training 3. Senior responds positively 4. System displays training program from the point it was before senior's accident
Alternative flows	3a Senior either responds negatively or he/she doesn't respond for a period of time: 1. System sends an alarm notification to relatives and the corresponding therapist
Security requirements	None

Title: Check senior's progress	
Brief Description	It describes the case that a therapist checks how a senior's performance is progressing.
Actors	Therapist
Pre-conditions	Therapist already logged into the system and is assigned the Therapist role
Post-conditions	The therapist is informed via reports for the progress of a specific senior
Trigger event	Therapist performs a search query
Basic flow of events	1. Therapist initiates a new query

	2. System displays query criteria form 3. Therapist enters identification of senior 4. System returns data asked by therapist and are printed on a report
Alternative flows	3a Identifier invalid: 1. System prints an error message on the screen and prompts user to re-enter senior's identification
Security requirements	Therapist should enter an identification number that exists and corresponds to a senior who is assigned to him/her. Otherwise therapist would not be able to access data.

5.3 LLM system use case model

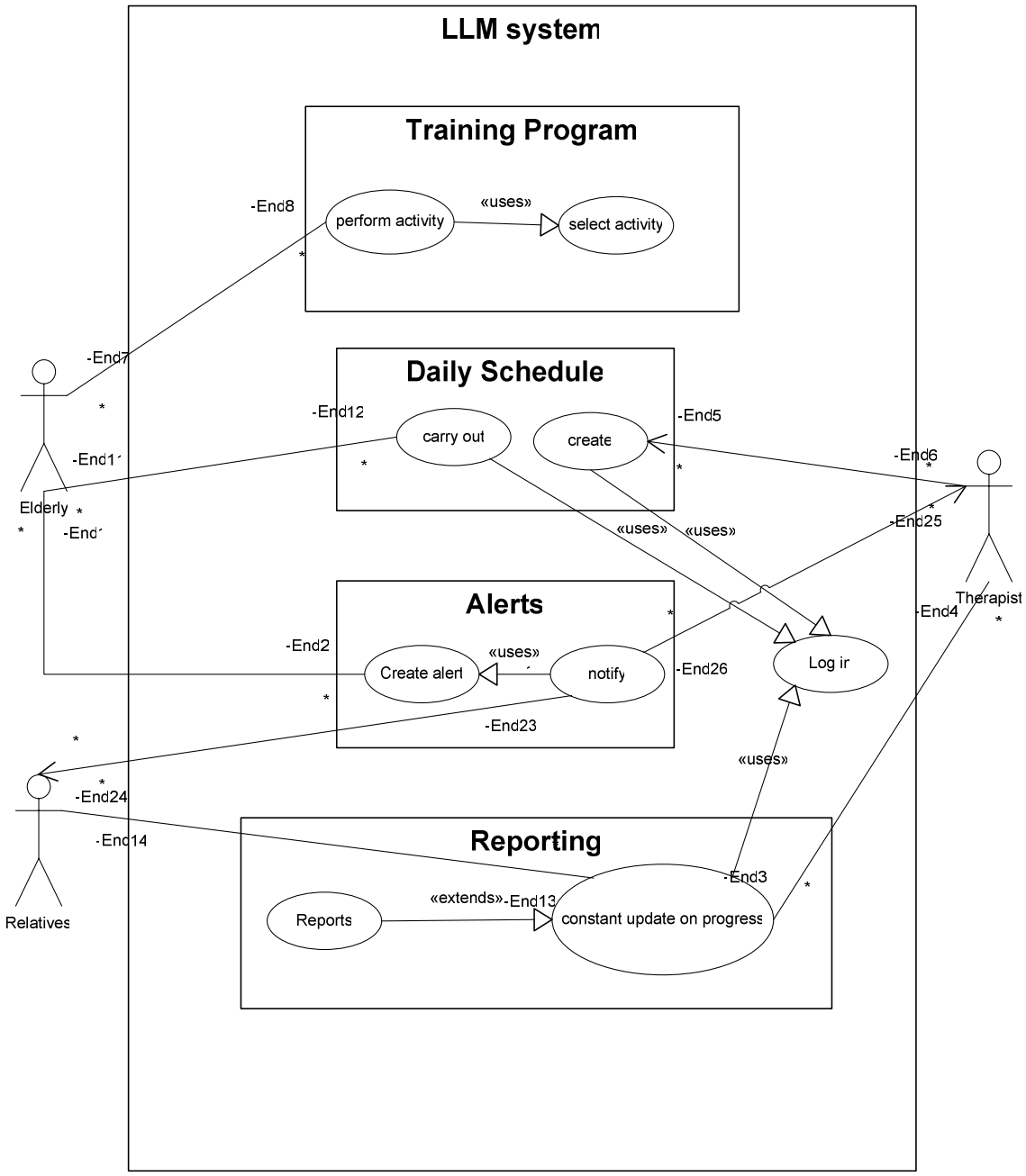

Figure 7: Use case model diagram

6 Integration design

The LLM system consists of the following components:

- Central Management System (CMS)that is the main component for interaction with the user
- An optionally for the user Human-like character (Avatar) which is part of the CMS;
- Training Program Element (TPE), which is responsible for the training session of the users and represents both Physical Training Component and Cognitive Training Component
- ILC, the e-Home system
- LLM Web service (LLMWS) which plays the role of the communication channel between TPEs, CMS and LLMDB.
- LLM Database (LLMDB) that stores all the information of the system (e.g. performance progress, alarms etc.)
- An intuitive user interface which consists the main access point for LLM users (seniors and/or experts) to the LLM service

The LLM system implements a model based on the integration of independent components which provide heterogeneous data and semantics. The integration aspects of the system are tackled on the basis of a web service and a database. The web service is responsible for providing all methods and functions in order to support the three independent components' functions.

Moreover, the web service is responsible for the authentication of the system's users according to their role. A database accompanies and supports the web service's procedures. Each of the three components accomplishes a different scope of application and provides heterogeneous data and semantic sources. According to these requirements the proposed architecture must support the integration of the data and the co-ordination of the components' functionalities. One of the major features that the proposed architecture should deliver is flexibility. The web service's architecture and functionality will be open in order to allow new developments to be integrated and supported by the proposed service in the future developed components (CTC, PTC and ILC). The only prerequisite for the candidate applications to be integrated into the proposed service is to be compatible with the general framework of the service.

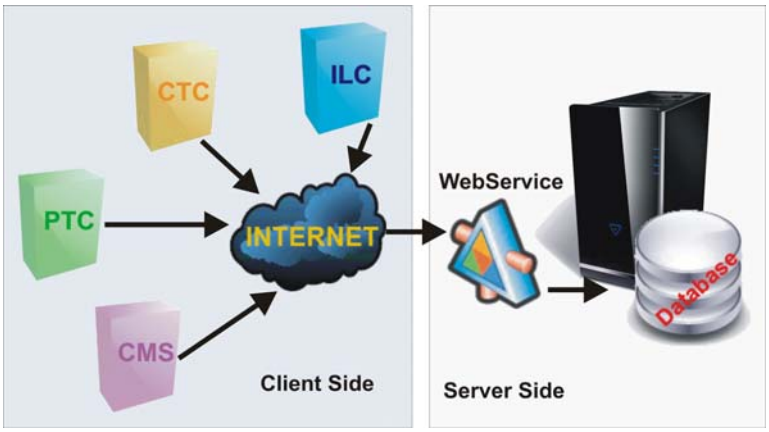

Figure 8: The web service supports the three independent components

The Web Service provides programmatic access to the system's features and services. Developers can build custom applications, tools, and services that correspond to the same services. Typical applications include add/edit and searching for registered seniors, add senior's progress to cognitive or physical training and add information about senior falling or alarms. The Web Service includes the Simple Object Access Protocol (SOAP), Web Services Definition Language (WSDL), and the XML Schema Definition language (XSD). These standards are supported by a wide range of development tools on a variety of platforms.

One of the most profound details of the design is the decision to treat the physical training equipment merely as an input device to the system, by providing signals corresponding to the performance of the user on that exercising device. This information is transmitted to the Central Management System (CMS) of the CTC, which digitalizes the signal and processes its values in three ways, by:

- storing it into its local database for future use,
- correlating it to existing values from the database to reach conclusions about the performance and effectiveness of the exercise, creating responses like "Very good", "Not so intense", "Try a little harder",
- forwarding the digitalized input as well as all processing resulting information to the eHome environment for display

Algorithms needed for the 2nd step of this procedure will simply look up predefined tables for each item of training equipment and elderly condition (sex, age, disability etc) and provide the appropriate response. These tables will be defined by a group of medical experts taking part in our consortium during task T.3.1. A relevant table will also be used by CMS to provide the personal training programme for LLM users. The parameters for the system's users will be set on installation. For "At Home" LLM installations a few user profiles (and corresponding training programme parameters) will be set on installation. The profiles will change from the LUI.

However, for "Day care centre" and "Formal Care Facilities", multiple user accounts and personal training programmes will be used. These will be administered by the trained staff, having direct control on the CMS system.

Meanwhile, eHome participates in the physical training process by monitoring the movements of the users and identifying potential problems, as it normally would for any other kind of daily activities.

In the case of a problem, the eHome environment will act according to its standard specifications and notify for help. Therefore, no technical adjustments should be enforced on eHome in this respect.

The cognitive training procedure is more complicated in the sense that the eHome environment and the CTC (i.e. the CMS) interact both ways: the CTC displays its software through the eHome Local User Interface (LUI) and the eHome transmits to CTC the response of the users – whether this means pressing a button on a remote control or pressing images on a touch screen. The high level description of this process is:

1. The CTC notifies the users for the initiation of the cognitive training procedure according to the training program by displaying a related message on the LUI of eHome

2. The user initiates the process

3. The CTC presents its training content through the LUI of eHome

4. User responds through the LUI

5. The CTC processes the response, stores its value (correct, false) into the database and interacts with the user

6. Steps 3-5 are repeated until the training is concluded or user decides to stop the procedure

To accommodate this procedure, a two way communications scheme should be followed to link CTC with eHome. More specifically, the operational requirements are:

- the CMS should display its exercises on the LUI of eHome
- feedback should be acquired by CMS from the LUI of eHome
- Home Control Unit of eHome (HCU) and CMS displays should appear interchangeably on the LUI

Consequently, technical requirements are as follows:

- signals from CMS should by-pass the signals from HCU to the LUI. In other words, once the cognitive training process starts, the LUI would display the CMS output (the cognitive training programme of the BrainFitness software) and not its normal display.
- The system should ensure that only the display of CMS or HCU appear on the LUI

The technical solution for these requirements would comprise of:

- developing a driver for the LUI unit on the CMS

- a switch that would have a controller deciding which display will be shown on the LUI

In conclusion, apart from the necessary wiring to physically connect the three components, the technical adaptations required are well focused, and thus realizable within the available time frame.

1. Senior Login (Success scenario)

The typical sequences of events that occur during senior's attempt to log into LLM system are as follows:

Senior approaches the touch screen where LLM service is hosted. He initiates the introduction procedure to the system through the LUI, entering his credentials (username and password). Then CMS calls LLMWS method to check if user's credentials are valid. LLMWS gathers results produced by querying LLMDB and provides CMS with the user role and his/her rights on system objects (in the present case user role is Senior) optionally. Finally, CMS welcomes senior showing a welcome reception call by the avatar.

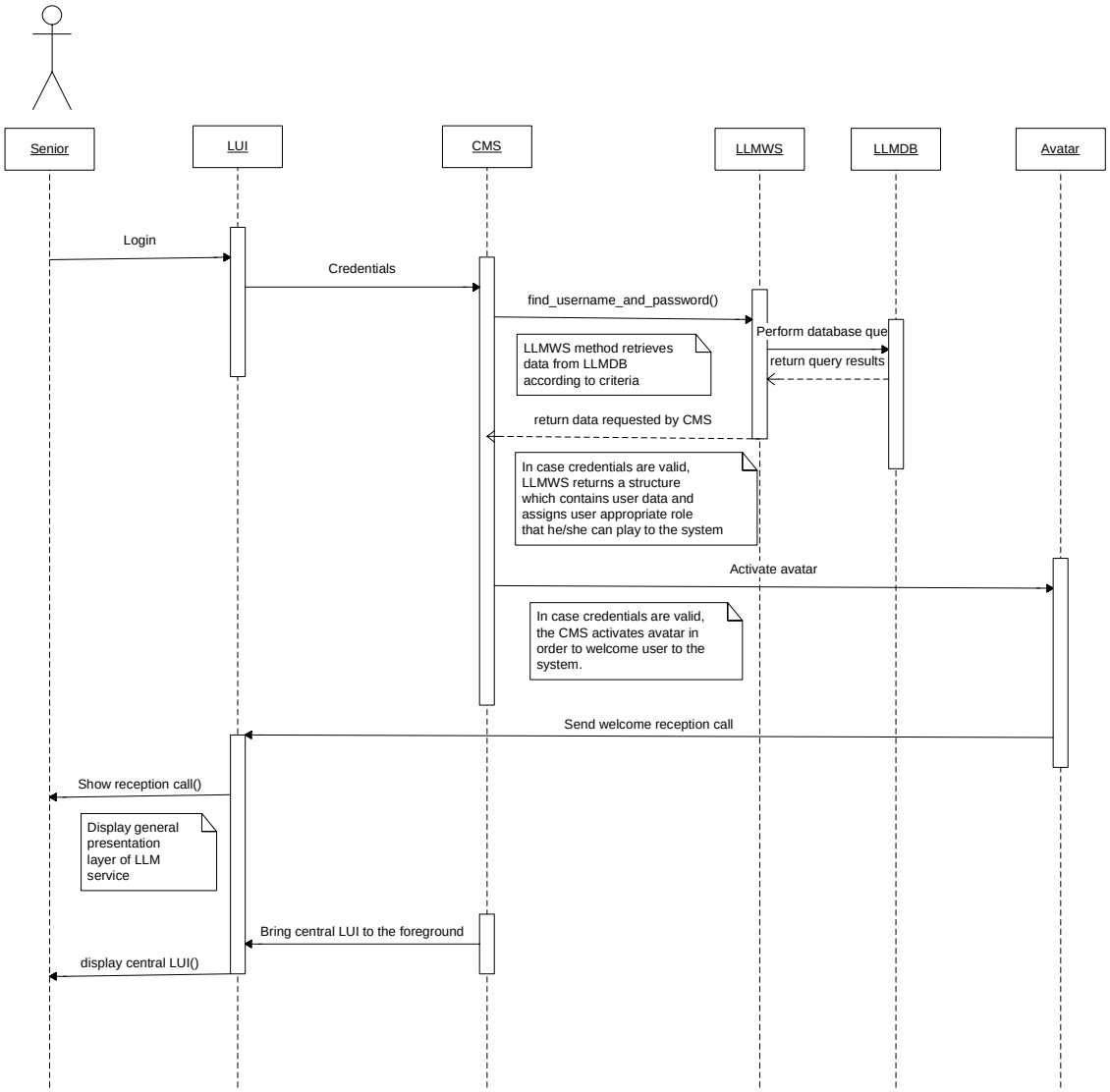

Figure 9: Senior Login to LLM system sequence diagram

2. Senior performing training session

Based on the daily schedule, the CMS motivates the user to interact with the appropriate TPE. In case of positive senior's answer the CMS brings up to the interaction screen (LUI) the selected TPE[4] . Working according to its "closed" concept the TPE starts

[4] In case of user's negative answer the CMS shows on the LUI the menu with the TPR icons. The user by simply touching the icon of one TPE can launch the corresponding TPE through the LUI. The CMS is responsible for bringing on the foreground the selected TPE.

training procedure and displays training content to the LUI. The senior interacts with the TPE by providing his/her feedback. After finishing the training procedure, the TPE informs the CMS through database information. Also the TPE calls the web service in order to store the senior's performance progress to the LLM database. The CMS acquires the recent senior's performance data (through Web service) from LLMDB and as an option interacts with the user by means of the avatar in the appropriate manner (messages like "well done! keep up the good work!", etc.).

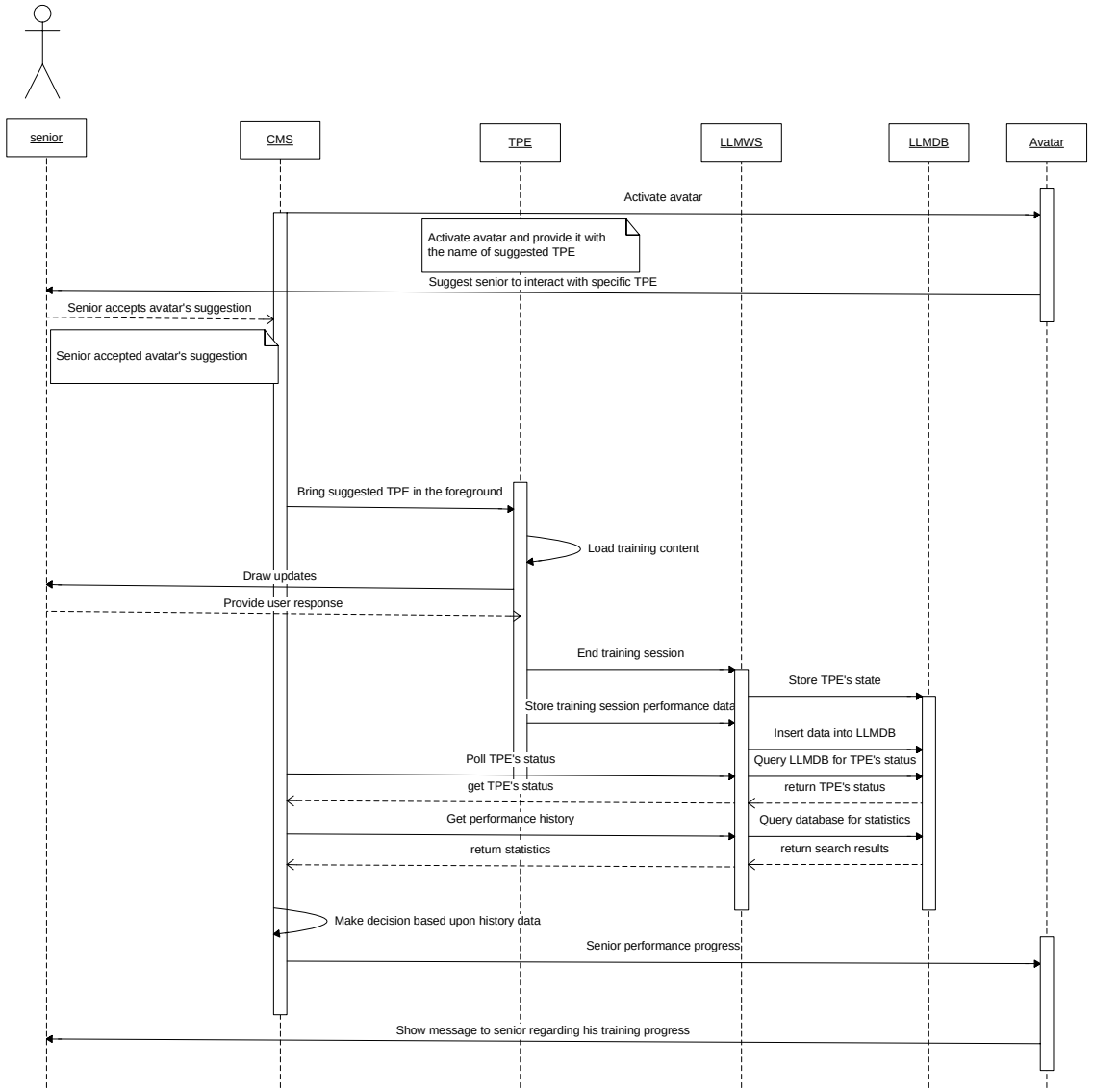

Figure 10: Senior training session sequence diagram

3. Senior having an accident during training

During physical or cognitive training senior may have an accident or feel dizziness. Therefore, ILC realizes senior's emergency situation either by senior's pressing a button on the LUI, or by means of sensors located on training room. Since ILC realizes an emergency, CMS sets ILC as the foreground application. Finally, LUI displays a message on the LUI of the touch screen and sends an SMS or an emergency call to a relative.

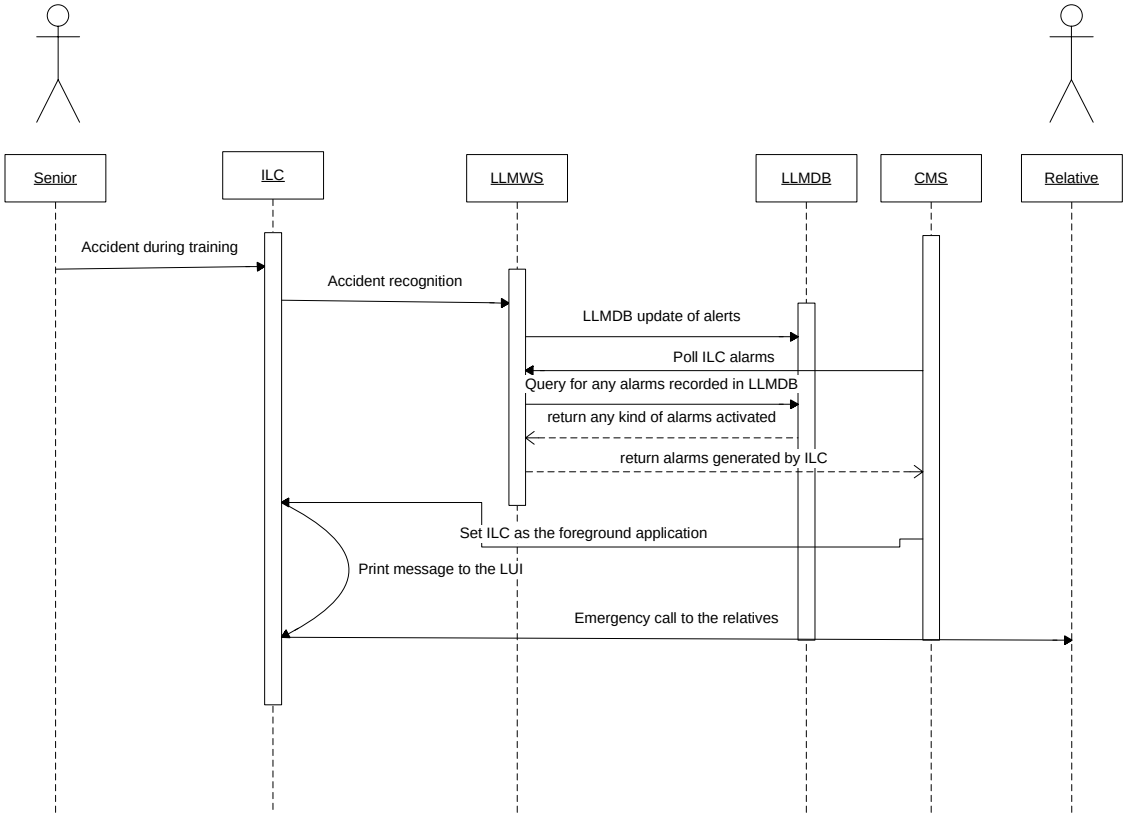

Figure 11: Senior's having an accident during training session sequence diagram

4. Expertise personnel check patients' progress

The therapist enters his/her credentials to the prompt window of the LUI. Then the LLMWS communicates with LLMDB in order to check whether the credentials entered by the end-user – therapist are valid. LLMWS returns the result and specifies the user role and rights of the therapist to the system. CMS loads the expert UI where only authorized personnel (aka therapists, trainers, etc.) can have access. Therapist then queries LLMDB for a patient or patients (they are assigned to him/her) whose performance progress he/she

wants to track. CMS addresses the request through the LLMWS to LLMDB. LLMWS responds with the requested data.

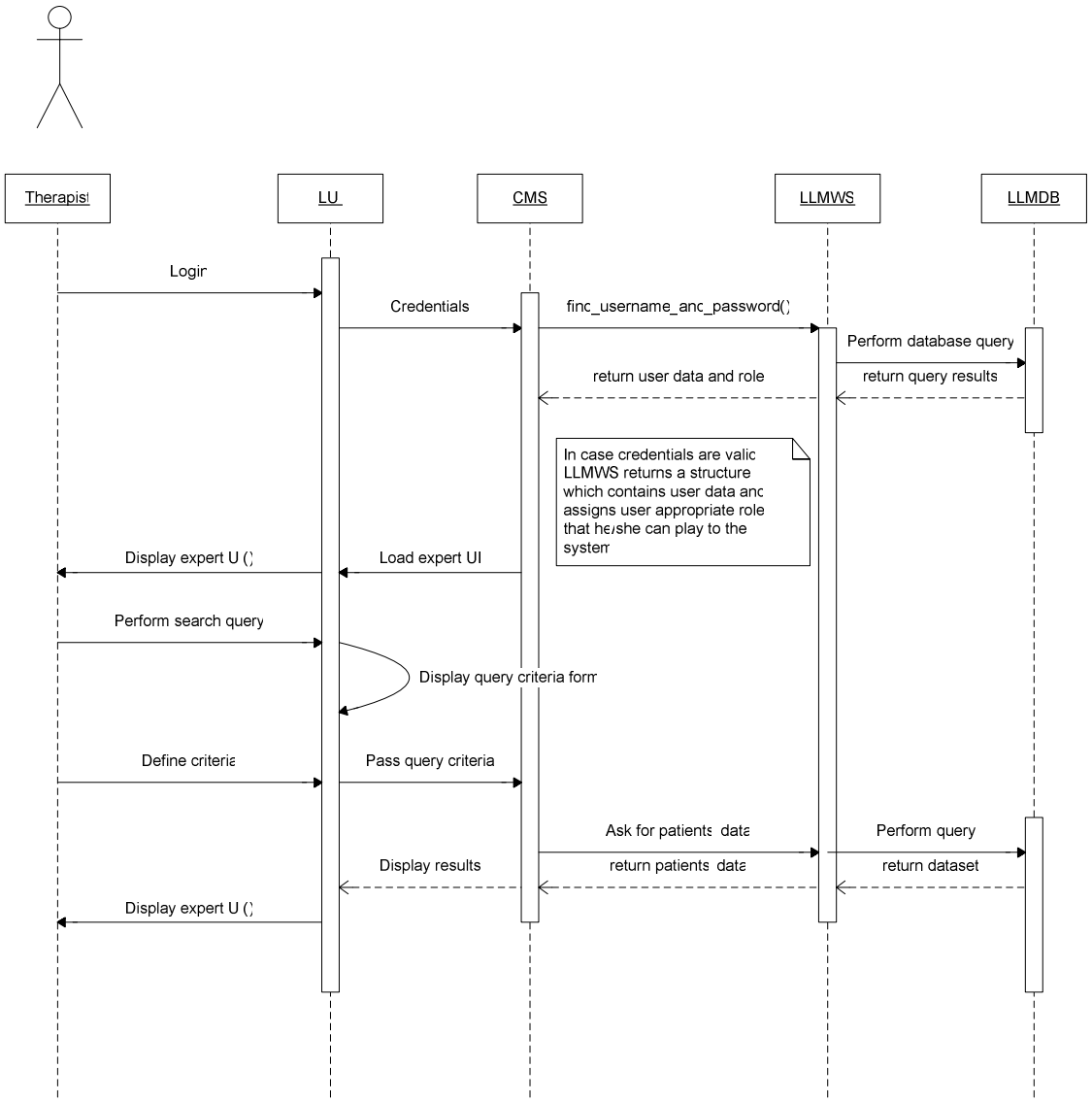

Figure 12: Therapist tracking seniors' performance progress sequence diagram

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A. Annex A – List of Candidate Software for CT and Criteria

List of software:

- BrainFitness program (Posit Science)
- CogniFit Personal Coach (CogniFit)
- GRADIOR (INTRAS)

List of criteria:

- Cost of integration
- Ease of integration
- Cost of adaptation/customization
- Ease of adaptation/customization
- Flexibility in adaptation/customization
- (Range of) cognitive functions affected
- Evidence for efficacy in cognitive function
- Cognitive exercise structure
- Motivation & attention control (reward & reinforcement schedules)
- Usability
- Attractiveness
- User acceptance & satisfaction
- Technical requirements for use
- Human resources for use (e.g., supervision)
- Duration & intensity of training
- Modifiability & flexibility of training
- Generalization to functional outcomes
- Design adapted to seniors (not childish)
- Multiuser / social network
- User interface options (touch screen remote control, etc.)
- Use of "state of the art" technologies
- Involvement & accessibility of manufacturing company
- European development

- Standards (interfacing, integration etc.)
- Web-based application
- Protection of privacy (user names, anonymous demographics)
- Progress and performance indicators
- Central data accessibility (web based)
- Expandability (e.g., new interfaces)
- Specific scientific theory underlying training structure & content

Software packages not selected for comparative evaluation:

- Fit Brains (Vivity Labs)
- Brain Age (Nintendo)
- SIGMA (Kounti Fotini, Batsila Georgia, and Tzanis Dimitrios)
- Brain Workout (Oak Systems)
- Lumosity (Lumos Labs)
- MyBrainTrainer (LLC)
- Happy Neuron

B. Annex B – Communication protocols for PTC

Communication protocols - widely used in the market - to be incorporated into the PTC application that will accompany physical training equipment (ergometer bikes and treadmills) will be:

- Ergoline ergoselect protocol
- Trackmaster (mostly for treadmills)
- H/p cosmos coscom protocol
- CSAFE (Communications Specification for Fitness Equipment)

Ergoline ergoselect protocol

Format of data to be transmitted: 1 startbit, 8 databits, no parity, 2 stopbits (transmit) / 1 stopbit (receive), no handshake. The baudrate is selectable between 1200 and 115000 Baud (default: 4800 baud).

Commands:

- commands can be received every 200 ms
- all bytes of a command have to be transmitted within 150 ms
- answer follows within 150 ms
- all received commands are performed immediately
- undefined or incomplete commands will be ignored

function	command	answer	short description
VERSION Ergometer	I [CR]	I<.....>[CR]	ergometer answers with ID string (compatible to ER900)
START bp measurement	S[CR]	S[CR]	ergometer initiates a bp measurement (+ start of stresstest timer)
START (without bp measurement)	s[CR]	s[CR]	start of internal stresstest timer
LOAD (target value)	W[nnn][CR]	------	load of ergometer is set to [nnn] Watt
LAST request	B[CR]	B[nnn][CR]	ergometer transmits actual load
RPM request	D[CR]	n[nnn]>CR>	ergometer transmits actual RPM
SYSTOLE request	O[CR]	O[nnn][CR]	ergometer transmits systole / status
DIASTOLE request	U[CR]	U[nnn][CR]	ergometer transmits diastole / status
HEARTRATE request	H[CR]	H[nnn][CR]	ergometer transmits heartrate of bp measurement
BEEP	K [CR]	------	ergometer beeps
STOP	F [CR] (F [CR])		ergometer stops the internal stress test timer
ECG transmit on/off	Z [nnn] [CR]	Z [nnn] Z [nnn]....	ergometer sends continuous ECG data

Figure 13: Overview of commands

COMMAND	B [CR]
hexadezimal	42h 0Dh
length	2 byte
description	request for actual load from ergometer
ANSWER	**B [hze] [CR]**
hexadezimal	42h 3xh 3xh 3xh 0Dh
length	5 byte
description	ergometer sends the actual target-load h = hundreds ASCII z = tens ASCII e = ones ASCII leading zeroes will be transmitted
EXAMPLE	Answer: B075 [CR] 42h 30h 37h 35h 0Dh the ergometer load is set to 75 W

Figure 14: Example of a command in ergoselect communication protocol

Trackmaster protocol

It supports communication between treadmill and PC, set of commands such as Get / Set speed and / or elevation. Below there is an example of a log file concerning activity performed on a treadmill and recorded by PC.

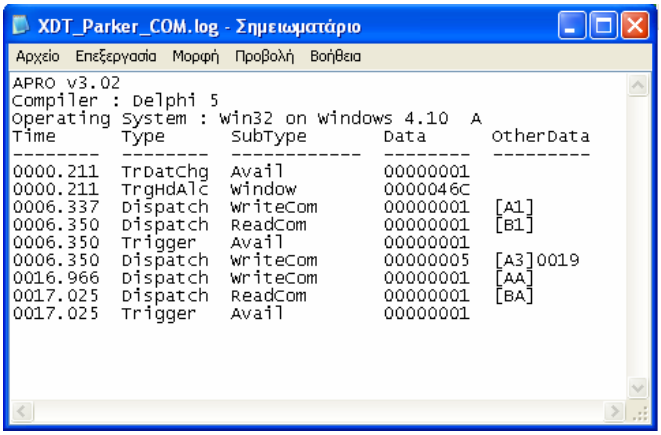

Figure 15: Log file of Trackmaster protocol

Coscom protocol

Coscom protocol is .NET oriented and its current version is coscom v3. It uses coscom v3 .NET Objects which are integrated into *.dlls, thus allowing the use of all important functions of the h/p/cosmos coscom-protocol. For example the direct control service has actions to control the speed of the drive and the grade of the elevator directly using *TreadmillDirectControl.dll*.

```
98          private void buttonSetSpeed_Click(object sender, EventArgs e)
99          {
100             if (IServiceDirectcontrol != null)
101             {
102                 try
103                 {
104                     // set a new drive speed
105                     IServiceDirectcontrol.SetDriveSpeed(float.Parse(textBoxSpeed.Text), 3, 0);
106                 }
107                 catch (Exception er)
108                 {
109                     MessageBox.Show("Error: " + er.Message);
110                 }
111             }
112         }
```

Figure 16: Coscom protocol application code

CSAFE protocol

It is specifically designed to support communications between various types of networked fitness equipment and it offers a standardized data packaging specification that provides:

- Data transparency
- Error detection
- Self starting frames
- Minimal resources in the exercise equipment
- Standardized formats for communicating parameters of interest to the fitness industry
- State machine model for exercise equipment
- Simple RS232, full duplex based implementation