

# COGNITIVE AND PHYSICAL TRAINING MEDICAL RECORD, A WEB SERVICE BASED ARCHITECTURE

E. I. Konstantinidis, A. Billis and P. D. Bamidis

*Laboratory of Medical Informatics, School of Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece*

**Keywords:** Cloud-computing, Web service, Physical training, Cognitive training, Medical record.

**Abstract:** Organizing, tracking, monitoring, and acting upon personal health and especially cognitive and physical training information has nowadays become a necessary and important procedure. This is true particularly for special groups of people with cognitive or physical impairments (or both). Elderly people with mild cognitive impairments, autistic children and other categories of people with impairments may obtain benefits by having their daily cognitive and physical activity been monitored. This piece of work, proposes an approach towards a solution for a physical and cognitive medical record held upon the cloud, and accessed through web services. In this way, various semantically described exercises and training platforms may exchange information with the record system and access user performance results obtained in the context of a standardized description of exercises with suitably associated results and scores.

## 1 INTRODUCTION

A famous ancient greek quotation has expressed the importance of having in good health both mind and body: “a sound mind into a sound body”; this has praised the need for people to equally keep their minds and bodies in good shape, so as to have a well balanced life and overall improved well being, that also includes their psychological status and self-esteem.

It is common knowledge that nowadays, the western way of life has changed dramatically, and is mainly characterized by a complete absence of any kind of physical activity among daily living activities (Troost et al, 2002). This situation has led to many severe health problems responsible for a significant percentage of deaths among the western world, such as obesity (Fox and Hillsdon, 2007), coronary artery disease (Fox et al, 1972), arterial hypertension, mobility impairments. There is sufficient evidence that people, who try to keep fit through exercise, are benefited to a certain extent in several aspects of their health, including: reduced risk of cardiovascular disease (Braith And Stewart, 2006), (Pollock et al, 2000), prevention of the development of arterial hypertension, control of diabetes, increased fat utilisation which can help to control weight, lowering the risk of obesity (Kesaniemi et al, 2001), maintenance of cognitive

functions and decreased risk of developing depression and dementia in senior citizens (Van Boxtel et al, 1997), (Perrig-Chiello et al, 1998) and finally moderation of stress (Hill et al, 1993).

It is imperative that in recent years, numerous information and communication technology (ICT) resources have become available to facilitate exercise and enrich a fitness training program. Apart from the traditional gym equipment, such as plain stationary or ergometer bikes, treadmills, dumbbells, there are also new trends in the way physical exercise is performed, such as “exergaming” (Bogost, 2005). Exergaming, which has lately drawn the attention of training experts, is a form of exercise through the use of video games whose main focus is the improvement and promotion of physical health of individuals through interactive game play. The way individuals can train themselves through a video game, is to physically interact with its content. Physical interaction means that a trainee via his/her body movements can manipulate a virtual character on the game screen, imitating this way different kinds of sport activities, like walking or running (Bonanni et al, 2006), (Mumford et al., 2008). Great examples of commercial exergaming platforms are Nintendo Wii Fit, XBOX Kinect, DDRs (Dance Dance Revolution) like Dance Town (focus on elderly population), ConnectAndPlay, Positive Gaming and many others (Billis et al, 2010).

Apart from the health problems related to physical inactivity, people are also exposed to cognitive and mental illnesses. These might occur at any time of the human's lifespan, from early stages of human life to old age. Examples of such cognitive illnesses are attention deficit-hyperactivity disorder (ADHD), autism spectrum disorders, schizophrenia, dementia and stroke. Most of the above mentioned pathological situations result to multiple cognitive and other deficits, thereby leading to partial brain malfunctioning. Much research has focused on the design and the application of cognitive intervention and rehabilitation programs (Solberg et al., 1994), (Merzenich et al, 1996) so to ameliorate most of the effects that the above mentioned situations have on human cognitive health.

Computer-assisted interventions have shown some very promising results in several areas of therapy and rehabilitation research (Hofmann et al, 1996), (Galante et al, 2007), (Tárraga et al, 2006), (Barnes et al, 2009). Computer games have also proved to be of great value for the overall brain function in several cases (Gamberini et al, 2006), (Green and Bavelier, 2003).

All this plethora of applications and technology devices form a significant field of interest as their primary goal is to promote and enhance either the physical or cognitive human health. These applications target to a wide range of groups with either different or similar profiles of health problems.

This piece of research work focuses on a service that can support special groups of people towards their physical and cognitive health, as well as, their independent living. The aim of the paper is to propose an approach towards a solution for a physical and cognitive medical record held upon the cloud, and accessed through web services, thus delivering a PaaS for the development, testing and deployment of either already existing software solutions or future developments. So, in the remaining of this paper the principles of the undertaken architecture and the technical design details of the proposed service are described, with emphasis drawn upon the web service architecture and the underlying database. It is shown in section 2 how the service combines structures, methods and functionalities on cognitive exercises against cognitive decline with physical activity in the framework of an advanced ambient assisted living environment (Konstantinidis et al, 2010). Section 3 presents scenarios of use, while a critical discussion and outlook are provided in the final section.

## 2 MATERIALS AND METHODS

As mentioned already, the main service is comprised of three different categories according to the training field:

- Cognitive Training
- Physical Training
- Independent Living

The service functionalities and methods are designed in a way that they are able to be consumed by already existing as well as future applications and hardware systems that deal with data related to the above three categories. Thus, sensors that monitor movements inside the house (movement and activity patterns), software dedicated to cognitive training and rehabilitation and 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, find a ready-to-use and well described data layer supporting their main functionalities.

### 2.1 Data Layer

The proposed service implements a model based on the integration of independent components, accomplishing different scopes of application, which provide heterogeneous data and semantics. According to these requirements the proposed architecture supports the integration of the data and the co-ordination of the components' functionalities, while acting either independently or in the framework of an interconnected training environment.

Independent fundamental entities in the database provide information for the candidate applications (the kind of the application, the available exercises, the score algorithm, the target group, etc.) and the type of exercises they support (description of exercise, difficulty levels, required devices if any, etc.). As a result, the database includes a semantically described schema of different training systems. This schema is updated by including new training components and new training devices.

The upper data layer provides information about the user interactions with the available training components, performance, daily compliance to the training schedule and monitoring of activities. The proposed service acts as the heart of the training data repository. This repository depicts the cognitive and physical health of the user.

## 2.2 Methods and Structures

The main functionality of the three independent components is met by means of a server side system, whose main component is the proposed service. The web service is responsible for providing all methods and functions in order to support the three independent component functions as it is depicted in Figure 1. Moreover, the web service is responsible for the authentication of the system's users according to their role and the provision of access rights on certain information of the database.

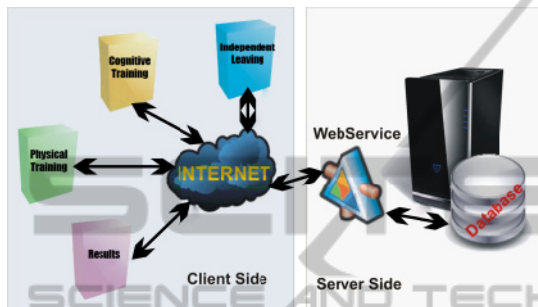


Figure 1: The web service supports the three independent components.

Providing programming access to the system's features and services, 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.

The web service provides structures (an example is given in Table 2) 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.

Table 1: Structure for senior's demographic data example.

<pre> &lt;s:complexType name="user"&gt; &lt;s:sequence&gt;   &lt;s:element minOccurs="1" maxOccurs="1" name="user_id" type="s:int"/&gt;   &lt;s:element minOccurs="0" maxOccurs="1" name="lname" type="s:string"/&gt;   &lt;s:element minOccurs="1" maxOccurs="1" name="birthdate" type="s:dateTime"/&gt;   ..... &lt;/s:sequence&gt; &lt;/s:complexType&gt;                 </pre>
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For example, in order to add an activity performed by a user we use the method shown in

Table 2. It behaves as a log file of the user's progress and activities. The required attributes that must be provided are shown in Table 2.

Table 2: User cognitive activity attributes.

Attribute	Description
user_id	The ID of the user performing the activity
ctcactivityid	The Cognitive Training Activity performed by the User
ctcid	The Cognitive Training Component used by the user in order to perform the Activity
datetimestart	The date and time that the activity started
datetimeend	The date and time that the activity ended
score	The score achieved by the User
level	The level of difficulty of the performed Cognitive Training Activity

An example using LLM web service method to record user's performance to a certain CTC activity:

```

ctcactx = new CTCUserActivity();
ctcactx.ID = 0;
ctcactx.ctcid = 4;
ctcactx.ctcactivityid = 3;
ctcactx.user_id = 10;
ctcactx.datetimestart = new
DateTime(2010, 6, 21, 10, 00, 00);
ctcactx.score = "23";
ctcactx.level = 5;
ctcsac = AddCTCUserActivity(ctcactx,
"username", "password");
if (ctcsac.error.ErrorCode == 0)
ctcactx =
ctcsac.CTCUserActivityList[0];
                
```

More information on the complete list of functionalities and data structures that are supported by the web service can be found at <https://nosmoke.med.auth.gr/PilotsIIm/LLMWebService.asmx?WSDL>.

## 2.3 User's Roles

As discussed above, the web service is responsible for the authentication of the system's users according to their role. Different roles accomplish different privileges on data and methods based on the relation link among users (supported by the service). The main roles of the system are:

- User
- Relative
- Therapist
- Administrator

A user is performing the system's activities and has the privileges for his own data and methods. The therapist is able to monitor the users related to him. She/he is responsible for accessing the daily

schedule programme and providing special notifications to individual users. The administrator of the system has all the available privileges for supporting the system and adding new functionalities. Finally, the “relative” role is a user that may monitor another user’s performance without being able to modify anything.

### 3 SCENARIOS OF USE

The open architecture enables already developed or future products to benefit by gaining access to correlative results of familiar applications or enriching their results by different types of applications. The former strategy enables applications to compare their results with results from familiar applications regarding a specific user. As the training components, their functions, exercises and results are semantically described the cognitive and physical performance curve is comparable among different applications. As a result, each application and protocol has the opportunity to be enriched in form of several different amounts of data results. The latter strategy, which makes use of heterogeneous data information, provides semantic data of different scopes for each user. For example, a cognitive training component for elderly people may enrich its results by having access or correlating them with the user’s (specific user) physical training activity. Useful results may accrue by the type and intensity of affection or even mood, if any, among training activities.

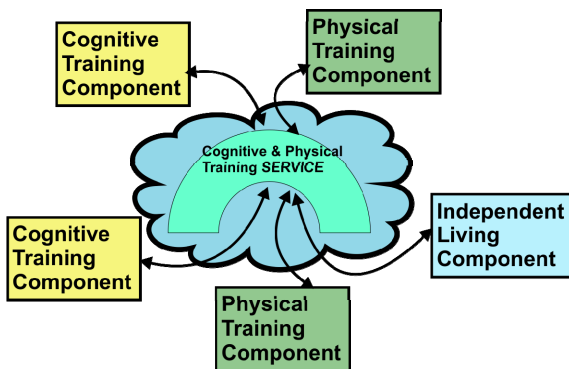


Figure 2: The proposed service acts as a gateway of intercommunication among different applications on the cloud.

Meanwhile, the semantically described training activities and their results should be the spark for evaluating different standards on cognitive and

physical training. As a result, a life-long physical and cognitive medical record is to take shape.

Forming a holistic framework, the proposed platform serves an abstract semantic communication layer among training applications and protocols. Cloud computing may promote this layer as a gateway of intercommunication among applications serving different scopes of data, as depicted in Figure 2.

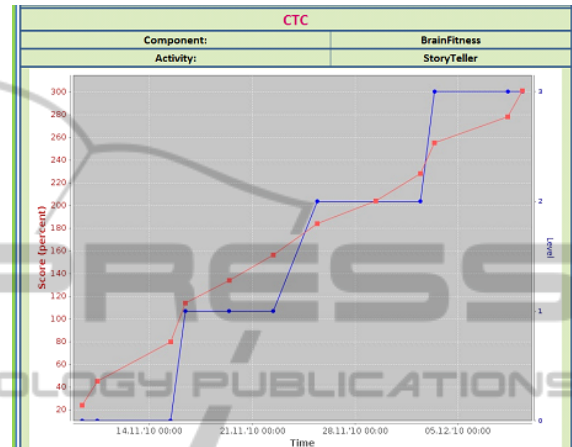


Figure 3: Indicative Cognitive Training results during an iterative trial of the system by senior citizens within the Long Lasting Memories European Commission Project (see [www.longlastingmemories.eu](http://www.longlastingmemories.eu) for further details).

The described service has been initially developed for the needs of the Long Lasting Memories European Commission Project (LLM EU project, 2010). This project utilizes a number of remotely operated screens, which are embedded in the independent living environment and connected to training equipment (like recumbent bikes, ergometers or treadmills). Light physical exercises are combined with a targeted set of cognitive exercises, while the environment's sensors ensure the safe and enduring application of this training, adjusting, intervening or providing motivation according to each person’s achievements and status/situation (Frantzidis & Bamidis, 2009). Figure 3 depicts results of cognitive training during a certain period of time. The results show summarized scores (and not raw data – i.e. log files) during a session of similar exercises (Cognitive Training in this case). Thus, each score represents a meaningful status of the user’s performance, which is available through the cloud and may accompany each user (senior in this case) in every aspect/step of his/her life, thereby contributing to the continuity of care EU policy target.

## 4 DISCUSSION

The research presented in this paper focuses on the development of an integration scheme for various independent applications that target on the promotion of physical and cognitive health. The integration of the applications is tackled on the basis of a web service and a database schema. Possible usage extension of the proposed framework is the creation of an application gateway, where each application will be able to interchange information and data through the data pool that is created and be shared via the open web service's architecture and database scheme. A possible extension to the existing infrastructure could be the introduction of an additional web service implementing Dynamic Decision Support System techniques in order to provide some automation techniques and add intelligence to the end system.

The existing framework combined with the future developments will allow the creation of a unique data pool that will focus on the physical and cognitive status of possible users, envisaging to set some standard way and technology for describing and exploiting applications within the nowadays chaotic field of physical and mental health.

## ACKNOWLEDGEMENTS

This work is partially funded by the LLM Project ([www.longlastingmemories.eu](http://www.longlastingmemories.eu)) through the ICT Policy Support Programme (ICT PSP) as part of the Competitiveness and Innovation Framework Programme of the European Commission.

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