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Diabetes management in OLDES project

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***Abstract*— EU project OLDES (Older People's e-services at home) develops easy to use and low cost ICT platform in order to offer a better quality of life to elderly people directly in their homes through innovative systems of tele-accompany, tele-assistance and tele-medicine. The elderly are able to access the services and send relevant medical data from their home by being connected to the central server via a low cost PC which is based on Negroponte paradigm. The OLDES platform interface uses television screens controlled through a remote control customized for the elderly. The feasibility of OLDES project is evaluated by the pilot study concentrating on compensation of diabetic patients. Compensation of diabetes is achieved by monitoring glucose glycemia level, blood pressure and weight. Moreover, the patient feeds into OLDES system daily consumption of food using interactive food scales and obtains advice if necessary.**

I. INTRODUCTION

The consequence of increasing life expectancy and decreasing birth rates is that population is becoming increasingly older [1]. Several projects deals with elderly disease management as CONFIDENCE [2], ATTENTIANE[3], ENABLE[4], K4Care[5]. Very similar platform to OLDES is developing INTEL under name Health Guide PHS6000 [6].

The aim of the project is to offer new technological solutions to improve the quality of life of older people in their homes. Thanks to an advanced and innovative technological platform, OLDES provides user entertainment services, through easy-to access thematic channels and special interest forums supported by animators, health care facilities based on established Internet and Tele-care communication standards. However, one of the major problems in IT-assisted ambient technologies is patient motivation and daily involvement in disease management systems [7]. OLDES promotes healthy life style by providing audio-visual content which helps in patients' social inclusion and their motivation. The content is created by social workers or volunteers which are often senior themselves. Information about constant monitoring of vital parameters and health state is surveyed in a call centre by GPs.

The following reviews suggest that computer-assisted interactive IT is an important tool and has great potential to improve diabetes care [8],[7].

This paper presents OLDES technical solution and the implementation of OLDES system project in management of patients suffering from diabetes.

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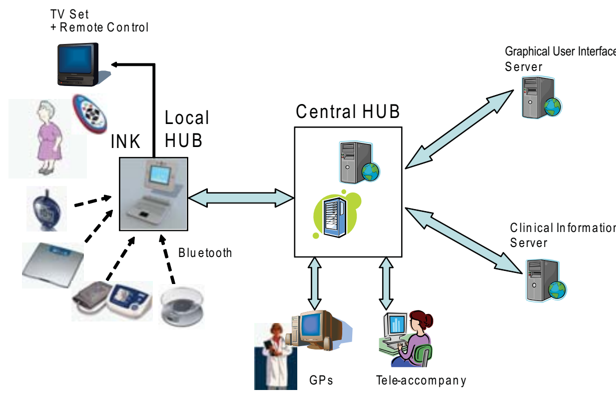

Fig. 1. Oldes architecture

The OLDES architecture consists of two main parts as depicted in Fig.1: *Local Hub* collects physiological data measured by sensors and communication channels implemented by Voice-IP. The information is collected by low-cost INK Laptop and sent via a secured ADSL link to *Central Hub*. Each senior has a health agenda stored in Central Hub. The senior continuously receives social-medical support by medical doctors, social workers and volunteers situated in the call center. Healthy life style is promoted trough an adequate scheduling of thematic entertainment channels. The feasibility of OLDES concept is evaluated under cardiomyopathy and diabetes pilot projects.

OLDES implements the following functionalities:

- Low Cost computer-based system: The elderly persons are provided with a low cost computer based system (the INK computer) which works as the access point for OLDES functionalities and services. The computer is connected to a classic television set which displays all the information provided by the platform by a graphical user interface (GUI).
- Adapted graphical user interface: The graphical user interface is especially designed to meet elderly person usability requirements. Its content is fully dynamic and it is based on web technologies. To select the options and access contents, elderly have an easy to use remote control.
- Tele-health monitoring system: The elderly persons are provided with communicant Bluetooth medical devices. The INK computer installed in elderly person houses automatically collects the data measured by these devices and sends them to a central repository in a secured way.
- Web portal: A web portal which provides interfaces for system administrators, GPs and professionals, discus-

sion groups animators and tele-accompany members.

II. Methodology

Cost efficiency is a major goal of the OLDES project therefore all implemented software in Local and Central Hub is open-source.

A. Local HUB:Home system

This section describes the hardware and software components of the home system located on the left side of Fig. 1.

On the hardware side the home system is composed of: i) a computer based set-top box adapted to elderly persons needs and called the INK computer, ii) an easy-to-use remote control and its receiver iii) an audio handset, iv)a set of medical devices communicating with the INK through Bluetooth or USB interface.

1) INK computer: The INK computer is an x86-based computer built on a VIA C7-M platform produced by Canadian company INK-media. This computer is based on Negroponte's principle: it has low cost ($200US), fanless and diskless operation with no mechanical moving parts, and full-featured while maintaining a small form factor suitable for use as a set-top box. The INK computer operates with a Linux Ubuntu operating system running OLDES software tools.

2) Remote Control: OLDES substituted classical keyboard with a remote controller in order to ease interaction with the system. The main idea of the Infra-Red remote control is to ensure functionality combining features offered by tele-tex (familiar from the standard TV sets) and by a joystick-like navigation system. The Infra-red Remote Control consists of two devices: 1) Remote Control keypad with IR transmitter 2) USB Infra-red Receiver. The first device is a final consumer product Weemote dV manufactured by American vendor Fobis Technologies. The second device is a specific USB dongle with two main competences: a) receive, demodulate and decode infra-red signal b) communicate over USB and emulate a regular keyboard's key presses - see Fig. 2.

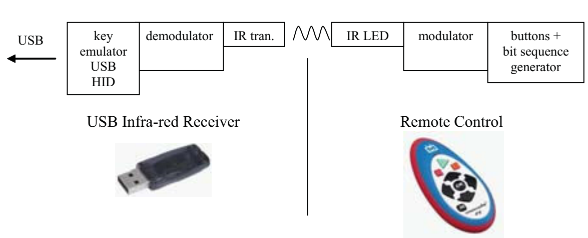

Fig. 2. Remote Controller

USB IR Receiver is implemented in Atmel's ATmega8 microcontroler. IR waveform is sampled by built-in UART peripheral. USB protocol is completely handled by software. The receiver is powered from the bus. No additional software is needed since the USB HID keyboard is a cross-platform spread standard.

3) Medical Devices: We have defined for diabetes pilot project list of patients parameters we have to monitor using medical devices listed in Table I.

TABLE I

Physiological values gathered during diabetes project

Measurement	Producer	Communication
glucose level	Lifescan OneTouch Ultra	Bluetooth
blood pressure	A&D UA-767	Bluetooth
personal weight	A&D UC-321	Bluetooth
food intake	Salter 1016	USB

The selected medical devices are easy to use by an old person and as less invasive as possible. This signifies that the medical devices are based on an easy to use user interface which requires only a few actions from the elderly person to operate properly. Lifescan glucometer doesn't provide an integrated Bluetooth communication interface. To ease device usage by the elderly persons and to ease its integration to OLDES system we developed an smart Bluetooth module, called WAND, which is able to communicate with the glucometer, collect the measurement in its memory and send theses data to the INK computer wirelessly. It has a very simple user interface composed of a simple button. When a measurement is taken, the user has just to press this button to send the data to the INK through Bluetooth.

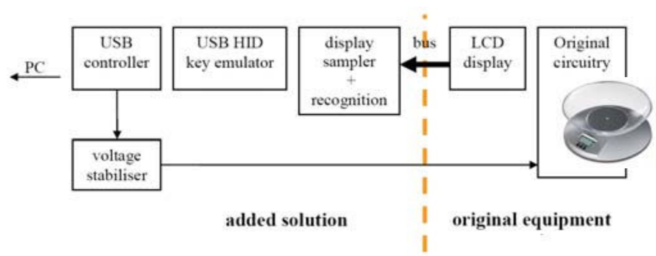

Fig. 3. Kitchen scales implementation

4) Supportive Home Appliances: The diabetes pilot project offers the users a possibility to control their diet, namely the input of their sacharids. The user selects the type of food which is currently on the scales using the remote controller to find out its nutrition values. A kitchen wireless scales based on Salter commercial scales were constructed. Primarily, the scale has no means of transferring measured data to any other electronic device. A custom solution that enables the scale to communicate with a personal computer is based on unidirectional USB connection.

Fig. 3 shows the data flow from scale electronics to the personal computer. Path is fully digital, thus no additional error of measurement occurs. Since the LCD display is used as a gateway to the original circuitry, value presented to user over USB is always the same as the value on the LCD. The accuracy of measurement guaranteed by the manufacturer is not influenced by added electronics.

5) Health Monitoring Software: The high level functionalities of this software tool chain are to collect health data

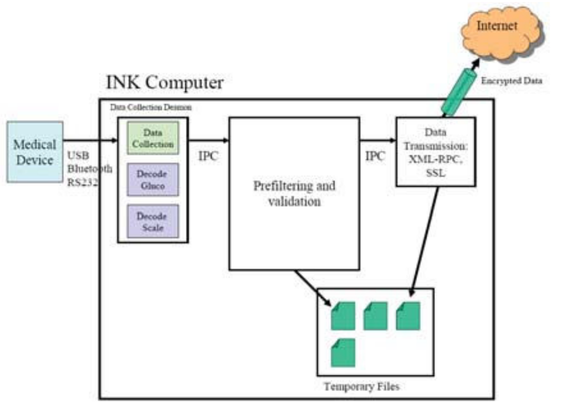

Fig. 4. Health Monitoring Software Architecture

measurements from various medical devices communicating using different technologies (Bluetooth, USB, RS232,), to pre-analyse these data and to send the measurements to OLDES central HUB through a secured encrypted internet connection. These operations don't require any human interaction.

Health Monitoring System is composed of several independent software modules communicating together through inter-process communication channels (IPC) - see Fig. 4. We have efficiently separated the data collection software modules from the data processing and data transmission modules.

Health Monitoring System architecture is basically composed of 3 main software modules:

- Data collection software which is device specific. Indeed, the different medical devices we selected communicate using not compatible data protocols, we need to analyse and decode the received data string. This is done by separate software function symbolised in Fig. 4 by boxes Decode Gluco and Decode Scale. There are as much decoding functions as different medical devices. The decoded data are encoded in a unified protocol and sent to the Prefiltering and Validation software module through an inter-process communication channel (IPC)
- Prefiltering and Validation software. This software module receives the data collected by the data collection software through an IPC and i) analyse the collected measurement data to avoid sending wrong data to the central, ii) ensure INK internal data security by copying the received measurement in INK non-volatile memory to avoid losing measurements if the internet connexion is down and the INK crashes.
- Data Transmission software. This software module sends the measurements to the central system through an SSL encrypted internet connection. It implements the XML-RPC (Remote Procedure Call) Webservice protocol which is a standardised protocol enabling software to transfer structured XML-based data over an HTTP communication.

6) Graphical User Interface Client: The aim of the OLDES project is to provide a complex of new interactive IT tools supporting independent life of seniors. Since all the envisaged tools count upon active involvement of their users, it is clear that the process cannot be reduced to development of novel IT functionalities. It is most important to ensure that the intended users are able (and willing) to access the offered functionalities in a simple way - this is the purpose of the graphical user interface (GUI). The interface is controlled by the remote controller only. The GUI framework is implemented as a standard client-server approach. GUI client, which runs on INKs, connect to a central GUI server to fetch resources and dialog pages. The client is running in web browser and via AJAX communicates with the server. In contrast to traditional web applications, the clients look and behave similarly to desktop applications based on an user-interface toolkit like Java AWT or Swing -see Fig. 5 for examples. The GUI client is written in Javascript and uses SVG (Scalable Vector Graphics) for rendering GUI pages and controls. The look&feel of GUI is configurable by means of skins.

B. Central HUB: call center

This section describes the hardware and software components of the call center located in Fig. 1.

1) Graphical User Interface Server: The server part is implemented in PHP and is responsible for handling client requests and generating GUI pages. Generated pages are sent as XML to the client, where the XML is parsed and the GUI controls are instantiated. The GUI server contains also basic support for content management, representing the content as set of content nodes. The examples of supported content types are welcome screen, menu, article and contact list - see Fig. 5. Each content type is defined in its own PHP generator template; the designed API makes it simple to add new content types.

Fig. 5. Food selection using order list or virtual keyboard

2) Clinical Information Server: This server implements an XMLRPC-based webservice which collects the measurement data sent by the INK computers. When data are received, this webservice inserts them in a centralised data base and sends back an acknowledgement to the INK. This webservice is implemented using standard and open-source technologies like PHP and Apache2 server. All necessary information gathered during clinical pilot is accessible via web clinical portal. Physicians can mainly inspect physiological values and food intake in case of diabetes pilot project - see Fig. 7. The server is implemented using Java Tomcat Servlet container and Apache Struts 1 web application framework.

III. Results and Discussion

A. Diabetes Pilot Project

The main goal of diabetes's pilot is to achieve better compensation of diabetes in hard-to-compensate patients by flexible individualized approach to insulin dose adjustment. The system is developed system for monitoring of physiological functions and self-diagnostics of diabetes in form of advisory system for a patient who is "feeling bad"- this situation is often caused by changes of arterial blood pressure (bad compensated hypertension, hypotension caused by high dose of antihypertensives).

Fig. 6. Example of food intake. Patient must select food item before food scaling using the remote controller

Patients measure its weight once a day, blood pressure three times per day, glucose level three times per day. After the data are transmitted via low cost INK computer to the OLDES central node, the physician can make recommendations of further procedures as acute intervention, eventually modification of chronic medication at home conditions without necessity of stay in the hospital, etc. Another part of OLDES is based on diabetic diet with restricted amount of sacharides and movement activities.

These patients can use interactive scale connected to a computer database of sacharides amount in frequent foodstuff - see Fig. 6. Automatic computation of total daily consumption simplifies patient's control of sacharides intake. The resulting information should be exported to a dietitian who can suggest recommendations for modification of patient's diet - see Fig.7.

IV. CONCLUSIONS AND FUTURE WORKS

The expected results of the project and of the diabetes pilots can be resumed as the following: i) providing an open

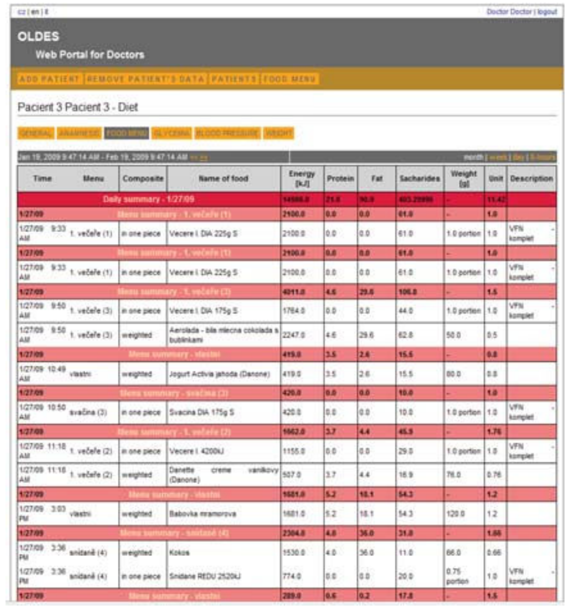

Fig. 7. Example of food daily consumption

service oriented platform allowing a granular management of users and of their authorisations, and an easy connection of new services by public, private or non-profit service providers; ii) providing a set of protocols for accessing existing services; iii) provide a low cost home access point allowing to access the services and to efficiently manage chronic diseases as diabetes applying vital physiological signals monitoring.

Acknowledgment

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