Infocommunication Research – Development Innovative IT solution in the service of home and clinical care

Attila Zsiros, András Fehér, Humansoft Kft.,
Gábor Élő Dr., Széchényi István University

With the development of IT and telecommunication technologies, new opportunities have been emerged based on which solutions with significant economic and social effects can be searched and developed. In professional medicine, Ambient Assisted Living (AAL) supported with IT devices has gained a more prevalent role in healthcare which may support the attendance of chronic patients in addition to prevention and patient monitoring. Special healthcare services can emerge which meet the expectations of patients and those of their nurses and physicians aimed at maintaining their life standards and quality of life. Additionally, economic savings may be achieved through increasing efficiency, rationalizing the processes and differentiating the workflow. We will introduce an IT-mechatronic environment suitable to be used for chronic patient care, with the help of which we can have an insight into the current state of technology and preview the future opportunities and the benefits thereof.

INTRODUCTION

In the world of the 21st century affected by globalization and in the business life which has become faster than ever before, the role of IT has gained strength; its economic and social impacts have grown significantly. In recent years, we have witnessed an extraordinary development in the fields of the IT and the telecommunications (ITC) market, and this trend seems to prevail these days as well. Technologies attempt to satisfy nearly all areas of business life, thus generating enormous competition and growing sets of requirements.

AAL and IT in medicine

In the application of IT in medicine, there are some healthcare-related areas where new opportunities are offered as a result of the development in IT, for example, the equipment which supports patient monitoring at home or in the institution, chronic patient care, therapy follow-up – support, replacing disabilities with IT equipment, and conscious prevention, health preservation and support of development. A highlighted area of AAL solutions is to develop IT devices which support diagnostics and nursing at home. We wish to introduce an innovative solution related to this topic which is intensively researched these days. The primary purpose of this solution is to provide an integrated mechatronic and IT environment for the home care of chronic child patients.

Monitoring at home, diagnostics and therapy follow-up

The ever growing requirements for home treatment, monitoring and therapy follow-up have become possible owing to the tendencies based on which

- patients are seen as interactive actors with personal responsibility who are interested in their own recovery;
- two-way flow of information is assumed between the patient and the physician/nurse;
- the scene of medical care is not a specialized institutional environment, but the natural home environment under remote monitoring.

AAL solutions have medical and economic advantages as well. One of the economic aspects which must be emphasized is increased efficiency which ensures the quick availability of information and the processing thereof, due to the improvement of speed, scheduling, storage and retrieval of processes. Thanks to them, preventive or urgent interventions can become faster which, in return, may impact significantly the condition of a patient. By being able to plan the costs better, scheduling the work of the physicians and nurses can be more effective and balanced.

Medical aspects of introducing AAL solutions into home care include the improvement in service level and the differentiation in services which have an impact on the effectiveness of therapy. Healthcare services which better fit the expectations and life style of the patients are aimed directly at restoring or improving the quality of life. Due to such solutions, patients can be diagnosed more accurately following the professional principle of Evidence Based Medicine – EBM, an increased amount of more accurate data can be collected, sorted out and made available. If the additional costs of AAL solutions are in line with the improvement of medical efficiency, then it is recommended for the patient, the family or for the community bearing the costs of treatment to choose this solution, that is, we experience a positive impact on efficiency.

With regard to chronic illnesses, additional expenses can be avoided due to the fact that the hotel service to be provided directly by the healthcare institution becomes shorter. By using the functions of reliable homecare equipment enforcing healthcare protocols, the time of the active, productive population spent with work can be increased. With the appropriate AAL equipment, we can enforce the more exact observance of the physicians' instructions (increasing compliance), which have an impact in increasing efficiency. The solutions developed in our project serve to measure patient participation and the development of cooperation,

and to provide information for a treatment under EBM principles, which makes appropriate diagnosis and intervention during treatment possible. Additionally, comfort considerations necessary to improve the quality of life have also been emphasized, that is, the devices must have the capability to be well integrated in the treatment process and in the family lifestyle as well.

IT AND MECHATRONIC SYSTEM FOR THERAPY FOLLOW- UP AND MONITORING AT HOME

Principles

The following items are some of the basic IT and technical principles for the system to be developed:

- portability: each device must be easy to install in a home environment; the system must become functional with the least possible effort. Additionally, if we avoid using cables, portability can be improved, and as a result, it is easier for the patient to live in an environment with these devices and the patient is less limited.
- scalability: the system can be easily extended using new devices which is increasingly important for being used in institutions. Besides, it can be extended with new measurement procedures, examination and nursing protocols without modifying the central core system and through support from the functions thereof.
- easy-to-use user interface for the patient: it is easy for the patient to learn how to use the equipment. More complex functions should be handled by nursing/medical/ IT professional personnel.
- standardization: individual parts of the system must be capable of cooperating with each other and with other equipment and systems as specified in IT communication standards. This also facilitates the expandability of the system.
- information security: the personal data, health condition information and reports of the patient must be stored appropriately, in accordance with information security principles and legal provisions.
- support for professional medical protocols: the implemented system of equipment and processes must be supported by professional medical protocols backed by medical profession. The implemented system of equipment and processes must result in the highest possible level of health profit for patients.
- integrated system: each part (sensors, data storages, servers etc.) must be an organic component of the whole, showing the users (patients, nurses, physicians, etc.) a unified user interface and mode of operation in accordance with consistent principles. The implemented system which is in line with the above basic principles can be considered as the highest possible standards of current technology, as an applied research and experimental development [1].

Intelligent devices

The general purpose of the project (Tender ID: INF-CARE8) is to develop an AAL solution which serves the professional medical and economic aspects while following the principles mentioned above, and to create an opportunity for a more pleasant a humane way of life.

The main target group of the developed mechatronic-IT system is that of the chronic child patients suffering from epilepsy.

The reasons behind this are as follows:

- in European societies, the topics related to children with diseases have great sensitivity (and evoke sensitive sociological reactions), thus generating new healthcare financing models and special health insurance systems;
- patient care tends to shift towards transparent, accountable, technology-based approach, eliminating the subjective and objective disadvantages of the currently used procedure (e.g. human errors, time limitation);
- a larger and larger percentage of parents with diseased children seeks services with which the lifestyle and the quality of life can be maintained and ensured.
- the solution can be easily extended to other target groups, since it provides a high-level solution for the problem.

The system consists of five main components: video monitoring system, intelligent patient bed modules, mobile diagnostics cap unit, central controlling software system, and back office subsystem.

The video monitoring system is aimed to assist the so called long term type diagnostics. Patients suffering from epilepsy must be monitored 24 hours a day to complement the data continuously measured by the devices. Patients are monitored by personal presence and by keeping a diary or by being monitored by video in a special room. In order to replace this system, we prepared a camera unit which

- is portable and can be set up anywhere,
- is digital and records in several frequency ranges (visible and infra) in a parallel manner,
- monitors patients in their natural living environment,
- can be handled and operated in a simple manner.

This compact device is connected to a software base system which makes it possible to extract and further process data.

The mobile diagnostic cap unit is a device supporting long term EEG examination with the help of which nightly sleeps can be registered in their entirety, and sleep deprivation can be eliminated. Data provided by the built-in electrodes can be written for 24 hours onto the local data storage of the cap unit. The device is fully portable; it can also be used in a home and institutional environment. By eliminating most of the cables and creating an appropriate design, we developed a device which has higher standards than the current devices from the aspect of comfort. With this small-sized, compact and helmet-like unit, patients can be examined in their natural environment.

The intelligent patient bed is identical to a traditional sickbed, but it is extended with functions which can serve both comfort and professional medical purposes. The modules developed in the framework of this project are designed to support monitored storage and administration of medicine, communication between patients, physicians and nurses, and entertainment. The intelligent medicine distributor ensures a more effective regulation and monitoring of the administration of patients' medicine. Following the alarms for administration or alarms related to a missed administration, the medicament which is not administered in the appropriate time interval may be locked up. The distributor has six different trays which are controlled automatically through the central software system. Trays are oppened in a scheduled manner periodically every day. The removable trays can be refilled by a central medicine distribution system which makes the process economic as well as secure.

Among the intelligent patient bed modules, the integrated nurse calling module and the communication module should be emphasized. Thanks to a motion sensor, the patients can call the nurses by just moving their hands towards the terminals. Bi-directional voice communication can be initiated with the patient using the fixed terminals located on the nurses' counter or using mobile devices (notebooks, smart phones, tablets etc.), and the image of the patient can also be seen through the integrated camera.

The back office system is designated to store the recorded data of the above mentioned subsystems and sensors. Regular usage of video monitoring, the mobile cap unit and the audio, video and EEG signals in the case of the communication module can generate a large volume of data which must be stored and categorized in a separate professional subsystem.

CENTRAL SOFTWARE SUBSYSTEM

The central base system is, in fact, a component consisting of one or more computer servers, which controls and connects all other parts of the system, creating integration between them, thus creating a coherent, unified entity (see Figure 1.). The server provides the following services among others:

- contacting each device and providing a two-way data flow if necessary (e.g. voice calls of the communication system between the patient and the nurse),
- submitting information (e.g. calls from patients) to users (nurses, physicians and patients), and receiving information related to controlling (e.g. schedule to open the medicine distribution boxes),
- ensuring integration with external systems (e.g. IKIR).

The above mentioned services can be implemented with the following main software components:

- maintaining the connectivity between the devices and integration with the external systems are ensured by a MiddleWare framework system based on Microsoft BizTalk [2]. This can be expanded with a media server to use a more developed patient-nurse-physician communication system with better scalability.
- the user interface is provided by the FrontEnd component which is a web application based on ASP .NET technology.

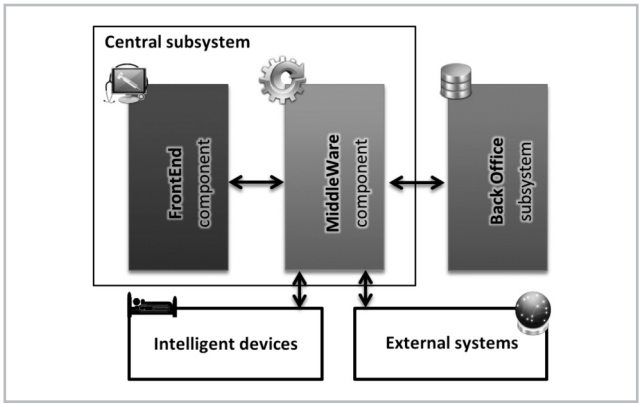

Figure 1
Schematic drawing of system architecture

In selecting the technologies to be the foundations of the software system not only modernity, innovative development and vision were considered, but the reliability, popularity, platform independence, vendor support, opportunities for further development and the practical experience of the available developer team as well. Although the devices and expectations related to function and integration were diverse, we tried to achieve technological homogeneity as well.

Basic features of the FrontEnd are authentication and access right functions. The primary user group, that is, physicians, nurses and system operators can be extended to patients as well. One advantage of the solution is that the FrontEnd subsystem provides a thin client architecture, which means that users don't have to install any type of software onto their computers or smart phones.

Patients' calling system indicates the call signals on all terminals at the same time with a popup warning notification. We wanted to use the most recent technologies and development techniques for this development effort; and as a result, patients' calling system was prepared using the JavaScript-based Comet [3] method. The communication module conveys a camera image and voice from the patient to more terminals if necessary, therefore, patients and nurses can contact the patient at the very same time (see Figure 2.). It is possible to send voice messages with push-to-talk, by pressing one single button. Since it is desired to be displayed in more and more versatile mobile and fixed platforms, communication through a media server is a part of this integrated solution. In addition to improving the scalability of the system, there is an opportunity to archive and replay the recordings as well. On the client, that is the user side, Flash technology ensures the most versatile platform support, but with the development of HTML5, there is a new way to build

Figure 2
The FrontEnd interface

a truly platform independent video and audio connectivity. Summarizing, the MiddleWare system is an intermediary subsystem which serves the FrontEnd, stores and calls data from the back office background component, and ensures connectivity with intelligent devices, sensors and external systems (e.g. PACS, IKIR etc.). In fact, this is the component where the logical operation and business intelligence is carried out to make the system integrated, and create consistent management from the standpoint of professional medicine and IT/communication [2]. The applied Enterprise Service Bus (ESB) technology and framework provides an expressly robust, reliable, secure and scalable system. Since the services are available through the FrontEnd using simple internet connection, only the intelligent devices must be placed in the home of the patient.

CONCLUSION

As the product of the INFCARE8 project, an innovative AAL solution was prepared which advances diagnostics, therapy follow-up and patient monitoring activities in chronic patient care both in a home and institutional environment. We wished to increase the efficiency and rationalization of care from an economic standpoint, and we wanted to achieve results in improving the quality of life and service level from a medical and human standpoint. Functionalities and capabilities of the prototype of the mechatronic and IT system developed by us wanted to leverage today's technical developments. Based on the developed system, it can be stated that the achievements are encouraging as far as practical usability, operational reliability and potentially decreased costs are concerned. With the development of IT, capabilities, reliability and price point of similar AAL devices will improve significantly, creating an opportunity for a more livable and humane life.

The development has been implemented with the support of the National Development Agency (Tender ID: INFCARE8).

LITERATURE

[1] University of Texas M. D. Anderson Cancer Center (2007): Cancer Center Saves Time and Money, Improves Care with Medical Record Solution, Case Study, http://www.microsoft.com/casestudies/Case_Study_Detail.aspx?CaseStudyID=4000000916

[2] Sarkar, M., Shaurya, V. (2009): Microsoft BizTalk Server – Making the Right Choice for Enterprise Integration, Infosys Whitepaper, http://download.microsoft.com/download/B/8/6/B86658A-A1A5-4116-9932CCD7D7638FAE/MicrosoftBizTalk_INFOSYSResearch%20Paper.pdf

[3] Crane, Dave; McCarthy, Phil (2008): Comet and Reverse Ajax: The Next-Generation Ajax 2.0. Apress. ISBN 978-1590599983.