Telemon – Romanian Experience for Real Time Telemonitoring of Chronic Patients and Elderly People

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Abstract — This paper presents a project that has as main goal researches, design and implementation of an electronic-informatics-telecom and scalable system, that will allow the automatic and complex telemonitoring, everywhere and every time (at home, in hospitals, at work, of mobile subject, etc., using several communication paths), in real time, of persons with chronic illnesses, of elderly people, of those having high medical risk and of those with neuro-locomotor disabilities. The complexity of the system is also proven by the multitude of physical monitored features: electrophysiological (vital) signs, signals for domotics (home surveillance, access control in a certain area), as well as by the automatic image analysis of the movements of the subjects. Also, the system will allow automatic generation of different alarms, specific to the health problems of patient.

Keywords: e-Health, Telemonitoring, Embedded Systems, (Bio)Signal Processing

I. Introduction

Telemedicine is part of the expanding use of communications technology in health care being used in prevention, disease management, home health care, long-term care, emergency medicine, and other applications. In Romania, the diversification of telecommunication networks and advances in communications technologies, including the Internet, has considerable potential as a medium for telemedicine applications. In this context, the University of Medicine and Pharmacy "Gr. T. Popa" / Faculty of Medical Bioengineering of Iasi is the co-coordinator of the TELEMON project, in collaboration with the Technical University, the "Al.I. Cuza" University and Romsoft SRL, a private company, all from Iasi, Romania.

The proposed project enables to design a secure multimedia transmission (medical telemetry, digital images, video, and text) and a secure medical records acquisition system in order to enhance the telemedical consultancy services. The main objective of this project is to enable *personalized teleservices delivery and patient safety enhancement* based on an earlier diagnosis with medical telemetry using and images, video, text transmissions, and also applying the suitable treatment according to the remote medical experts' recommendations [Cos06].

Our project represents an answer to the challenges of the society, also is approaching a thematic priority of the Frame Programme 7 of the EU ("informatics systems for public services"), and its implementation will allow persons having different (chronic) diseases and to elderly/lonely people to be monitored from medical point of view [EC]. In this way the medical risks and accidents will be diminished. The final product – the TELEMON system – will act as a pilot project destined to the implementation of a *public e-health service,* "everywhere and every time", *in real time*, for people being in different hospitals, at home, at work, during the holidays, on the street etc.

II. The basic structure of telemon system

The main objective of this project is the achievement of an integrated system, mainly composed by the following components that are near patient (Figure 1): a personal network of wireless transducers (RPT) on the ill person, a network of transducers/actuators for domotics, a data multiplexing block and a personal computer (PC). After local signal or image processing, according to the specific monitored feature, the salient data are transmitted via one of internet, GSM/GPRS or a telephonic line to the database server of the Regional Telemonitoring Centre. The personal network of transducers (RPT) includes a medical device for vital signs (ECG, heart rate, arterial pressure, oxygen saturation, body temperature), a movement sensor, eventually a respiration one, all these components having radio micro-transmitters, which allows an autonomic movement of the subject. The project will also approach the situation of the mobile subject. In this case the patient will have the personal network of transducers, the data processing will be done by a PDA (Personal Digital Assistant) having GPS localization, and data transmission will be obtained by using GSM / 3G module of the PDA. Concerning the application programs, they will act and correlate on two levels: a local data processing, near the patient, as well as another one database

server. So, the general software architecture will be a client-server one, and the project will develop a so-called SOA – *Service Oriented Architecture* [Bur][Mor]. The results of data processing will be in principal and if necessary different locally generated alarms, and transmitted to the central server, to the family or specialist doctor, to the ambulance or to a hospital. Other results of locally or on server data processing will be different medical statistics, necessary for the evaluation of health status of the subject, for her/his therapeutic plan and for the healthcare entities.

The TELEMON system will include the following hardware and software components.

A. ***A local sub-system***, composed by:

(1) *a personal network of wireless medical sensors / transducers* (RPT) for vital signs (ECG, heart rate, arterial pressure, oxygen saturation, body temperature), a movement transducer (accelerometer), a respiration one, all these having radio micro-transmitters [Bon], [Shn], [Wel]; for monitoring of the glicemic level, a non-invasive glicometer will be acquired;

(2) *a network of sensors / transducers/actuators* for domotics and audio *communication* patient – caregiver [Geh], [Gia], [Sho];

(3) *a video camera*;

(4) *a personal* computer, interfaced by radio with the above sub-systems;

(5) *for mobile subject* the data processing will be done by a PDA interfaced with the personal network, and data transmission will be done by GSM/GPRS/UMTS and GPS modules of the PDA;

(6) *a local network of „ad hoc" type*, composed by mini-computing units with radio transmission of data and necessary to cover a specific surface [Fre], [Wat].

B. A ***server*** computer for the **main database** and other applications programs, situated at the Regional Telemonitoring Centre (CTMR).

C. A ***server*** computer for tele–diagnosis (*on-line consultation*) and tele–consulting (*off-line*), where a video–conference program will be installed (also useful to organize a *webinar*).

D. ***Applications Programmes for***:

(1) medical data *acquisition and processing, domotics signals analysis, patient images analysis* [Cos04], data *transmission to* central server;

(2) *the same functions as above, but for mobile patient*;

(3) interface programmes for duplex *communication* between local *sub-system and central server*;

(4) *specific alarms generating and their* transmission to the Ambulance, family doctor, to the specialist or to a nurse; here there are necessary *decision aided /expert* systems based on medical specific knowledge [Dis], [Ohn];

(5) specific *applications of e-rehabilitation and e-learning* (at least 4);

(6) extra-data *processing programmes, at the central server level* (medical statistics, researches, etc.)

E. ***Programmes for data/knowledge bases*** (including user-interfaces) installed on the server.

F. A program for the informatics *management* of the system, also installed on server.

Besides the medical and technical objectives, TELEMON project also proposes ***economic objectives***:

- *the decreasing of budgetary and personal expenses* dealing with the un-justified transport of patients to the hospital;
- „zero costs" for *the hospitalization* of patients who may be treated at home.

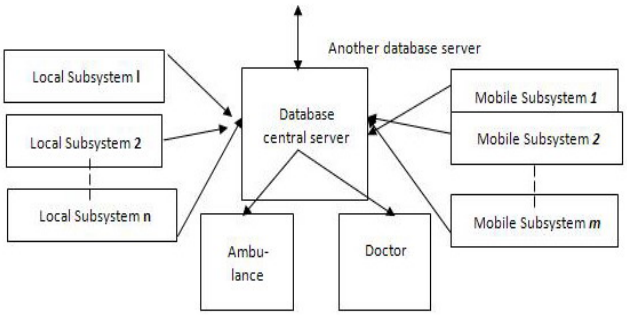

Figure 1. The basic structure of TELEMON system

The TELEMON system (Figure 1) is built around a database server which receives data from local subsystems *1*... *n* and also from mobile subsystems. The transferred information to database server are represented by those data above the limits and they are formed by medical recordings and also by audio/video recordings.

The database server stores the recordings and it is capable to send alarms to the ambulance service and patient's doctor. Also, the database server can be connected to another database server, for example a hospital server, in order to send the patient's medical parameters and recordings. The subsystems are connected to the database server through an Internet connection (if it is available), through GSM or a telephone line (dial up). So, the database server has to be connected to the Internet and also be equipped with GSM and dial-up modems.

The *Local Subsystem* for the home monitoring of the patient (Figure 2) is built around a personal computer (PC) which receives data from the patient. The data are provided by a personal sensors/transducers network in form of medical parameters such as ECG, SpO_2, blood pressure, body temperature a.s.o. [Tia]. The outputs of the network are connected to a radio module that sends the data to the PC. A very important feature of the network and also of the radio module is their low power consumption. Another component of a local subsystem is the sensors/actuators for domotics. The domotics sensors collect data from different points of the house sends them to the PC. The PC takes the decisions and sends commands to the actuators such as: light adjustment by controlling the windows, by controlling the patient access at doors level, by controlling the room's temperature, by controlling the audio-video receivers a.s.o. The Local Subsystem allows the video monitoring of the patient through a video camera connected to the PC. The PC records and stores images of the patient during the acquisition of the

medical parameters, process these images and can send to the database server images and also processing results (e.g., alarms). The PC is equipped with a radio module that receives data from the patient's personal network, runs the monitoring algorithms, activates the alarms if the medical parameters are above the limits and sends the results to the database server. The PC is connected to the database server through an Internet, GSM or dial up connection. The same personal network is connected to a Personal Digital Assistant (PDA) through an interface module. The PDA runs the monitoring algorithms and sends the results to the database server by using the GSM connection. In the case when the patient is in a bad condition and he/she needs an emergency medical assistance, the PDA can send to a database server and from here to ambulance service the precise coordinates of the patient by using the internal GPS module. As to the medical wireless devices, we use some monitor units that can measure 3-channel ECG, cardiac rhythm, arterial pressure, respiratory rhythm, oxygen saturation and body temperature. They are connected with the telemedical centre via a radio interface having USB output and a radio interface with the fixed telephonic network [Har], [Lor].

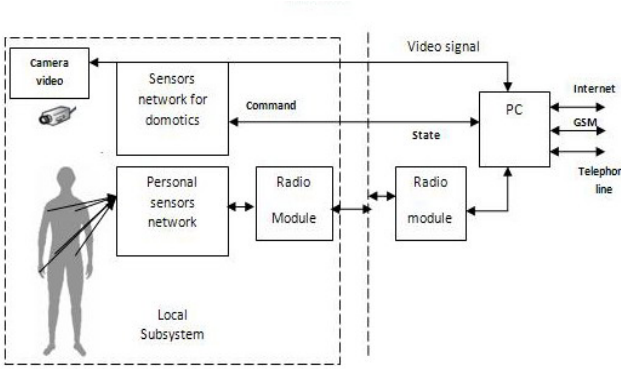

Figure 2. The local subsystem for home monitoring of the patient

III. CONCLUSIONS

In this paper it was presented the TELEMON project that aims to develop a secure multimedia system designed for medical consultation teleservices. The main goal is to build a complete pilot system that will connect several local telecenters into a regional telemedicine network. This network will enable the implementation of complex medical teleservices (teleconsultation, telemonitoring, homecare, urgency medicine, etc.) for a broader range of patients and medical professionals, mainly for family doctors and those people living in rural or isolated regions. Thus, a multimedia, scalable network, based on modern IT&C paradigms, will result. The regional telecenter in Iasi will allow local connection of hospitals, diagnostic and treatment centers, as well as a local network of family doctors, patients, and even educational entities. As communications infrastructure, we aim to develop a combined fix-mobile-internet (broadband) links.

As a first step *we have implemented and tested teleconsultation and telemonitoring applications for ECG signal.* (www.telmes.ro)

Such a regional telecenter will be a support for the developing of a regional medical database, that should serve for a complex range of teleservices such as teleradiology, telepathology, teleconsulting, telediagnosis, telemonitoring. It should also be a center for continuous training tasks, by tele-learning for medical personal or for informing/education of patients.

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REFERENCES

[Bon] P. Bonato, et al. Data mining of motor patterns recorded with wearable technology. IEEE *Eng Med Biol Mag.*, 22(3), May-June 2003.

[Bur] S. Buraga, XML Technologies, Polirom Publ. House, Iasi, 2006 – ISBN 973-46-0249-7

[Cos04] H. Costin, Cr. Rotariu: Processing and Analysis of Digital Images. Applications in Biomedical Imagistics, Tehnica-Info Publ. House, Kishinev, Rep. Moldova, 441 pp., 2004, ISBN 9975-63-196-7.

[Cos06] H. Costin, et al., "A multimedia Telemonitoring Network for Healthcare", Enformatika, Transactions on Engineering, Computing and Technology, Vol. 17, 2006, Cairo, pp. 113-118.

[Dis] E. Dishman. Inventing wellness systems for aging in place. *IEEE Computer*, 37(5), 2004.

[EC] European Commission, IST Directorate General, Resource book of *e*Health projects, Sixth Research and Development Framework Programme, 2006.

[Fre] http://www.freescale.com, Zigbee Technology from Freescale

[Geh] GE Healthcare. Corometrics 340M–Telemetry ambulatory monitoring during labor; gehealthcare.com/usen/perinatal/mat_fetal_mon/products/

[Gia] D.Giansanti, *et al*, Is It Feasible to Reconstruct Body Segment 3-D Position and Orientation Using Accelerometric Data? *IEEE Trans. BME* 50(4), 2003

[Har] http://www.eecs.harvard.edu/~mdw/proj/codeblue

[Lor] K. Lorincz,*et al*., "Sensor Networks for Emergency Response: Challenges and Opportunities," *IEEE Pervasive Computing*,16-23,oct.-dec.2004

[Mor] Morancea Octavia, Purdel Anca, Srbin L., Djan M. – „A Technical Students View Regarding the Development of Health Informatics Projects and Multidisciplinary Cooperation" – Proceedings of the European Federation for Medical Informatics, Special Topic Conference, June 2007, Brijuni, Croatia, ISBN 978-1-58603-763-5, pp 68-70.

[Ohn]L.Ohno-Machado *et al*. SMART: Scalable Medical Alert Response Tech., http://smart.csail.mit.edu/

[Sho] Shorey R., Mobile, Wireless and Sensor Network: Technology, Applications and Future Directions, Ed. Wiley, 2006

[Shn] Victor Shnayder, *et al.*, Sensor Networks for Medical Care, *Tech. Report TR-08-05,* Division of Eng. and Applied Sciences, Harvard University, 2005.

[Tia] Tia Gao, *et al*., Vital Signs Monitoring and Patient Tracking Over a Wireless Network, *Proc. 27th Conf. IEEE EMBS*, Shanghai, Sept. 2005.

[Wel] Welch A., Micropaq Wireless Patient Monitor. http://www.monitoring.welchallyn.com/products/wireless

[Wat] Wattenhofer R., (2005), *Algorithms for ad hoc and sensor networks*, Comp.Comm.,28, p.1498-1504