PatRis – Software Tool Applicable in Monitoring Systems for Patients at Risk

Mariana Dimitrova Manoeva, Serafim Dimitrov Tabakov and Ivo Tsvetanov Iliev

Abstract – **The new wireless technologies for tele-care give new possibilities for monitoring of vital parameters of risk patients, especially for patients with cardio vascular disease. The use of telecommunications for remote diagnosis is growing rapidly, and there are several products and projects within mobile ECG recording using Internet solutions, Bluetooth technology, cellular phones, WAP-based implementations and wireless local area networks, WLAN. A remote diagnosis systems integrating digital telemetry consist of wireless patient module, intermediate stations (access points) and central station (server). A software solution (Patient at Risk - PatRis), applicable in tele-monitoring systems is proposed in this paper. PatRis combines the advantages of appropriate drivers for data flow control between access points and server with user-friendly interface, visualization capabilities and database management.**

Keywords – **Wireless ECG, Telemedicine**

I. Introduction

In the last years, the cardiovascular disease (CVD) has become one of the most critical chronic diseases in many countries. Therefore, many cohort studies on cardiovascular disease aim to find the interplay risk factors and to build an assessment model based on such factors. For example, the absolute risk of cardiovascular disease in any individual is determined by a complex interplay of several factors, of which age, sex, smoking status, blood pressure, and serum concentrations of total cholesterol (TC), high density of lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol are the more important. In order to provide proper healthcare services and timely handle an emergency for the patients with CVD, it is indeed necessary to monitor their physiological parameters over a long period. Furthermore, some abnormal symptoms for the heart, such as congestive heart failure (CHF), myocardial infarction, arrhythmia, ventricular fibrillation, etc., are often the major cause of sudden death in chronic patients with CVD if the symptoms cannot be discovered in time.

Hence, to continuously monitor the electrocardiogram (ECG) signal, it is very important to diagnose CVD and to detect abnormal conditions or symptoms in the early stage and is helpful to analyze and keep tracks of the patients' health conditions, and to promptly provide an emergent care service at the critical moment ([1, 2]).

In recent years, due to the rapid development of information and communication technology (ICT), the feasibility of tele-health care conception [3] has been highly raised. Many physiological monitoring systems for tele-health care and pervasive health care applications had been widely investigated. This includes ECG monitoring and transmission using cable television (CATV) network [4] or over the Internet [5, 6], personal health monitoring by wearable or portable devices [7]. Other decisions used clothing-embedded transducers and wireless physiological monitoring systems based on existing mobile communication technologies such as wireless application protocol (WAP) [8], wireless local area network (WLAN) [9], and global system for mobile communications (GSM)/general packet radio service (GPRS) [10], or over emerging ad-hoc wireless networks or sensor networks [11]. From these literature data, there is a general tendency for healthcare monitoring systems to integrate wireless mobile communication network technology to provide more freedom, portability, and convenience to patients, especially in applications for indoor environment such as hospitals.

At present, the commonly used approach of home and hospital-based health care monitoring systems is as follows. The patients' physiological information is acquired by wireless physiological parameter acquisition devices (personal analyzers) attached on their body, and is then transmitted to a remote central management unit (such as a care server setup in the healthcare center or the hospital) for storing, long-term monitoring and analysis by medical and health care professionals via WLAN. However, in indoor environments, the signal strength of access points in WLAN can be weakened by 30–90% as it passes through doors, walls and windows depending on the material and construction employed. Thus, the coverage area of WLAN will be reduced and subsequently lead to a dead spot that will cause a communication disconnection between the mobile-care device and WLAN [12, 13]. The patient's critical physiological information may thus be lost at that time. To remedy the defect, the number of access points can be increased, however, resulting in a higher initial cost.

M. Manoeva is with the Department of Electronics and Electronics Technologies, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: manoeva@abv.bg

S. Tabakov is with the Department of Electronics and Electronics Technologies, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: savi@ecad.tu-sofia.bg

I. Iliev is with the Department of Electronics and Electronics Technologies, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: izi@tu-sofia.bg

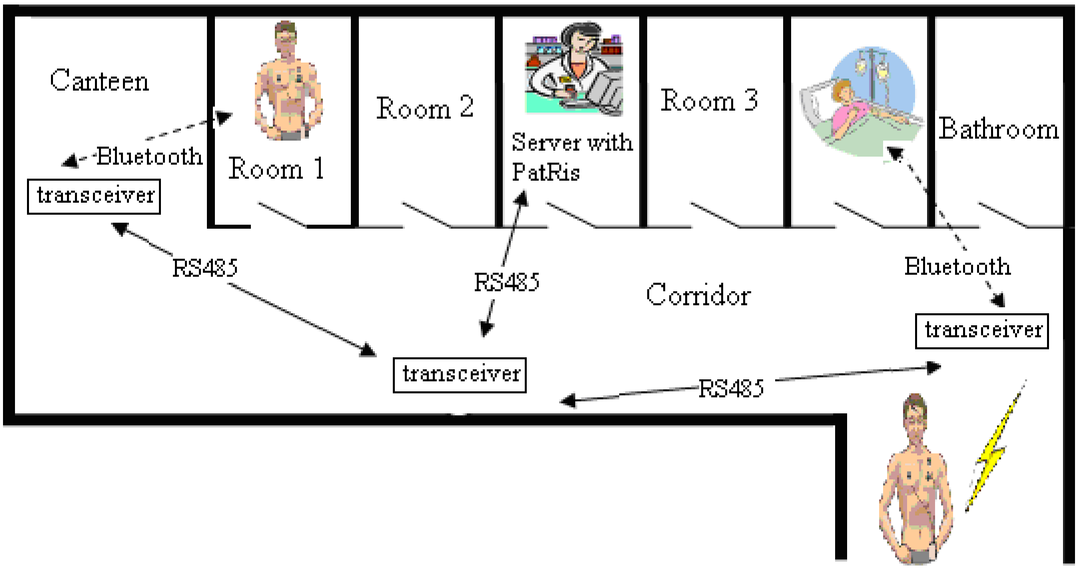

Fig. 1. Heterogeneous (wire/wireless) system configuration for telemetric monitoring of high-risk patients

Therefore, the wireless sensor network (WSN) technology [14] with the main features of low-cost sensor nodes for dense deployment in a specified and interested field and self-organizing as an ad-hoc network and with the capability of multi-hop data relaying is taken into consideration [15].

In [16] Iliev proposed an approach to overcome of above mentioned problems by usage of heterogeneous data transmission configuration, combining the capabilities of wireless (Bluetooth) and wired (RS485) interfaces. The base configuration of the system is given in fig. 1. In this paper we proposed a software tool, named PatRis (Patients at Risk), applicable in monitoring systems for telemetric observation of high-risk patients with cardio-vascular diseases. The system differentiates with the following factors:

- In-hospital application with possibility for simultaneously monitoring of up to 16 patients;
- Real time data analysis and alarm activation if dangerous conditions (tachycardia, bradycardia, 10 exclusive beat contractions appeared in a time interval of 30s) were recognized;
- Data transfer in pre-selected period (5 min, 15 min, 30 min, 60 min) – acquiring, storing and visualization of 10s ECG epoch;
- On-demand function – allows to receive and visualize of 10s ECG epoch at any time;
- Data Base management.

II. Method and Software Implementation

Short description of the methodology and the sequence of processing branches implemented in the computer-based telemetric system with embedded specialized software PatRis, is described bellow.

Preprocessing

All activities relating to: ECG registration, data processing, abnormalities recognition, alarm decisions, etc. are concentrated at the personal analyzer. It works, based on processing of one channel ECG signal sampled at 250Hz.

PatRis features

The software application PatRis (Visual Basic) is running under Windows with the following PC resource requirements:

Processor - Inter Core 2 Duo E5200 2.5GHz MotherBoard - LGA775, supporting Intel Core 2, Front Side Bus 1333MHz, Hyper-Threading Technology, EM64T supports Dual-channel DDR2 1066/800, Max. 8GBExpansion Slots2 x PCI-E x16, @ x16, x4, SerialATA II (3.0Gb/s) shared with ATA 133/Ultra DMA Mode 61 x floppy connector, up to 2 FDD, 1 x WiFi x HDMI_S/PDIF header AC'97 audio codec, LAN- Speed: 1000 Ethernet, Rear Panel I/O Ports1, PS2, Mouse 2 x USB 2.0, 1 x Parallel1 x Serial1 x eSATA II1 x RJ451 x 1x in/Front Speaker/Microphone", ACPI 1.1, Form FactorATX
RAM- 4GB DDR2 800MHz
HDD - 640GB Sata
Optical - DVDRW 22X Sata
Videocard - nVidia 9500GT 512MB
Monitor - TFT 22"(55.9cm)
Mouse - Turbo-X by Microsoft
Keyboard - Turbo-X New Design USB

The main function of PatRis is data control of transfer in mixed (wire/wireless) net. For this purpose, specialized drivers, are developed. A standard protocol S0-S9 was used. The bit configuration is presented in fig. 2.

S0 - Begin trasmit

Len	DevFrom	DevTo	Event/Command	Time	CS

S1 - Data From/To Device

Len	DevFrom	DevTo	Data	CS

S9 - End transmit

Len	DevFrom	DevTo	Data	CS

Fig. 2. S0-S9 bit configuration

S0 - Transmit header

- **Len**: 1 byte data lenght + Check Summ
- **DevFrom**: Transmiter ID
- **DevTo**: Reciver ID
- **Event/Command:** Event or Command
- **Time**: datatimestamp of transmiting data, format:HHMMSSDDMMYY.
- **CS:** Check Summ (0–EXOR of data + data length)

Note: All data in string are ASCII coded, e.g. 1 byte is represented using 2 ACSCII codes.

S1 - Data From/To Device

- **Len**: 1 byte data lenght + Check Summ
- **DevFrom**: Transmiter ID
- **DevTo**: Reciver ID
- **Data**: ECG Data
- **CS:** Check Summ (0–EXOR of data + data length)

S9 – End of data exchange for given caleder time

Len, DevFrom, **DevTo, Data, CS** – like S0-S1. When ECG device transmits data in **Data** field is a HR value for the current 30 sec ECG sequence.

PatRis components

Embedded module for personal records of service (fig. 3) - contains personal data for patients: name; family; age; sex; insurance number; contact person; etc., data relating to the health procedures carried out at the hospital (health status, period of monitoring, doctors name, etc.).

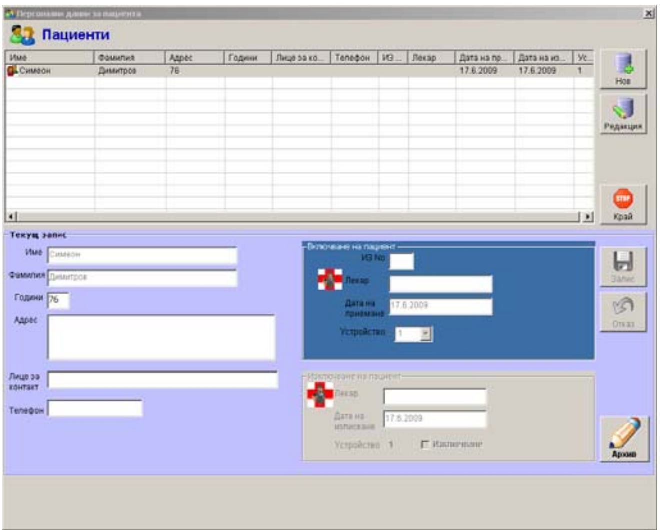

Fig. 3. *Module for personal records of service*

Embedded module for system status and patient alarms – is the system's base window (fig. 4). The active ECG modules (attached to corresponding patient), and current condition of the selected patient are presented on the screen. There is possibility for manual adjustment of the period for data collection, independently of patient status. A considerable system's advantage is the option "on demand". This option allows the doctor to receive data at any time (pressing virtual button 10 sec ECG).

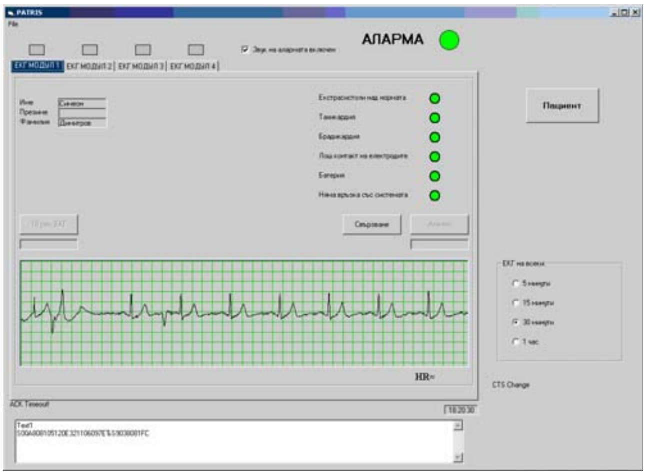

Fig. 4. Module for system status and patient alarms

Embedded module for data base management – combines a function for personal records service with visualization of records for selected patients (fig. 5).

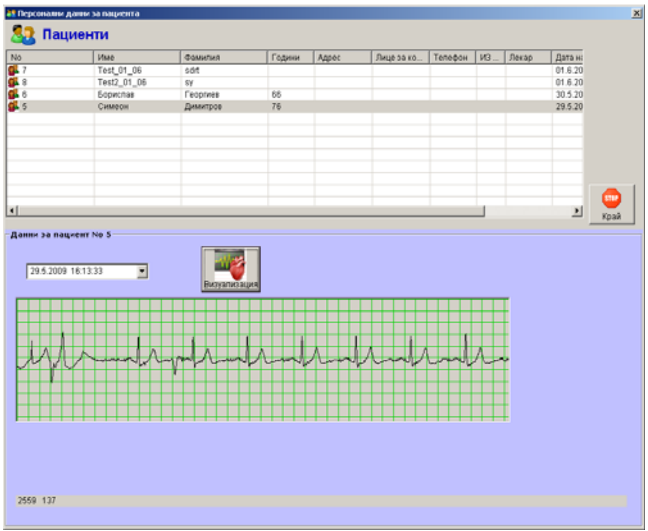

Fig. 5. Module for data base management

III. Conclusion

We have developed a computer-based system for analysis, visualization, and database management suitable for telemetric monitoring. The system integrates complex software skills and knowledge about ECG signal interpretation and visualization as well as data flow control in mixed (heterogeneous) net. It implements optimized methods for alarm classification with adequate visualization of the results in the context of easy diagnostic interpretation. The basic software is open for cardiologist-assistant supplements.

Acknowledgments

*This work has been supported by the Science and Research Fund Grant Contract No:**091ни036-03/2009** of the Technical University of Sofia.*

REFERENCES

[1] Jeong GY, Yu KH. Design of ambulatory ECG monitoring system to detect ST pattern change. In: Proceedings of SICE-ICCAS international joint conference, Busan, Korea, 18–21 October 2006. p. 5873–7.

[2] Lee R-G, Chou I-C, Lai C-C, Liu M-H, Chiu M-J. A novel QRS detection algorithm applied to the analysis for heart rate variability of patients with sleep apnea. Biomed Eng Appl Basis Commun 2005;17(5):258–62.

[3]Koch S. Home tele-health—current state and future trends. Int J Med Inform 2006; 75(8):565–76.

[4] Lee R-G, Chen H-S, LinC-C, Chang K-C, Chen J-H. Home telecare system using cable television plants—an experimental field trial. IEEE TransInform Technol Biomed 2000; 4(1): 37–44.

[5] Herna´ndez AI, Mora F, Villegas G, Passariello G, Carrault G. Real-time ECG transmission via Internet for nonclinical applications. IEEE TransInform Technol Biomed 2001; 5(3): 253–7.

[6] Spasov G., Petrova G., Web-based Personal Health Systems – Models and Specifics, *Proceedings of the International Scientific Conference "Computer Science'2008"*, 18-19 September 2008, Kavala, Greece, in press.

[7] Anliker U, Ward J A, Lukowicz P, Tro¨ster G, Dolveck F, Baer M, et al. AMON: a wearable multiparameter medical monitoring and alert system. IEEE Trans Inform Technol Biomed 2004; 8(4): 415–27.

[8] Hung K, Zhang Y-T. Implementation of a WAP-based telemedicine system for patient monitoring. IEEE Trans Inform Technol Biomed 2003;7(2):101–7.

[9] Leijdekkers P, Gay V, Lawrence E. Smart homecare system for health tele- monitoring. In: Proceedings of the 1st international conference on the Digital Society (ICDS 2007), Guadeloupe, 2–6 January 2007.

[10] Lee R-G, Hsiao C-C, Chen C-C, Liu M-H. A mobile-care system integrated with Bluetooth blood pressure and pulse monitor, and cellular phone. IEICE Trans Inform Syst. 2006; E89-D(5):1702–11.

[11] Milenkovic´ A, Otto C, Jovanov E. Wireless sensor networks for personal health monitoring: issues and an implementation. Comput. Commun. 2006; 29(13–14): 2521–33.

[12] Bratan T, Clarke M, Jones R, Larkworthy A, Paul R. Evaluation of the practical feasibility and acceptability of home monitoring in residential homes. J Telemed Telecare 2005;11 (suppl. 1):29–31.

[13] Nicopolitidis P, Papadimitriou GI, Pomportsis AS. Design alternatives for wireless local area networks. Int J Commun Syst 2001; 14(1): 1–42.

[14] Akyildiz IF, Su W, Sankarasubramaniam Y, Cayirci E. A survey on sensor networks. IEEE Commun Mag 2002; 40(8): 102–14.

[15] Chien-Chih Lai, Ren-Guey Lee, Chun-Chieh Hsiao, Hsin-Sheng Liu, Chun-Chang Chen, A H-QoS-demand personalized home physiological monitoring system over a wireless multi-hop relay network for mobile home health care applications, Journal of Network and Computer Applications, 2009, – in press.

[16] Iliev I. System for Telemetric Monitoring of High-Risk Patients at Hospital Enviroements., Tenth National Conference on Biomedical Physics and engineering, 16-18X, 2008, ISBN 978-954-91589-2-2.