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Application of a concentrator of biomedical data in a telemedical modern system to diagnose people with heart disease

Abstract

The article presents the concept of building a prototype demonstration series concentrator to collect measurement data, data biological parameters of the patient as well as an information on immeasurable type, eg. stress, appetite, mood, etc. A special feature of the solution is the ability to work with biomedical devices, focusing a lot of types and models of sensors. Measured data are analog, but on the output of biomedical devices are sampled signal able to transmission to the communication channel and the collection of data in non-volatile memory. Therefore, an important element is also due to the nature of the data, the realization of self-diagnosis function. The aim of the task was to develop a prototype device, which is featured by small size. Great importance is also low power consumption by the device, because the device is powered from the battery. Since the device will work in the environment of the patient, necessary risk analyzes and tests of safety were performed. A separate block of tasks concerned the analysis of the components, such as processor, with particular emphasis on the economics of energy and ensure low energy to the work. The solution is focused on standard transmission media, having today special meaning: GSM, Wi-Fi, Bluetooth.

Keywords: monitoring vital functions of on-line data concentrator, ECG, heart disease.

1. Introduction

The function of the concentrator is acquisition measurement data (biological parameters) of the patient, which include, among others, ECG signals, heart rate, impedance, and then transfer them to the server (ICT platform). Measuring devices with biosensors are equipped, which at appropriate places on the patient are located. The concentrator sends the collected data to a server where only persons appointed have access to them and are informed about the incident risks health by short message initiated by the emergency button. This message contains key information on registered irregularities together with patient data and its current location.

Transferring data from the measuring device to the concentrator, as well as from a concentrator to the server is doing wirelessly, depending on the possible access to transmission medium - GSM or Wi-Fi. Each module of the biomedical concentrator is equipped with a GPS receiver. The present system characterized a high level of reliability. It is not only resistant to damage, but also minimizes the effects of various failures. Risk analysis for system was performed. The functioning of medical devices is dependent on two external factors. First is the presence of power, and the second condition is wireless transmission. The device may be exposed (due to failure or attempted dispose system) on power failure, as well as hampered or a broken connection to the server.

None of these situations shouldn't lead to the complete cessation of operation of the system. First of all, a concentrator module of biometric data - MONITEL has its own reliable, high-performance battery power, allowing for the execution of full cycle of the measuring device. It also has security system and signaling in order to provide the means to make entirely measure and eliminate the threat of its interruption due to power loss. In case of problems with the connectivity required to make the device with one hand, trying to immediately connect to the server, on the other hand, that the data received from external devices (biomedical) they weren't lost and were memorized in the internal non-volatile memory. The presence of this memory is able to in future sent to the server all the data that have not been sent for reasons attributable to the telecommunications network. Sending data will occur as soon as the transmission is re-established after its prior loss. Data sending will be occur when the transmission will be re-established after its prior loss.

2. Design of telemedical system

The role of the concentrator is read the stored measurements, previously transmitted from the measuring devices (Monitel 1, 2, 3) and to send them wirelessly to a server that supports data acquisition system (Fig. 1).

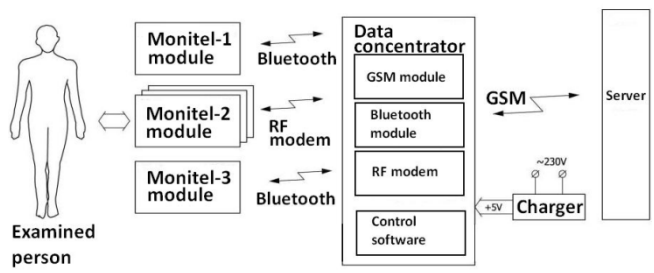

Fig. 1. Schematic diagram of the system

Connecting a compatible concentrator with biosensor, automatically activates the device, initiates reading data from the measuring device and connects to the server system. Concentrator MONITEL periodically connects to a server, which transmit queries about data a specified period of time. If the transmission attempt fails, the server may force it. There aren't have disconnecting operations data concentrator from biosensors. The project prototype telemetric system for reading data from a data concentrator describes the mechanism of reading the collected patient data without physically connecting to devices Monitel 1, 2, 3.

Data transmission occur in the form of a radio signal. In the case of radio transmissions are not required sockets and plugs that need to connect to devices (sensors). Assuming a large number of patients served by the system in the future, from which will read biometric data performed readings will efficient and fast without unnecessary and troublesome wiring. There aren't necessity to connect to a power source voltage alternating and also work on batteries characterized long runtime – it is advantage of modules used in the above-described method. Because the concentrator Monitel will be used by the patients, it should ensure its compatibility with other medical devices, ensuring the fulfillment of the guidelines in compliance with the medical industry standards [1]. This device is intended primarily for use in all conditions - not only in the clinic, hospital, adjacent place near hospital , but also at home, in shopping malls, any means of communication (eg.: buses, coaches, trams, trains, etc.), thus freeing the measurement from geographical location. With the right software, it is possible fast read information about the parameters of the patient and adding and registration current information about: measurable and immeasurable parameters.

Novelty is, eg. a survey on the state of health on-line - telemedicine (Fig. 5). The device is equipped with a GPS module, so that the read data are always automatically including information about the exact location of each patient at the time of measurement, if GSM network is on-line [2, 3]. In the case of the development of the system is the practical possibility of using other stabile wireless systems in the future, for example the WiMax [4]. After reading all the available parameters, a comprehensive report on the state of the patient is sent to the

database (data packet on the GSM network) to the data collection node (Fig. 2). Authorized user has access to all the read data on-line and receive alarm notifications, has access to the entire history of the measurement parameters of the patient. The basic feature of the telemedicine system consisted with concentrator Monitel and devices Monitel: 1, 2, 3 is monitor, record parameters to file, write to the database and their visualization (curves change over time), e.g.:

1) body temperature,
2) impedance: a) sweating, b) filling liquids,
3) ECG,
4) physical activity of the patient,
5) pulse wave velocity,
6) pulse,
7) oxygen saturation, blood, etc.

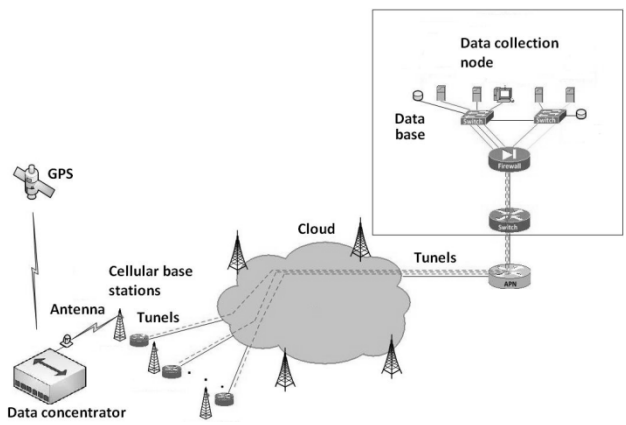

Fig. 2. Structure of a data communications system

Telemetry system, integrated all logged data concentrators with the data collection node is able to direct measurement of parameters of the patient in terms of measurable parameters. It isn't required to be supplied from the AC voltage source, because ensured work on maintaining battery. Operation of the system is ensured by presence licensed medical personnel and concentrator Monitel cooperate with GSM network. Reading the information is in electronic form in a fixed format data, imposed by the protocol modules Monitel 1,2,3. Used are commonly known, standardized electronic wireless interfaces.

3. The concept of data communications system

The main function of the concentrator is reading and storing data from the measuring devices through Bluetooth transmission and RF, and then transfer the recorded data via GSM or Wi-Fi [5] to the server (Fig. 2), in which the collected data are constantly presented and evaluated (Fig. 4).

The correct functioning of the concentrator assume continuously assess the biological parameters of patients who require checks 24h/day. The system can support specialists in issuing the correct diagnosis of the condition of the patient, but also through appropriate sounder can inform health professionals about the risk of the patient's health. Risks due to lack of essential functioning may cause distortion of the transmitted data causing data loss or corruption of the result, preventing proper assessment of the state of health of the subject. The telemedical system always is embedded in the terrain and should be analyze environment of the patient (flats, houses, shopping centers, leisure centers, etc.) and the receiving part through which medical staff receives and interprets incoming from patient signals, helping them (sending a team rescue after detection of pressing the alarm button and locate the patient on the map background). Today progress technology reduces the size of the recording equipment ECG signal so that the study of heart patient may be lead outside the medical center.

Application of mobile devices is solution that fulfills this need. Use of biometric data concentrator by patient enable monitor his health without the need attend daily visits to the medical center. An additional possibility, which may prove a key advantage is the ability to quickly respond to any irregularities by notifying the appropriate emergency services and send additional information on the current status of the patient, knowledge of which may speed up the proper intervention - sending notifications to dispatching systems (SWD - command support systems). In the project, in terms of the usefulness, a few of radio circuits were analyzed, e.g.: CC3200 [6], LMX9830 [7], LMX9838 Texas Instruments [8], NRF905 (Nordic) [9], AMB 2300 [10], nRF51822 (Nordic) [11], modem Quectel M10 [12] (GSM). Suitable formulas allow selection of operating frequency (f_{OP}) in order to exposure of the human body to electromagnetic waves. For example, the output frequency of the NRF905, is configured by setting the appropriate bits of the register CH_NO and HFREQ_PLL according to the following formula:

$$f_{OP}=(422.4+CH\_NO/10))\cdot(1+HFREQ\_PLL)\ [MHz] \quad (3.1)$$

and so for the operating frequency f_{OP} = 430 MHz HFREQ_PLL registry value is [0], while the value of the registry CH_NO is [001001100]. Because the basis of telemedical system is wireless transmission, it is able to calculate the time packet transmission. This is important parameter in terms of the transmission delay time and signal propagation. To calculate the time of packet transmission the following formula is used:

$$TOA=t_{startup}+t_{preambule}+[(N_{address}+N_{payload}+N_{CRC})/BR] \quad (3.2)$$

where: $t_{startup}$ and $t_{preamble}$ are connecting time, $N_{address}$, $N_{payload}$ and N_{CRC} are the number of bits of address, data and checksum, BR is the bit flow equal 50 kB/s.

The time of receipt of packages is the sum of configuration and setting the connection. Packet length field is the sum of the initial address, data and checksum. In the project the use of several types of wireless networks were considered: Bluetooth [13], ANT, Bluetooth Low Energy (BLE) wireless network and IEEE 802.15.4. Wireless solutions comparisons were made. Based on the analyzes of parameters standards the most optimal solution was chosen.

4. Questionnaire as interactive dialogue with the patient

Fig. 3. The concentrator of biomedical data – visualization of chassis, degree of protection IP 22

Access to patient data in contemporary telemedicine and diagnostics is extremely important, especially available data is very much, and they are often a key value for the physician (diagnostician). Therefore the exploration and development of all possible methods of supporting the medical profession (diagnostician) is justified, including those whose aim is present medical data, eg. in the form of a graph or statistics.

Technology described in this paper showing made turnkey telemedical system and is one of method to support the work of a doctor, and uses the possibilities cooperation sensors with concentrator of biomedical data in wireless manner, enabling data transfer to a central data collection node. Technology is one of method to support the work of a doctor, and uses the possibilities cooperation sensors with concentrator of biomedical data in wireless manner, enabling data transfer to a central data collection node. It should be noted that the technology demonstrator allows create a very extensive and distributed network. In the project a system (ICT) was created. ICT aims: data storage and biomedical visualization (Fig. 4a, b).

a)

b)

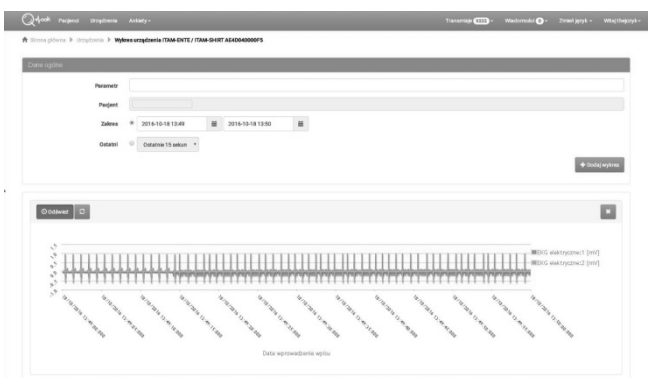

Fig. 4. Monitoring vital signs on-line on real conditions in ICT a) the choice of equipment b) on-line monitoring ECG

Concentrator Monitel (Fig. 3) is a mobile device, and classified as manual and transit-operabile (the device is a medical device: I according to rule 12, class of software: A). Enterprise ENTE Ltd. therefore fills a new niche: diagnosis of the patients and create professional devices for telemedicine. Concentrator Monitel has enhanced wireless communication capabilities that include interfaces: Bluetooth, RF and fast transmission of GSM. The structure of digital data from sensors (Monitel 1, 2, 3) presenting the actual structure of the various data obtained from patients is presented. Basic units of information include: information about the patient, the type of test, a series of results obtained during the examination, and data, etc. Medical data are available as a stream of information transmitted in the network. Most of the application logic on the server side (Fig. 4) is located. This application is characterized by high versatility and allows to reach a larger audience. Due to the confidentiality of transmitted medical data presented in the browser www, special attention their safety was devoted. Through authorized access to the data server (login and password) it's was achieved. Connection encryption provides the required additional confidential transmission. The user of the system or the patient has the opportunity to send a questionnaire matched to the specific case, e.g about unmeasured parameters regarding comfort life, frame of mind, etc. As an example, a questionnaire consisting of 21 questions grouping 6 replies was presented. The following questions are intended to indicate how heart failure (heart disease) affected the patient's life. After each question the patient must select a number from 1 to 6, to show what he assesses the quality of his life.

Example content of the questions below are presented:

Did your heart failure prevent you from living as you wanted

1. causing swelling in your ankles or legs?
2. making you sit or lie down to rest during the day?
3. making your walking about or climbing stairs difficult?
4. making your working around the house or yard difficult?
5. making your going places away from home difficult?
6. making your sleeping well at night difficult?
7. making your relating to or doing things with your friends or family difficult?
8. making your working to earn a living difficult?
9. making your recreational pastimes, sports or hobbies difficult?
10. making your sexual activities difficult?
11. making you eat less of the foods you like?
12. making you short of breath?
13. making you tired, fatigued, or low on energy?
14. making you stay in a hospital?
15. costing you money for medical care?
16. giving you side effects from treatments?
17. making you feel you are a burden to your family or friends?
18. making you feel a loss of self-control in your life?
19. making you worry?
20. making it difficult for you to concentrate or remember things?
21. making you feel depressed?

Questionnaire can be arbitrarily configured on the server (Fig. 5), considering doctor guidelines, and transferred it to completed by the patient using a simple application made available on the concentrator (Fig. 3).

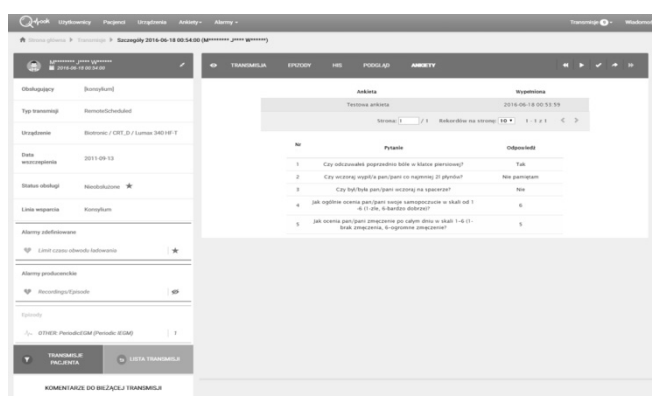

Fig. 5. Test questionnaire from the ICT platform application

5. Conclusions

Elaboration of the project prototype telemetry system for reading data from a data concentrator describes the reading mechanism collected from patient data without physical connect to the devices Monitel 1,2,3, collecting data directly from the patient. At the stage of engineering tests actual devices were used and libraries simulating real signals. Data transmission occur in the form of a radio signal. Implemented software allow now fast wireless reading information about parameters of the patient and adding and registration currently information about: measurable parameters (ECG, oxygen saturation, heart rate, etc.) and unmeasurable parameters such as, eg. questionnaire on the state of health. The device is equipped with a GPS module, so that the read data are always automatically accompanied by information about the exact location of each patient at the time of measurement, if there is GSM coverage. After reading all the available parameters, entirely report about the state of the patient is sent to the database (data transmission in the GSM network), to data center collection node. Authorized user has access to all the

read data on-line and receive alarm notifications, has access to the entire history of the measurement parameters patient. Considered should be for the use other transmission media, such as Wimax system, which allows creates an administrative data network with a guaranteed quality of service.

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