PATIENTS MONITOR SYSTEM BASED ON THE BLUETOOTH TECHNOLOGY

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Abstract: The paper presents a new application of the Bluetooth technology in the medical field. The proposed application checks some of the Bluetooth capabilities in order to monitor simultaneously two or more patients in the recuperate stage of a heart disease/failure. The patients are required to work on some effort devices (such as medical bicycle, run band etc.) or to perform any others activities that require physical effort, the body parameters being measured (in the studied case were simulated two behaviors) and sent in well-established intervals. The developed application consists of two parts: the patient (client) application (with two alike but distinct functioning programs) and the monitor (server) application. The server imposes some restrictions for the patient (client program) that will act in the manner dictated by the reactions of the server to the received data. The two applications are synchronized and the user does not perceive time differences during the communication process. The implementation can be extended to allow more patients to be monitored with just one device. Taking into account the advantages and the accelerated development of the Bluetooth technology, the present study can constitute the basis for a future successful application.

Keywords: Wireless Communication, Bluetooth, Telemedicine, Wearable Medical Instruments

1. INTRODUCTION

The number of wireless devices in health care is expected to triple by 2005, according to a study by Technology Assessment Associates. Wireless-enabled handheld usage by U.S. physicians is likely to climb to 55% by 2005, up from the current 18% [1]. Bluetooth is one of the latest technologies in wireless communication with possible, successful future applications in the medical field, contributing to the evolution of mobile telemedicine systems.

The needs that Bluetooth addresses are: the eliminating of existing cabling, the providing of mobile access to information, the providing of mobile data acquisition, the enabling of the device-device communication, the enabling use of peripherals, the enabling of new device architectures.

Some of the Bluetooth most important characteristics are: non line-of-sight transmission through walls and briefcases, the including of up to 8 devices in a piconet; the omni-directionality, real-time data transfer usually possible between 10 and 100 m.

The asynchronous data channel can support asymmetric data rates up to 723.2 kb/s with a 57.6 kb/s back channel, or a symmetric channel data rate of 433.9 kb/s in both directions.

Power consumption of wireless technology has previously prohibited battery power for truly wireless operation. Bluetooth's low power requirement reduces the cost and size of battery power for operation and the single chip design has resulted in the ability to include the technology in small instruments without necessitating large enclosure extensions.

Taking into account all previous considerations, medical devices and medical information management represent opportunities for Bluetooth wireless technology. There are three important categories in which BT could implement with success: physician personal tools; medical devices and diagnostic instrumentation and telemedicine.

It must be mentioned that sensors with incorporated Bluetooth capabilities are not yet available on the market, but wearable devices are now in a trial stage. There is only one qualified medical final-product, Ortivus Mobimed patient monitor, which uses Bluetooth specification 1.0b [5]. Some laboratories investigate non-invasive electrodes for assessing and monitoring vital parameters and for recording of electrophysiological signals. A block diagram of one of the medical wearable device is presented in [2]. On the other part, wireless sensor networks – networks of small devices equipped with sensors, microprocessor and wireless communication interfaces – are a technology that has gained a lot of interest lately. The broad spectrum of new and interesting applications, ranging from personal health-care to environmental monitoring and military applications is proposed for such networks [3].

The proposed application checks some of the Bluetooth capabilities in order to monitor simultaneously two or more patients in the recuperate stage of a heart disease/failure.

2. THE ARCHITECTURE OF THE APPLICATION

The generic architecture presented in Figure1 is considered to integrate the Bluetooth technology in a telemedicine system that allows the interpretation of cardiac rhythm disorders. A master-slave configuration, Figure 2a, that can be extended as in Figure 2 b or 2 c, [4], is used.

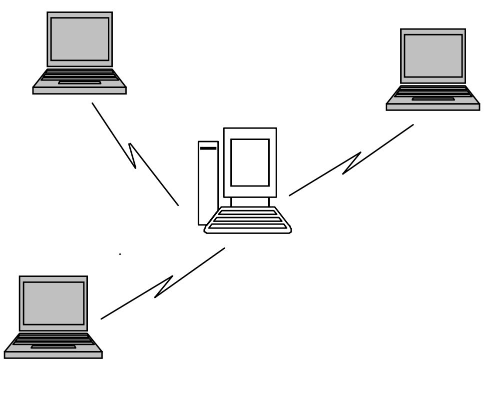

Figure 1 - The application architecture

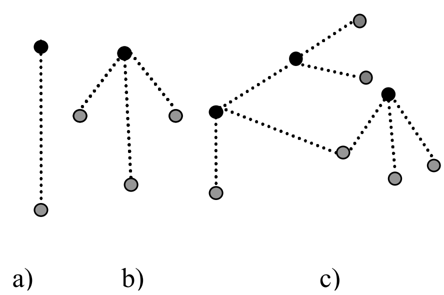

Figure 2 - Master-slave configurations

The patients are required to work on some effort devices (such as medical bicycle, run band etc.) or to perform any others activities that require physical effort, the body parameters being measured (in the studied case were simulated two behaviors) and sent in well-established intervals. Two important objectives have to be considered: to create the possibility to monitor more patients simultaneously and to leave maximum freedom to the patient. Taking into account this last goal, the application constitutes only a part of a more complex system that must include wearable sensors, based on the Bluetooth technology. Thus, the patient will be free to move while measurements are performed.

The operational area must be from 5 meters to 10 meters (a circle with radius of maximum 10 meters), but it should be operational in small crowded areas too.

Because the necessary smart sensor node, having as possible structure the connected components presented in Figure 3, is not available yet on the market [3], a set of data representing the patients' evolution characteristics during the recuperate stage is given. It replaces the data that will be sent in the real case by each patient to be processed by the server in order to take a decision. It was assumed that a possible short transmission delay will not put in danger the patients' life.

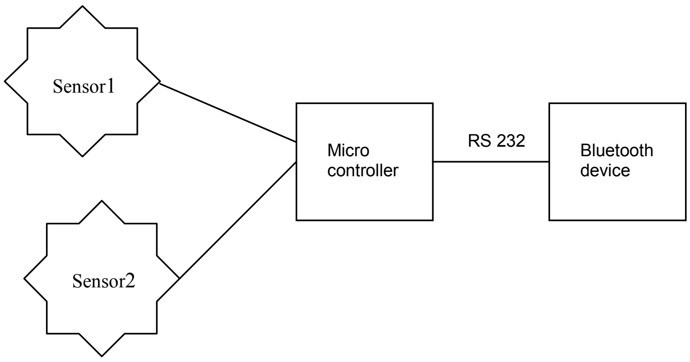

Figure 3 – Smart sensor

3. IMPLEMENTATION ASPECTS

The developed application consists of two parts: the patient (client) application (with two alike but distinct functioning programs); the monitor (server) application.

The behavior (pulse values and ECG) of two monitored patients is simulated, only one monitor being required. The implementation can be extended to allow more patients to be monitored with just one device. The two applications must interact according with specified times and transmitted messages. All time related issues were established in a way that the application keeps its functionality and respects the previous specified time intervals.

The simulation does not treat any kind of interferences that can occur within the interactions of other wireless devices. Some of these aspects were studied in [6].

The server – monitor application translates the data received by the patients into charts that illustrated the dynamic behavior. The interface allows the user (monitoring personnel) to perform a sequence of actions that are recognizable for the client. So the user (physician) is able to stop, to exit, to view charts representing pulse and ECG (electrocardiogram) of each patient, and this action should not interfere with the program of other patient.

The server imposes some restrictions for the patient (client program) that will act in the manner dictated by the reactions of the server to the received data [3]. The two applications are synchronized and the user does not perceive time differences during the communication process.

Test duration for each patient is 3 min and can be modified by setting the time interval. The client application is set to transmit data at each 1 sec (at each second a value for ECG and a value for pulse are transmitted to server). In both cases data is stored initially in local buffers from which are transmitted or taken.

The server receives almost instantly the data and after a process of comparing, places it on the dynamic charts. A counter holds the number of times in which the limit values are exceeded and according to the initial specification the application is stopped; otherwise an analysis messages will appear for the patient.

The demonstration of the simulation is made visible. In a future system the client application will be embedded in the corresponding medical device.

Two computers with Bluetooth capabilities were used:

- Desktop Athlon 950MHz processor 256 Mb DDRAM with a MSI 6869 main board with MSI Bluetooth Transceiving Module (Transceiving Module, Dipole Antenna, Cable for pin connection) (manufactured by Cambridge Silicon Radio ver373 – USB type);
- Laptop Sony Vaio Intel Pentium 550MHz processor 128Mb SDRAM with Belkin PCMCIA Bluetooth dongle (manufactured by Cambridge Silicon Radio ver115 – PCMCIA type).

The server application is run on the desktop and two client applications can be run simultaneously on the laptop. The server and client class diagrams are given in Figure 4, respective 5.

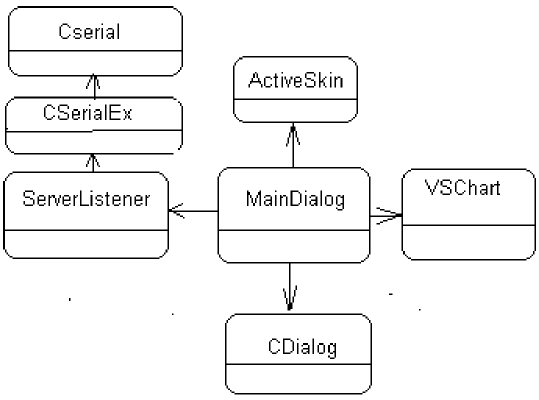

Figure 4 Server Class Diagram

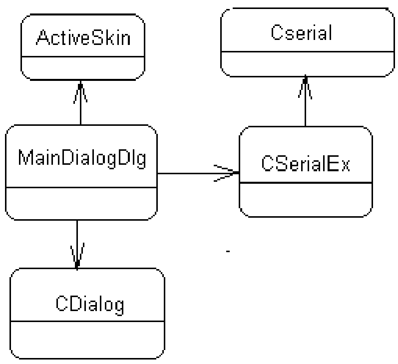

Figure 5 Client Class Diagram

The serial communication is implemented using a set of open source classes. These classes are available as a serial communication library that allows several operations and communication protocols using the serial ports. The CSerial class can open a connection to a listening server and to perform several operations on this connection. The most important operations are the data sending to the listening server and the data reading from server. In order to be able to accept data from server, the CSerialEx class must be used. This class enhances the CSerial class with server-like abilities. Objects of this class can be very easily turned into listening mode or standard mode. The two states/modes of serial connections coexist because of optimization and performance raisons.

Serial communication wraps the Bluetooth protocol. Communication's speed on serial port is limited by hardware components.

4. EXPERIMENTAL RESULTS

The main functional characteristics of the proposed application were tested and evaluated.

The server monitor interface, with Patients 1 and 2 running is presented in Figure 6. Figure 7 represents an ECG chart transmitted during the test. It must be mentioned that, taking into account the previous considerations, the chart illustrates a given set of data transmitted during the simulation test and not the real data corresponding to an ECG.

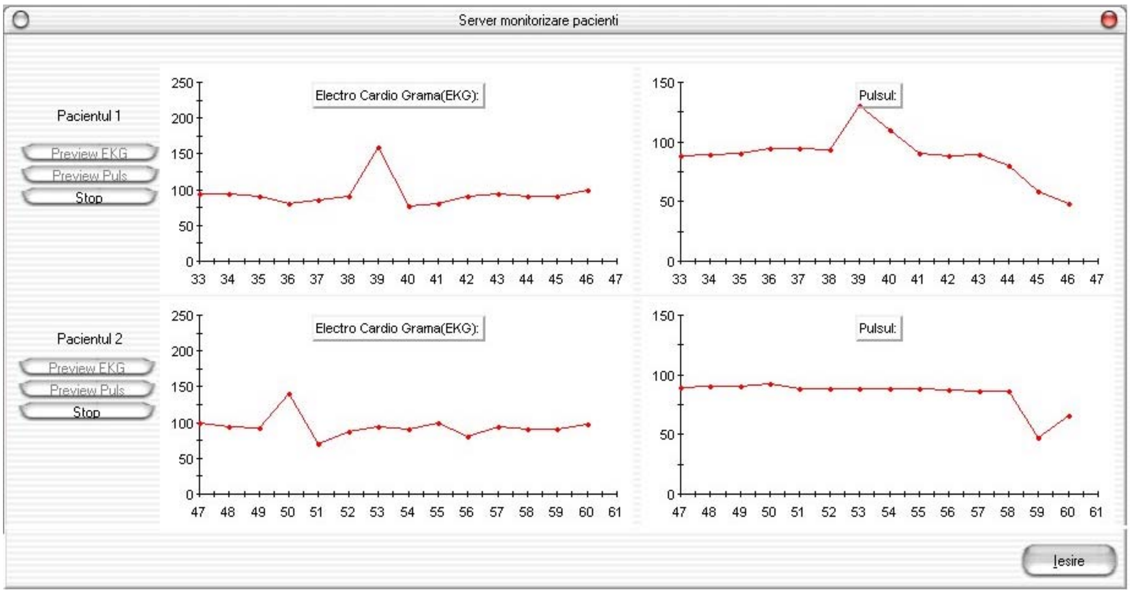

Figure 6 - The Server Monitor Interface

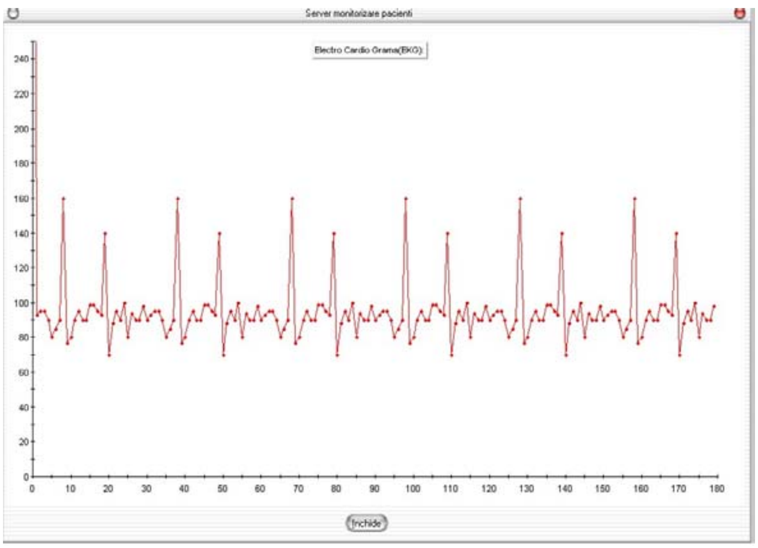

Figure 7 – ECG of Patient 1

5. CONCLUSIONS

A new possibility to use the Bluetooth technology in the medical domain was proposed. The approach combines features of auto-testing and distance surveillance systems in order to guide simultaneously the activity of more patients in the recuperate stage of a heart disease/failure. The experiments prove the possibility to transmit the necessary information in the case of two monitored patients, without observable delays. The operational area must be from 5 meters to 10 meters, but it should be operational in small crowded areas too. In order to leave maximum freedom to the patient, sensors with incorporated Bluetooth capabilities have to be used. Taking into account the advantages and the accelerated development of the Bluetooth technology, the present study can constitute the basis for a future successful application.

6. REFERENCES

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