Database Architecture for real-time accessing of Personal Biotelemetric Systems

ONDREJ KREJCAR, JINDRICH CERNOHORSKY, DALIBOR JANCKULIK
Centre for Applied Cybernetics, Department of Measurement and Control
VSB Technical University of Ostrava
17. listopadu 15, Ostrava Poruba 70833
CZECH REPUBLIC

Abstract: - This project deals with the problems of utilization of mobile equipment working in the biomedicine field, particularly telemedicine. The whole system is based on the architecture of .NET Compact Framework, and other products, such as SQL Server by Microsoft too. The mobile equipments are used primarily for measuring and processing of data from the sensors and their visualization as a graph. The data is also given to the server for further processing and the analysis of current health of the patients, due to small efficiency of the mobile equipment. For the analysis of received data and further evaluation of the electrocardiogram, there is a self-organizing neural network. The connection between all nodes of Personal Biotelemetric System is made on Real-Time basis.

Key-Words: - Mobile Device, Portable Device, PDA, biotelemetry, migration, SQL CE Database

1 Introduction

Many middle-aged people like businessmen, CEOs, managers and other have very hectic lives with much stress and without good ways of living. Sometimes these people have a collapse, breakdown or heart attack and must be in hospitals or health resorts for a long time to regenerate their bodies. The time that they spend in these institutions, is nonutilisable and very long for them. Possibilities of today physics are restricted by many of prescripts so patients cannot use some of the newest techniques (like hyperbaric or arctic chambers), which make it possible to reduce the regeneration time by weeks or months. For example, these chambers are restricted to patients in the first six months after heart attack due to no information about patients’ conditions during the procedure.

Values are measured with the existing equipment, which communicates with the module for processing via Bluetooth wireless communication technology. Most of the data (according to heftiness) is processed directly in PDA or Embedded equipment to a form that is acceptable for simple visualization. Two variants are possible in case of embedded equipment – with visualization and without visualization (entity with/without LCD display). Data is continually sent by means of GPRS or WiFi to a server, where it is being processed and evaluated in detail. Processing and evaluating on the server consists of - receiving data, saving data to data storage, visualization in an advanced form (possibility to recur to the older graph, zoom on a histogram (graph with historical trend), copying from the graphs, printing graphs), automatic evaluation of the critical states with the help of advanced technologies (algorithms) that use Artificial intelligence to notify the operator about the critical state and its archiving.

Application in PDA, Embedded equipment is comfortable, with minimum time - the first configuration, but also configuration after downfall of application. The level of visualization will be lower. The described system can be used with small modifications for monitoring of patients in hospitals or people working in extremely hard conditions. The biggest limitation is the availability of measuring devices in acceptable and adaptable sizes or comfortable enough to have one around.
Figure 1 Measurement schema

The measuring device (ECG, plethysmograph) was tested in extreme conditions in a cryogen room in Teplice (-136°C), where the final system will be installed. Implementation of the data transmission security was not solved. The whole system is classified as „work in progress“ system and it is in a testing phase where we found mistakes and repaired them.

2 System Architecture

This system consists of several interconnected parts that can communicate among themselves, so they can approach their function. These parts are: measuring sensor, PDA or embedded device, and server for data processing and evaluation. Beside these, the most important parts that are worth mentioning are various kinds of accessories, such as GPRS, WiFi, GSM, Bluetooth or GPS modules. By means of them we can communicate. We mostly use the fastest technology in signal coverage.

Data acquisition and data transmission are the most important parts of this system. The Responsible for correct working are: correct sensor configuration, sensor calibration, data transfer synchronization, and mutual communication between sensors and data receiver. The system can display saved data from a database file. The doctor can configure or set a neurone network. A change of that is shown in the XML file enshrining, where the neurone network setting of the patient is kept. The doctor receives information about worsening of patient’s status. In case of doctor’s reaction, he sends for an expert assistance, such as a helicopter or an ambulance. In case of false alarm, he can configure a neurone network or leave it unchanged if that was a sporadic incorrect interpretation.

The patient can browse data concerning his health status. Measured data is sent to server by WEB service. Client’s data are not only received but also preprocessed (data checking, risk elimination etc.). Measured data is saved. And now, it is possible to analyze the data using a neurone network. If the analysis shows that the measured data from ECG is critical, a warning is sent. That notifies a doctor of incoming data.

2.1 Mobile Part

The main part of the whole system is an Embedded or PDA device. The difference in applications for measurement units is the possibility to visualize the measured data in both Real-time Graph and Historical Trend Graph, which can be omitted on an embedded device.

PDA is a much better choice for Personal Healthcare, where the patient is already healthy and needs to review his condition, or for multiple person usage. Embedded devices can be designed for one user, with the option to use an external display used for settings or with the possibility of usage in extreme conditions. [4,5]

The application is communicating with an ECG Measurement Unit (Corbelt or Blue Keg) through a virtual serial port using wireless Bluetooth technology. Then, after pushing a button, all necessary parameters are set and the communication may begin. Measured data is stored on a SD Memory Card in a database in MS SQL Server 2005 Mobile Edition.
the system registry (HKEY_CURRENT_USER / Software / Guardian). Working (saving, reading, finding) with registry is easier and faster as saving this informations in file. User registry values are crypted with simple algorithm (shifting char ASCII value).

2.2 The Real Code Migration between .NET Compact Framework applications

We were dealing the usage of already created application for PDA on embedded device and smartphone. It is possible to run an application for PDA on embedded pc. However, it’s not possible on smartphone - not all the components are implemented in API.NET Compact Framework. The operation system of the embedded pc is readed from the Compact Flash card during the start-up to ROM memory; that is why it is necessary to include the .NET Compact Framework and MS SQL Server via Platform Builder to the operation system´s image.

It was necessary for smartphone to substitute the missing elements and modify the source code for information entry and notices to comboes, splitting the application to man, properties, user and health data forms, graph stays the same as in PDA application. In the case of embedded, the user and health data forms were united to one, due to enough room in the displayed space.

The serial port for the bluetooth communication needs to be configured manually, because embedded does not contain of integrated bluetooth module, therefore the operation system used (Windows CE) does not include Microsoft or Broadcom stack. Smartphone working with Windows Mobile 6 standard reversely supports the point-to-point communication, where we can set (by the bluetooth manager) any serial port for the device connected. The resulting application is almost the same as application used in PDA equipment type. It is obvious from technology used, where the whole application is based upon .NET Compact Framework platform, version 3.5. The compiler of development environment Visual Studio 2008 generates the MSIL code, which is transferable to equipments, where the .NET CLR runs [5]. The application for embedded device is primary without visualisation. We should connect the external touch screen and easily start-up visualisation.

Our embedded device contains:

- Intel XScale PXA255 processor at 400MHz clockrate
- 64 MB SDRAM system memory
- Ezurio Bluetooth module via RS-232
- WiPotr WiFi module via RS-232
- Siemens GSM module via RS-232
- Leadtek GPS module via RS-232
- Accelerometer via RS-232

3 Server part

In order to run a server, an operating system supporting IIS is needed. IIS is an Internet Information Server application allowing users to connect to the web server by the well-known HTTP protocol. The web service transfers data between the server and PDA/Embedded devices. It reads the data, sends acknowledgments, stores the data in the database and reads it from there. The service is built upon ASP.NET 2.0 technology. The SOAP protocol is used for the transport of data, which is
in XML format. That is an advantage since it allows communication of multiple different technologies and platforms. The Wireless ECG approaches a real professional ECG with data rate as high as 800 records per second [4]. That makes 48,000 records per minute and 2,880,000 per hour. Considering 100 patients, the value gets to 288,000,000 records per hour. Even if the server accepted only 50 records per second, the sum of records for 100 patients per hour would be 18 million. That is an extreme load for both the server and the database system; hence a better way of storing data is needed. Methods that devices communicating with the web service can use include:

- receiving measured data
- receiving patient data
- deleting a patient
- patient data sending

![Server visualization](image)

Figure 5 Server visualization

To observe measured data effectively, visualization is needed. A type of graph as used in professional solutions is an ideal solution. To achieve this in a server application, a freeware Zed Graph library can be used. For data analysis, neural nets are a convenient solution. However, there are problems in the automatic detection of critical states. Every person has a specific ECG pattern. What is completely normal for one person can indicate crisis for another. The Neural net has to learn to distinguish critical states of each patient separately.

Basic characteristics of a neuron network: (10 x 10 neurons, learning is based on 3-4 minutes of recording, which is approximately 36,000-45,000 recorded values, incorrect values are filtered out, filtering decreases the amount of values to about 10%, which is still good enough for learning, the learning cycle with 4,200 values takes approximately 30 seconds (CPU PIII 1.2 GHz with C# implementation). To make the specialist’s or operator’s intervention possible, the system must be provided with a user-friendly interface, possibly imitating those on medical appliances. This area is still in an early phase of development [2].

## 4 Data Analysis

Data acquired from the measuring device is incomprehensible for a man, because it is represented by a HEX format packet. The data needs to be stripped of redundant information like packet numbering and transformed to a recognizable state – a graph. This is done during the packet parsing in PDA/Embedded device, where HEX information 2 bytes in length are transformed to a binary state, where the data is carried on the first 12 bits. It is transformed to a decimal state and sent for further processing – sending the data to the server, storing it in a local database or visualizing it. The visualization using PDA/Embedded is just a simple visualization of a curve in real-time or historical graph. In the server application, the visualization is far more complex, with the possibility of storing the current curve as an image, printing, or zooming. Neural net of the SOM type on the server is 10x10 in size. The initial weight of each neuron is random. The weights are assigned progressively by learning. Finally, the whole structure is ready to accept data to analyze. Each patient has his own neural net stored on a server in XML format.

Acknowledgement

The support for this research work has been provided by the project 102/06/1742: Experimental real-time database testing system, provided by Czech Science Foundation.

This work was also supported by the Ministry of Education of the Czech Republic under Project 1M0567.

## 5 Conclusion

The evolution of Telemedicine is unstoppable and apparent; therefore ways need to be found to improve the quality of hospital services, spa services or hazardous environment workplaces. The area of software products working in embedded devices in hazardous environments or PDAs in personal healthcare is still open and unoccupied. Personal healthcare products are freely available [6, 7] and with minor hardware modifications they can be used for data acquisition using wireless Bluetooth, WiFi or ZigBee technologies. By means of data transfers, the acquired data can be
gathered in database systems providing access to your personal doctor, who can be: alerted in case of trouble; send information and system message to our application; remotely change properties of devices (change alarm of critical limits in ECG, e.g.). Why are there systems available to protect our property and not our health? Is it not the most valuable property of ours?

References:
[13] Krejcar, O.: Prebuffering as a way to exceed the data transfer speed limits in mobile control systems, In ICINCO 2008, 5th International Conference on Informatics in Control, Automation and Robotics,