Mobile Monitoring Stations and Web Visualization of Biotelemetric System - Guardian II

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Abstract. The main area of interest of our project is to provide solution which can be used in different areas of health care and which will be available through PDAs (Personal Digital Assistants), web browsers or desktop clients. The realized system deals with an ECG sensor connected to mobile equipment, such as PDA/Embedded, based on Microsoft Windows Mobile operating system. The whole system is based on the architecture of .NET Compact Framework, and Microsoft SQL Server. Visualization possibilities of web interface and ECG data are also discussed and final suggestion is made to Microsoft Silverlight solution along with current screenshot representation of implemented solution. The project was successfully tested in real environment in cryogenic room (-136^{O}C).

Keywords: PDA, Embedded Device, Biotelemetry, ECG, Silverlight, Cryogenic Room.

1 Introduction

Aim of the platform for patients' bio-parameters monitoring is to offer a solution providing services to help and make full health care more efficient without limitations for specific country. Physicians and other medical staff will not be forced to make difficult and manual work including unending paperwork, but they will be able to focus on the patients and their problems. All data will be accessible almost anytime anywhere through special applications designated for portable devices web browser or desktop clients and any made changes will be immediately at disposal to medical staff based on the security clearance. Nurses will be able to find out prescribed procedure of patient treatment which was written down by doctor during regular round. Physicians will have immediate access to the patient's newest results of accomplished examinations. In the case that the ambulance have to go to some accident, rescue team can due to portable devices send information about patient health condition directly to hospital where responsible doctors and staff will have information needed to execute immediate operation without delaying by preparation of necessary equipment. Patients who need not hospitalization will be able to be treated at home due to the

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system capable of remote transmission of information about patient's bio-signals, so patients will be constantly under medical supervision and doctors will be able to make necessary measure if needed. All bio-signals data will be stored and automatically analyzed by neuronal network. System will evaluate presence of critical values which could be the sign of worse medical condition of a patient. In the moment of crossing the border of monitored bio-signals values inserted by doctor, system will inform responsible medical staff and provides all information which could help to determine the cause and seriousness of the problem.

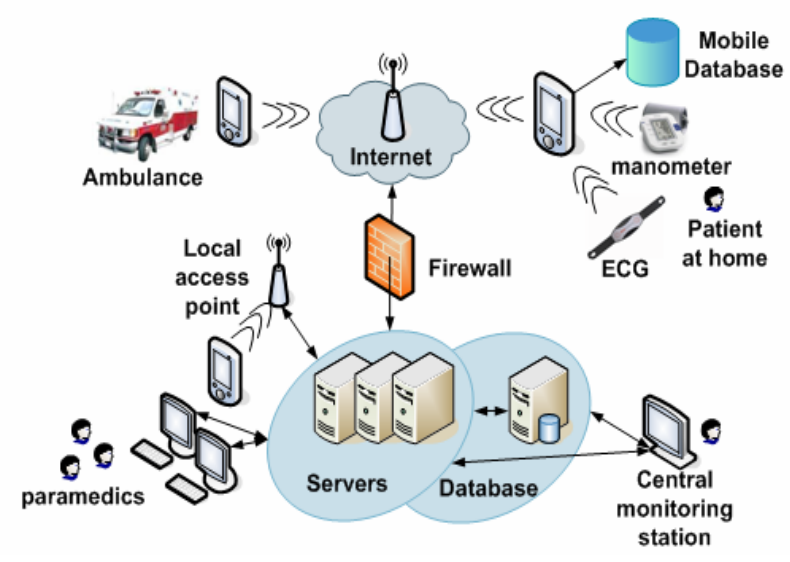

Fig. 1. Architecture of Guardian II platform

The basic idea is to create a system that controls important information about the state of a wheelchair-bound person (monitoring of ECG and pulse in early phases, then other optional values like temperature or oxidation of blood etc.), his situation in time and place (GPS) and an axis tilt of his body or wheelchair (2axis accelerometer). 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.

2 Developed Parts of Platform

Complete proposition of solution and implementation of the platform for patient's biotelemetry as it was described in previous chapter requires determination and teamwork. Every single part of the architecture has to be designed for easy application and connectivity without user extra effort, but user must be able to use given solution easily and effectively. Crucial parts of whole architecture are network servers, database servers and client applications. Due to these crucial parts the development is focused particularly on proposition and implementation of desktop client application, database structure and some other important web services.

Scenario for communication among desktop client, web services and Microsoft SQL Server is: desktop client runs on user´s computer and connects to web services on remote application server. After the desktop client is connected, web services connect to remote database server. Web services provide methods for users so users are capable to work with different data stored in database.

2.1 Mobile Parts

The main part of the 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. 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.

As measurement device is possible to connect several device with Bluetooth communication possibility. In our application we use an ECG Measurement Unit (Corbelt or BlueECG) through a virtual serial port using wireless Bluetooth technology. Measured data is stored on a SD Memory Card as a database of MS SQL Server 2005 Mobile Edition. The performance of available devices seems insufficient for sequential access; parsing of incoming packets is heavily time-consuming. Pseudo paralleling is required. A newer operating system (Windows Mobile 6) must be used to allow the processing of data from a professional EKG due to thread count limitations. The informations about user, as ID, name, surname, address and application properties are stored in 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).

Devices based on PDA type have a several limitations such as low CPU performance, low battery life or small display, which is possible to solve by embedded version of such mobile clients. We created a special windows mobile based embedded device. During the development process the several problems occurred. One of them and the most important was the need of a new operation system creation for our special architectural and device needs. We used the Microsoft PlatformBuilder for Windows CE 4.2 tools. The created operation system based on standard windows

mobile has several drivers which we need to operate with communication devices and measurement devices.

2.2 Server Parts

In order to run a server, an operating system supporting IIS (Internet Information Server) is needed. IIS allow to users to connect to the web server by the 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 XML data. The Wireless ECG approaches a real professional ECG with data rate as high as 800 records per second [1]. 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. 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. The Neural net has to learn to distinguish critical states of each patient separately.

Important part of Guardian is central database. There are stored all data of medical staff and patients. Data of patients include different records such as diagnosis, treatment progress or data which are results of measuring by small portable devices designated to home care. These data represent the greatest problem, because amount of these data rapidly increase with increasing amount of patients. Due to this fact database servers are very loaded.

Next important parts of the platform are web services, which allow us effectively work with medical records or other data. Guardian web services are: User management, Data management, Configuration management, and User management. Each web service deals with common security module, which provides methods for one-way encryption and also implementation of methods for authorization and other security components is planned.

2.3 Visualization

We have much posibility to plotting the graphs, but in every case we can catch any disadvantage, which is caused by a lot of elements. We will try to map these solutions and find the best one for the EKG data representing.

For the main programming of the entire application it is used the ASP.NET 2.0 platform. ASP.NET is the next generation ASP, but it's not an upgraded version of ASP. It is an entirely new technology for server-side scripting. It was written from the ground up and is not backward compatible with classic ASP. It is also the major part of the Microsoft's .NET Framework.

There a lot of questions between choosing the right choice for the graphical data representing. We can use for example the Dundas Graphs, Adobe Flash or the new

Microsoft Silverlight. Dundas Graphs is a very popular choice, and we can say the best-known between commercial use. This is also the big disadvantage – we could not use it for ourselves as the open – source solution, and the customizing is disabled, too. Macromedia Flash is the best-known choice for its very good internet viewer's compatibility, but it has also many disadvantages. For example, if we have rendered .SWF file, and included into the HTML code, it is impossible for us to edit it. XAML of the Silverlight is very good solution, because it could be edited just in the notepad for example.

Microsoft Silverlight is a programmable web browser plug-in that enables features such as animation, vector graphics and audio-video playback that characterizes rich Internet applications. Silverlight provides a retained mode graphics system similar to Windows Presentation Foundation, and integrates multimedia, graphics, animations and interactivity into a single runtime environment. In Silverlight applications, user interfaces are declared in XAML and programmed using a subset of the .NET Framework. XAML can be used for marking up the vector graphics and animations. Textual content created with Silverlight is searchable and indexable by search engines as it is not compiled, but represented as text (XAML). Silverlight makes it possible to dynamically load XML content that can be manipulated through a DOM interface, a technique that is consistent with conventional Ajax techniques. With version 2.0, the programming logic can be written in any .NET language, including some derivatives of common dynamic programming languages like Iron Ruby and Iron Python.

We were focused mainly to the mapping of new possibilities about the EKG signal, next to the new technologies possibilities. As it has been appeared, there are many platforms, which we could use for the work with the EKG data and as a next step graphical solution, but we have to know, everyone has their advantages and disadvantages. We have to find the compromise, which can be easily available and we do not have to pay for it for the price of complete research of the new solution.

We mentioned about possibilities of the Dundas Graphs, Adobe Flash and in the main case Silverlight, the new platform from the Microsoft Storage, so we realized, the final solution will be best exactly with that. It is quite new technology, which come into existence with purpose of vitalize and light up the web, thanks to using their own rendering and vector graphics representing. Nowadays it is very popular between developers and even there were some problems with starting explorer compatibility, in this time it raised up and it is very good future leader on the field of vector internet graphic.

In the case of starting problems with the C# programming language it was a problem for us to find a best choice of cooperation between ASP.NET application and the Silverligh. First draft of the application program was mainly based on editing the JavaScript file and including the Silverlight files into the HTML source code. This JS file is the main file for the setting and programming the Silverlight graph behavior. It is very good to use it, because we can make our own ASP.NET project with database binding and the Silverlight is only just included component. The problems come if we want to trace the program to find some bugs. We could transfer variables between ASP and SL by the overwriting the JS file, or by the session variables. All of these solutions are just temporary, because of very slow program run and low application effectivity.

As we realized in the final part of the application, it was quite difficult to find the best choice for the application, but we would like the solution with the linear cooperation

Fig. 2. User web application interface screenshot with ECG (in native Czech language)

between Visual Studio 2008 and the Silverlight Toolkit. There are so many possibilities, for example mainly saving the data right from the web-service database to the silverlight xaml.cs file. Then we have our application much faster and work is more effective. The reason is, Silverlight graph could read the source data for their graphic interpretation right from the variables, set by the Silverlight itself. We can also use very wide spread of components, for example DropDownList, Button, RichTextBox to the database components like our very good known DataGrid.

Current application interface is shown in figure [Fig. 2]. Left part consist of menu for patients with a possibilities to manage with personal data, Physicians, diagnosis, hospitalizations, data, results or payments. Upper part contains a menu for public, patients or physicians access to application. Middle part provides an access to ECG data of patient. Selection of several part of signal history is possible by mouse click or date/time setting. From the graph is possible to select several value of ECG curve and get a numerical value of these points.

Fig. 3. Infracamera picture from Cryogenic room

3 Conclusions

The measuring device (ECG, plethysmograph) and Guardian PDA client was tested in extreme conditions in a cryogen room in Teplice (-136°C), where the final system will be installed [Fig. 3]. 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.

We think all the web application could be raised on the better level in the future, by the application of a few improvements. We can include to our graphical user interface some script, which could be used as the communication element between patients and doctors, for example for some messages or requests. As the final improvement in the future, the application would have some special algorithm, which could recognize any symptoms of the QRS curve, and make the job for the doctors much easier. As next improvement we would like to apply the better script for the Pan&Zoom function – it is very easy to control and we could find our place of interest very fast.

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