THE IEC-60870-5 STANDARD FOR A PERSONAL SERVER APPLIED TO TELEMEDICINE

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***Abstract*—This paper presents a proposal of a flexible telemedicine system for remote patient monitoring. It can be used in different kind of environments where there is only available low speed transmission links like Radio Frequency. This proposal includes the use of a previous work where the IEC-60870-5 standard was applied to the development of an open and flexible RTU (Remote Terminal Unit) based in open hardware, a SoC-type design using a FPGA programmed with the open core LEON and open source, so both the hardware and the ISO are open source.**

I. INTRODUCTION

Telemedicine systems allow the remote diagnosis and treatment, which saves time and patient movement[1][2][3][4][5]. This paper presents a proposal for remote patient monitoring for those situations where high speed transmission technologies are not available like catastrophe response, mountain rescue, etc.

The general system scheme of the proposal is showed in the "Fig. 1". A sensor network is placed on the patient in order to acquire different measures, like pulse, temperature...

This sensor network communicates with a Personal server, a central device in charge of acquiring data from the sensors. This communication can be implemented by wire and wireless connections (Zigbee, BlueTooth...). The sensors in charge of the body monitoring constitute the BAN (Body Area Network). The Personal server coordinates the data acquisition from the BAN network and also from other environmental sensors.

Personal Server sends the data acquired by the sensor network to a Control center that will be in charge of processing this data. The communication between both devices is in different transmission technologies (radio frequency, GSM, GPRS, 3G...). The chosen transmission technology depends on the scenario.

The proposed system is similar to a SCADA (Supervisory Control And Data Acquisition) one where one or more controlled devices, called Remote terminal Unit (RTU) send

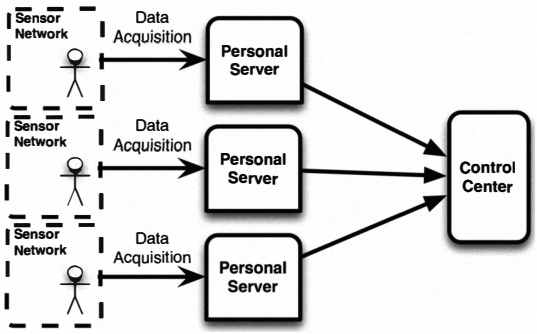

Fig. 1. General system scheme

data to or receive command from the other component, the controller device, called Control Center (CC). As shown in "Fig. 1" the RTUs are the Personal Servers. In the field of SCADA systems there is a series of standards specified by the IEC[8] (International Electrotechnical Commission), called IEC 60870-5, for telecontrol equipment and systems. These standards define specific requirements and conditions for data transmission in telecontrol systems, showing the ways to meet those requirements in order to make sure compatibility between devices from different suppliers. The proposed system presented in this paper complies with these standards.

Next section describes the previous work that is all ready done and can be used to implement the Personal Server and the transmission protocol that connects the Personal Server to the Control Center. In section 3 there are described future research lines to complete the implementation of the system previously presented. In section 4 the conclusions are presented.

II. PREVIOUS WORK

At previous work it has been developed as shown in [9][10][11] a system composed of a Control Center (CC) and a set of Remote Terminal Units (RTUs) that complies the the IEC 60870-5 series. The CC is a PC computer and the RTUs

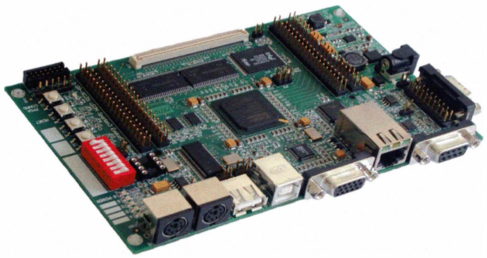

Fig. 2. Personal Server prototype

are based on open hardware and software as explained in the following section.

In this paper there is a proposal of using this protocol for the communication between the Personal Server(RTU) and the Control Center.

A. Personal Server

The hardware platform is an embedded system, a SoC-type design using FPGA. The FPGA itself has been programmed with an open core called LEON[6] an SPARC compliant system capable of running Linux for SPARC. The processor is an open core (i.e. an open hardware), this means that hardware platform is open, and also it is the operating system running over it (Linux Debian for Sparc has been installed in the system [7]). So, the RTU is, in essence, a Linux-Sparc system. This means that every program available may be used for this platform and, more important, the whole software can be developed in a very similar way than in any standard Linux programming environment. Based on previous experience with LEON it is adequate to be the Personal Server due to its versatility.

For prototyping the Personal Server, the GR-XC3S-1500 board, "Fig. 2", has been used. This board is supported by the co-operation between Gaisler Research and Pender Electronic Design. For communication, the transmission channels available in the Personal Server are Radio Frequency (RF), GSM (Global System Mobile) and GPRS (General Packet Radio System). This paper is focused in situations where high speed transmission technologies are not available and RF is used for communications.

In order to send data acquired from a sensor, a environmental temperature sensor and a GPS are connected to the Personal Server via RS-232. The temperature sensor is integrated in a PICDEM 2 Plus, "Fig. 3" demo board and provides the temperature value through a serial port in an ASCII string. Although it is not a medical sensor the acquired data is useful in order to test the right behavior of the transmission protocol.

The GPS is a GARMIN, "Fig. 4". It is connected to the Personal Server to provide localization data of where the temperature measures are taken. The location data is sent in NMEA protocol strings by the GPS.

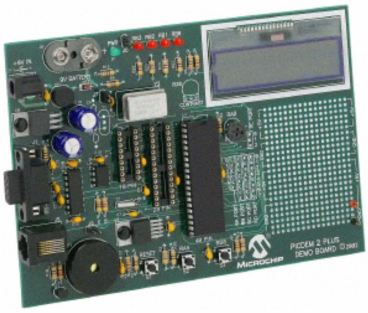

Fig. 3. PICDEM 2 Plus

Fig. 4. Garmin

B. IEC Protocol

A brief description and implementation of the IEC 608670 is presented next.

1) Description: Telecontrol protocol stack usually implements the specification provided by the International Electrotechnical Commission (IEC), called IEC-60870-5. This document, which specifies a suite of protocols, is divided into six parts and specifies an application-layer protocol and a data-link layer protocol. This standard also defines a combination of the application layer using TCP/IP transport services.

Two different scenarios are possible where or not the CC and RTU's are permanently connected "Fig. 5" or connected via Internet using TCP/IP Architecture "Fig. 6". For the first scenario all the protocols described in the standard has to be implemented, included the IEC 60870-5 (application functions) and for the second one, only the IEC 60870-104 because the other layers are yet implemented in most operating systems (TCP/IP stack, the internet protocols). Although open source software is widely used in Internet, it is not very common in the telecontrol networks area, so it is necessary to developed the open software for this protocol stack in the Personal Server.

The open source implementation and test of the IEC 60870-5 data link layer protocol, described in IEC 60870-5-2, and the IEC 60870 -5-5. application layer, are presented in [10] and [11]. As justified in [9] when the transmission channel is half-duplex, RF, it is necessary to use a protocol that controls

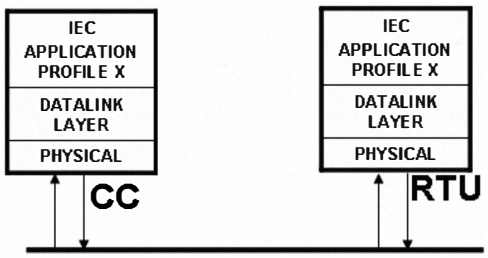

Fig. 5. RTU and CC permanently connected

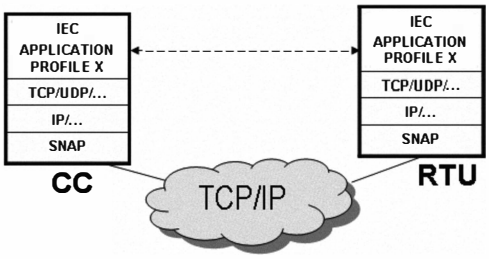

Fig. 6. RTU and CC connected via internet

the medium access, that is what the IEC 60870-5-2 protocol makes.

2) Implementation: In order to develop IEC protocol it is necessary to use protocol engineering techniques. Using natural language to describe it, as it is described the IEC protocol, creates problems like ambiguity, and it would be difficult to be sure about its functionality, actually, there is a extended agreement about using formal description techniques as an adequate way of describing the behavior of protocols. Formal Description Techniques (FDT) is used to name any technique or method that allows to define completely the behavior of a system (hardware or software) using a language with formal syntax and semantic. Because of that, it is ideal to describe the protocol behavior.

The Finite State Machine (FSM) was designed from the IEC 60870-5 standard after reading and studying this standard and are available at [10].

IEC 60870-5-5 defines a series of Application Protocol Data Unit (APDU) to carry the data from the RTUs to the CC. IEC standard is designed for telecontrol applications and none of the defined APDU is able to contain the required data when transmitting position and temperature information. The IEC standard consider the option of defining new APDUs, in this way a APDU has been specified and implemented in order to carry this data.

All functions has been developed by standard C++ libraries and they are available through an interface. As LEON has a standard Linux Debian distribution getting the executable file is as simple as compiling the same source code use its gcc compiler.

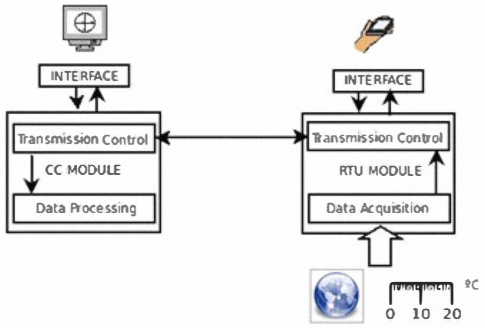

Fig. 7. Software design

C. Design

The software design is divided in two different modules, Personal Server module and CC module.

The Personal Server module performs two different activities: the acquisition of the data provided by the GPS and the temperature sensor and the transmission of this data to the Control Center. The acquisition is implemented in one process. This process associates the temperature value to a position and time and then it is saved in memory in order to be sent to the Control Center when this information is required. To transmit this data an independent process has been implemented. Transmission process implements the initialization and transmission procedures defined at IEC 60870-5-5 for the Personal Server.

The CC module is also divided in two different processes, one for transmission control and other for data processing. Transmission control process implements the standard defined by IEC 60870-5-5 for the primary station and will provide initialization and polling procedures in order to establish communication and request data to the Personal server. Data processing module analyzes and prepares the data received from the Personal server.

D. Field tests

The RTU prototype has been tested with serial cable, RF and GSM transmission channels where the focus was on setting the appropriate number of retries; in the case of RF because of the high transmission delays, the cost in time for any retries is very high but setting a high number of retries, implies a lower protocol performance, although there are more successful poll each are more costly, i.e., the whole time spent is higher. Using a faster transmission technology, GSM or serial cable, allows increasing the number of retries to higher values, although the protocol performance is also reduced there are more completed polls, and the information received is more accurate. The results of these tests are presented in detailed at [11].

III. Future research work

Further research work implies testing the system with medical sensors, which implies a study of the data format

and transmission technology to be used. Also, an acquisition module at the Personal Server to acquire data from different kind of sensors must be built.

Other future work implies the implementation of a data processing module at the Control Center. This module will be in charge of formatting the data acquired in order to be compatible with the one used in medical applications.

IV. Conclusion

This paper has presented a telemedicine proposal for remote monitoring with a low speed transmission technology (RF).

As previous work it has been presented a Personal Server based on a FPGA that has been programmed with the open core LEON with Linux operating system running over. The IEC protocol has been implemented, i.e., data link and application layer, with poll function as a first application profile. All these software has been made in a PC platform using standard development tools. The source code generated for the protocol has been compiled with the standard Linux gcc compiler in LEON.

Finally future lines of work has been presented in order to implement the system designed previously in this paper.

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