DATA RECORD SYSTEM FOR MICROPEL'S PLC NETWORK

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Abstract: This paper presents design and implementation (including both hw and sw) of a new device aimed for data acquisition from network of PLCs. The newly developed device provides RS485 interface, short-term UPS and includes a single board computer FoxBoard G20 which is running Linux. A new driver which enables communication with MICROPEL PLCs based on RS485 bus was developed. Data are read from PLCs, saved to a database and afterwards they are made accessible to user via web interface.

Keywords: FoxBoard, Linux, Data acquisition, Micropel

1 INTRODUCTION

In many industrial processes recordings of their parameters are required. These records are necessary for a quality assurance, but they can be also used to understand a process better and to optimize it. Many different methods are used to acquire these records. Traditionally mechanic recorders with a clockwork mechanism were used. With the advance of digital circuits and computers, electronic devices gain popularity. Most recent data recorders are digital devices containing a computer. Design of one such device is described in this paper.

The device described in this paper is designed to gather data from a PLC network. Gathered data are saved to a SQL database for future processing. Gathered data are available through web interface. This allows to access data from remote places.

2 HARDWARE

A main component of the described device is FoxBoard G20 single board computer based on Atmel AT91SAM9G20 processor[2]. FoxBoard includes Ethernet interface with an RJ45 connector, a real time clock (RTC) and a slot for micro SD cards. The designed device needs other circuits for an RS485 interface, a short term uninterruptible power supply, power supply and power monitoring. These circuits are added on a custom board and they are connected to FoxBoard using pin header.

2.1 RS485 INTERFACE

A network of Micropel PLCs uses a RS485 interface. FoxBoard has 6 UARTs. Some of this UARTs have RS485 support (RTS signal is set high during transmit to switch between transmit/receive mode). Voltage levels on UART pins aren't compatible with an RS485. To add an RS485 support RS485 driver is necessary. A galvanic isolation between RS485 and FoxBoard is required because the network is often large. There are many integrated circuits (IC) with this function. But most of these ICs require two isolated power sources for both isolated sides. This means additional costs and requires space on a PCB. In this design IC MAX1480A was used. This IC includes its own isolated power source which simplifies circuit design and PCB footprint.

2.2 UNINTERRUPTIBLE POWER SUPPLY

Power failures are a serious problem when working with data on a flash memory. One problem is consistency of data in the database and a consistency of the used file system. These problems can be solved with the right settings of a database and a file system [1]. The greater problem is consistency of data on SD card. All SD cards employ some sort of wear leveling algorithms. This means that logical blocks are mapped dynamically to physical blocks on a device (size of the logical and physical block is different). These algorithms reduce wear of most used blocks, but it brings other problems. All consumer grade SD cards and even some of industrial SD cards do not guarantee atomic writes. This means that in case of a power failure not only that the written data could be corrupted, but also any other data on a card could be corrupted (wear leveling could be moving some static data to switch them with newly written data).

The problems described above can be eliminated using an uninterruptible power supply (UPS). This supply provides power necessary to safely terminate all work. For this purpose only a short term UPS is required. On the other hand, designed device should be maintenance free. For this reasons super capacitors were used instead of a rechargeable battery. They have a better service life and don't require any maintenance. Their lower capacity isn't problem in this case because only short backup is necessary. Another advantage of super capacitors is that they are fast to recharge and easy to test[2].

3 SOFTWARE

One of the advantages of the selected hardware platform is that it is supported by the Linux kernel. The use of Linux allows to use of many existing libraries and programs. This is a huge advantage for implementation of data storage and web interface. On the other hand it makes access to hardware more difficult.

3.1 LINUX

GNU/Linux is used as operating system. Installation of Linux on an embedded device isn't as straightforward as installation on a regular PC. It is not possible to use a prepared installation medium. The device described in this paper uses Emdebian [4]. Emdebian is a Linux distribution based on Debian prepared for embedded devices. Its installation consists of two stages. In the first stage basic system is prepared on a regular PC using chroot environment. In the second stage prepared files are transferred to an embedded device and installation continues on this device.

3.2 DEVICE DRIVER

Communication on a PLC network has multi-master architecture[1]. It's using a token to control access to the bus. The advantage of this approach is deterministic access times to the network. On the other hand it requires low latency when replying to the token [3]. Such short responses can't be achieved using the application in standard operating system[3] user space. Another problem is 9 bit characters used in PesNet network which are not supported by generic drivers. This means that device driver had to be created. This allows to run a low latency code directly in interrupts generated by an UART hardware.

For this reason device driver for PesNet protocol was created. This driver consists of two parts. The first part prepares packets for accessing PLCs memory based on requests from user space programs.

[1] Use of journal for both data and metadata prevent inconsistency of a file system, but increase wear of a flash memory.

[2] Test is performed by connecting a load resistor and measuring time until voltage drop to certain level. When performing this test all writes have to be suspended

[3] Protocol specification requires that the latency is lower than the time used to transmit 3 characters

The second part is handling interrupts and it is very simple. Interrupt handler send only prepared packets and token responses.

3.3 DATABASE

Information about users, record parameters and recorded data are stored in a SQLite database. SQLite was designed to be simple with low system requirements. Unlike most database engines, it doesn't use client-server architecture. It's a library which is linked to application and access database file directly. This approach is simpler and has lower system requirements. On the other hand it doesn't allow concurrent write access.

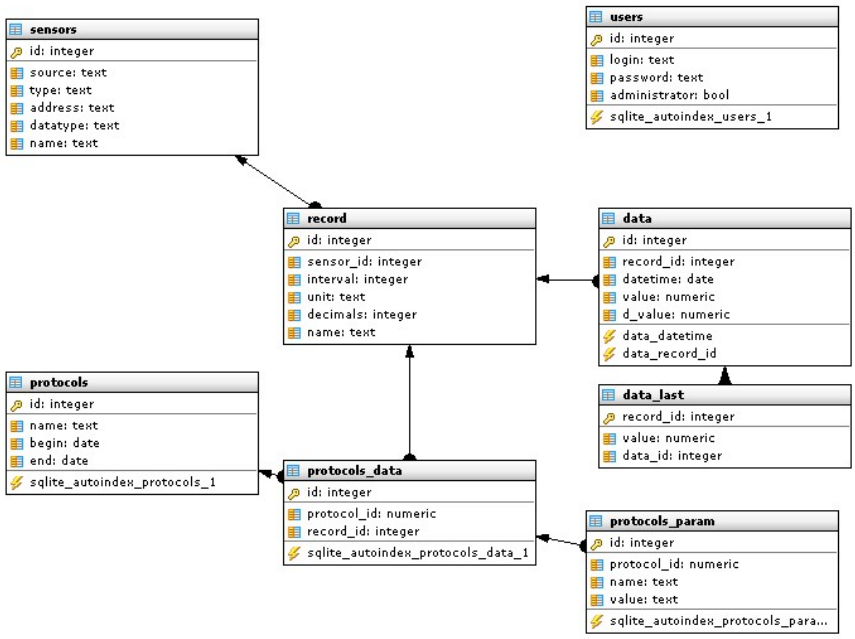
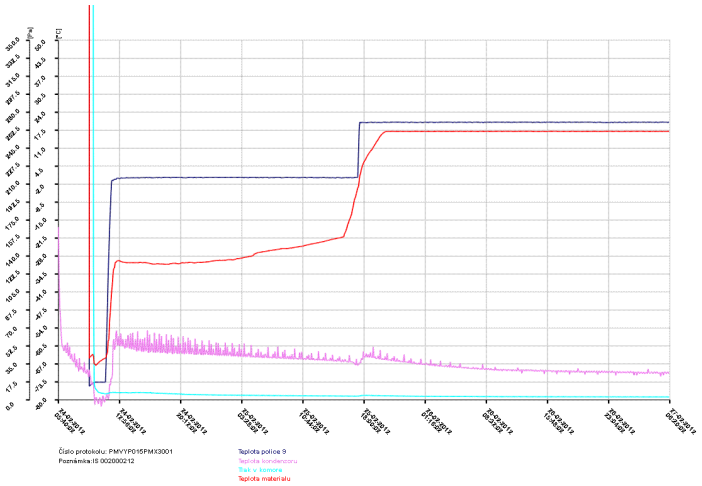


Figure 1: Database model

A model of a used database is on fig. 1. The table **users** is used to save login information of users and their rights. The table **sensors** contains addresses of sensors and their parameters. This table is referenced from the table **records**. This table contains required sampling frequency and information necessary to present data to the user (Unit of measurement, conversion from raw value). The table **Data** contains all recorded data. The recorded data could be used to create protocols which are stored in the **protocols** table. This table contains a protocol name, information about the beginning and the end of the protocol.

3.4 WEB INTERFACE

All interactions with the user are realized using web interface. This interface allows the user to check current sensor measurements, to create protocols from recorded data and to change record parameters (only if user has administrator rights). On the server side PHP scripts are used to create XHTML documents which are served to the browser. Graphs are created in an SVG format. Screenshots from web interface are on fig. 2. On the left side there is a main page with current values and on the right side there is a protocol prepared to print.



Lyo 1												
Čas	Teplota police 1 [°C]	Teplota police 2 [°C]	Teplota police 3 [°C]	Teplota police 4 [°C]	Teplota police 5 [°C]	Teplota police 6 [°C]	Teplota police 7 [°C]	Teplota police 8 [°C]	Teplota police 9 [°C]	Teplota kondenzoru [°C]	Tlak v komoře [Pa]	Teplota materiálu [°C]
24-02-2012 05:40:02	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	-17.5	1000.0	6279.9
24-02-2012 05:50:02	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	6280.3	-46.8	1000.0	6279.9

Figure 2: Web interface.

4 REMOTE ACCESS

The web interface is generally accessible via local network. Remote access is required for service access (changing parameters of the records, backups) and checking long term processes. If the internet is accessible on the site than remote access could be provided by appropriate settings of the router. In some cases the internet connection isn't available. In this case GSM modem could be used.

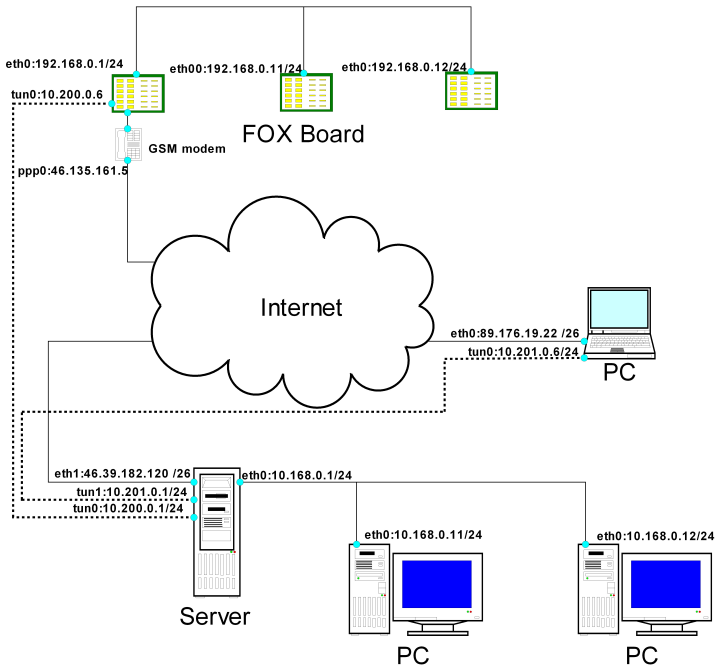


Figure 3: Remote access schema.

An MC75 gprs/edge modem is used in an application described in this paper. A web interface can't be accessed directly via address assigned to a GSM modem for several reasons. There could be more devices connected to one GSM modem and most internet providers don't assign public IP addresses to mobile clients. It's not very secure to open access from whole internet because software in embedded devices doesn't receive security updates too often. Another problem is that considering bandwidth of a GSM connections, it's easy to create a denial of service attack. For these reasons, the connection is configured not to accept any incoming connections. It connects to the single trusted server using virtual private network (VPN). Remote access is then possible only from this server and computers connected to it. Schema of remote access is on fig. 3

5 CONCLUSION

The newly developed device described in this paper enables data acquisition from the network of PLCs. The Data are saved to the database and made accessible to users via a web interface. The hardware concept uses a single board computer FoxBoard G20 as the main component, furthermore, it supports RS485 interface and provides short-term UPC. The software solution includes a new driver for PesNet protocol, software for access to the SQLite database, PHP scripts for interaction with users via a web interface and remote access over GSM modules limited to trusted server using VPN from security reasons. The whole system was realized and tested.

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