Remote Access to the System of Alternative Energy Sources

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Abstract- The paper presents a distributed control and remote monitoring system of alternative energy sources situated in Herbertov (South Bohemia) – a teaching and research centre of the Faculty of Mechanical Engineering, the Czech Technical University in Prague. The whole system consists of two main parts. The data acquisition and control part of the system is based on an embedded controller with a hard real-time operating system (PharLap). The remote access and monitoring part uses internet connection via GSM/GPRS network.

I. Introduction

The research of alternative energy sources available in the Czech Republic being performed in the Department of Environment, Faculty of Mechanical Engineering CTU in Prague. The experimental system of renewable energy sources was built in Herbertov in 1982 and reconstructed in spring 2004. The present system consists of:

- small hydro power plant (max. electrical power of 120 kW),
- solar collectors with the parabolic mirrors (max. heating power of 100 kW),
- two water-source heat pumps (max. heating power of 120 kW).

Heat pumps are used for the primary heating of the buildings, solar collectors are connected to a separated water heating circuit.

II. Process control and monitoring

A new distributed automatic control and monitoring system provides an adaptive control of the alternative energy sources, their monitoring and back up of all important data describing a long-term performance of the energy system. The control and monitoring system consists of:

- autonomous data acquisition and control system based on an embedded controller with Phar Lap's Realtime ETS Kernel;
- computer used as file server for the data back up, local process visualisation and manual control ;
- GSM/GPRS modem for wireless internet connection;
- database and web server for data storing, visualisation and presentation
- remote clients.

The autonomous control system uses industrial embedded controller (with the Intel Pentium II, 700 MHz processor and ETS Kernel) that communicates with the data acquisition (DAQ) and control modules via the PC104/RS-485 and RS 232/RS 485 interfaces.

The Realtime ETS Kernel is a simple, compact RTOS for 32-bit x86 processor platforms that supports C/C++ libraries and a subset of the Win32 API functions. The ETS provides deterministic control, multi-threaded process support, priority-based scheduling, and robust networking capabilities for embedded applications.

The Siemens MC39i modem is used for wireless internet connection. The MC39i is dual-band GSM/GPRS modem which supports GPRS multislot class 10 (4+1 or 3+2 timeslots; downlink/uplink) and the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4.

III. Remote access

A. Data transfer and format

An actual state of the alternative energy sources system is automatically stored at the local file server every 120 seconds and simultaneously transferred using socket communication to the WEB server placed at the building of the Faculty of Electrical Engineering in Prague.
Considering another utilization of the measured data in WWW presentation, it was decided to use XML (eXtensible Markup Language) data format. The size of a file stored in this format is about 4 kB. The XML files are pre-processed at the server and the measured values are saved to MySQL database. The actual XML files are used for visualisation and presentation on WWW pages (see Fig. 4).
Backup long-term data records covering 24 hours time intervals are stored at the local visualisation computer placed in Herbertov in a CSV (Comma Separated Values) format. The size of the single data record is approximately 620 kB. The archive of the CSV files can be transferred from the local file server to any remote client computer using FTP (file transfer protocol).

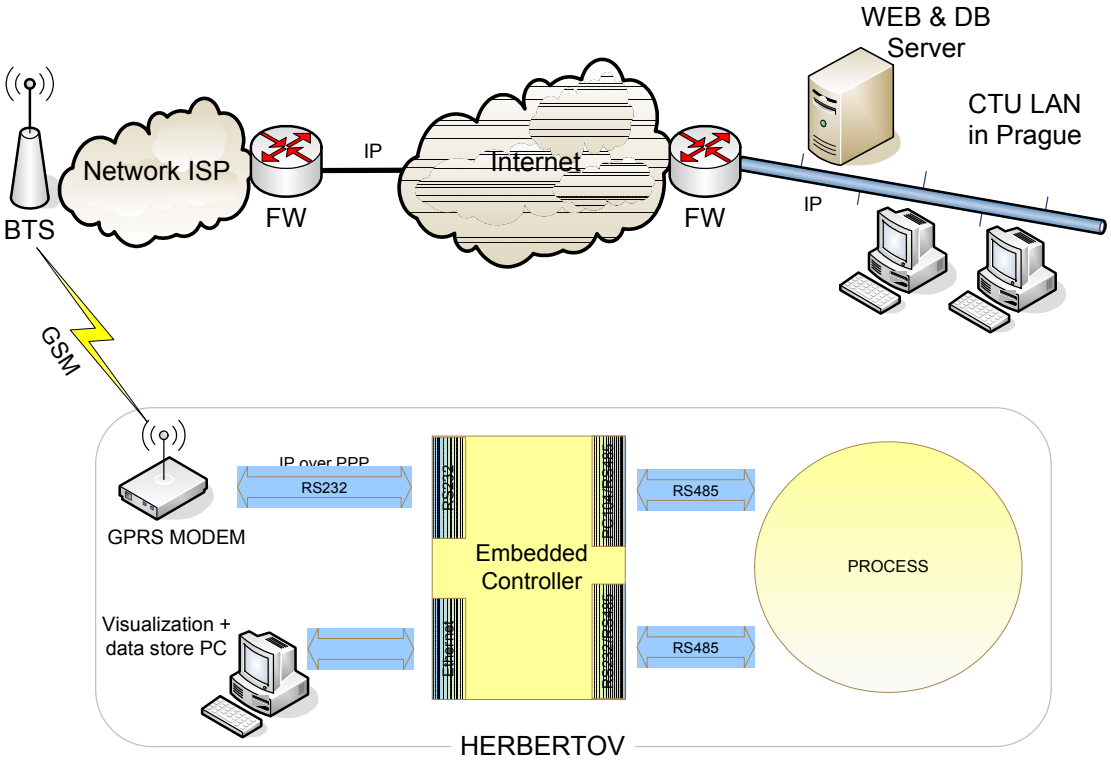

Figure 1. Diagram of the distributed control and monitoring system

B. GPRS technology

GPRS (General Packet Radio Service) offers data transmission via a GSM network within a theoretical range 9.6 kbit/s to 171.2 kbit/s. The GPRS transmission speed depends on the capacity of the modem (e.g. the number of timeslots: 4+2, 3+1, etc.), coding scheme (CS-1, CS-2, etc.) and by the current workload of the base transceiver station (BTS) to which the modem is connected during data transmission.

Coding scheme	1 timeslot	2 timeslots	4 timeslots
CS-1	9.05	18.1	36.2
CS-2	13.4	26.8	53.6
CS-3	15.6	31.2	62.4
CS-4	21.4	42.8	85.6

Table 1. Coding schemes, number of timeslots and maximum net data rates in kbit/s

In case of the MC39i modem, theoretically achievable transfer speeds are 53.6 kbit/s (downloading) and 26.8 kbit/s (uploading) - GSM operator supports only CS-1 and CS-2 coding scheme.
Experimentally measured average data transmission speeds with the Siemens MC39i modem are 46,2 kbit/s for downlink and 26,2 kbit/s for uplink. The uploading speed is more important in our case because most data is transferred from control computer in Herbertov to the database server in Prague.

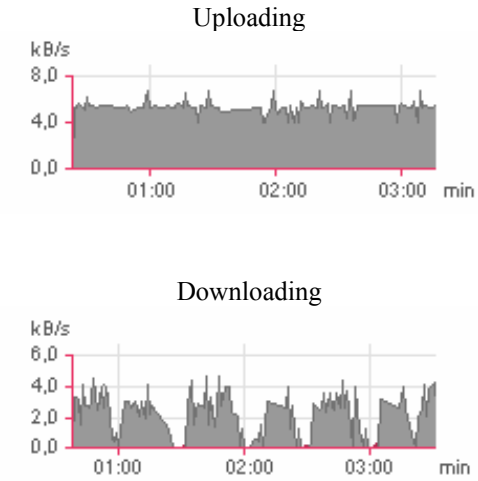

Figure 2. Real transmission speed (continuous data block)

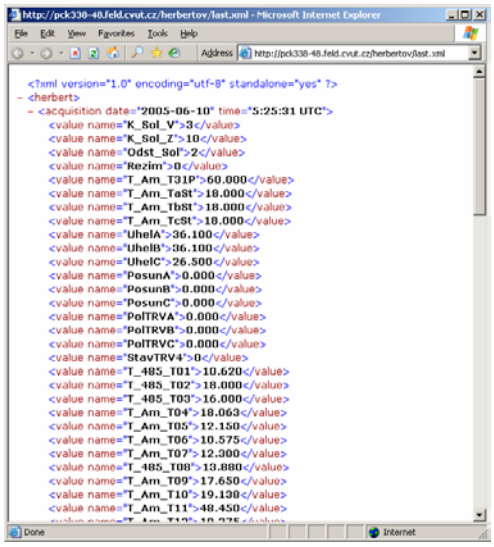

Figure 3. Example of the XML file

The measured data transmission capacity is sufficient not only for transfer of the XML file with actual state of the system (size about 4 kB) but also for communication with the remote control application. This application allows the user to adjust and configure all important parameters of the energy system.

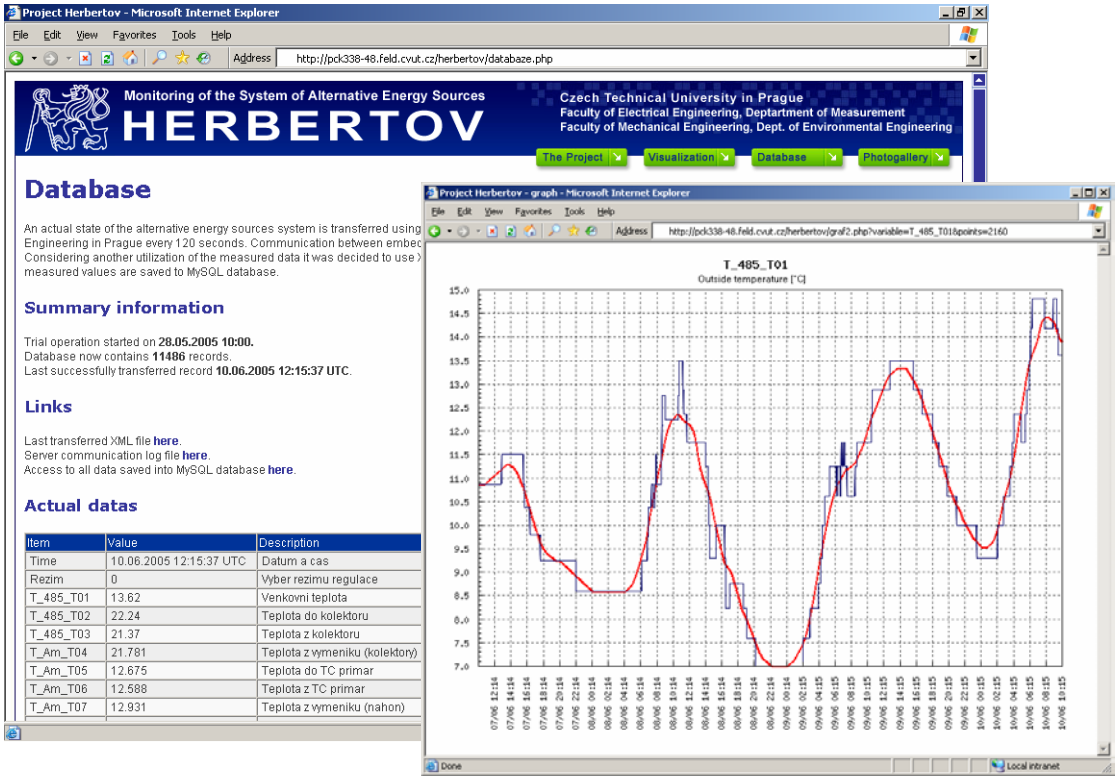

Figure 4. Preview of presentation Web pages

C. Watchdog mechanism

Several watchdog mechanisms are implemented in the control as well as the communication program. In the event of GSM network failure, the data are saved to a queue to be sent later. The queue is able to retain 300 records (10 hours failure equivalent).
Control computer system date and clock is also automatically and regularly synchronized using RFC 868 - Time Protocol.

D. Presentation

Measured, transferred and pre-processed values are saved to MySQL database. The data from the SQL database can be simply exported to another format (e.g. MS Excel table) for use in specialized energetic/environmental analytic programs. The data in the table or graphical form (according to the user request) are accessible at the generall web pages. PHP scripting language and JPGraph library are used for web presentation. The graphic library JpGraph for PHP makes possible measured data to be displayed in variety of graphs.

IV. Conclusions

The control and monitoring system described above enables remote access to the system of alternative energy sources. Communication between remote user and embedded controller uses wireless internet connection over GSM/GPRS. Described system can be used not only for common supervision and control but also for practical education at the Czech Technical University and for research focused on the utilization of alternative energy sources in the Central Europe territory.

Acknowledgement

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References

[1] *TNT Embedded Technologies Guidebook*, Phar Lap Software, Inc., Cambridge, 2000.
[2] R. Grehan, R. Moote, I. Cyliax, *Real-Time Programming*, Addison-Wesley, Reading 2000.
[3] *The construction of solar thermal collectors in Herbertov*, Technological Sheet ST003, Technological Centre of the Academy of Sciences of the Czech Republic, Prague, 2003.
[4] *RFC 1661: The Point-to-Point Protocol (PPP)*, www.rfc-editor.org
[5] *RFC 868: Time Protocol*, www.rfc-editor.org
[6] *http://pck33-48.feld.cvut.cz/herberto* - project development and presentation web server