Possibilities for Electric Energy Consumption Distant Reading System Organization

Radoslav Velichkov Ivanov, Todor Stoyanov Djamiykov and Peter Ivanov Yakimov

Abstract - **The paper presents the investigation of some possibilities for distant reading of the consumed electric energy. The purpose is to organize an automated system for data communications between different points and a control centre. The architectures of SCADA systems are proposed. There are described possibilities using standard serial interfaces, Ethernet and GSM/GPRS communication.**

The presented results will be used in further investigation of more complex systems for electric power management.

Keywords – **SCADA, Ethernet, communications, electric energy measurement**

I. Introduction

The energy effectiveness requires strong control of the electric consumption. This is of a great importance for all companies and enterprises but especially for big consumers. So there is a need of control measurement which has to double the commercial one in order to ensure information for the energy transfer with the system operator. The energy consumption monitoring will deliver information for the relation between the technological processes and the load curves of the different production sections. Because of the large scale of the enterprises the distances between the measuring devices and the central station are quite long. This causes the need to organize a system for automated distant reading of the consumed electric energy. The obtained information will give the management an opportunity to:

- reduce the expenses due to the non-balance between the required and consumed energy by control the consumption within the framework of one hour;
- compare the quantities measured electric energy with the commercial measurement.

This information will be very useful in load prognoses. They are important because of the possibility for real time load control and orientation the great consumption within the framework of tariffs with fewer prices. This will result in improving the effectiveness.

Realization of such project requires modern hardware and software solutions. The Supervisory Control and Data Acquisition (SCADA) systems integrate functions of measurement, data collection and transmission to a decision central control.

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II. Possibilities for Data Transmission in SCADA Systems

The major components of the SCADA system are:

- substation remote data acquisition, metering, control unit such as RTU (Remote Terminal Unit);
- data processing unit such as a substation server or an Intelligent Electronic Device (IED);
- MMI (Man Machine Interface) and central data processing unit installed in the control centre.

The data transmission can be developed using different types of the communication media:

- fixed networks including public switched telephone and data networks (PSTN);
- wireless networks including cellular telephones and wireless ATM (Asynchronous Transfer Mode), radio systems, microwave (radio signals operating in the 150 MHz to 20 GHz frequency range);
- power line carrier is the most commonly used communication media for protection function. However, this medium does not offer a reliable solution for wide area data transmission. Communication with remote sites can not be maintained during a disturbance;
- computer networks including various dedicated LANs, WANs, and the Internet;
- the satellite network is another segment of the communications system that can provide important services which are difficult to carry out with normal communication techniques. These services include detailed earth imaging, remote monitoring of dispersed locations and time synchronization using signal from GPS (global positioning system).

Local area network is widely used as data communication backbone in many power system control and monitoring systems due to its high performance and scalability. Among different LAN systems such as FDDI, Ethernet, Token Ring, Token Bus, Ethernet is normally chosen as physical / data link layer network because of its predominant role the marketplace and the subsequence availability of low-cost implementation and associated network hardware (bridge, router and switch) [1, 2, 3]. In addition, the scalability of Ethernet is well defined with 10/100 MB implementations. Processors are available today with multiple Ethernet ports integrated into the chip and next generation designs are planned with Gigabyte Ethernet. Ethernet also supports open system and cross-platform architecture, information exchange and communication can be done with minimum effort.

Due to the above reasons, more and more substations currently make use of Ethernet as the main data communication backbone. Another interesting feature of local area network is its ability to support cooperative client/server application.

However, existing SCADA information management systems cannot satisfy the new challenges as more and faster information has now become desirable by many users [4, 5]. Technological advantages in networking have made it possible to develop a low cost communication system for accessing real time power system information over digital network. One solution to these problems is to connect the device to a PC and have the PC make the connection to the Internet via an Internet service provider using Secure Socket Layer. Unfortunately, this solution may not meet the low-cost criterion and, depending on configuration, can lack reliability.

An alternative to using a PC is an embedded solution: a small, rugged, low-cost device that provides connectivity capabilities of a PC at a lower cost and higher reliability. This device (sometimes referred to as an Internet gateway) is connected to the equipment via a serial port, communicates with the equipment in the required native protocol, and converts data to HTML or XML format. The gateway has an IP address and supports all or at least parts of the TCP/IP stack—typically at least HTTP, TCP/IP, XML file, just as if it were any PC server on the World Wide Web. In cases where the equipment incorporates an electronic controller, it may be possible to simply add Web-enabled functionality into the existing microcontroller.

The open nature of the Internet requires data security measures when implementing Internet-based SCADA systems. Processes, procedures, and tools must address availability, integrity, confidentiality, and protection against unauthorized users.

SCADA system gathers incoming power system data for further processing by a number of distributed processes. The architecture of Internet-based SCADA system which is developed to work with data bases is shown on Fig. 1. The structure is organized on three layers. The first layer consists of remote terminal units (RTU) which measure the values of the electric power system parameters. The second layer includes an applied server (Web server) and data base. The client interface is realized by standard Web browser.

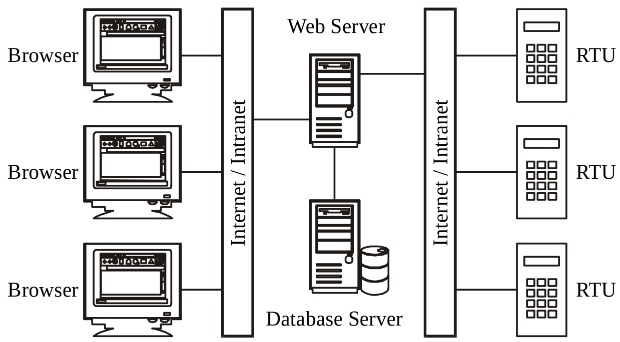

Fig. 1. Internet-based SCADA system architecture

III. SCADA SYSTEM ORGANIZATION PROPOSALS

The reliable function of the system depends strongly on possibilities of its components. Their choice must be made concerning a complex of features like accuracy, price, reliability, supported interfaces and etc.

As the accuracy of the measurement depends on the RTUs a special attention must be paid to the equipment for the first layer of the system. For the monitoring of the energy consumption are used electricity meters with proper interfaces or universal transducers which measure all electric quantities.

After market investigation and comparison of a variety of models produced by different companies the electricity meter ZMD405CT44.0007 of Landis+Gyr (Fig. 2) has been chosen. It is intended for industrial and commercial metering. The device is transformer operated and measures active and reactive energy in 3-phase 4 wire networks with the following accuracy:

- active energy to IEC 62053-22 class 0.5 S;
- reactive energy to IEC 62053-23 class 1.

In addition the unit forms a load profile.

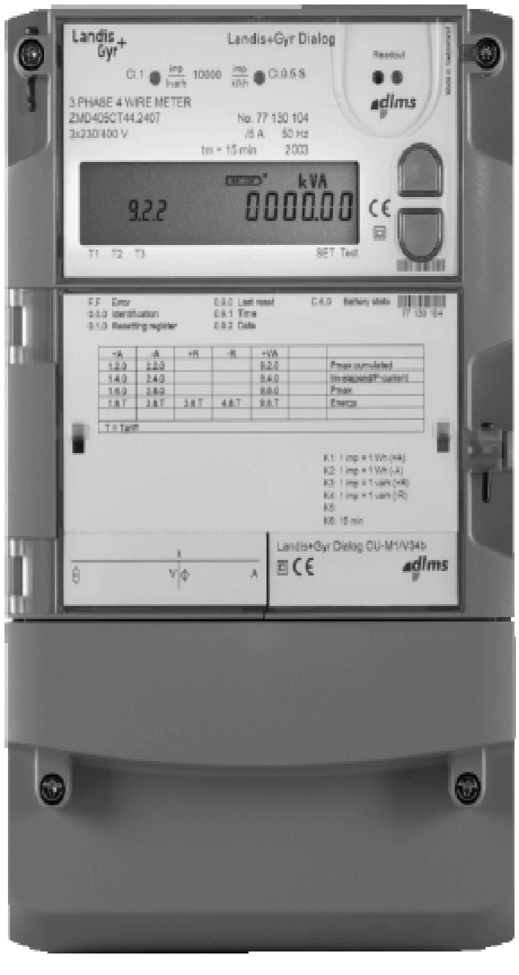

Fig. 2. Electricity meter ZMD405CT44.0007

A great advantage of the chosen electricity meter is the ability to work with exchangeable communication units.

Landis+Gyr offers a variety of communication units with different interfaces. They can be integrated with the electricity meter and a various ways of system configuration are possible. There are units with interface for remote access – Ethernet, GSM, GPRS, PSTN, RS232. Each of them has standard interface – RS485 and two wire current interface which allow multiple connection of electricity meters.

To support the dialog with the meters Landis+Gyr developed the software instrument “MAP120 Parameterisation Tool” [6]. It is able to communicate with all modern electronic meters from Landis+Gyr and also with many units from other manufacturers, which comply with the standards according to *dlms* or IEC 62056-21 (formerly IEC 1107).

The main function of the Landis+Gyr "MAP120 Parameterisation Tool" is the readout and modification of parameters of Landis+Gyr meters and communication units. Its functionality also includes further functions, like billing data readout, readout and export of profiles (load profile, stored values and event log) and execution of IEC commands. Communication channels RS232, RS485, CS, PSTN, GSM, GPRS and Ethernet are supported.

As an example, on Fig. 3 is shown the block diagram of the communication unit E22. It combines Ethernet communications with RS485 and current interface CS.

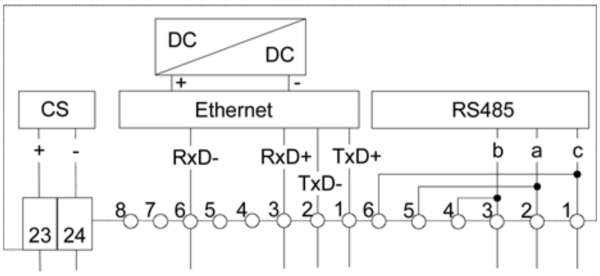

Fig. 3. Communication unit E22 block diagram

A. Ethernet communications based SCADA system

On Fig. 4 is proposed the structure of Ethernet based system for electricity meters distant reading.

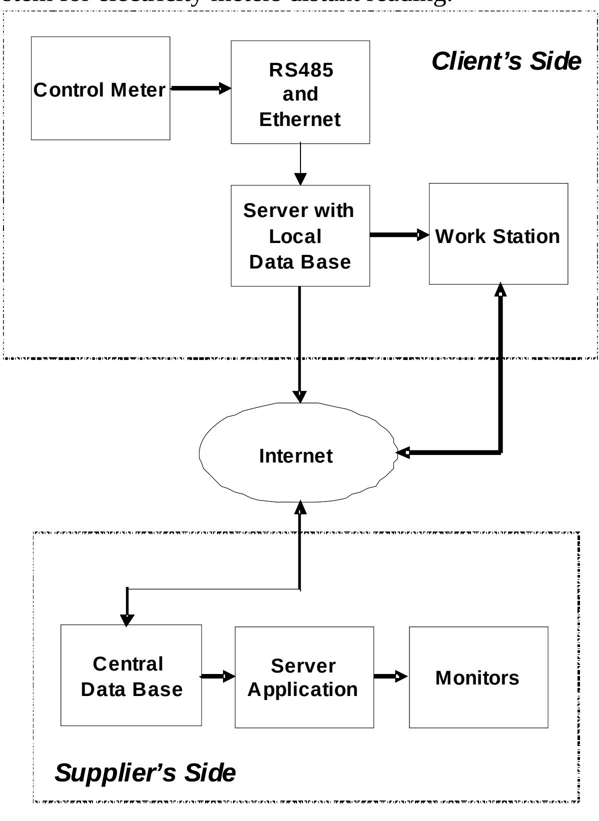

Fig. 4. Ethernet based distant metering system

The client's side is organized at the territory of the industrial object. The layer of RTUs is developed using electricity meters ZMD405CT44.0007. One of them is equipped with the interface module E22 and will function as a master but the others – with the modules B2, which have standard interface RS485 and they will be slaves. The number of slaves is limited to 31. So a network of electricity meters is built using RS485. The communications between the network and the server with the local data base is done via Ethernet. For local control of the energy consumption is intended a work station. The server with a local data base and the work station are connected to Internet.

The supplier's side is organized at the territory of the control centre. There are situated the central data base, the server and the monitors. At the control centre the information from different clients is stored, processed and observed. The information is easy of access from everywhere using standard Web browsers.

B. SCADA system using GSM/GPRS communications

The proposed structure of a system for electricity meters distant reading using GSM/GPRS communications is shown on Fig. 5.

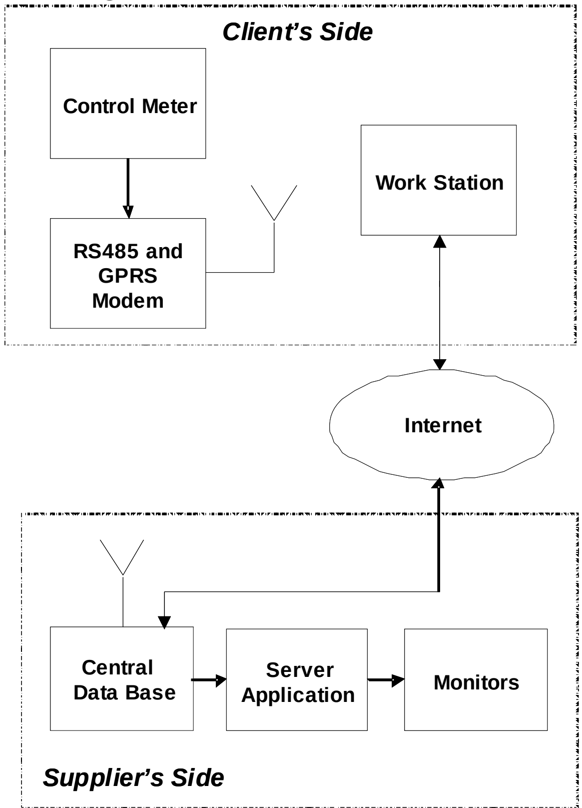

Fig. 5. Distant metering system using GSM/GPRS communications

The communication unit P22 has GSM/GPRS modem and also supports RS485 and current interface CS. This is very useful and allows a various of possibilities to develop the network of electricity meters at the client's side. If the industrial territory is large, a wireless network of RTUs can be organized. In another case only one meter has to be equipped with interface module P22 and it will function as a master. The others will be slaves. They can be completed with modules B2 and will be connected to the master using RS485. If the number of slaves exceeds the limit, the network can be split to sub-networks. In this proposal the work station at the client's side is not connected directly to the metering network. It can access the information of the central data base via Internet.

The central data base at the supplier's side must be equipped with GSM/GPRS modem. All the rest are standard hardware and software resources.

IV. Conclusion

In this paper some possibilities for data transmission in SCADA systems are given. The application of SCADA systems in distant electric energy consumption measurement is discussed. Intelligent electricity meters, communication units and software tools of Landis+Gyr are investigated. Two variants of the system structure for organization the distant electric energy consumption control using Ethernet and GSM/GPRS communications are proposed. The obtained information and results will be a part of more complex investigation on hardware and software tools for automated distant reading of the consumed electric energy.

References

[1] R. Suresh, P. Shukla, G. Schwenke. *XML-based data systems for Earth science applications*. IEEE 2000 International Symposium on Geosciences and Remote Sensing (IGARSS) Proceedings, Vol. 3, 2000, pp. 1214 - 1216.

[2] Larry L. Peterson and Bruce S. D. *Computer Network: A System Approach*. Morgan Kaufmann, 2000.

[3] Alex Berson. *Client/Server Architecture*. McGraw Hill, 1997.

[4] Pao-Hsiang His, Shi-Lin Chen. *Distribution Automation Communication Infrastructure*. IEEE Transactions on Power Delivery, Vol.13, No.3, July 1998, pp. 728 - 734.

[5] B. Qiu, H.B. Gooi. *Internet-based SCADA Display Systems (WSDS) for Access via Internet*. IEEE Transaction on Power System, Vol. 15, Issue 2, May 2000, pp. 681 - 686.

[6] Landis+Gyr. *MAP120 Parameterisation Tool*. User Manual.