The Possibilities of Data Communication for Telemetry Systems in Energetics

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Abstract—**The paper describes the possibilities of communication lines for automated data collection from any energy meter installed on the client's side. There are compared some types of communicatin lines, classical modem communication over PSTN, TCP/IP communication over Internet and PLC (Power Line Communication) - communication over power electrical distribution chain. The main focus is presented to PLC system. The remote data acquisition is modern trend for metering of energy, gas, water, heating steam etc.**

Keywords—**PLC, data aquisition, communication, power lines, energetics**

I. Introduction

Today, many electricity distribution companies try to find efficient ways to gather information regarding clients' energy take-off. The old-style method when a qualified person knocks at your door and asks for the relevant information seems to be outworm. This significant move towards automated data collection opens new doors for telecommunication companies and organizations. A lot has been written about data capture using classical telephone lines, xDSL and wireless technologies. The latest development in the field of Power Line Communication (PLC) allows us to use Power Line technologies (PLT) to transmit the relevant data from a client to the distributor's data access point and further on through the distribution network [4] [5]. The first chapters provide a brief overview of the available Power Line technologies, summarizing advantages and disadvantages as well as the implementation areas. Later chapters will try to analyze PLT and draw the scheme for automated energy data capture. Energy measurement devices represent highly sensitive information source most often installed on the clients' side of the electrical distribution chain. The implementation of an encryption standard on the entire data exchange network is an extremely critical and complex task. We avoid describing the higher level securing methods and concentrate on lower level implementations instead. Out of many available encryption standards we picked AES system.

II. The comparision of technologies for remote data acquisition

Recently, it is mainly telephone network (PSTN), dedicated industrial lines and GSM that is used for remote data acquisition. Pilot projects are focused on possibilities of the internet utilization, GSM GPRS and PLC utilization. However, this technology brings along plenty of new problems, mainly

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from the point of view of the data transmission security and the communication reach. We also know other technologies designed particularly for acquisition of data via mobile data stations. Emphasis is placed on transmission reliability and data security. The speed of the data transmission is not so important. Nowadays, common data transmission speed is about 9600 kbps and its increasing is not the main problem. The comparison of available communication technology can be seen in TABLE I.

III. Overview of Power Line Communication

Power Line Communication is a general term used for describing communication over common power lines. Energy distrubution net represents the densest network in every country, where each building has a power line connection and a power line termination - electrical plug - is present in every room. It is obvious that use of the power line net as a data communication medium, is a very resourceful idea. At the latest stage, each device plugged into an electrical plug would be able to use the Internet services. Making of Power Line a suitable communication medium, however, opens some new issues:

- Power line medium is not suitable for high frequency signals. It actually introduces high attenuation and noise to the signal (e.g. pulse interference from motors or SMPS sources). The existing EU laws enable the usage of a frequency range from 3 kHz to 148.5 kHz for PLC transmissions[10].
- The topology is still not determined.
- Since devices are being plugged and unplugged from the electrical network randomly, the line impedance is strongly dependable on frequency and time.
- Power lines serve as antennas and they introduces harmful interference to the neighborhood.
- Transformers block the communication across Low- Voltage (LV) and Medium-Voltage (MV) network.
- The data sent from one point of the local LV network are present at all the other points, what is connected with a high security risk.

There seem to be no PLC standardization for all the implementation platforms, but some separate standards for industry and home usage exist.

A. EIA-709 Specification

The EIA-709 was originally proposed by Echelon Lonworks and standardized by EIA (Electronic Industries Association) as the protocol specification EIA/CEA 709.1-B-2002. The specification is available for purchase only. The

TABLE I
COMPARISON OF AVAILABLE COMMUNICATION TECHNOLOGY

Technology	positive	negative
GSM	- signal coverage in habitation area - solidity b	- price - more providers - poor signal coverage in non habitation area
Wi-fi	- non licence range - price	- radio interference - attenuation
Satellite comm.	- excellent signal coverage - excellent rate	- single way comm. - price
Laser comm.	- excellent rate - solidity	- direct visible of terminal unit
Dial-up	- availability - price	- obsolete - rate
ISDN	- digital comm. line	- rate
ADSL	- rate - price	- rate depend on distance
Structured wiring network	- rate - availability	- installation complexity
Optical fibre	- excellent rate - solidity	- price
Power line network	- pre-existent comm. line - rate up to 200Mbps	- interference - power line is not dedicated for data comm.

TABLE II
FREQUENCY RANGES FOR POWER LINE SIGNALING IN EUROPE

Band	Frequency range [kHz]	Application
A	9 - 95	Electricity suppliers
B	95 - 125	Consumer use without protocols
C	125 - 140	Consumer use with the CENELEC protocol
D	140 - 148,5	Consumer use without protocols
-	¿ 148,5	Prohibited

Echelon transceivers PL31xx [2] work in band A and C (see TABLE II for bands in Europe) in the double carrier mode with primary carrier at 86 kHz and 132 kHz respectively. Echelon guarantees data transfer rate 5.4 kbps (using BPSK) in band C up to distance of 1.5 km. Another transceivers work in band A with spread spectrum and data transfer rate 2 kbps. Transceivers PL31xx use narrow-band technology with digital signal processing to correct impulsive and continuous tone noise, phase distortion, etc. For error correction it uses patented low overhead FEC (Forward Error Correction) and classical CRC. LonWorks protocol uses all the seven layers of the OSI/ISO model. Three 8bit Neuron processors are the core of all the transceivers. They process MAC, network and application layer data. Additionally the receivers are consumer programmable using NodeBuilder Echelon's development tool. The LonWorks protocol is frequently used for capturing the energy consumption data from energy meters. Over 30000 nodes (devices, meters) can be connected to the same power line segment.

B. Topology of PLC for Energetics

The topology of data net for remote acquisition and control system via PLC is shown in 1. The data communication is possible between electricity meter and the first substation with concentrator unit of 1. level. It is acceptable communication over maximum three repeaters. This communication is on LV power line. Communication on MV power line is realized between concentrators of the first level and the second level. The conectivity to telemetering acquisition system or to control

system is necessary create by another way, for example via Internet, PTSN, GSM or otherwise [11] [12].

IV. IMPLEMENTING AUTOMATED METER READING

There are three types of electrical meter reading: EMR (Electrical Meter Reading - On-Site Meter Reading), OMR (Off-Site Meter Reading) and AMR. Automated Meter Reading (AMR) [3] uses fixed telecommunication network (mobile or fixed radio, dial-in/out, PLC, broadband cable [4], Internet) to collect data. Data modem installed on the client's side sends the required information to the distrubutor's data access point or central database. The connection itself is often realized using backbone network built upon TCP/IP, telephone, ISDN or xDSL technologies. Speaking of capturing data from clients' energy meters, we need to point on the fact that not all the monitored places are connected over one of the mentioned technologies and the Power Line is the only remaining one. The actual implementation of AMR differs from manufacturer to manufacturer. One of the possible solutions is shown on 2. In this example, PLC serves as a communication medium in the access network and optionally in the distribution network. The data access point is placed in the MV/LV station. It is used to collect data from electric meters from all the connected clients. They can either have PLC installed or they can use one of the standardized protocols (Euridis, DLMS/COSEM, IEC 60870-5-102) to connect with a PLC modem. Data from the data access point can be send either via MV PLC or other communication medium (optical fiber, xDSL, PSTN, GSM) [8]. This solution is suitable for the environments,
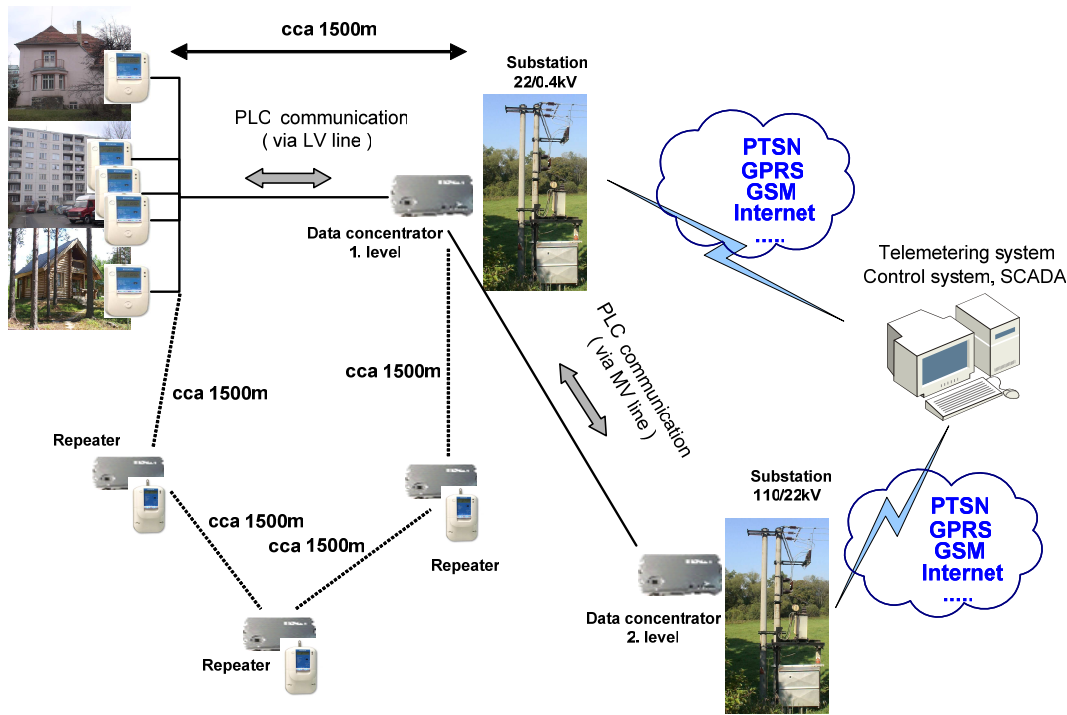
Fig. 1.   System of Data Acquisition via PLC in Energetics

where it would be difficult or expensive to use other fixed communication network (PSTN, GSM) directly to the meters, e.g. villages with one MV/LV transformer have one data concentrator, which will connect to the central via PSTN, GSM or other technology and via PLC with all the electric meters.

Using PLC in the distribution network brings some issues mentioned earlier in the paper. Their elimination connected especially with the use of massive injection capacitors and additional data paths in the transformer stations may result in highly expensive solution. Data modems often represent a simple counter block with PLC output. The counter module counts the incoming impulses while the communication unit encrypts and sends the data over a PLC line to the first data access point. This structure allows the devices to be used for counting of variety input pulse signals from e-meters including gas meters, water meters etc. The devices are additionally often equipped with a programmable interface such as RS-232. The core of the communication modules is usually built upon a programmable Digital Signal Processor (DSP) platform since it needs to contain support for encryption standards.

V. Building Secure Path over Power Line Communication

The implementation of an encryption standard on the entire PLC network is an extremely critical task. We recommend to use advantages of a physical-layer (hardware) encryption instead of building a complex upper-level security standards. Building VPN (Virtual Private Network) and IPSec on top of TCP/IP might be seriously considered when large data fragments are to be transported over the network. Hardware implementations of cryptographic algorithms have a long history. In confrontation with software implementation, it can be of benefit for high-speed applications applications where a cryptographic co-processors perform the cryptographic operations as well as the applications where low power and low area requirements are stringent. In both cases, the secure storage of cryptographic keys is crucial. Today, the traditional algorithms such as DES and RSA are being replaced by the AES (Advanced Encryption Standard). AES is suitable for small 8-bit microprocessor platforms, common 32-bit processors, and it is appropriate for dedicated hardware implementations. Hardware implementations can reach throughput rates in the Gigabit range [9]. The algorithm can encrypt and decrypt blocks using secret keys. The key size can either be 128-bit, 192-bit, or 256-bit. The actual key size depends on the desired security level. The different versions are most often denoted as AES-128, AES- 192, or AES-256 [9].

VI. Conclusion

Remote data acquisition is burgeoning area not only in the power energetics.. The main problem is suitable transfer channel that is brought to measuring equipment. Generally, we can use different technologies. All of the technologies are still in phase of improving but the most important improvement we want to achieve is coverage of the specific area. It was proved that it is necessary to employ several technologies and use their combination. The use of the internet and PLC systems is certain alternative how to provide connection between telemetering central system and remote measuring equipment. PLC is a communication method that makes use
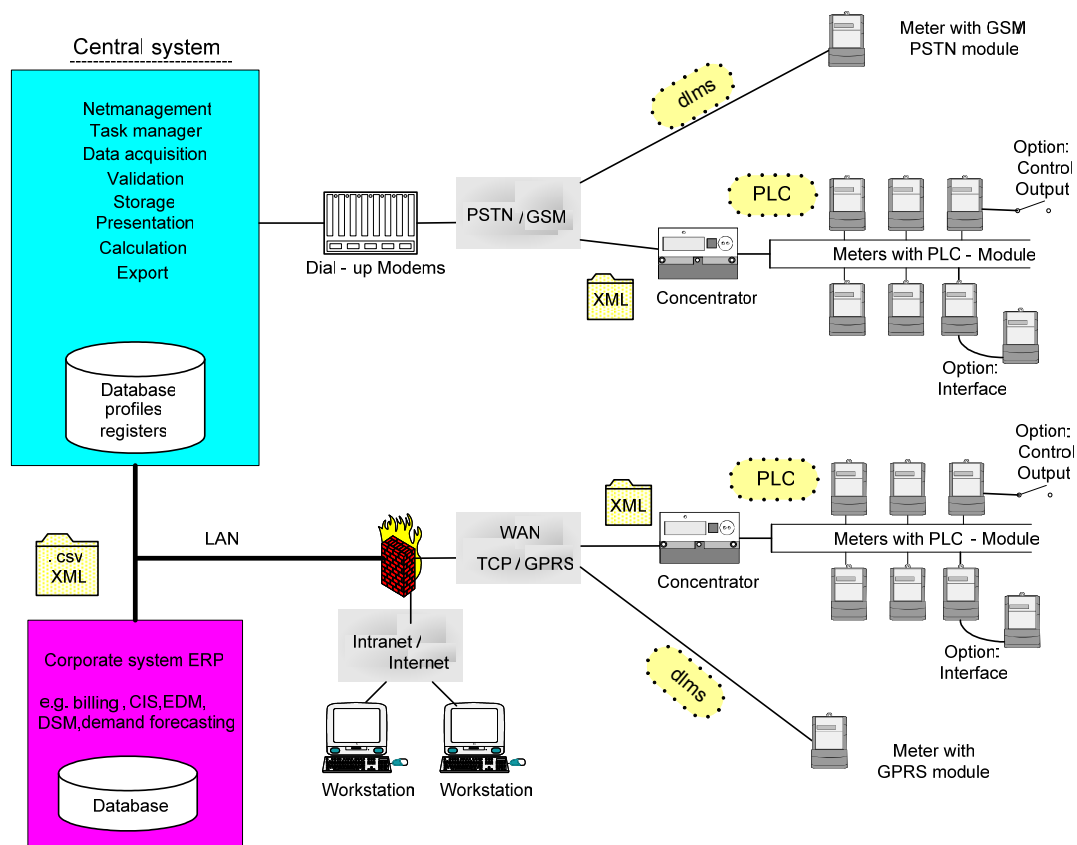
Fig. 2. Using Power Line Communication for Automated Meter Reading (AMR)

of the existing LV power lines as a communication channel. The possibility to transmit data messages with the use of the existing power lines as a communication medium has brought a new impulse to the development of applications in the field of industrial automation, integration and other communication solutions. The implementation of the PLC technology in the field of Automated Meter Reading seems to be a progressive way ahead. Nevertheless, the producers of the energy data collection devices tend to deploy their own private solution which leads into the lack of ability to communicate with devices of different origin. The AMR-PLC principal scheme for automated e-meter data collection is quite simple. On the client's side the energy measurement device is usually connected to a communication modem. Distributors access point is most often represented by a communication modem and server gathering information from all the clients. The PLC technology may be implemented in the access network. AMR represents a highly-sensitive information chain and the encryption standard is a crucial task. We strongly recommend to use existing hardware implementations of AES encryption algorithm. On a larger scale when the entire electrical distribution network must be considered we recommend to think of an upper level security management such as VPN.

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