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ANALYSIS OF COMMUNICATION PROTOCOLS FOR SMART METERING

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ABSTRACT

This presented article deals with the issue of VDWS and DLSM communication protocols, that are used for remote reading of intelligent electrometers for smart metering. This article analyzes the real data communication from the distribution networkof CEZ, a.s., one of the biggiest elektricity distributor in EU. Based on the analyzed data the authors then introduce their recommendations and the direction of further development and utilizations of remote readings in smart metering networks.

Keywords: VDEW protocol, DLMS protocol, remote reading, smart metering, IEC 60870-5, IEC 62056.

INTRODUCTION

In the beginning when remote communication was being set on meters, the most common communication technology was PSTN (Public Switched Telephone Network). For distribution companies it usually meant minimal installation costs. Either the connection was already available, or the customer was forced to create it. It concerned mostly big customers or facilities owned by the distribution companies, mainly distribution points and power plants. But because of inefficiency and rather high operation costs, distribution companies abandon this technology very fast. It is utilized mostly on places where it is not possible to use another technology for remote reading. Another utilized technology slowly building its position is AMM (Advanced Meter Management), which comes under the concept of so called intelligent networks (Smart grids). These systems allow the customers to, for example, closely observe the current electricity consumption in households. AMM technology is still in its very beginning and therefore it is not possible to choose a suitable number of samples for analysis. In the Czech Republic two major technologies, GSM and GPRS, are used for remote data reading. An integral part of remote reading are communication protocols serving as an interface between the electrometer placed on the offtake point, and the controlling reading system. One of the oldest protocols used is SCTM (Seriál Coede TeleMetering), which is now used only for older meters and its lifespan ends when the meter is changed for a newer model. Distribution companies nowadays utilize VDEW and DLMS protocols for remote communication with electrometers.

Possibilities of efficient smart grid and industrial utilization are then directly dependant on correctly designed architecture of a communication network from the reading exchange to the end user, which is, in our case, an intelligent electrometer. This issue is then closely investigated in general view in (Emilio A., et.al., 2013). An important part of these networks is the need of compatibility of the used communication with the IEC 61850 standard, as mentioned by (Carré, O., et. al, 2012), (Pruthvi, P., et. al, 2013), (Han, G., et. al, 2013), (Han, G., et. al, 2014), (Horalek, J., at.al., 2013) and (Naumann, A. at. al., 2014), who focus mainly on this combination of IEC 61850 and smart grid networks. The problem of efficient utilization of remote readings is its dependency on not only the architecture of the data network it selfs, but also on appropriately chosen and correctly implemented protocols for communication between the reading exchange and the intelligent electrometer, principles of which are investigated in (Yang, Y., et. al. 2013) and (Otani, T., et. al. 2013). The uniqueness of this article lies in the analysis of real data obtained from long-term VDEW and DLMS protocol usage in industrial utilization, their analysis, assessment, and subsequent recommendation for reliable and continuous operation. From the analysis of measured real operation data, the range of conclusions and their impact on the real use of VDEW and DLMS protocols can be drawn. Our findings obtained on the basis of real operation, should be reflected in the design of further development of smart metering.

COMMUNICATION PROTOCOLS

Several types of communication protocols are used to communicate with electrometers. These protocols are intended for communication between electrometers and reading metering system. This article discusses the options of utilization and optimization of implementation of two most commonly used protocols, VDEW and DLMS, which are supported in Czech energetic system. Both below introduced and tested protocols belong to the family of IEC 60870-5 and IEC 62056 protocols, which are standards defining systems used for remote dispatching control and data collecting, in electrotechnical and energetic systems automation of application.

IEC 60870-5 provides communication profile for sending basic remote messages between two systems, which use permanent directly connected data circuits between the systems. The standard is based on the master-slave model and specifies functions for remote control systems. It is a division of roles units whose use serial bus when the master unit (control) sends requests (inquiries, orders, requests) gradually to all their slaves units. Each slave unit responds individually to sended requests. This scheme (request-response) has fixed rules (polling). One of the most important functionsis the Report By Exception

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(RBE) mechanism for timestamps assignment. For the master unit, located by default in the central control, is important to learn as quickly as possible about an extraordinary events on the slave unit. For this reason the RBE is used. This mechanism allows remote slave stations to request communication with the master. According to IEC 60870-5, slave has the possibility to initiate transaction. For example, "I'm process variable no. 33 and I have changed my status from 0 to 1." It is understoodable that the variable belongs to a slave device; without RBE function the master can notice the variable values change only via a regular polling order. Timestamps allow the user (or application that processes the data) to monitor particular events. Time stamp is attached to each event and provides information about occured events. For example, the event "I'm variable no. 33 and I have changed my status from 0 to 1" is accompanied by a timestamp in the format year-week-day week-hour-minute-second-milliseconds. Time stamps are used to identify the event and its ranking. It also specifies a robust and powerful synchronization mechanism for the exact time data processing regardless of the distance between the unit and the unit RTU master.

IEC 62056 is then a system of norms for metering electric energy and change of figures according to International Electrotechnical Commission. IEC 62056 norms are versions of international DLMS/COSEM specification standard. DLMS, or Device Language Message Specification, is a system of norms created and maintained by DLMS User Association, which was passed according to IEC TC13 WG14 to the IEC 62056 set of norms.

Protocol VDEC (IEC 60870-5-103) theory

VDEW protocol belongs to the IEC 60870-5 protocols stack. The protocol is defined for all seven layers of OSI model and enables sending data of variable length. The functions on individual layers are the following:

- Layer 1 (physical layer): describes meida transmission using, which can be a LAN network, a PSTN line, a radio network, or GSM/GPRS networks. The physical network can be configured as point-point.
- Layer 2 (link layer): controls communications between network elements communicating with each other. This layer is responsible for serial/parallel communication, frames synchronization, error detection and correction, signal quality tracing, station address identification, generating control codes, processing the length of a telegram, recovering from errors, data block labelling, and channel switching.
- Layer 3 (network layer) performs the change of message priority, and ensures message directing.
- Layer 4 (transport layer) is not used with SCTM protocol.
- Layer 5 (relation layer) creates and divides data connections if this method is implemented via public networks (PSTN, GSM/GPRS).
- Layer 6 (presentation layer): provides data format delivered to the user.
- Layer 7 (application layer): describes individual types of information, query strategy, set of commands for data saving, and passwords for the user level. The protocol controls individual commands including special ccommands and testing telegrams.

VDEC is principally very similar to its ancestor, the SCTM protocol, and as SCTM's direct successor it is extended by other commands. Protocol architecture is based on three-layered EPA architecture. EPA is a simplified ISO/OSI layer model, from which four layers (presentation, relational, transport, and network layers) were extracted. Communication speed of the VDEW protocol is, according to EPA, set to either 9,600 baud rate (Bd), or 19,200 Bd.

Set of IEC 60870 norms consits of the following standards (ABB, 2011):

- IEC 60870-5-1: Transmission frame formats.
- IEC 60870-5-2: Link transmission procedures.
- IEC 60870-5-3: General structure of application data.
- IEC 60870-5-4:Definition and coding of application information elements.
- IEC 60870-5-5:Basic application functions.
- IEC 60870-5-6:Conformance testing guidelines.
- IEC 60870-5-101 Transmission protocols, companion standards especially for basic telecontrol tasks.
- IEC 60870-5-102 Companion standard for the transmission of integrated totals in electric power systems (this standard is not widely used).
- IEC 60870-5-103 Transmission protocols, companion standard for the informative interface of protection equipment.
- IEC 60870-5-104 Transmission Protocols, Network access for IEC 60870-5-101 using standard transport profiles.

Communication with the meter - protocol VDEC

IEC 60870-5-103 protocols can operate in communication systems with the master - slave model utilizing a serial bus. One unit is always the controlling one (master) and successively sends requests (queries, commands, appeals) to all its subordinate units. Every subordinate unit reacts to the requests designated for it. Classic request/response schema has set rules called polling. The requesting process can be conformed to individual requests. Many widely spread communication protocols are based on this model. In this type of protocol, each data or message transmission on a network is controlled by the master unit. In not so widely spread classic control systems (device, production line, and

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operation control) the programmable automat or similar devices is the master unit of the communication network, and slave units are sensors, actuators, I/O modules, regulators, other PLC, etc. In a special case of large electrized systems, the control unit is usually a computer placed in the dispatch, whereas the units being controlled are called RTU (Remote Terminal Unit). It is mostly industrial computers, or PLC controlling electric substation Figure-1.

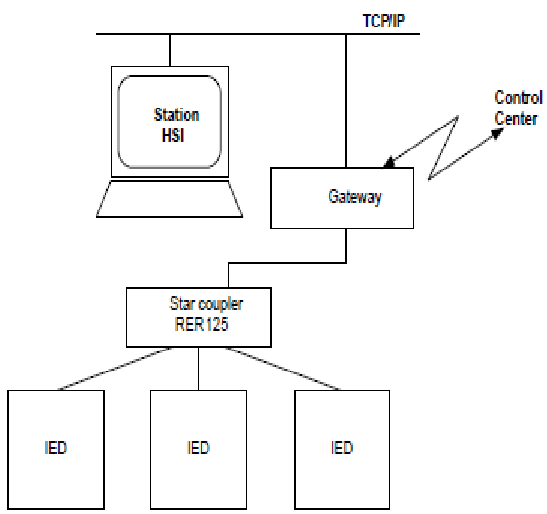

Figure-1. Example of a protocol used in substation communication structure in automatic mode (ABB, 2011).

It is obvious that for the master unit placed in the exchange dispatch, it can be crucial to recognize if there was a variable value signaling an emergency in the subordinate unit. That is what RBE (Report by Exception) function is for. It allows remote slave units to request communication with the master unit. According to IEC 60870-5, the slave unit has the ability to initiate, for example, transaction like this: 'I am a process variable no. 27 and I changed my status from 0 to 1'. It is understood that the variable belongs to a device of a slave type. Without the RBE function the master unit would recognize the change in variable value only when the slave unit would be sent a request as regular.

Protocol telegram used for data transmission between the control station (Master) and the controlled station (Slave) is of a variable length and it is able to communicate both ways Figure-2.

Orig. ID	Text	Value	Time	System ID
F.F	Fehlerregister A3	00000000	-	01XX000F0XX
0.0.0	Geraetenummer	87499650	-	01XX00000XX
0.1.0	Rueckstellzaehlerstand	1	-	01XX00010XX
0.2.2	Time switch program number	TAR1	-	XXXX00022XX
0.4.0	Scale factor for demand display	100	-	01XX00040XX
0.4.1	Reading Factor for Energy current	100	-	01XX00041XX
0.4.2	Current transformer ratio	800	-	01XX00402XX
0.4.3	Voltage transformer ratio	1100	-	01XX00403XX
0.9.1	Zeit [13]	11:14:36	-	01XX00091XX
0.9.2	Datum	13-11-30	-	01XX00092XX
C.2.1	*****PRAG	13-11-26 14:35	-	XXXX0C021XX
C.2.2	*****PRAG	13-11-26	-	XXXX0C022XX
C.6.0	Batteriestunden	000092	-	XXXX0C060XX
C.6.3	Batteriespannug	6.2*V	-	XXXX0C063XX
1.6.0--1	Monats-Max., Wirk+, No Tarif, Vorwert	0*MW	-	01XX0106001
1.6.1--1	Monats-Max., Wirk+, Tarif 1, Vorwert	0*MW	-	01XX0106101
1.6.2--1	Monats-Max., Wirk+, Tarif 2, Vorwert	0*MW	-	01XX0106201
1.6.0	Monats-Max., Wirk+, No Tarif, aktuell	309*kW	+2013-11-28 13:15:00	01XX01060XX
1.6.1	Monats-Max., Wirk+, Tarif 1, aktuell	309*kW	+2013-11-28 13:15:00	01XX01061XX

Figure-2. Extracts from the registers of electricity using protocol VDEW.

Protocol DLMS (IEC 62056) theory

DLMS (Distribution Line Message Specification) is an international communication standard running on a server-client principle. The connection here is established by the client. The client can communicate with more servers, or other way around, more clients can communicate with one server. The DLMS protocol became a global standard of Smart Meter designers for interoperability between metering systems for various kinds of energy, such as electricity, gas, heath, and water. Interoperability is ensured across both various communication methods, such as RS 232, RS485, PSTN, GSM, GPRS, IPv4, PPP, and PLC, and for safe access to data using AES 128 encryption. The protocol independently communicates on devices from various manufacturers, kinds of metering instrument, or metered quantity. It is given by COSEM (Companion Specification for Energy Metering) specification, where rules for message transmission, object oriented access, and kinds of transmission media are investigated. The protocol utilizes overall three levels of transmission security. The highest level of security even supports encryption of transmited data. It runs in the aplication layer of an OSI model and it is independent on the protocols in lower layers and transmission media.

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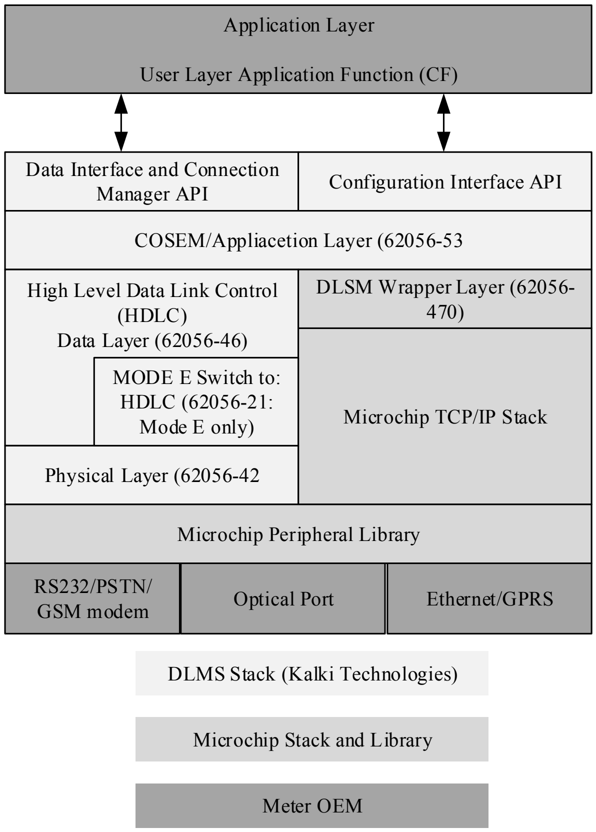

Figure-3. DLMS principle (IEC 62056-21, 2002).

Features of the protocol are described in IEC 62056 (IEC 62056-21,2002) norm and also in four books published by the DLMS User Association. These books are color coded based on their contents: DLMS - Blue Book (2013), DLMS - Green Book (2013), DLMS - Yellow Book (2013), and DLMS - White book (2013).

IEC 62056 set of norms consists of the following standards:

- IEC 62056-21: Direct local data exchange (3d editionof IEC 61107) describe show to use COSEM over a local port (optical or current loop).
- IEC 62056-42: Physical layer services and procedures for connection-oriented asynchronous data Exchange.
- IEC 62056-46: Data link layer using HDLC protocol.
- IEC 62056-47: COSEM transport layers for IPv4 networks.
- IEC 62056-53: COSEM Application layer.
- IEC 62056-61: Object identification system (OBIS).
- IEC 62056-62: Interface classes.

Object model devices

Every metering device has its own logical structure. At the same time an object model exists for every metering device. Objects contain attributes for accessing data and methods for working with the objects. They also have names assigned to them according to their functions and their access rights as well. The name of the object is an important attribute hinting on the purpose of that object. The name is a chain of 16 characters and allows its global identification. The chain consists of two parts. The first three characters are the manufacturer identifier (DLMS UA user association and FLAG association). With the last 13 characters the manufacturer must ensure their uniqueness. Object oriented access is provided by the COSEM application layer. The meteringdevice must contain one Management Logical Device containing information about other logical devices. It is used to establish the connection. The methods and attributes can be accessed using either Short Name or Logical Name (Blue Book, 2013).

Object identification system

To identify objects, OBIS (Object Identification System) is used. This system originates from the German EDIS system. It provides unique identifiers for all data inside the meter. These identifiers do not serve only for metered values, but also for calibration, or information about the meter. OBIS code is formed by hierarchical structure of six values labelled by letters A to F. Values from OBIS are then saved into designated classes and their objects (DLMS - Green book, 2013).

OBIS value group:

- A - types of metered energy
- B - the number of the metered channel
- C - differentiation of individual subjects of the same type of energy or abstract objects
- D - the method of metering and processing the physical quantity
- E - rate of metering
- F - billing period

DLSM protocol utilizes several basic classes of objects including:

- Data Class - used to save configurations of simple data.
- Register Class - used to save metered quantities including code and units. It is derived from the Data class.
- Extend Register Class - it is intended to save quantities, condition, and time of reading. It is derived from the Register class.
- Demand Register Class - this class stores information about average value of the metered quantity. It is also derived from the Register class.
- Profile Generic Class - it serves for collecting larger amount of data from other objects. These data are used to create a profile. Objects from the Data, Register, Extend Register, and Demand Register classes can serve as a source for such data. Read data follow the selected criterion.

- Clock Class - provides access to time unit of the meter. It provides methods of configuration and time shifts.

Other classes for advanced functions are, for example: Register Activation, Script Table, Register Monitor, Single Action Schedule, Schedule a Special Day, and Activity Calendar.

Communication with the meter - protocol DLSM

The client connects to the meter using a communication profile. This meter stores its address in every communication profile. The meter hosts several independently addressable logical devices. The client first connects to the Management Logical Device and recognizes other logical devices contained in the meter. While establishing the communication an application process, which connects to the client's logical device, is created. Application Association of both sides takes place. A part of the application layer ensures the connection is called ACSE (Association Control Service Element). A server assigns access rights to the application process, so that the process can work with objects. The connection lasts during the entire data exchange and it is termined after the transmission ends (DLMS - Green Book 2013).

Connection to the meter

The client's application layer hosts several processes. One of these processes serves to ensure connection and utilizes services of individual layers. In the first phase physical layers of the client and the server connect. In the next phase link layers connect, and application layers connect last. The connection starts with the Connect. request command on the physical layer and an attempt to connect follows. The response to this command is Connect. Confirm, which is a confirmation of successful establishment of a connection. Using the application and link layers, the connection to a known address of a logical device is established. Authentication follows establishing a successful connection. Next, a method of object identification is selected. From that moment on the client can access methods and object attributes. After finishing the work with objects, the client terminates the link connection. With terminating the link connection, the application connection terminates as well. If no new connection to the logical device is established, even the physical connection is terminated. If a connection is not established for whatever reason, the other side receives a Connect. Indication response (DLMS - Blue book 2013).

DLMS RawData

Virtual Device ID: 224065634
Firmware:
Reading time: 21.11.2013 00:23:43.039 SDT Central Europe Standard Time
Data start time: 21.11.2013 00:23:43.039 SDT Central Europe Standard Time
Data end time: 21.11.2013 00:23:43.039 SDT Central Europe Standard Time

All Maximum Demands:

Maximum Time From Meter	OBIS Code	Value	Scale	Unit
15.11.2013 21:15:00.000 SDT W. Europe Standard Time	1-1:1.6.1	67.00	1000.00	W
15.11.2013 10:45:00.000 SDT W. Europe Standard Time	1-1:1.6.1	64.00	1000.00	W
15.11.2013 21:00:00.000 SDT W. Europe Standard Time	1-1:1.6.1	63.00	1000.00	W
15.11.2013 11:30:00.000 SDT W. Europe Standard Time	1-1:1.6.1	62.00	1000.00	W
15.11.2013 14:45:00.000 SDT W. Europe Standard Time	1-1:1.6.1	55.00	1000.00	W
19.11.2013 06:15:00.000 SDT W. Europe Standard Time	1-1:2.6.1	564.00	1000.00	W
17.11.2013 08:15:00.000 SDT W. Europe Standard Time	1-1:2.6.1	564.00	1000.00	W
16.11.2013 19:15:00.000 SDT W. Europe Standard Time	1-1:2.6.1	564.00	1000.00	W
19.11.2013 03:15:00.000 SDT W. Europe Standard Time	1-1:2.6.1	563.00	1000.00	W
18.11.2013 06:15:00.000 SDT W. Europe Standard Time	1-1:2.6.1	563.00	1000.00	W
15.11.2013 11:30:00.000 SDT W. Europe Standard Time	1-1:5.6.1	17.00	1000.00	var
15.11.2013 21:15:00.000 SDT W. Europe Standard Time	1-1:5.6.1	16.00	1000.00	var
15.11.2013 10:45:00.000 SDT W. Europe Standard Time	1-1:5.6.1	16.00	1000.00	var

Figure-4. Extracts from the registers of electricity using the DLMS protocol.

Securing data access

Securing data access is performed against any client access to all meter's objects. Three levels of security for authenticating the identity of a client establishing the connection are used. Based on this authentication, the client is granted access rights to individual objects.

- Lowest Level Security - There is no authentification performed with this type of security. It must be supported by the Management of Logical Device.
- Low Level Security – Here, the client must provide a password. The password can be overheard.
- High Level Security - The highest possible security utilizing algorithms and encyrption keys. This type of security is used only in cases when it is not possible to prevent overhearing of the communication channel (DLMS - Blue book, 2013).

ANALYSIS OF VDEW / DLMS COMMUNICATION PROTOCOLS

The system of comparing both communicating protocols was based on practical testing and assessment of advantages and disadvantages of both communication protocols. Their reliability during performed data readings was an important factor. Selected samples of the meters reflect types of meters used by CEZ Distribution services, s.r.o., namely electrometers ZXD3 by Landis&Gyr (Toshiba Corporation) with type CU and SL 73 by Actaris (Itron) communication units and with communication units of series V1, V2 and V2.1i.

Data were obtained from data reading exchange Converge governed by ČEZ Distribuční služby, s.r.o. in

Hradec Králové. 60 samples of meters were used for testing. DLMS protocols utilize mostly GPRS and VDEW technologies for communication and it is then possible to read data using both GSM and GPRS. Each tested type of meter is represented by only ten electrometers. Mutual differences of the same type of electrometers is excluded in this analysis. For this reason the selection is relatively small. The main focus was placed on including as highest percentage of used types working with VDEW or DLMS communication protocols as possible. It was important to select meters with long-term successful reading to eliminate elements, which could distort the results of this analysis.

Electrometers selected for analysis

Most used electrometers from the ZXD series by Landis&Gyr (Toshiba Corporation) and SL7 by Actaris (Itron) were selected for analysis. It is not a specific definition of a model series of both manufacturers, but more of a universal label for mutual differentiation. Complete names then contain specification for the type of metering, class of precision, number of systems, etc. SL7 electrometers communicate solely on the DLMS protocols. ZXD series can communicate on both DLMS and VDEW. It was also important to divide these series based on whether they read only off take or off take along with supply. Three profile (3LP) meters are used for off take. One profile is for active off take and two for reactive energy. Electrometers with six profiles (6LP) are used for supply. Here, two profiles meter active off take and supply. Remaining four are for reactive energy.

Division of meters according to the number of profiles was necessary for metering time demand during remote reading. There was a suspicion that meters with higher number of profiles can significantly slow down the process of data collection. Mostly in groups with higher number of electrometers. Profiles in commonly used electrometers were defined a fifteen minute period, i.e. the highest reached average maximum per time unit. In some specific cases a sixty-minut period is subtracted. This period is used mostly by outdated coders, but those are not the objects of this testing as they are recently being replaced by newer ones.

- Elenctrometers with DLMS protocols - SL7 3LP, SL7 6LP, ZXD 3LP, ZXD 6LP.
- Electrometers with VDEW protocols - ZXD 3LP, ZXD 6LP.

Methods of reading and statistical data collection

Communication between electrometer and reading data exchange was performed the same way with both protocols. A virtual electrometer, on which the type of protocol and the number of profile has been predefined, was created at the reading exchange. Data reading was performed every day between 1. 4. 2014 and 31. 8. 2014. With every reading a download of values (telegrams) of the profile, registry values, and control of time unit was performed. Profile values for all electrometers were defined a fifteen minute period. Value reading always started on the last time stamp. There never was any time overlap or unnecessary rewriting of an already saved profile. Remote reading for registry values was different. The reason was also, of course, the difference in data. In registries, some values are being rewritten (dial values), changed (voltage on phase), or added (maximal values). It is more about technical values with more extensive data. During data reading, time of reading exchange was compared to the time of the communication unit. If there is a difference up to two seconds in both times, its synchronization with reading exchange time will be performed. If the difference in times is more than two seconds, no synchronization will be performed and the time has to be reset manually. The reason for such difference in times can be too long time period between data reading caused by, for example, inaccessible signal from the operator, low battery in the electrometer, or an error in electrometer's memory. In the last two cases a service action directly at the place of offtake is necessary.

Process assessment by comparing VDEW/DLM

The difference in time demand for both communication protocols is shown in Figure-5. The VDEW protocol needs far less time to handle the data transmission between the reading exchange and the meter than the DLMS protocol. Such a big difference in times is given mainly by the amount of transmissioned data. The advantage of VDEW over DLMS is the possibility to configure what data are to be obtained during the transmission. The configuration is done directly on the electrometer via parameterization software. Such configuration is not possible with the DLMS protocol. However, the problem is not caused only by the communication protocol itself, but partly also by the reading exchange, in which relevant drivers for this type of communication are absent. Therefore, all data from the electrometer are collected during a reading. That way even unnecessary data is read and the selection is done directly at the reading exchange. This very often burdened the reading exchange itself disproportionately. Another big difference between the DLMS and VDEW protocols is in establishing and terminating a connection. The DLMS protocol showed far shorter time necessary to establish and terminate a connection. The difference in terminating a connection is not that noticeable. Increased time demand for time control for ZXD 3LP running on VDEW protocol is worth noticing. Here, the time difference was very common. In two cases it was not possible to perform a synchronization and the time had to be set manually. Although time is not set right, the data exchange attempts to perform the synchronization until the reading limit expires. That was one of the reasons for increase in time demand. This error can certainly be blamed on the communication units and it is not caused by the protocol itself.

Error rate of communication protocols

In the following metering, errore rate of individual telegrams (profile, registry, and time)

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transmissioned between the reading exchange and electrometers was observed. The error rate was best observable on the number of interrupted telegrams during the communication itself. If an iterruption of a telegram occurred, the data exchange initiated a new transmission after 30 seconds. Five attempts were set. After exhausting these five attempts, the transmission is assessed as unsuccessful. In the whole observed time period, this situation occured only once and it was on 30. 6. 2014. The error was not caused by the transmission of communication unit telegrams, but because the mobile operator and internal IT services supplier intervened in their technologies and considerably decreased transmissions in GPRS8 mode. Although, the situation is not quite noticeable on a graph of the VDEW protocol. One third of the ZXD electrometers was read in operational GSM mode.

SL7 electrometers primarily communicate via GPRS and because of this reason the data collecting was not successful. Average error rate of these protocols is shown in graphs (Figure-6 and 7).

VDEW protocol showed noticeably higher percentage of interrupted telegrams during data reading. The biggest part of this percentage was consumed by reading registers of the electrometer. This phenomenon was anticipated more with the DLMS protocol, where it was registers that demanded the longest time control needed to read data. Time delays connected with repeated calling occurred during reading. During an unsuccessful call the time limit for this action expired and data reading ended in time out status (an error after exceeding the maximum time for awaiting a telegram). It is about the same item. The opposite of telegrams for registries were telegrams for inspection, or synchronization of a time unit. Data were not read on the first try only eight times and only once the limit of five attempts was exceeded during the whole observed time period. As it was previously mentioned in the chapter Process Assessment, this problem was not the fault of VDEW protocol. Another influential factor was that the communication protocol is not able to continue interrupted telegrams. A new call had to made after the interruption. In most cases one or two telegrams were read with no problems and other telegrams were read on second to fourth attempt. Although the VDEW protocol shows far shorter times for data transmission, its advantage was invalidated because of the repeated calls.

For the DLMS protocol the data were read on the second attempt at the most for one whole day (30. 6. 2014). There was a minimal number of interrupted protocols. It was almost always just individual places. Just like with the VDEW protocol, there had to be a new call made after a telegram was interrupted. Not even this protocol can continue with interrupted data and it is necessary to read the whole package for a telegram again. The DLMS protocol was able to establish a connection far better, which showed on the graph itself. Frequent interruption of a telegram for electrometer registry was anticipated with the DLMS communication protocol. This was not confirmed during testing. The communication protocol has far longer time mode for reading registries, but when communicating with the reading exchange it can usually maintain the established connection and the data are read. That way it came closer to the level of reading using the VDEW protocol. During the observed time period there were no repeated inspections (or synchronizations) of the time unit. Everything was performed to a maximum of one attempt of reading.

Analysis assessment

Several conclusions can be drawn from the conducted analysis. The first one is that in case of a significant interference into IT technology or technology of the mobile operator errors in data reading occur. The next conclusion is that the VDEW communication protocol needs less time to communicate than the DLMS protocol. This advantage is, on the other hand, invalidated by a higher percentage of attempts to call caused by a number of interrupted telegrams. The DLMS communication protocol has, on the other hand, less problems with establishing and terminating a connection. On the side of the reading exchange there is an absence of needed drivers for data transmission. For this reason the DLMS communication protocol is significantly put at a disadvantage and its assets are not used to their full potential.

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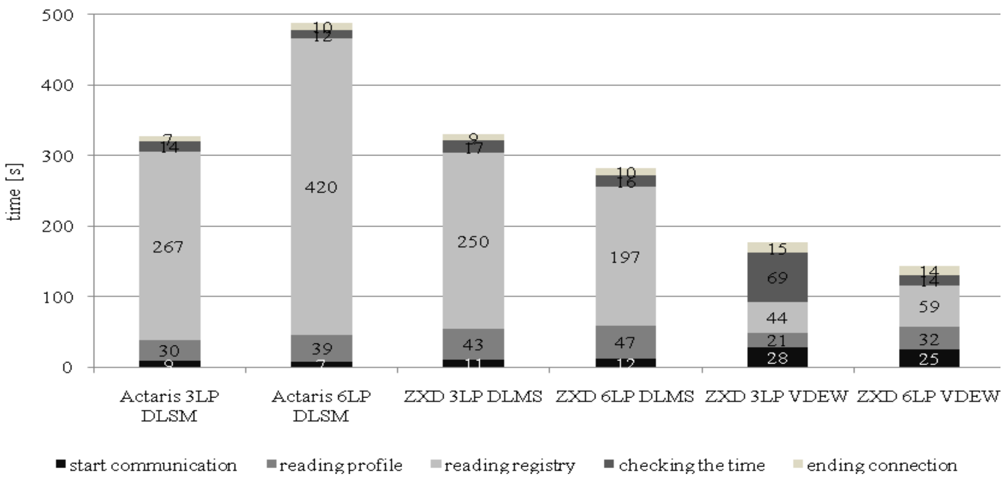

Figure-5. The average time required for readings.

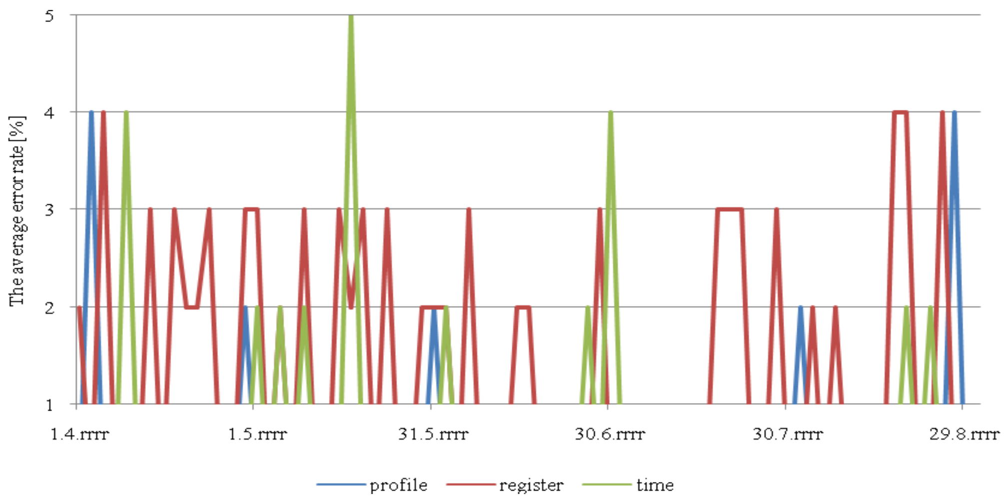

Figure-6. The average error protocols VDEWFigure 6: The average error protocols VDEW.

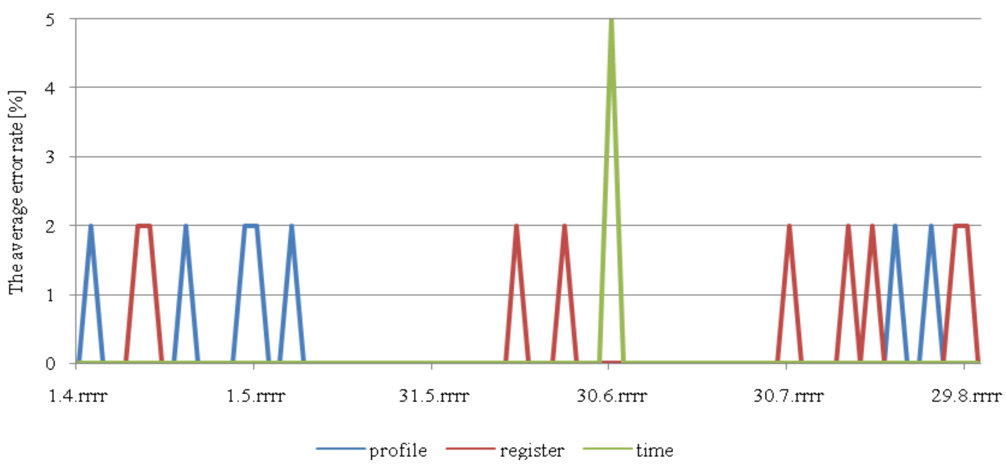

Figure-7. The average error protocols DLMS.

CONCLUSIONS

The aim of this paper was to analyze contemporary tools used for Smart metering, compare their features, and lastly make appropriate recommendations. It is obvious from the analyzed data that even suppliers themselves do not prepare their products for operation. One proof of such behavior was a comparison of communication protocols. The DLMS protocol would unequivocally top its competitor, VDEW. Because of absent drivers, the DLMS protocol disproportionately burdened the reading exchange by a number of unnecessary data. A repair patch in the reading exchange would solve this problem. Not all advantages of this protocol were used to their full potential. One serious problem caused by interference with mobile and IT technologies was noted during the testing. During an extensive blackout on 30. 6. 2014, a large number of electrometers working in the GPRS mode was not read. This incident mostly points to a problem of ensuring a backup data collecting, rather than to the problem of the GPRS technology. Data collection for such a large number of unread places cannot be performed in a short period of time. It would significantly strain the reading exchange and other problems would ensue. Even though the communication units working with GPRS can establish a connection via GSM, it is not possible to use such backup route for such a large amount of meters. The costs for such solution would skyrocket. Even communication windows cannot be used. They appear daily in set times and in maximal duration of fifteen minutes. And each location is set for a different time.

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