PILOT PROJECT OF AUTOMATED METER READING AND MANAGEMENT SYSTEM

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INTRODUCTION

Modernization, presently taking place in many distribution utilities worldwide, can partially be represented by introduction of the AMR system (Automated Meter Reading) for remote reading of meters. This system could become the most important utility infrastructure, partially due to the fact that deregulation will increase the trade with electrical energy and consequently increase the need for metering. More convenient name for all deployed AMR project in near past, and most definitely in future would be Automated Meter Management System (AMM system), because meter reading is just one of its features. However, due to wide acceptance of this abbreviation we shall keep expression “AMR” in this document.

Distribution utility Elektrokrajina, Banja Luka has decided to invest in AMR system. In such a way, Elektrokrajina has also initiated modernization of its business process of power consumption reading. Pilot project of AMR system is installed at two distribution transformer substations. It is seen as a first phase in mentioned process, and will be shortly followed with procurement of the commercial AMR system.

Pilot project must present robustness of this system, and particularly of PLC communication (Power Line Communication), in our power network. From that reason we have chosen one suburb transformer substation, with many consumers, and with very heterogeneous network (in respect of conductor's type and cross-section), that will additionally hinder communication. Second transformer substation is in rural area, with long network, and expected frequent atmospheric discharges.

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MAIN BUSINESS CASE DRIVER

All investments must be based on some sort of “cost/benefit" analysis. Several drivers for the business case of AMR system deployment can be identified. One of the most important drivers is the request for more frequent meter reads. In that case one can see that main user benefit is going to be generated from reduced costs of labour force otherwise needed for meter reading. This was a major reason for introduction of the AMR technology to the Sweden. Second possible driver for AMR system introduction can be found in energy theft reduction. In our case it is the most important business case driver. This said, it can be seen that all features of AMR system had to be selected in order to achieve energy theft reduction. It must be stressed that mentioned driver is not the only one that should be considered as a benefit generator, but since in our case it is already a sufficient one to justify deployment of the AMR system, it is the only mentioned.

In aim to make a business case for any commercial deployment as strong as possible, we wish to see effects gained with minimal investment, that is only by replacement of meters in respect to reduction of losses. Our cost/benefit analysis is primarily based on value of reduction of losses compared to needed investments, so we wish to establish if it is sufficient only to replace a meter, or we need additional investments in improvement of metering points. This is especially important for future planning of funds for commercial procurement of this system, for the area of whole Elektrokrajina and for speed of deployment.

In the phase of Pilot project preparation we had to make an assumption in respect to deployment of future commercial AMR system. We have concluded that introduction of commercial AMR system to the area of whole Elektrokrajina in a single phase and in a single tender procedure was not viable, due to the lack of funds. From that reason, commercial procurement shall be conducted in several phases. As a result of all this, one can see that it is of critical importance that AMR system design is based on an open standard.

Consequently, open standard was one of the key requests, since it is our wish to be producer independent. We consider such dependence unacceptable and dangerous for utility, because in case of procurement of AMR system based on proprietary protocols, it would have been not possible to install AMR equipment from any other producer in following phases. That would have put us in risk of paying extra in later procurements, because of lack of competition. In our case that standard is DLMS (Device Language Message Specification).

SYSTEM COMPONENTS

In this chapter AMR system architecture shall be explained. It comprises:

- electronic meters (at customer premises and in transformer substations);
- data concentrators (in transformer substations);
- computer system (in the Directorate of the Elektrokrajina); and
- hand-held devices for local reading and management of electronic meters.

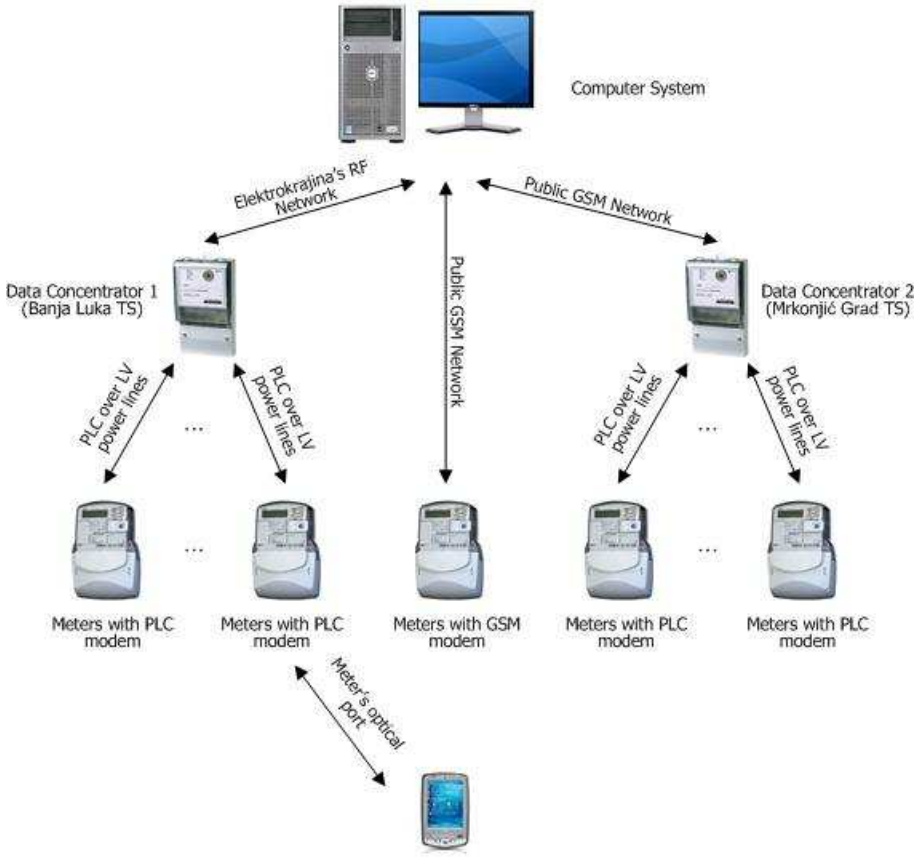
Electronic meters

Their main task is to provide for accurate and safe measurement of consumed energy. It is installed at customer premises and in transformer substation. Electronic meters use PLC or GMS modem for communication with data concentrators, or directly with the computer system.
Some important functions of meters, that we wish to emphasize and explain in more details, are:

- voltage measurement (This function will enable voltage quality monitoring. In future we shall be obliged to deliver supply quality statistics to the Regulator, and therefore voltage measurement was mandatory request.)
- maximum demand power calculation (The request for this function was due to its connection with meter function as a load control management device, that is power limiter. Also it shall enable move to different tariff systems, especially for household customer category.)
- module for remote disconnection/reconnection (It can be activated based on a command from the computer system, or by a command from the meter itself, when it functions as a load control management device. This module will have great impact in increase of payment discipline of customers. It is also expected to improve power system’s flexibility and

procedures in case of power shortage. Till now that situation has been dealt with by restrictions, that is temporary disconnection of some customers. With this module in place one could deal with this situation by overall decrease of maximum demand allowed to all utility's customers. In that manner one could be able to avoid unpopular power restriction, at least in less drastic cases of power shortage. In order to address safety issues, this module must be integrated with meter itself. In our case it is independent and optional feature for meter that, if used, is placed under the terminal block's cover and therefore meet the request. It is a very interesting solution, if compared with previous situation in respect to terminal block damaging due to the overheating and burning. In that case old meter had to be removed from the network. In our case the meter need not to be removed, but only module for remote disconnection/reconnection shall be replaced with a new one.)

- micro-switches for detection of meter and terminal box covers' opening (This function shall enable permanent information whether the meter was opened, that is possibly tampered. It is of critical importance to ensure that cover opening alarm can not be deliberately erased by any means from the event register. It is also important that information on cover's opening comprise time tag also.)
- Load profile (It can help us in future planning of consumption, when as accurate as possible prediction shall be important. Accurate prediction of consumption will minimize utility's purchases of energy at the "spot" market, resulting in bigger income. This function could also help in closer location of possible energy theft.)
- "plug and play" configuration in AMR system.
- Optical port (It will be used for local reading and configuration of meters via hand-held devices, in case of temporary breakdown in communication.)



Data concentrator

Data concentrator enables communication with meters. It contains data storage capacity and modules for communication with meters (PLC communication) and with computer system. From the functional point of view it can be seen as a mediator between computer system and electronic meters, that is as a gateway between network segments which use different communication channels. Main driver for

utilization of data concentrator in first place is economic one, since it will reduce costs of communication with meters. In this manner communication between data concentrator and meters takes place via Elektrokrajina's infrastructure, while for communication between data concentrator and computer system is mostly used public GSM network. Data concentrator can also be accessed locally from a PC via RS232 serial port. Naturally, access to the data concentrator is protected by the password. It is preferable that communication modules are integrated in a single casing with data concentrator itself. In our Pilot project data concentrator contains PLC and GSM communication modules, and in case of utilization of an RF module (Radio Frequency), separate standalone unit is used.

Computer system

Computer system's primary task is to collect all data from meters, process them and subsequently distribute them via utility's local area network and internet to interested parties. Computer system also manages whole AMR system, that is change tariff schemes, disconnect defaulters, monitor supply quality, monitor theft alarms, etc.

In case of Elektrokrajina's Pilot project computer system comprise only one server, though the commercial large-scale AMR system will have "dedicated" servers with special roles (communication server, ...).

The most important part of this AMR system's component is software. One of the biggest challenges in the process of Pilot project evaluation will be to establish its practicality and quality.

Selected software contains following modules:

- Database management module
- Module for communication toward meters and data concentrators and for data collection (Its mission is to enable communication with all data concentrators and meters. That communication and data collection is carried through “communication channels”. In this module schedules for automatic data collections are created.)
- Module for data validation (This module conducts logical validation of all collected data. It is important to run this validation test on all data that are afterwards going to be used as billing data. Module has a number of prepared validation procedures, but we expect to increase their number during Pilot project's evaluation.)
- Report system (This module is of great importance, since it will help us to transform retrieved data to information (e.g. Report on level of losses at a transformer substation, report on daily events in the AMP system, etc.). It is a very flexible module and one of the most important tasks during the process of Pilot project's evaluation will be to study its function in close details.)

Other general requests that should be addressed by the AMR system's software are:

- different access levels to modules functions
- Web access to data

COMMUNICATION

Besides requested functions, that should help to reduce level of losses and increase payment level, in this Pilot project's selection emphasize has been put on selection of communication channels. In that regard, chosen system architecture is in accordance with European mainstream architecture, where PLC communication has been selected for communication between data concentrators and electronic meters (operate in so-called CENELEC band), and GSM communication for communication between computer system and data concentrators. It is important to note that CENELEC band (3 - 148.5 kHz) is standardized and described in the standard EN50065-1:1991.

However, Elektrokrajina's unique request has been that communication from one data concentrator to the computer system must be via RF communication. That is because Elektrokrajina has its own modern RF communication system, and it pays a fee for its licensed frequency. Our wish is to establish which is cheaper to use as a main communication channel between computer system and data concentrators, during this Pilot project. It can be easily seen that initial cost of acquisition is

bigger for RF communication, due to the fact that standard version of the data concentrator already contains GSM modem, but cost of operation will be bigger for GSM communication, at least in our case.

Generally, it was our wish to have heterogeneous communication infrastructure at all AMR system's segments. In that manner communication with all meters can be assured. Pilot project's AMR system includes meters with PLC or GSM communication modems, upon our request. This was requested from the following reasons:

- Firstly, if customer is far from transformer substation or in cases where strong interference obstructs PLC communication, meters with GSM modems shall be installed and provide for full coverage of the area.
- Secondly, installation of data concentrator is not financially acceptable in case that transformer substation covers only one or few customers. In that case it is more adequate to install meter with GSM modem at those customers' premises.

As we have already mentioned above, the biggest problems are expected in PLC communication. From that reason it is important to emphasize another feature of or Pilot project, and that is “repeater mode” of operation. This feature increases reach of PLC communication, since each meter is capable to amplify signal of a communication package sent to other meter, which is otherwise to far from the data concentrator, and thus subject to excessive signal attenuation.

SELECTED AMR SYSTEM FROM DIFFERENT PERSPECTIVE

In this paragraph we wish to inspect selected AMR system's architecture in respect to criteria acknowledged as key for successful implementation of AMR system.

In addition to the request that open standards are used for AMR system's design every successful AMR system must be created with respect of following criteria:

- safety,
- reliability,
- utilization of heterogeneous communication network.

Question of safety is of great importance for our utility. Since the main objective of AMR system is acquisition of billing data for energy consumption, it can be assumed that these data could also be of interest for a malicious persons, as they could gain financial benefit from data alteration. Access to all AMR system's components can be characterized as easy or very easy. Let's analyse safety risks connected to all components. Easiest AMR system's component to access is a meter, and a hardest one is a computer system in the Elektrokrajina's offices. The meter is installed at all customers’ premises, and in most cases that is a place where energy theft occurs. Since these are electronic meters, which store billing and other data in memory registers, safety and inalterability of these data must be guaranteed. Safety of meters supplied with our Pilot project is increased by two requests that we put. First request was that communication module and module for remote disconnection/reconnection must be integrated within the meter's casing, and second request was that meters must be equipped with micro-switches for detection of meter and terminal box covers' opening. Due to the inherent safety risk that power line as a communication medium has, there must be a some kind of protection of communication between meters and data concentrators. That issue is addressed with use of DLMS standard, since it includes authentication mechanisms. If we look at a data concentrator we can say that its physical safety is also questionable, since they are installed in transformer substations. This carry a risk that data concentrator could be stolen and analysed. This is addressed also in design of AMR system, and each data concentrator has access password. Very useful feature is capability of meters installed in transformer substations to initiate communication toward computer system in case of alarm triggering, that is not to communicate only in "master-slave" mode of communication. This feature enables us to install micro-switch to the door of cabinet with AMR system's equipment, and to constantly monitor safety of transformer substation.

Since public GSM communication network is also used for communication between computer system and data concentrator and meters we had to address safety risks of unauthorized dial-up access to the data concentrator or meters. That risk was eliminated by selection of appropriate service from MOBI's mobile service operator. Mentioned service called VPN (Virtual Private Network) enabled us to restrict communication only between phone numbers that are part of a Virtual Private Network.

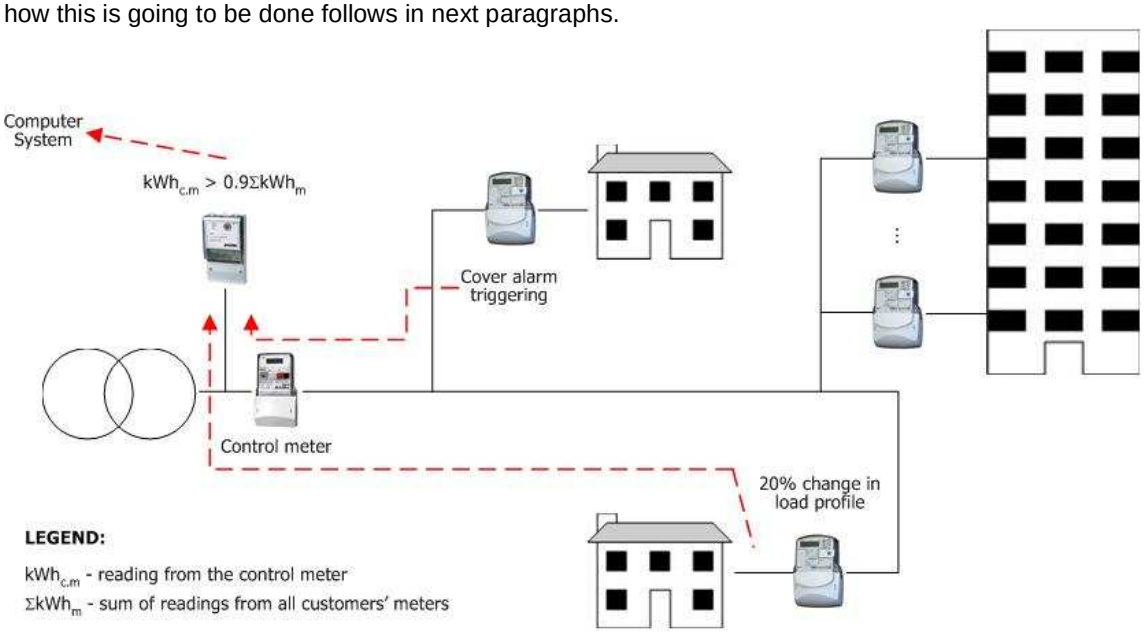
We have carefully considered reliability issue for all AMR system's components, and for a system as whole. Chosen AMR system architecture had to provide for easy and quick replacement of any malfunctioning component. It also had to ensure that system's operation would not be jeopardized by failure of a single component. Since most critical component of AMR system is computer system, its reliability had to be carefully examined and improved. Computer hardware design was requested with redundant components. In details, it has redundant power supply, and hard disks connected in RAID 1 mode of operation (so-called "Mirroring"). It also has a backup device, and fast recovery from software failures has been secured with a request that system must be supplied with so-called "recovery" disks.

Mentioned criteria for utilization of heterogeneous communication network was addressed with utilization of PLC, GSM and RF communication. We have a choice to change communication channels later during evaluation phase of the Pilot project, without any consequences to the system as a whole. We also paid attention not to rely only on our own communication infrastructure, but to also use public infrastructure. That will additionally increase reliability of the AMR system.

From all abovementioned it can be concluded that selected architecture for our AMR system should ensure successful implementation of this project.

REDUCTION OF LOSSES

As stated at a beginning of this document major driver for the business case is expectation that it will solve a problem of energy theft. On top of that reduction in technical losses is also expected. Since system's performance at a theft issue influence the return on investment a great deal, explanation on how this is going to be done follows in next paragraphs.



Worldwide experiences tell us that at this moment struggle with energy theft requires minimization of human influence in process of theft location. Majority of ways for theft of energy will already be eliminated only by installation of new electronic meters (phase inversion, disk's slowing down, ...). Along this, micro-switches for detection of meter and terminal box covers' opening are going to minimize weaknesses of the seal. Seal is also a sort of toll for detection of cover's opening, but far slower and less reliable (due to tiring process of visual inspection). Our AMR system can locate energy theft at a level of the transformer substation. We have requested installation of a meter in a transformer substation to enable that. This “control” meter register total energy delivered through substation to all customers. During every readout cycle sum of energy registered at all customers’ meters is compared with one registered at the “control” meter in transformer substation. If there is excessive difference (greater than one expected due to the technical losses) we have signalization of possible theft at particular transformer substation’s area. Upon that signalization duty crew shall be dispatched to the area.

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One could anticipate that “load profile” feature in all meters may be of use in closer location of energy theft, but that is going to be clarified during Pilot project’s evaluation.

CONCLUSION

In this document we have tried to give insight in the process preceding procurement of the AMR system, starting from business case driver's identification, along with assumptions that guided specification of system's architecture. We have also explained significant features of all system's components, and anticipated possible benefits that we could yield from this investment. However, all abovementioned is still waiting to be tested and verified in Pilot project's operation.

Despite, we are very satisfied with system's features, several aspects where we would like to see improvement if possible are:

- introduction of event initiated communication from all meters (that would give us fastest possible information on any alarm)
- additional improvement in software (more intuitive and user friendly interface, information sent as SMS messages)
- additional improvement in protection of communication

Since this Pilot project has been put in operation just recently, we did not mention any findings. However, we wish to call all colleagues, which are already familiar with AMR systems or wish to learn about this technology, to contact us on all needed information, and also to take part in collection of valuable information from operation of Elektrokrajina's Pilot project.

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