SMART GRID USING 1ST GENERATION AMR METERS – AN OPERATIONAL VIEW

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ABSTRACT

This paper describes how the DSO Mälarenergi Elnät AB has used their 1st generation smart AMR meters to control the LV network.

Due to the early meter regulation in Sweden, Mälarenergi bought their AMR meters in 2006. To fully take advantage of the 1st generation smart meter functionality to control the LV network, Mälarenergi started a project to connect the DMS system with the AMR meters. The benefit is that the control room can monitor the whole operational chain from Substation to customer. This results in better customer service, faster handling, localization and restoration of faults in LV network.

The project has also given many valuable experiences regarding possibilities as well as limitations in the existing AMI solution. This will be useful input for Mälarenergi when specifying the requirements for 2nd generation smart meters and AMI solution.

BACKGROUND

Swedish government established a national metering regulation in 2003 that required [1] [2]:

- All customers with a connection fuse > 63 A, to be read hourly by 1st July 2006.
- All customers with a connection fuse <= 63 A, to be read monthly by 1st July 2009.

Due to this regulation Sweden has developed fast in the AMR (automatic meter reading) area. Already 2009 the Swedish DSO's (distribution system operator) had implemented AMR meters at all electricity network customers.

Mälarenergi, with some over 100 000 network customers, specified the requirements for AMR meter 2004 and purchased them in 2006. At this time the requirements mainly focused on meter reading and interruption information in past time. From this point of view, the purchased 1st generation smart AMR meters are quite well equipped and intelligent.

Examples of information and functionality [3] that the chosen meters manage are:

- Meter reading, in many different ways
- 4-quadrant metering
- Voltage and current per phase
- Power failures on one or two phases
- Over/under voltage
- Disconnection/tamper
- Time stamp on outage
- Remote disconnection/connection
- Remote update of software

The main limitation of the meters is that they lack functionality to push information or alarms. Another limitation is that the battery backup only is sufficient to keep the real time clock alive if power supply is down.

For the collection and handling the meter readings, Mälarenergi has an in-house AMI (advanced metering infrastructure) solution with three different systems. The communication with meters mainly uses meshed radio (75%) and PLC (25%). PLC (power line communication) is used in the rural area where there are long distances and not possible to use meshed radio.

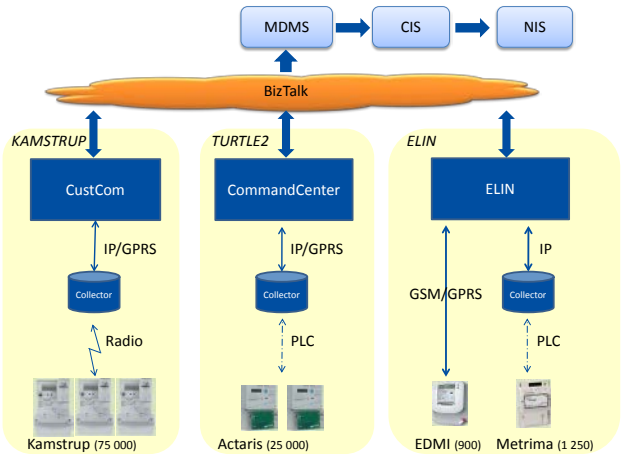

Figure 1. AMI solution at Mälarenergi (in-house)

VISION

In order to control the high- and medium voltage network Mälarenergi has a well-functioning SCADA (supervisory control and data acquisition) system with real time connection to DMS (distribution management system). DMS is part of the NIS (network information system) and the main tool for operators in the control room, in order to monitor the distribution network. This solution does not include the possibility to control the LV (low voltage) network. Mälarenergi rely on customers to call when they have LV interruption or other problems. This is neither a satisfying situation for the involved parties nor a sufficient solution for the future smart grid. To improve and better control the LV network, Mälarenergi decided to use the AMR meters in connection with the DMS system.

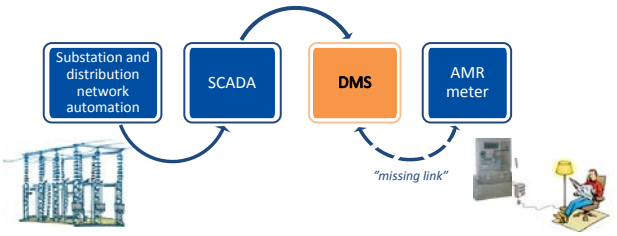

Figure 2. AMR is the missing link in order to control LV network from DMS system

By connecting the AMR meters with the DMS system, to complete the whole operational chain from Substation to customer, Mälarenergi would like to accomplish the following:

- Automation of LV interruption management with real time information
- Faster handling, localization and restoration of fault in LV network
- Possibility to verify the status of LV network
- Faster response and higher quality on customer service
- Simplified and more accurate outage statistics on customer level

With the growing focus on the electricity network industry and development of smart grid/metering, the customers become more interested and also more demanding. In the future customers will have higher demands on the DSO´s to deliver electricity with high availability and high quality. They will also expect extremely good service at all times. For example that the DSO´s monitor the entire network in real time, quickly restore faults and notify the customers about interruptions instead of the other way around.

Mälarenergi wants to be part of the development and proactively meet the customer demands and give the best possible service.

PROJECT

Mälarenergi started a project in 2011, with the scope to set up integration between AMR meters and DMS/NIS system. Focus for the project were AMR meters with radio communication since Mälarenergi's PLC communication is to slow to be of interest in an operational view.

The project compared and mapped meter functionality [3] with functionality in the DMS system [4]. The information can be categorised in alarms (events) and values (quality data). The result became a list of alarms and values that were technically possible to implement in the integration.

There are two main principles to obtain information from meters to DMS. Either by sending a query from DMS asking for information from specified meters, or that meters spontaneously send information (push) into DMS.

The next step in the project was to interview personnel from the control room in order to understand how they would like to work with LV monitoring in DMS, and what alarms and values that would be useful and improve their work. This resulted in five use cases that became the basis for the continued work in the project:

1. Send query to one or few meters, to check status (connection, voltage/phase, alarms) during customer call
2. "Clean-up" – after outage restoration, send query to meters in concerned area, to make sure that there are no remaining faults in the LV network
3. "Check-up" – send reference query to selected or all meters
4. Push alarms (missing phase, over/under voltage, broken neutral), spontaneously when they occur
5. Push PDM (power down message) alarm, spontaneously when they occur

PDM is an alarm when all power supply is down for the meter. To be able to send such an alarm, the meter must be equipped with enough backup power e.g. battery. This makes the PDM alarm more complex than other alarms.

Fault localization can be much more efficient when creating a connection between DMS and AMR meters. Interruptions can be registered automatically in DMS based on alarm from AMR meter or customer call. DMS then uses the network topology to send query to AMR meters fed from the concerned LV feeder. Based on the answers DMS finds the most likely fault location. This can be an iterative process depending of the complexity of the fault.
It is possible to configure DMS to the desired level of automatic fault localization.

After the functional demands were clear the technical solution could be decided. Mälarenergi chose to use Microsoft BizTalk as an integration platform. Most of the development and mapping between AMR and DMS interfaces were done in BizTalk. The aim was to do a minimum of development in the systems that were integrated (DMS-AMR-MDMS).

The use of an integration platform for mapping and monitoring of the interfaces will make it more flexible and easy to connect another AMR system in the future.

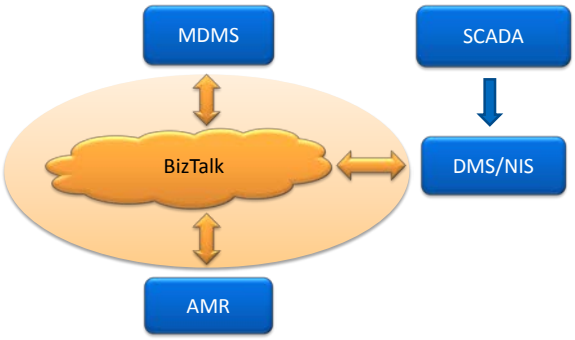

Figure 3. System overview of integration between AMR meters and DMS/NIS

Apart from DMS and AMR, also MDMS (meter data management system) is an important part of the integration since it is where Mälarenergi has the component record for all meters and AMI components. Information about which meter to send queries to is retrieved from MDMS.

Due to the fact that information in the meters is not stored and accessed in an optimal way for the projects purpose, some logic has been made in BizTalk in order to improve the response time.

To accomplish a successful integration between DMS and AMR meters and create a useful tool for the control room the following prerequisites are important:

- Communication technology is reliable and enables event-based services on a large scale and without due delay.
- AMR meters are capable to trigger and send spontaneous alarms when a predefined event occurs.
- AMR system can respond to queries sent to the meters, without due delay.

All the prerequisites were not fully met initially, but has been developed and improved during the project and will also be continuously improved onwards.

Within the project there has been close cooperation with the system suppliers. To accomplish push functionality from existing meters, new software has been developed, tested and are about to be rolled out remotely to the metering system.

The project has worked in two general steps where the first step has been to test functionality in a pilot area with approx. 1000 meters. After the functionality has been approved in the pilot area a full scale implementation has been made to all radio communicating meters.

Up until now Mälarenergi has completed integration and full scale implementation of functionality that correspond to the use cases number 1-3, all three based on that the DMS system sends queries to meters.

Push functionality for alarms, use case number 4, has been developed and tested in the pilot area. By the middle of 2013 Mälarenergi will finish the roll out of software for push functionality in full scale.

The last use case, number 5, spontaneous PDM alarms when a power down interruption occurs will not be possible to implement until the meters are replaced by 2nd generation meters with enough backup energy.

EXPERIENCES

Fast and reliable infrastructure and communication is absolutely crucial for the success of using smart meters for control of LV network. The communication must be two-way and the meters must be able to answer to queries or push information without due delay. Old information is not relevant in the control room.

It is of high importance to fully understand how the meters and AMR system works when mapping the interfaces. Especially where the information is stored and on what level of detail is important, to optimize the response times when asking for information.

Intelligent alarm filtering is significant in order to only send relevant alarms to DMS so that the amount of alarms will be possible to handle for the control room personnel.

The meters should be equipped with both push functionality and enough backup power (e.g. battery) to be able to send PDM.

Smart grid cooperation between system suppliers (AMR and DMS/NIS) is something that has started and that we hope to see more of in the future. It is important to create standard interfaces between the systems to make it easy to use all smart functionality from the meters.

NEXT STEP

The next steps for Mälarenergi are to:

- Continuously work to improve today's infrastructure and communication in order to create higher reliability and faster response time.

- Specify the requirements on 2nd generation meters and test both functionality and communication solutions. The project has identified several new requirements for next generation smart meters, especially important are that they has faster and more reliable communication and possibility to spontaneously push alarms including PDM. Also more easy access to information is of importance.

- Gradually replace today's meters with 2nd generation smart AMR meters. The most interesting meters to start with is in rural areas (overhead lines and long distances), communicating with PLC. New meters in these areas, connected to DMS, would give the control room a great benefit.

REFERENCES

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[3] Kamstrup A/S, 2009, "Technical description Kamstrup 162/382".

[4] Tekla Corporation. Jukka Kuru, 2011, "Tekla Xpower DMS-AMR integration-Product Description"