TEKLA

[Document type]

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SGEM task 1.4.7

Demonstration of LV Network Outage Management

Report

Description	This paper is a report for SGEM task 1.4.7 (Advanced utilization of AMR data in outage management and customer communication). The paper demonstrates the integration between AMM and DMS systems as well as the development in Tekla DMS regarding the utilization of information from smart meters in low voltage network outage management.
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1. General

The purpose of this task was to study and demonstrate the possibilities what advanced utilization of AMR data can achieve in customer communication and outage management processes of distribution system operator. In this report we concentrate on the outage management process and delimit the examination on a low voltage side.

2. Background

Outage management or generally network operation requires real-time information on the state of the distribution network. Traditionally this information has only been available in medium voltage network. The integration of AMM and DMS systems enables the extension of online monitoring and control also to the low voltage networks. This can be seen as a counterpart to SCADA systems in MV networks.

So far fault interruptions in the LV network could mostly have been detected until a customer has given a call to the control centre telling one being without the supply of electricity. AMR meters of today are able to detect and send automatically alarms to the DMS system. An alarm can mean missing phase voltage or other voltage abnormality. The missing phase voltage information enables to expose fuse blow outs and broken phase conductors. Yet there are situations where alarms are not an efficient enough tool to detect every interruption. Queries included in the advanced DMS systems fill the remaining gap. With the help of queries the dispatcher can effectively detect e.g. broken LV lines.

3. Benefits

Integration between AMM and DMS systems arouses many benefits regarding to LV network outage management. When the operative data is available from AMM system, DMS can manage switching state real-time in which enables more accurate outage management in LV network by means of automatic low voltage fault location and interruption registering. This not only shortens response times to start supply restoration process but also improves the detection of broken neutral type of incidents in low voltage networks and single conductor cut offs in rural medium voltage networks.

Interoperability between DMS and AMM improves the accuracy of outage statistics and direct compensation analysis. It expands the potential of customer voltage quality monitoring in real time. Moreover, potentially less trouble calls have to be taken care of by the control centre because high-level outage communication services like subscription based SMS service can also cover interruptions in LV network.

4. AMM-DMS Integration

System-specific interfaces are the basis in the integration between AMM and DMS systems. Tekla DMS implements several interfaces to different AMM systems. However, the following story is based exclusively on the interface specified by Tekla and referred to as “interface”.

The interface is implemented using Web Service technology, based exclusively on WSDL and XML-schema definitions adhering to Web Services Interoperability (WSI) recommendations. Each request message carries a header with authentication information. The message exchanges can alternatively take place over HTTPS.

The interface enables transferring alarm notifications spontaneously from smart meters to DMS. Tekla DMS utilizes this data for managing the real-time switching state. To accomplish this optimally, the following is required: Unsolicited delivery of alarms should take place without undue delay, i.e. within a few minutes, preferably in seconds. This is a rational requirement due to a reason that a notification arrived only after a substantial amount of time is worthless because the cause and the extent of the incident will already be deducted from received trouble calls.

Several alarm types are supported by the interface: “broken neutral” (i.e. zero conductor fault), “phase voltage missing” (separately per phase), “asymmetry” (i.e. voltage unbalance), “voltage level violation” (separately high and low and per phase), “wrong rotation”, “reverse current”, “enforcement of consumption limiter” and finally, “tripping” (of the device’s internal circuit breaker). Alarms generated by device self-diagnostics, like “malfunction” or “tampering” are also supported. It is noteworthy that transfer of deactivation events (i.e. indication off) is also supported by the interface but currently ignored by Tekla DMS.

For the time being, lot of variation exists regarding how well different equipments, communication technologies and AMM systems on the market covers the listed alarm types and the following performance and pre-processing requirements. When two (or three) phases are lost they all should be part of a merged “two phase voltages missing” (or “all phase voltages missing”) indication, instead of being sent as two (or three) separate indications. An unsolicited alarm should not be sent many times within a short time span. This may occur when a value hovers close to a threshold. An unsolicited alarm should not be sent if it would be followed by a more specific alarm within a short time. An example would be a voltage level violation which is immediately followed by asymmetry detection.

The interface between Tekla DMS and AMM also enables DMS to request and receive asynchronous read-outs from the meters regarding currently active alarms and measurements. It should be possible to query read-outs of a large set of devices and receive the results without undue delay. The expected response time is the same as for unsolicited delivery. In practice, the amount of targeted devices is limited by the software operating systems and/or runtime environment’s buffer limits and configuration. Those should easily support a few hundred targets by default. It is up the AMM to deliver the requested data in a single invocation (if the number of items is reasonable), or in chunks while data collection is still proceeding. However, it is desirable to start delivering as soon as possible to provide feedback to the user who made the query. Running several queries in parallel must be supported. In practice, there may be a few dozen.

Tekla DMS supports four different types of queries. Manual query allows user to select targets and pass a query to AMM system at any time. Semi-automatic query is used immediately after final supply restoration step meaning that DMS selects the targets automatically and prompts a user to

start the query. Automatic queries are performed when a new LV interruption triggered by an alarm has been registered. This is done without any confirmation from the dispatcher in order to locate the interruption. Reference query is another fully automatic query type. Here DMS performs a query to predefined targets periodically, e.g. once in 24 hours, in order to find presumably de-energized consumption sites of special interest.

The potential replies from AMR meters are briefly reviewed in this chapter. In case of “unknown device” response, there is an identification information mismatch between the systems and the query becomes worthless in this respect. On the other hand, an OK type of response, i.e. targeted device responds with no active alarm status values, is a proof for DMS that the consumption site is energized. An alarming type of response i.e. targeted device responds with one or several active alarm status values, gives a plausible indication about an unacceptable situation. In both OK and alarming type of responses, the message can include (when supported by AMM) instant measuring or average values about load currents and phase voltages. The remaining types of response, which are presented next, are perhaps even more interesting. In case the target is unreachable, AMM should response with “device not responding”. Unfortunately, interpretation of this information is ambiguous: The consumption site might be affected by an outage or it is locally de-energized with intent or the communication is out-of-operation due to another reason. In order to make interpretation easier, it is profitable if AMM is able to distinguish intentionally de-energized cases from the other ones. For this purpose, the interface includes additional response values: “electric service suspended” (e.g. due to unpaid bills) and “site disconnected” (e.g. residential site without inhabitants).

The interface also specifies an additional service for requesting and receiving asynchronous read-outs of last contact times. AMM is assumed to return this information from its database. This information help dispatchers in the control centre to take stock of the situation e.g. when browsing the results of the latest reference query that includes single or few “device not responding” results for consumption sites expected to have supply.

5. Tekla DMS functionality

In order to manage smoothly outages in LV network one must pay attention to the development of analysis functionality as well as usability in DMS. Tekla DMS executes analysis of AMM data constantly against network topology and known outage situation. It responds to conflicting situations by means of automatic outage registration. The software concludes the most suitable fault location in order to bound affected zone correctly. It records an appropriate event (typically opening the fuse expected to be blown) and performs the other assigned tasks like generating a new interruption record and updating the data in outage communication services.

Tekla DMS browser (Figure 1) is an integrated tool for managing actual network operation information especially aiming to help when dealing with AMR information. Dispatcher can easily browse ongoing interruptions, actual events, trouble calls, alarms and queries with clear presentation of the interconnectivity between the items. The dialog contains a tree structure with which the browsing of various items is simple.

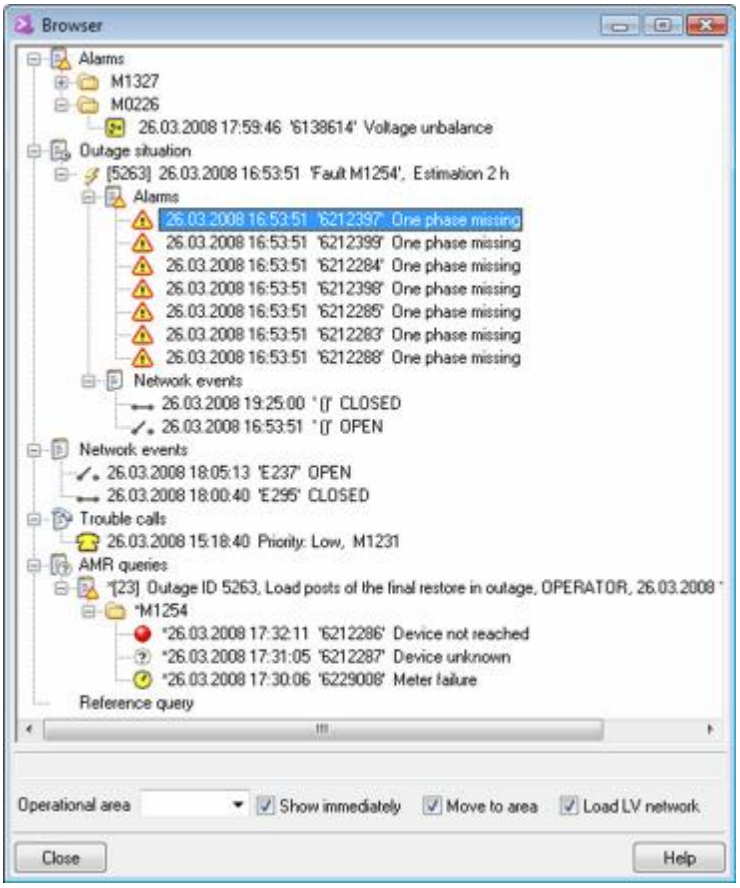

Figure 1. *Tree structure tool for managing operational data in Tekla DMS*

Tekla DMS includes many advanced features related to visualization of actual alarms and query replies including automatic decluttering of symbols and tooltips close to each other. A user may view the selected information from the browser also on the network map. Figure 2 illustrates a situation in which an interruption is registered automatically based on several “phase voltage missing” type of alarms received from AMR meters on one LV feeder.

Dynamic colouring in the figure indicates the de-energized network (white lines) and the location of the fuse expected to be blown. An automatic query has been sent to all consumption sites on the same feeder where the alarmed ones are situated. In addition to alarmed AMR meters there are two devices which are not reached (indicated as red symbol) and one without the proper device (indicated as question mark).

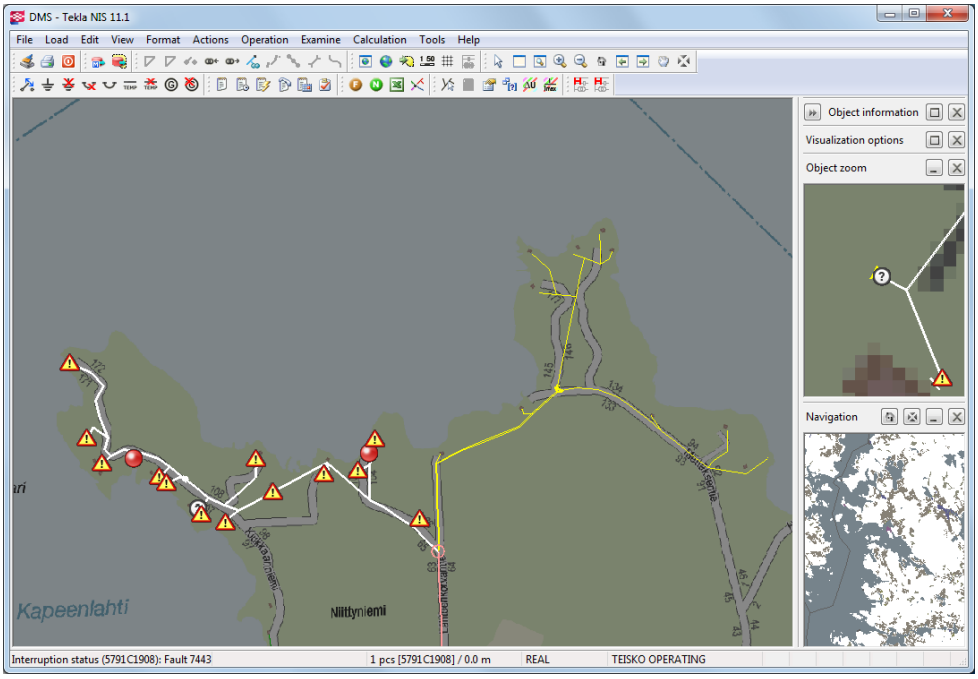

Figure 2. *Visualization of AMR alarm data on the network map in Tekla DMS*

Figure 3 presents a situation where there has been done a manual status query to all AMR meters behind the distribution substation except the ones on the LV feeder having a fault. Eight meters has already replied answered OK (indicated as green symbol) and DMS is still waiting for replies from two devices (indicated as yellow symbol).

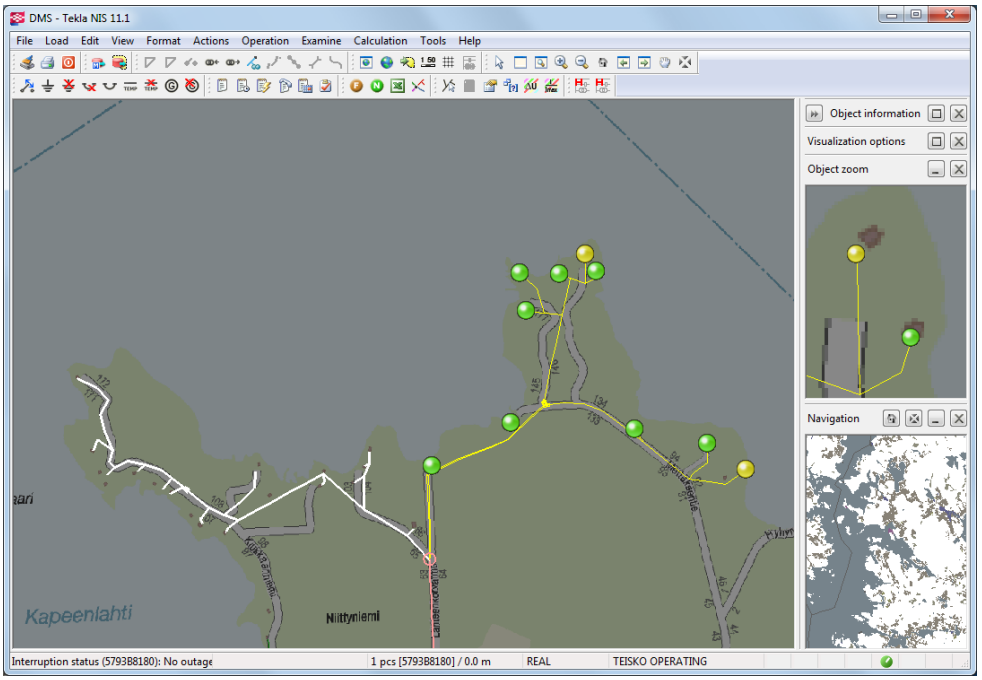

Figure 3. *Visualization of AMR query data on the network map in Tekla DMS*