Enhancing Customer Services by efficient integration of modern IT-systems for Asset Management and Network Operation

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I. NOMENCLATURE

AM/FM Automated Mapping/Facility Management (approximately same as NIS)
CIS Customer Information System
CMMS Computerized Maintenance Management System
CRM Customer Relation Management
DMS Distribution Management Systems
GIS Geographical Information System (NIS contains a GIS solution)
ERP Enterprise Resource Planning
NIS Network Information System
SCADA Supervisory Control and Data Acquisition
Spatial Geographical information, such as maps and one-line diagrams

II. INTRODUCTION

There is a never-ending increase in demand from society for a reliable and high quality supply of electric energy at lowest possible cost, with negligible impact on the environment and with a high level of customer service satisfaction. The deregulation of the electrical supply industry that is taking place in many countries is a response to this demand. Although the supply networks are natural monopolies in reality, there is also for those a strong emphasis on maintaining or even improving network supply quality in terms of minimizing outages and improving voltage quality. This under pressure by the regulator authorities to also minimize the cost.

A modern society is very dependent on an uninterrupted supply of power for its efficiency and comfort, and this will probably be even more important in the predictable future. In order to meet these demands the network owners have to optimize network investments and the cost of maintenance and to lower the operation cost to a minimum, while at the same time meeting more stringent quality objectives. To do this, IT tools are essential.

III. BUSINESS PROCESSES

A. Main processes

In a Distribution Utility, one normally finds three different groups of business processes as shown in figure 1:

Three main business processes in a network utility

1. The Network Asset Management process covers all the activities regarding planning, building and maintaining the network.
2. The Network Operation Process covers the activities that keep the network up and running providing a high quality supply of energy to the customers.
3. The Network Market processes covers all the interfaces with the customers. Routines for metering, accounting, billing are included based on contracts or access agreements with the customers.

As the picture indicates there are dependences between the business processes. They have to be coordinated. Beside the main processes there of course are a number of different support processes.

B. Addressing major costs

The Utility industry is a capital-intensive industry. The total company efficiency depends on making optimal investments (at the right place and at the right point in time) and at the same time making the human resources work efficiently. A study in Sweden has shown the following yearly cost profile for providing and operating a distribution network (Energy retail is excluded).
Investments 40%
Customer support including metering, billing, corrective maintenance and administration 31%
Preventive maintenance 14%
Operation 11%
Inventory 4%

Economic results of Distribution Utilities depend very much on investments, maintenance and operation of the network assets. These figures from Sweden are not, of course, the same in other parts of the world. For countries with rapid demand growth the investment part may be even bigger. But in general the picture is similar as a Utility has the same tasks independent of country and therefore the above conclusion is still valid.

C. Customer satisfaction and supply quality
Customer satisfaction with distribution services depends on different factors such as:
• The technical quality of the energy supply such as supply reliability and voltage quality.
• The quality of customer communication. Advance notification of planned outages and prompt and precise information on unplanned outages are examples.

IV. IT-SYSTEMS
A. Main IT systems
The main IT-systems supporting the Distribution Utility processes are presented in figure 2 below.

Major IT-Systems

The reason for this subdivision of functions is due partly to traditional industrial product subdivisions and partly to the type of databases they are organized around.

SCADA/DMS (Supervisory Control And Data Acquisition/Distribution Management System) functionality is typically oriented around a model of the distribution network and its auxiliary systems which is kept updated in real-time. This model is geared to real time performance and has extensions that are required for network operation.

CMMS (Computerized Maintenance Management System) functionality is very much oriented around a detailed register of all Utility assets. It also contains transactional data, such as work order management, project management and purchasing. An ERP (Enterprise Resource Planning) is a similar, but broader solution that also contains functions like Human Resources and Financing.

Traditional CMMS and ERP products do not support the connectivity and spatial models required for electrical and spatial analyses. Therefore an additional NIS system is also required.

NIS (Network Information System) functionality is oriented around a detailed electrical model of the distribution network. The model comprises connectivity as well as spatial views of the network. An NIS solution often contains GIS-functionality as well.

CIS/CRM (Customer Information System/Customer Relation Management) functionality is oriented around the customer data registers.

B. Functional distribution
The functional distribution between the SCADA/DMS and NIS is more thoroughly elaborated below.

SCADA/DMS is the major tool for supervisors and operators to monitor, control and plan operation of the distribution network and comprises typically following functions:
• Monitoring and control of network devices and auxiliary equipment.
• Maintaining a real time maintained model of the network as being operated. The model comprises electrical, connectivity, operational and spatial aspects of the network. Graphical presentation may be in form of world maps and schematic diagrams. Also model versioning for studies and planning purposes are supported.
• Planning, management and execution of switching schedules for enabling maintenance and construction works in the network.
• Outage management, including comprehensive functions for:
  o Fault Localization by evaluation of:
    ▪ Customer trouble calls
    ▪ Protection and fault indicator signaling
  o Fault Isolation Switching
  o Supply Restoration switching
  o Call Center and IVR (Interactive Voice Responding) Communication
  o Crew and Resource Dispatching backed by Outage Extent Analysis and Prioritization Support
  o Outage history storage and reporting
• Network operation optimization such as:
  o Load Forecasting
  o Load Flow - real time estimation and monitoring of load flows and voltage drops based on a combination of measurements and statistical load models
  o Optimal Network Sectioning
  o Coordinated VAR and Tap Changer Control

NIS (Network information system) is used for documentation, planning and analysis of the distribution network. Its kernel comprises the detailed topological, electrical and spatial model. Its database can concurrently handle both as-built versions and future versions including planned extensions or modifications. The network model graphical presentation may be spatial (world maps) as well as schematic. The NIS also includes a tool set for doing analyses of the distribution network, both the as-built version and future versions, typically including:
• Load Flow Studies
• Protection Coordination Engineering
• Reliability Estimates
• Interactive optimal structuring and dimensioning of the network
• Engineering and budgeting tools
• Also Spatial analysis, such as listing property owners affected by a planned line construction

C. Interrelations between systems

There are interrelations between the main IT-systems described above that must be supported in a rational IT-implementation. The basic information interchanges required are similar for all Utilities and are here illustrated by an IT-implementation for a Scandinavian utility (see the figure 3 below).

Major information interchanges

![Diagram of information interchanges](image)

The reasons for these exchanges are described below. The numbering refers to the numbering in the figure.

1) Both the NIS and SCADA/DMS have electrical topology models combined with spatial information. They are, however, used for different reasons: The NIS has a detailed model of every single object in the network, which is used throughout the organization. It often consists of tens of millions of objects with hundreds of users. The SCADA/DMS has a real time database representing the actual process and meets very high demands for security, performance and redundancy. As a consequence of this, a Utility needs both the NIS and SCADA/DMS databases, but the common content must be synchronized. There are, therefore, bulk and incremental exports from the NIS to the SCADA/DMS database. This common use of model data rationalizes the company wide maintenance work and ensures information consistency. In a distribution network there are a continuous stream a network modifications taken into operation. These modifications will primarily be documented in the NIS, but the SCADA/DMS model must always be kept updated. Therefore it is necessary to timely keep the NIS database updated with a subsequent incremental export and installation of the changes to the SCADA/DMS database.

2) The Outage Management part of the SCADA/DMS needs to know customer identities and where they are connected to the network. These data are periodically updated from the CIS database. The Outage Management part also has real time connection to the CRM (Customer Relation Management) system. The CRM system will be on line updated of the outage situation and estimated restoration times. The DMS will also respond to CRM requests about actual or planned outages for customers calling in. The CRM system will submit customer trouble reports to the DMS system for notification and evaluation. The DMS operator will then initiate appropriate actions for troubleshooting and supply restoration.

3) The network analysis parts of the NIS and SCADA/DMS need to have data about the statistical load profile curves of connected customers in order to perform load flow analyses. This as real time measurements are normally not available for all loads. (More advanced statistical load profile curves also models the weather dependencies of the load.) Statistical load profile curves by customer category together with annual meter reading results provide the basis for constructing the load models used in the applications. The CIS periodically provides the NIS with applicable data for constructing these models. In DMS the load models can be calibrated on-line to match actual SCADA measurements.

4) The SCADA/DMS part will update the CMMS part with data needed for planning corrective and preventive maintenance of power system components, such data as:
• Equipment fault reports for corrective maintenance
• Equipment usage history for estimating wear or more general reliability indices

5) Most of the power system components in the NIS database also have their equivalents in the CMMS database. Some attributes of the components are identical (common)
while others are unique in the respective systems. To ensure consistency of the common contents of the databases these parts are synchronized. When updating one system the other will also be updated by a replication. New objects will normally be entered in the NIS database first. Applicable subsets of object data will then be replicated to the CMMS. In CMMS additional attributes, not represented in the NIS database will be added.

When these information links have been implemented, the Utility will have a co-operative IT-solution for efficient business operation and analysis. This can be used for improving Investment, Maintenance Management and Operation or in other words for the improving the overall Asset Management.

V. A SCANDINAVIAN REFERENCE

ABB is building an IT-environment as described above for a Scandinavian Utility. The ABB part of the delivery is the NIS and SCADA/DMS parts and their integration to the CIS/CRM and ERP/CMMS, which are provided by others.

A. Main business objectives

The main customer objectives for the SCADA/DMS and NIS investments are to reduce cost, maintain (or slightly improve) system reliability and improve customer service satisfaction as follows:

**Reduction of future network investment cost**

The NIS provides analytic tools to optimize the structure and dimensioning of network extensions and reconstructions.

**Reduction of operational cost.**

- By merging old dispersed SCADA systems into one Utility-wide SCADA/DMS system and by introducing flexible control center manning tailored to actual work load, a considerable reduction of in the number of operators and supervisors will be achieved. The scheme implies a dynamic allocation of authorities and responsibilities between personnel. The SCADA/DMS workplaces are sited in different locations within the area served by the Utility.
- Management of the switch orders required for planned network maintenance and construction works will be much more efficient. The new SCADA/DMS includes semi-automatic generation of switching schedules, security checks of planned switching actions, security document management, approval procedures, document distribution and execution monitoring.
- Maintenance of asset data collected in the synchronized NIS and CMMS will also be handled more efficiently.
- Asset Maintenance will be optimized by the maintenance optimization and grouping functions in the CMMS.

**Improved system reliability**

- The SCAD/DMS Outage Management application shortens unplanned outages that may occur. More rapid fault localization, faster restoration switching and more efficient dispatch of field personnel do this.

**Improved customer communication**

- The outage management of in DMS supports improving the customer relations in the following manner:
  - Customers will individually be notified of planned outages affecting them.
  - When registering an outage the SCADA/DMS will provide detailed state information about it, e.g. when restoration is expected.
  - Customers can subscribe to an SMS-messages service (Short Message Service) giving them on their mobile status of the outages affecting.
  - Customers can subscribe to an outage SMS-messages service (SMS = Short Message Service). They will then on their mobile phones automatically be notified on status of the outages affecting them.
  - General outage information will be published on web pages.

B. Experiences achieved

The result of computer aided asset management and advanced operation support is very much dependent of correct and complete documentation data. In the Scandinavian case described, like in most Utilities, asset data was retrieved from a number of different sources. Some data was even found in multiple sources of different completeness and quality. The data models varied between the sources. Some sources were computer files while other were on paper only. Due to the historical background where different parts of the network belonged to different owners, even different naming conventions were applied. It therefore required a major effort to create a rational IT environment cleaning, harmonizing and securing the quality of the original data. Automatic data model conversions have also been applied in the import procedures.

To facilitate openness, the data models of the new NIS have been adapted to OpenGIS® specifications for spatial data and to CIM draft specifications for network model data. All NIS data is stored in one and the same spatial-enabled relational database, which also facilitates data mining. The user interfaces of the NIS are fully web-enabled, providing open access to different users inside and outside the Utility without requiring special client installations. There is, of course, an authorization management procedure to give only certified users specified rights to access data and applications.

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1 The OpenGIS® specifications are established by a consortium of more than 220 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications.

2 CIM (Common Information Model) is a draft specification by IEC for modeling the physical aspects of Energy Management System Information. WG 14 of IEC is in progress of extending the model for also Distribution Management applications.
The data interchange between the NIS and the SCADA/DMS has been facilitated by the use of the CIM data model but also because both systems are delivered by the same vendor. In future one may anticipate emerging IEC standards for such data exchange.

For replication and synchronization between the NIS and CMMS system there have been difficulties defining interfaces and methods due to the lack of standards. Some interfaces were available but unique for each product. As an initial solution a customized bridging gateway will be implemented.

For interfaces between CRM/CIS and NIS and SCADA/DMS customized solutions have also had to be applied.

C. Conclusions
To meet all demands from the owners and society in general, an electric Utility must ensure that it has an efficient IT-structure. One strategy of achieving this is to have as few systems as possible. There are however some constraints, such as different needs in different business processes and standard solutions available from the major IT suppliers. Taking this into account, the optimal IT-structure for an electrical transmission and distribution utility is centered around four core database: CIS, NIS, SCADA/DMS and ERP.

Those databases have to be synchronized to facilitate a consistent IT-structure. The most important is the Asset Register, since it must be distributed to many different systems. There are two specific characteristics of the asset register for a transmission or distribution company: electric connectivity and spatial data. Fortunately, standards are emerging for those characteristics: CIM and OpenGIS®. Other standards, such as for customer data, have yet to be defined.

An important and often costly, obstacle for achieving a consistent IT-structure, is data quality. Mergers and acquisitions that have led to even more inconsistent information often exacerbate this problem. Once again standards, such as, CIM and OpenGIS®, can assist in the process of improving data quality.

A consistent IT-structure is a requirement for efficient business processes and for business analysis. When it has been achieved, the Utility is well placed for good Asset Management.

VI. BIOGRAPHIES

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