Smartness in control

New integrated SCADA/DMS innovations put more analysis and control functions in the hands of grid operators

MARINA OHRN, HORMOZ KAZEMZADEH – Over the last decade, the electric power industry has experienced unprecedented change. This has been fueled both by technological breakthroughs and by the restructuring of the industry itself. Restructuring has seen many utilities move from a regulated environment to a more market-oriented paradigm. At the same time, the IT systems that supported transmission and distribution operations became more robust and powerful, and have now reached the point where multiple applications can be presented on a single platform. The future grid will be largely automated, being able to apply intelligence to operate, monitor and even heal itself. This smart grid will be more flexible, more reliable and better able to serve the needs of tomorrow's world. The following article is largely US-focussed, however most of the challenges and learnings are of universal applicability.

As a long-standing industry leader and innovator in the power technology sector, ABB is at the forefront of the development of IT systems for power transmission and distribution. The 1970s saw the introduction of Supervisory Control and Data Acquisition (SCADA) and Energy Management Systems (EMS), followed by Market Management Systems in the 1980s, and Outage Management Systems and Distribution Management Systems (DMS) in the 1990s. All these solutions have been developed and enhanced over the years. A more recent direction of system development has been toward a higher degree of integration in the form of a common platform.

This platform is ABB's Network Manager™. It fully integrates the above applications and also includes ABB's Network Manager DMS – an operations management system designed to help utilities reduce operating and maintenance costs while enhancing customer service. DMS provides advanced network modeling and management, integrated switching and tagging, trouble call and outage management, crew management, and also handles the recording and presentation of events.

As the fruit of many years of research, development and ample experience, as well as close collaboration with utilities around the world, ABB is uniquely qualified to understand both the big picture and the nuts and bolts of the emerging technologies and applications necessary for today's utilities.

A brief history of SCADA and DMS

Power control traces its origin to the 1920s when ABB's predecessor companies, ASEA and BBC, supplied their first remote control systems for power plants. It was not until the 1960s, however, and the advent of computerized process control, that modern power network control systems became possible.

At that time, SCADA systems were usually designed exclusively for a single customer. They were proprietary and closed off from one another. The resulting difficulties in coordination meant networks remained vulnerable. There was thus a need for strategies that could prevent faults from developing into outages of the scale of the 1977 New York blackout.

The 1980s saw computing technology advance further. Methods were developed to model large-scale distribution networks in a standardized way. Similarly, SCADA and EMS became more sophisticated, providing transmission operators with better tools to control bulk power flows. In the business world, the 1980s were also an era of deregulation. With airline, telecommunications and natural gas industries all being liberalized, regulators and utilities both began to consider whether the same could be achieved for electric power.

Such a move would have called for entirely new types of IT systems (mostly to serve the wholesale markets), as well as enhancements to existing SCADA/EMS technology. Perhaps not coincidentally, the new generation of control systems that had emerged by the early 1990s was able to fulfill these demands.

Progress in computing also changed DMS and OMS. DMSs had originally been distribution-level extensions of SCADA/EMS systems or stand-alone systems, but the unique demands of distribution operations made them more clearly distinct.

Classical monitoring and control systems for distribution networks were relatively low-tech. Typically, such a system was based on a wall board displaying the system's status. Such a board would often be covered with sticky notes and pushpins concerning ad hoc changes. This made the overall system difficult to monitor and inflexible and also presented security challenges. The distribution circuit maps used for maintenance work were paper based. They were often annotated manually and risked being out of date. The orders used to plan, execute and track scheduled switching on the system were also paper based. Outage calls from customers were received by operators who did not always have direct access to all the necessary information. These outages were also tracked with paper-based tickets. Communication with crews in the field was radio based. Crews had to inform the operating centers of their location, and the communication of switching, the placement of tags and other operations were coordinated verbally.

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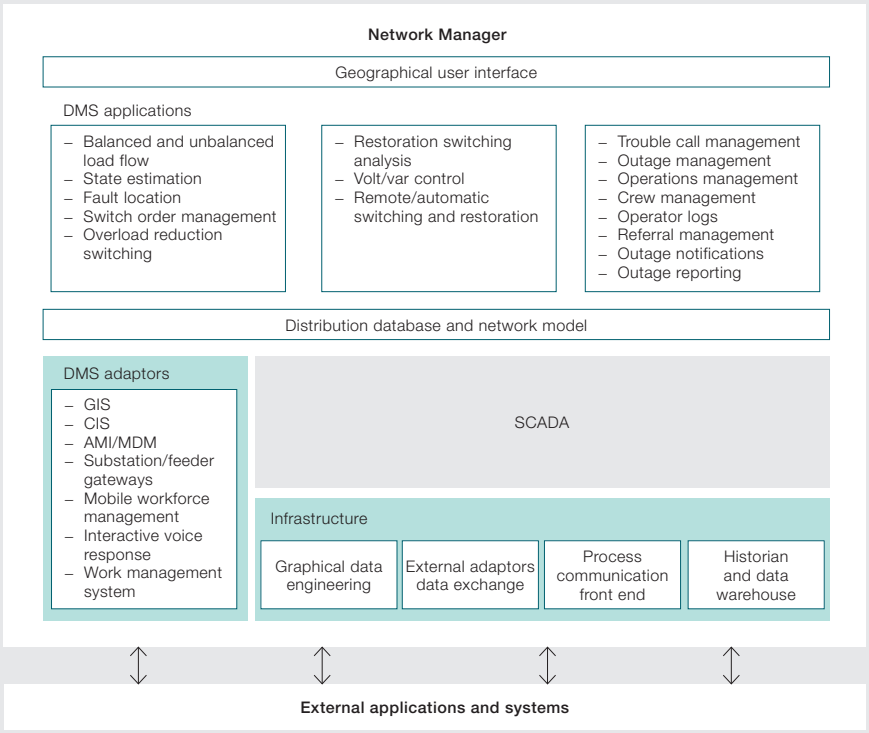
This should not imply that distribution operations stood still over time. As technology and business needs changed, so too did many distribution operations centers. Many SCADA systems were extended from the transmission system to cover monitoring and control of distribution-side medium-voltage (MV) feeder breakers. In some cases, the reach of SCADA was even extended out beyond the MV feeder circuit breaker to equipment such as reclosers, switches and capacitor switches.

1 The coordination of and communication with field crews is an important aspect of network management.

2 Network Manager is an integrated platform for SCADA, DMS and OMS.



Analytical software and other advanced applications are providing more far-reaching analyses and permitting automated operations.

DMS continues to evolve

As distribution systems continue to becoming ever “smarter” and more secure, the operations centers that control them are also changing to take on new roles in managing the evolving grids. The separate IT systems used in control centers are becoming more streamlined and are communicating seamlessly to provide an integrated monitoring and management system. Analytical software and other advanced applications are providing more far-reaching analyses and permitting automated operations. The control systems of operations centers are not only helping to make the grid smarter, but are also helping to improve support for operations, maintenance and planning. Such integrated operations centers are helping distribution organizations meet their goals despite ever-increasing demands → 1.

Control center systems

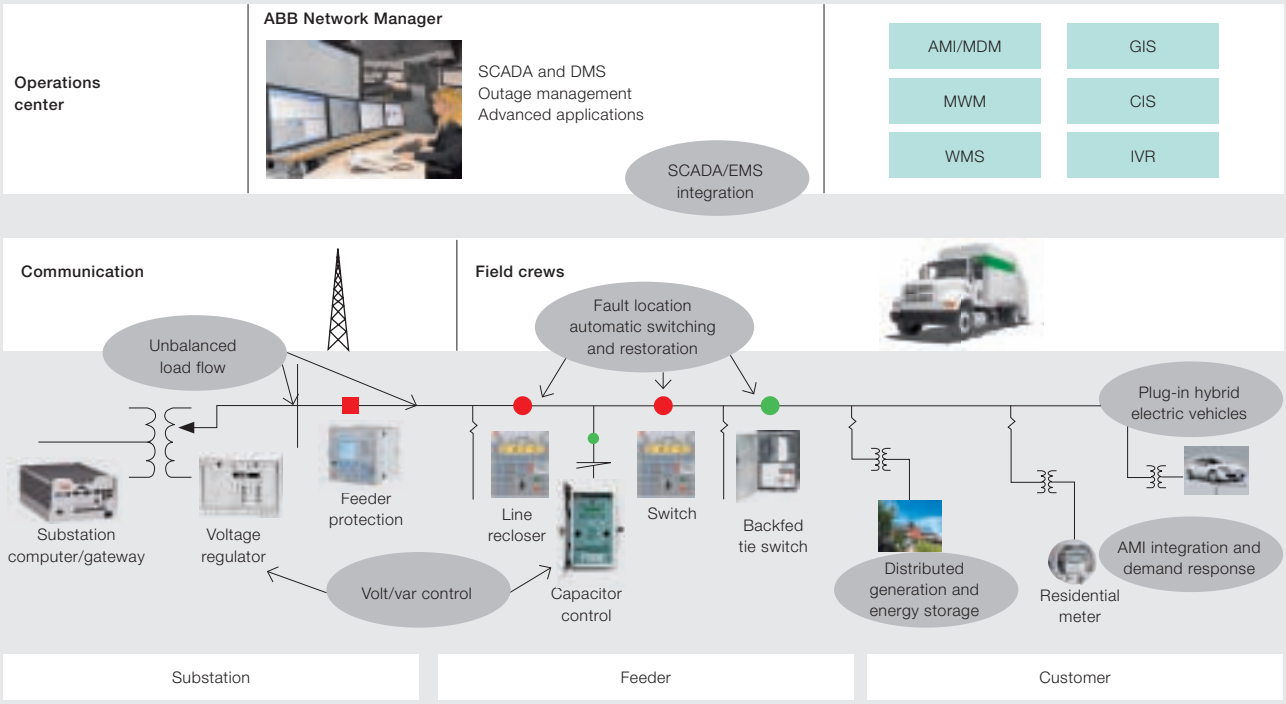
Within the last few years, several interconnected but external factors have accelerated the development and expansion of applications for smart grid technology. These include society, government, the changing business environment and technology.

The increasing role of renewable energy and distributed generation and the associated demand-response issues are calling for fresh approaches in grid management. Market liberalization and power trading are furthermore permitting end users to choose the source of their power. Another important contributor is the increasing cost of generation and transmission, both in terms of infrastructure and fuel. From a business perspective however, distribution organizations are also looking to smart grids to help them maintain or improve reliability, increase asset utilization, deal with aging infrastructure and help reduce the impact of knowledge loss as employees reach retirement age in many parts of the world.

Another significant enabler of the development of smart grids is technology: Many of the required tools and capabilities were simply not available some years ago. One such resource is communication. Distribution companies can now choose between many different means of communication: They can use a dedicated network they themselves own (eg, SCADA radio networks), or use third-party infrastructure (eg, cellular communications). Various factors may influence such a decision. One trend, however, is definite: The importance of two-way communication is set to increase.

The number of distribution equipment items on the feeder featuring sensing,

3 The operation center system of the future integrates various IT systems as well as field devices and customer information.



Many distribution organizations are enhancing substation automation. This improves access to information in the intelligent electronic devices.

data processing, control, and communications capabilities is increasing. Smart devices and appliances are even entering home networks. The deployment of this technology will depend upon the development and unification of interoperability standards.

The benefits of systems integration

ABB is a global leader in the development of the smart grid, and has invested much time and resources in developing the operations-center systems that are a critical part of any smart grids solution. Three important areas of systems integration are DMS integration with SCADA, advance metering infrastructure (AMI) integration with DMS, and the integration of data from substation gateways and intelligent electronic devices (IEDs).

ABB has long been a leading advocate of the integration of SCADA at the distribution level with DMS applications. With more distribution companies now installing additional SCADA on the distribution system, ABB is continuing to improve the outreach of its integration solutions. Available functionality now includes the transfer of status/analog points from SCADA to the DMS; the sending of supervisory control and manual override commands from the DMS to the SCADA system; and an integrated user interface running on the same PC operator console with integrated single sign-on for users ➔ 2.

Utility grid operators are seeing tangible benefits from implementation of integrated SCADA/DMS systems. This includes increased operator efficiency within one system, thus eliminating the need to use multiple systems with potentially different data. It also includes integrated security analysis for substation and circuit operations to check for tags in one area affecting operations in the other, and streamlined login and authority management within one system. Operators have also noted improved, consolidated system support for DMS, OMS and distribution SCADA.

Much of the discussion about developing the modern-day smart grid has, until now, revolved around the potential of AMI and emerging advanced metering technologies. As a result, installations of AMI systems are rapidly growing in number. ABB is now developing ways for distribution grid operators to improve the leverage of AMI data. Interfaces between AMI, meter data management (MDM) and SCADA/DMS have been created and improved for outage notifications, meter status queries and restoration notifications. Resulting benefits include: reduced customer outage times and a more efficient use of resources in the field. The

use of other AMI data in DMS applications, such as voltage indications and interval-demand data, has also been explored. Benefits of this include better voltage profiles throughout the system and an improved understanding of system loading.

Additionally, many distribution organizations are enhancing substation automation and the number of substation gateways on their systems. This improves access to information in the IEDs that are installed in substations and distribution systems. The advanced communications capabilities that many of these IEDs possess include more intelligent recloser controls, switch controls, and voltage regulator controls. Integration of these systems with the DMS allows for decentralized control at the substation/feeder level, while providing system optimization through the DMS at the system level [1]. Integrating SCADA/DMS with other utility systems provides a truly integrated operations center for managing the smart grid.

The integrated operations center

A smart and fully integrated distribution operations center will include DMS applications for the management of the distribution systems with respect to efficiency, voltage control, equipment loading, work management, outage management and reliability. These DMS applications utilize a model based on the distribution database and electrical network topology. The network model uses data from a geographic information system (GIS), and is periodically updated to retain accuracy.

A central aspect of a smart and integrated distribution control system is the integration of the various IT systems found within it ➔ 3. Many distribution companies are expanding the reach of SCADA beyond the distribution substations and onto the feeders, allowing for improved situational awareness and control of the distribution system. Interfaces to other systems include AMI and MDM systems, and substation/feeder gateways and data concentrators.

> With more distribution companies now installing additional SCADA on the distribution system, ABB is continuing to improve the outreach of its integration solutions.

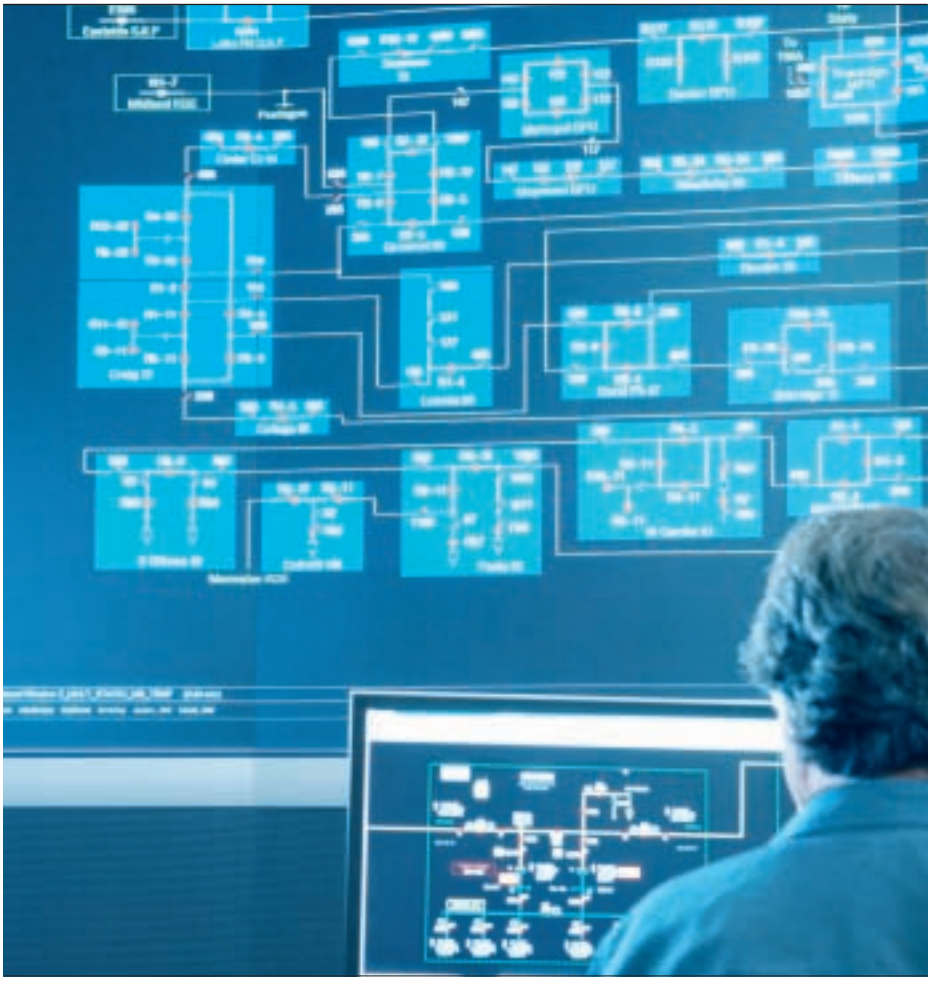
The strategy for sharing between the integrated operations center and field devices will differ from one distribution organization to another. There might even be several approaches used within a single utility.

Advanced network applications

With its Network Manager platform, ABB is the industry leader in the development of advanced applications for distribution system management. The Network Manager platform provides advanced applications that use the network model to provide recommendations for optimal network operation. The platform includes built-in advanced DMS applications for power flow analysis of the distribution network, optimal operation of capacitors and regulators, and fault and restoration switching analysis for faults and outages ➔ 4.

The Network Manager Distribution Power Flow (DPF) application is an integrated application that provides unbalanced power-flow solutions for the online analysis of the real-time network, on-demand analysis of “what-if” scenarios in simulation mode, and automatic analysis of service restoration switching plans. The Network Manager DPF application is designed to accommodate large scale distribution models extracted from GIS and provide fast solutions in realtime. The application can support distribution networks connected in meshed configuration and include multiple swing sources, electrical loops and underground phase loops.

4 Advanced applications allow operators to analyze system conditions more quickly and make better operational decisions.



Footnote

1 See also “Information, not data“ on pages 38–44 of *ABB Review* 3/2009.

The Volt/var Optimization (VVO) application enables a distribution company to minimize peak demand and reduce real power losses. This defers the need for additional generation, transmission, and substation capacity, reduces fuel and power purchase costs, and hence reduces greenhouse emissions. The VVO application monitors the distribution network and computes the optimal distribution control settings by minimizing a weighted function of demand, loss, and voltage/current violations in three-phase, unbalanced and meshed distribution systems. The VVO application computes the optimal control settings for switchable capacitors and tap changers of voltage regulating transformers.

The Network Manager Fault Location (FL) application utilizes short-circuit analysis and can help significantly reduce CAIDI and SAIDI [2] values, by reducing the time required for troubleshooters or repair crews to locate system faults. The application computes the possible locations of faults on distribution circuits by looking at fault current measurements and real-time network connectivity.

> Demand response, whether controlled by the electricity provider or the consumer, will impact power flow and voltage profiles.

The Network Manager Restoration Switching Analysis (RSA) application provides the operator with a quick method to identify switching options to isolate a faulted area and restore power to as many customers as possible without creating new overloads. The RSA application computes and analyzes switching plans to isolate a specific fault location and restore power to customers isolated from the fault zone.
These applications provide decision support to operators in manual mode and support fully automated operation without operator intervention in automated mode. As utilities move more and more toward smart grids and utilize better data and more advanced technologies, advanced applications will increasingly be run in automated modes, further improving reliability and efficiency of distribution operations.

The future of smart distribution centers

The integrated operations center will be a key to the smart distribution grid. ABB is continuing to increase the functionality of operations centers to meet distribution organizations' technical and business requirements.

The overall operation of distribution systems is certain to become more complex. Growth of distributed generation and energy storage will affect power flow on the system. Demand response, whether controlled by the electricity provider or the consumer, will also impact power flow and voltage profiles. In addition, there is an increasing trend to deploy additional intelligence in devices on the distribution system, such as intelligent electronic devices (IEDs), substation computers and gateways, sensors, and advanced meters. Some of these will result in additional local control actions, further increasing the complexity of distribution systems' operation.

In the presence of increasing amounts of decentralized intelligence and control, the integrated operations center will be a centralized way of overseeing and coordinating the entire system.

What next?

The smart distribution grids of the 21st century will require innovative operation centers. ABB is investing heavily in the further development of integrated operations centers for smart distribution grids. This includes both the advanced integration of existing systems and the development of new applications.

Smart grid operators will have a comprehensive view of the distribution system, including system status and monitoring, control, outage response, planned work, optimal equipment loading, and improved control over distributed generation, energy storage and demand response resources. These integrated distribution operations centers will help distribution companies in their mission to meet the goals of customers, owners, employees and society itself.

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Footnote

2 CAIDI: Customer Average Interruption Duration Index, calculated as the sum of all customer interruption durations divided by the number of those interruptions. SAIDI: System Average Interruption Duration Index, calculated as the sum of all customer interruption durations divided by the total number of customers served.