How the Convergence of IT and OT Enables Smart Grid Development

by Jeff Meyers, P.E.

Executive summary

The goal for any utility that invests in smart grid technology is to attain higher efficiency and reliable performance. A smart grid platform implies the convergence of Operations Technology (OT) – the grid physical infrastructure assets and applications–and Information Technology (IT) – the human interface that enables rapid and informed decision making. This paper describes best practices for migrating to a scalable, adaptable, smart grid network.

998-2095-08-13-13R0

Introduction

Operations Technology (OT) represents a broad category of components that utilities depend on for safe and reliable generation and delivery of energy. OT encompasses operating gear, from oil circuit breakers and sectionalizers to solid-state relays, and many devices in between. OT also often includes control room applications, such as supervisory control and data acquisition (SCADA) systems that monitor the network, reaching out to devices as complex as substation gateways, or as simple as sensors. OT is often applied within a mission-critical framework and is recognizable to every person working in utility operations, but it is seldom, if ever, considered or understood by anyone else.

If OT is the purview of the few, Information Technology (IT) is just the opposite. IT systems are in place to allow machines to exchange information directly with humans, usually within a second or longer. The utilities industry has experienced an exponential increase in both quantity and quality of IT systems. Improved Enterprise Resources Planning (ERP), Geographic Information Systems (GIS), and Customer Relationship Management (CRM) systems, along with office-based productivity tools and mobile computing devices, have permeated the utility workplace. Yet, until recently, the growth in IT stood independent of the hidden OT equipment quietly humming along in the field, serving and protecting the grid.

The Smart Grid is transforming utility operations and pushing IT across its traditional boundary into OT at a remarkable clip, rapidly blurring the distinction between the two categories (see **Figure 1**). This paper discusses the dynamics of IT and OT integration and how utilities can leverage this convergence for smarter, more cost effective, and more reliable operation.

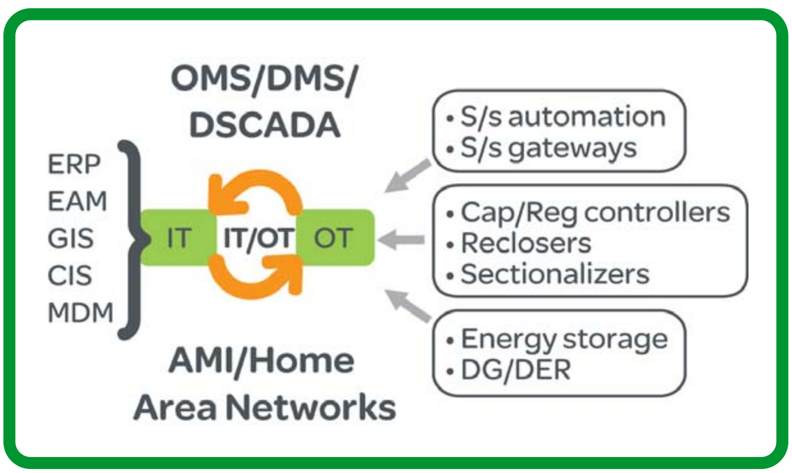


Figure 1
IT and OT becoming one.

Smart Grid redefining technology norms

The growth in grid modernization is driving an important conceptual change in the way utilities deploy smarter equipment and automation. This modernization is characterized by the following trends:

1. The continuous growth in OT deployment
2. The continuous implementation of IT by the utility to model, monitor, and manage its distribution system
3. An urgent requirement for utilities to integrate their IT and OT networks

OT growth drivers

New types of devices for the network

The growth of OT deployment has lead to the development of a smarter grid in several ways. New technologies introduced to the marketplace over the last several years are helping to make the grid a smarter network, from superior monitoring and control of supply, to more efficient generation and consumption to more innovative energy storage.

Examples of newly-minted grid technology include a host of devices with integrated communications modules, such as:

- Medium- and low-voltage line sensors and low-voltage circuit breakers
- New inverters to streamline the integration of renewable energy sources by chiseling the power flow waveform
- On-load tap changers that enable transformers to become active elements that make the grid flexible
- Grid- and consumer-scale energy storage devices based on lead-acid, lithium-ion, and flow battery technology

OT role expands to consumers

Advanced Metering Infrastructure (AMI) has enabled an entirely new range of consumer-based OT, most of which is beyond the reach or control of the traditional utility.

Home area networks and the 'prosumer' movement, where consumers elect to curtail energy use or self-generate to meet their needs, are rapidly becoming a reality, with implications for grid operators.

Smart meters and home area network technologies are also helping to blur the lines between energy supply and energy distribution domains.

Smarter, more sophisticated functionality in traditional equipment

In addition to new technologies, many improvements to existing devices are being deployed today. These include increased 'smarts' in solid state relays and controllers for reclosers and sectionalizers and improved regulators and capacitor controllers. As an example, capacitor bank controllers today can utilize remote, real-time parameters to influence switching, while monitoring and reporting on power quality through an integrated communications module.

More devices and equipment interconnected and exchanging data

The proliferation of every kind of device, a 'more of everything' mentality around the modern grid has also helped to drive growth in OT. As recently as 2006, most surveys indicated that SCADA control existed for fewer than 20% of all distribution feeders in North America. Since then, distribution substation automation has grown at an annual rate of about 7%, according to research by ARC – a trend that most industry observers expect to continue through 2020.[1]

While those numbers represent growth inside the substation fence, the real proliferation of OT is occurring out on distribution feeders. Feeder automation, as opposed to substation automation, may account for 7 to 10 line devices, or more, for each automated feeder. An increased focus on volt/VAR control will add to the number of capacitor and regulator controllers, as well as line voltage sensors in many cases. Feeder automation for self-healing and improved switching control will contribute to an increase in intelligent switching devices outside the substation.

IT redefines role

Information technology in the operations domain is undergoing a steady transformation. Distribution Supervisory Control And Data Acquisition (DSCADA) and Distribution Management Systems (DMS) applications were once developed and maintained in complete isolation from the rest of the IT infrastructure. They were also exclusively focused on controlling a limited number of operating assets. Now DSCADA and DMS applications are characterized by far broader application and integration requirements.

[1] www.researchandmarkets.com/research/7fd6e6/global_scada_based

Meanwhile, the Outage Management System (OMS) at many sites has migrated away from the enterprise and towards the operations domain. Once considered by many to be an extension of a call center application, modern OMS deployments now embed network intelligence to support restoration and switching. The more accurate and up-to-date the OMS network model is, the more likely it is to be integrated into the other applications and workflow of the operations center. It might seem obvious, but the convergence of IT and OT has far-reaching implications for the operational applications that model, monitor, and manage the distribution network.

Modeling

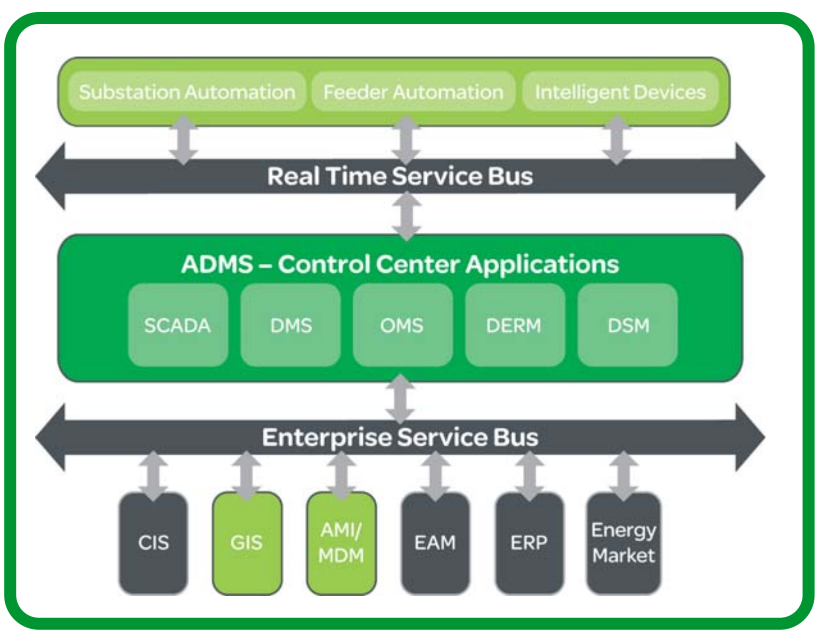
Driving the increase for integration on the front end for many SCADA, DMS, and OMS applications is the need for accurate network models. Maintaining an up-to-date view of the network is a challenge for many legacy SCADA, DMS, and OMS applications.

The distribution grid changes on an ongoing basis with daily major and minor work orders. The performance requirements of an OMS or DMS – and to some extent Distribution SCADA (DSCADA) – dictate that the up-to-date network model, or at least relevant parts of it, be available immediately. When an outage occurs or an emergency switching operation is imminent, grid operators require the model be in its most accurate, current state. Sourcing that current, high-performance model can be a challenge.

Most utilities today use a geographic information system (GIS) as a critical part of their network and asset management toolset. GIS-based network models can furnish an important representation of the as-built network, but that model must be more complete, correct, and current than ever before.

In order to support performance and current state requirements, a new level of network model integration is required. Modern integration technology and architecture can make it possible for SCADA, DMS and OMS to share a common model sourced from the GIS as-built network. The single, unified environment and user experience – in effect, 'a single version of the truth' – can be achieved without sacrificing data freshness or speed (see **Figure 2**).

Figure 2
The unified utility management architecture.



Monitoring

The large number of endpoints available to monitor the grid enhances operational awareness. However, the size and complexity of the distribution network model represents a management challenge. The IT/OT system must be able to handle the large quantity of information and must also quickly sort through and identify the data points with operational relevance.

As more connected devices are added to the grid, and as DSCADA systems expand both inside and outside of the substation fence, the IT/OT system will have to digest ever-greater volumes of data to understand the grid's current state. A critical limit in traditional OT equipment makes this task a challenge. Most legacy field devices rely on proprietary communications protocols not designed for upgrading or refreshing. Integrating these devices with more modern, open technologies is a critical task for IT/OT convergence.

Advanced Distribution Management Systems

In addition to helping operators manage a high volume of IT/OT information, ADMS offers many optimization and grid improvement functions for demand and efficiency management; analyzing and managing distributed energy resources; and supporting automated switching for self-healing.

An advanced ADMS can support 'closed loop' control, in which the operator simulates the forecasted grid conditions, typically with forecast data from advanced weather systems, and selects an optimization scheme from a set of potential solutions proposed by the system. ADMS then executes the grid optimization program; it monitors and readjusts switching or volt/VAR settings automatically as grid parameters change.

The use of an intelligent 'substation gateway' can ease the integration of legacy devices and help access mission-critical or situational data. These devices 'talk' in the open, standard protocols of modern substation automation – such as IP, DNP3, IEC104, and IEC61850. They provide the functionality to connect with and translate a host of older or proprietary protocols that might exist in legacy OT equipment.

High volumes of information from the field contain valuable insights that are challenging to find and extract. It is crucial for sound grid management that the data be analyzed and parsed to allow for further improvements in reliability or power quality. If this data is hidden or overshadowed by normal operational information that accumulates through integration, then opportunities for improvement are lost. Traditional meter data management (MDM) tools and enterprise data mining systems are usually not up to the task of recognizing and extracting valuable grid operational information in a timely fashion. Deployment of an operational data store, based on a platform designed to manage and interpret data in real-time or near-real-time, can help achieve this goal.

Managing

Control of the distribution network through the converged IT/OT system is both easier and more difficult than a traditional system. On one hand, more data and enhanced functionality mean more informed and faster decision making. On the other hand, added complexity can increase the risk of operational errors. In many utilities, operators will struggle to process the higher volumes of information and will need to select operating options from an increased set of alternatives.

Furthermore, siloed DSCADA, DMS, and OMS applications won't support efficient operation of the distribution system. Imagine the control room scenario during an emergency switching operation. Image that the operator has to restore service to an entire neighborhood or commercial installation such as a shopping mall. Now picture the distribution system operator trying to pay attention to three different systems. The operator has to monitor the DSCADA system for alarms and network parameters while keeping an eye on the DMS to determine whether any switching might be possible for restoration. Meanwhile, the operator needs the OMS to identify the likely source of the outage, to visualize any reported hazards, to obtain a count of how many customers are out, and determine where the crews are that can be dispatched to help. This is a daunting task, especially when performed under the pressure of a major service interruption.

One approach that some leading utilities and their vendor partners take is to integrate distribution operational applications into a single platform. This helps to streamline the management of the overall system and offers improved workflow, and simplifies task execution. Often referred to as Advanced DMS (ADMS), this approach merges DSCADA, OMS, and DMS into a single platform. By giving users a single tool that presents an integrated flow of information in a unified, straightforward user experience, operations and analysis of the distribution grid are simplified for the operator, and high-speed, high-quality decisions are enabled.

Integration on a massive scale

Convergence of IT and OT means bringing together applications and devices in new ways, and tying together systems that have primarily operated in isolation. Along with growth in numbers of devices and increased IT and OT functionality, bringing the systems together introduces integration on a new scale. Addressing the needs of the IT/OT-integrated distribution grid requires advances in communications, adherence to expanded standards, and a focus on architecture and security.

Communications and Protocols

The IT/OT-integrated world will likely consist of a federation of networks which combine private and public infrastructure, and integrate standards-based, open technologies such as IP with existing proprietary, legacy solutions. This integrated group of interdependent communications systems will grow and evolve. No operating utility will be able to start with a clean slate and design its communications infrastructure from point zero. The important parameters to be maintained are those that support OT in mission-critical applications. Those are the systems that ensure reliability, availability, security, and predictable performance.

Standards

One of the most important side benefits of the Smart Grid is the work being performed by government and industry groups in collaboration. Developing interoperability standards will play a key role in supporting grid modernization. The work of the National Institute of Standards and Technology (NIST) and industry associations such as the International Electrotechnical Commission (IEC), the Electric Power Research Institute (EPRI), the Smart Grid Interoperability Panel (SGIP), and trade groups like the Gridwise Alliance (GWA) and Gridwise Architecture Council (GWAC), all contribute to establishing the definitions and specifications for connecting grid devices. These groups have enabled a rapid movement forward in the development of the Smart Grid.

Processes are already in place to close the gaps in current standards. Most grid-focused interoperability projects that adhere to the current standards can now move forward with a high degree of confidence.

Cybersecurity in the IT/OT world

While interoperability standards have flourished, security continues to be a significant topic and has been made even more critical by the convergence of IT/OT.

The new world, with thousands of new endpoints outside the sphere of physical control of the utility, will not make securing the grid easier. A comprehensive approach that considers the entire network, targeting security, patch management, and compliance together, is needed to succeed in this evolving and heterogeneous environment.

Architecture

In addition to addressing the core requirements of reliability, security, and performance, the new Smart Grid IT/OT architecture must support the integration of existing enterprise systems within the grid modeling, monitoring, and management environment.

The modern grid architecture must consider a utility’s current and future ecosystem. It also needs to be flexible and adaptive to meet future needs while providing the scale and security required for mission-critical aspects of the environment. As with communications infrastructure, no operating utility has the luxury of designing and implementing an architecture from scratch. But industry-proven architectural roadmaps exist to help utilities work through the design process. Two useful versions of a reference architecture for utilities are Microsoft’s Smart Energy Reference Architecture (SERA) and Cisco’s GridBlocks Architecture. Both come with a well-documented reference model and offer helpful discussions on integration design.

Both of these reference architectures cite the significance of the technology chosen for connecting the endpoints of the IT-enriched OT. Many modern architectural approaches segregate the real-time or near-real-time data streams from the enterprise data streams, resulting in two separate data paths based on time and priority. This ‘Two-Bus’ concept is not entirely new, but it does help grid company architects consider the differing requirements for data integration and choose appropriate technologies to meet those needs.

Conclusion

Utility stakeholders need not fear the prospect of an IT/OT converged world. Although almost every facet of the traditional way of operating a utility will change, Smart Grid technology deployment will allow utilities to better serve their customers.

The move to the Smart Grid is an evolution and not a revolution. The change begins with a simple awareness of the significant influence of IT on operational equipment. Next is the recognition of a need to create a clear, long-term roadmap for a smarter network. That roadmap should include communications infrastructure and, most important, an architecture that accommodates the trend of IT/OT convergence. With the roadmap in hand, an IT/OT-converged approach will allow utility personnel to deploy each grid modernization application project as a part of a connected whole. Finally, decisions involving network modeling, monitoring, and managing systems must be carefully weighed. Deployment of and Advanced DMS will help the utility to succeed in achieving IT/OT technology acceleration.

About the author

Jeff Meyers, P.E., supports Smart Grid technology for Schneider Electric’s Smart Infrastructure Division with expertise gained during his 30-year utility career. During that time, he has designed electric substations and transmission lines; developed projects for a variety of gas, electric, and other public utilities; and led the Telvent Miner & Miner company to world-class status. Jeff currently focuses on helping Schneider Electric customers apply integrated technology to realize energy efficiency. He is a member of the IEEE, IEC, GITA, and International Who’s Who of Professionals – and a five-time recipient of GITA’s Speaker of the Year award.

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