IT/OT convergence

How their coming together increases distribution system performance

TIM TAYLOR – Historically, information technology and operational technology have developed along separate paths, with separate goals, operating in separate arenas, living separate lives, so to speak. Now there is much to be gained by marrying, aligning and integrating the work that goes on in both. IT/OT integration is happening across numerous sectors and industries. With the increasing sophistication and application of smart grid technologies in the electrical distribution industry, IT applications can now work in tandem with OT applications to increase distribution system performance. Over the last several years ABB has established a leadership position in integrated IT/OT for distribution management. Distribution organizations are now applying integrated ABB solutions to increase organizational performance, enhance system efficiency and reliability, and improve customer satisfaction.

Title picture
IT applications now work in tandem with OT applications to increase electrical distribution performance.

With practical examples at many distribution organizations, IT/OT convergence is not entirely new. But now there are strong technology and business reasons driving increased distribution IT/OT convergence.

Defining IT and OT

While there are no industry-standard definitions of IT and OT in the electric power industry, it is possible to delineate the two ➔ 1 – 2. OT is typically associated with field-based devices connected to the distribution system, and the infrastructure for monitoring and controlling those devices. This includes control center based systems such as Supervisory Control and Data Acquisition (SCADA) and Distribution Management Systems (DMS). Most communications are performed device-to-device, or device-to-computer, with relatively little human interaction. IT is traditionally associated with back-office information systems used for conducting business-type transactions, such as cost and tax accounting, billing and revenue collection, asset tracking and depreciation, human resource records and time-keeping, and customer records. Manual data entry is often involved, and the computing resources have tended to be centered in offices, server rooms and corporate data centers.

Technical development

Electric distribution systems have been set up with some degree of OT intelligence for a long time, in that local equipment controls have long been applied to voltage regulators, LTCs (load tap changers), capacitor bank switches, reclosers, sectionalizers, load-break switches and even electromechanical relays as local intelligence. Yet IT and OT systems are becoming increasingly more sophisticated, and the level of OT data for electrical distribution organizations continues to increase as more intelligent devices and communications are added to the grid ➔ 3.

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1 IT and OT software applications

Information Technologies are mostly software applications for commercial decision making, planning, business processes management and resource allocation. Applications include, among others:

- Enterprise Resource Planning (ERP)
  For managing financial and human resources, materials and assets.
- Enterprise Asset Management (EAM)
  For supply chain, inventory management, work and asset management.
- Mobile Workforce Management (MWFM)
  For managing mobile field crews, mapping, work scheduling and optimization.
- Customer Information Systems (CIS)
  For managing customer data, metering data, settlements and invoicing.
- Energy Portfolio Management (EPM)
  For energy planning, portfolio optimization, scheduling, energy trading and risk management, market analysis, retail management, price and load forecasting, ISO bidding, settlements and post analysis.
- Demand Response Management System (DRMS)
  For managing demand response programs and virtual power plants.
- Advanced Metering Infrastructure (AMI)
  For gathering and managing metering data (interval and non interval). Includes remote reading, and possibly remote control.

Operation Technologies include software applications that provide operational control of assets in the electric network in real time (or near real time). Applications include, among others:

- Supervisory Control and Data Acquisition (SCADA)
  For real time data acquisition.
- Distribution Management Systems (DMS)
  For managing and control of distribution networks. Includes advanced applications such as Fault Location, Isolation and Restoration, Volt/Var Optimization, State Estimation, Outage Management Systems (OMS), etc.
- Energy Management Systems (EMS)
  For managing and control of transmission systems.
- Geographic Information Systems (GIS)
  For mapping and geographic information.

For example, the amount of OT equipment with sensing, data processing, control, and communications on feeders is increasing. The installation of separate SCADA systems for distribution, or the extension of transmission system SCADA to distribution, has become common. Advanced DMS network applications, which are often implemented in conjunction with new outage management systems (OMSs), are being performed. More organizations are using advanced metering infrastructure (AMI) data in their outage management and for providing loading information to operations. The evolution of IT for electric distribution includes IP-based LAN and WAN networks, integrated enterprise resource systems, continued adoption of geospatial technologies, server virtualization, some implementations of cloud-based systems, and mobile technologies. The complexity of these developments demands, and also allows for, the convergence of the two technologies.

This recent implementation of all these IT and OT systems in distribution organizations presents a large organizational improvement opportunity which is to date largely untapped. By eliminating silos which exist between IT and OT organizations can enable data sharing that will improve system performance, reduce costs and improve customer satisfaction.

Total distribution management

Ventyx, a company recently acquired by ABB, has developed the total distribution management concept that is based on the recent developments in IT/OT convergence ➔ 4. Total distribution management combines real-time and near-real-time data, system modeling, visualization, simulation, and integration to all major systems used in distribution operations, to provide a new platform for managing and operating electric distribution systems.

> Potential benefits include the conversion of unplanned outages into planned outages.

The operational technologies include intelligent electronic devices (IEDs), remote terminal units (RTUs), meters, and other field equipment that communicates back to the control center. While revenue meters typically use AMI communications infrastructure, the other devices use the SCADA communications infrastructure. A single network model of the system, which explicitly represents the system connectivity and electrical characteristics, is shared across

2 Differentiating information technology and operational technology

	Information Technology (IT)	Operational Technology (OT)
Purpose	Transaction processing	Asset monitoring and control
	Systems analysis and applications	Process control, metering, and protection
	Technical and business analytics	Device-to-device communications
	Human decision support	Server-to-device communications
Operating environment	Corporate data centers	Substations
	Officers and server rooms	Field equipment
	Control centers	Control centers
Input data	Manual data entry	Transducers and sensors via RTU's and PLC's
	Other IT systems	IED's, relays, and meters
	Data from OT systems	Operator inputs and other OT systems
Output	Data summaries	Device control actions
	Results of analysis and calculations	Displays of status and alarms
	Commands issued to other OT systems	Operating logs
Owners	CIO and IT departments	Operations and engineering managers
	Finance	Line of business managers
	Operations (OMS, DMS, EMS)	Maintenance departments
Connectivity	Corporate network	Process control protocols
	IP-based	IP-based, serial, hardwired analog and digital

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both the outage management system (OMS) and the advanced DMS applications. The integrated SCADA, OMS, and DMS are interfaced to the other IT systems. An advanced business intelligence system, developed specifically for electric distribution organizations, connects to all the systems and provides meaningful analytics and information, tailored for the different individuals internal and external to the organization ➔ 5.

Distribution system impacts

A model-based volt/var optimization (VVO) application has recently been introduced as an application in Ventyx's Network Manager DMS. The VVO application continuously monitors the distribution network and computes the optimal distribution control settings to minimize an objective function of MW demand, MW energy loss, or both MW demand and MW energy loss, subject to voltage/current violations in three-phase, unbalanced and meshed distribution systems. VVO computes the optimal control settings for switchable capacitors and tap changers of voltage regulating transformers. (ABB's activities in voltage/var are more fully described on page 44.) The optimized system condition is based on the current load flow solution that is performed on the system model. The VVO application then transmits the required control actions to the OT devices, such as capacitor switch status or voltage regulator tap position. For the distribution organization, the benefits can include a reduction in the amount of generation capacity that must be built or bought on the market, and a reduction in the real energy losses on the system.

Another example of how DMS OT applications are utilizing the GIS (geographic information system) network models, adapted for as-operated network conditions, is the FLISR (fault location, isolation, and service restoration) application. The FLISR application uses inputs such as fault current, faulted circuit indicator status, and breaker/switch status, along with the electrical network model, to determine the optimal switching plan to isolate a fault and restore service quickly to as many customers as possible. Unbalanced load flow calculations using the network model are performed to determine if any thermal or voltage violations will be produced for the possible switching plans. Once the optimal switching plan has been chosen, the appropriate control actions can be transmitted to the field devices through SCADA communications. Benefits for the distribution organization include improved reliability performance and higher customer satisfaction.

Impacting workforce

There is an increasing trend to use data from OT systems, like automation and SCADA systems, in combination with IT systems for workforce process efficiency

3 Technological developments enhancing IT/OT convergence

A range of technology developments in the following areas are helping to advance the coming together of IT and OT systems in distribution organizations:

Remote data collection and communications
The cost to collect and transmit operational data continues to lower. More cost-effective, wider bandwidth communications between the control center and remote field devices, such as gigabit backbones and wireless Ethernet radios, provides the data communications back to the organization's IT. Networks installed for AMI, which have not typically been broadband, are also being leveraged for operational monitoring, and even control, in some cases.

Standard IT architectures
Certain operational technologies, such as SCADA, DMS, and OMS, have been using standard IT platforms for some time, including Linux- and Windows-based software running in IP-enabled networks. This enables IT organizations to economically manage these resources, since such systems can be configured and monitored with standard network management resources. Chip capacity and higher disk and network capacity continue to lower costs throughout the OT and IT domains, providing the economic, high-scale computing capacity needed for increased distribution automation and advanced data analytics.

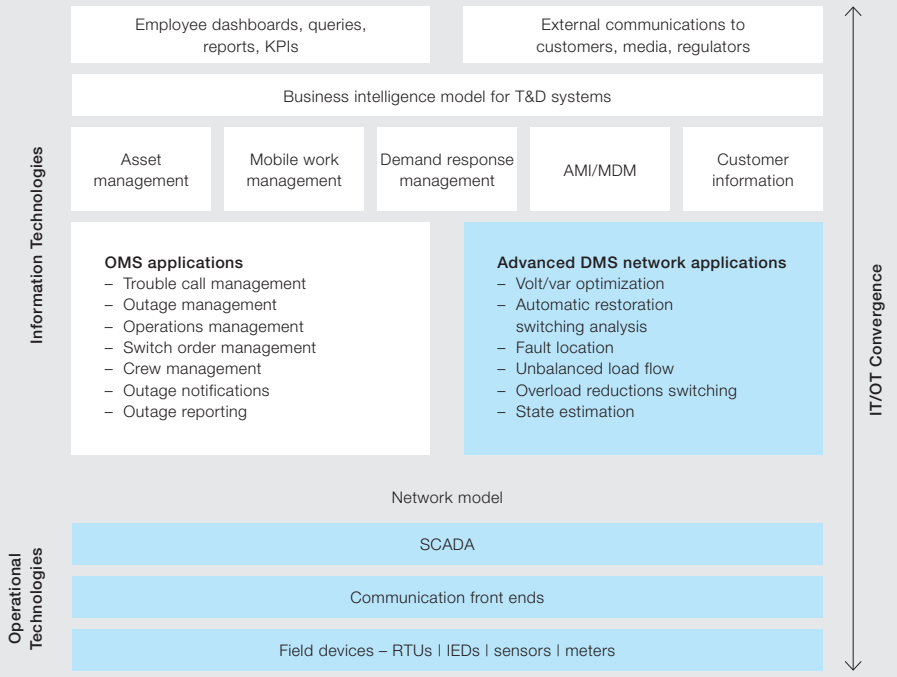
Applications integration
Technologies available for system integration have evolved substantially. Real-time publish/subscribe messaging middleware has made it possible to apply some of the principles of enterprise application integration (EAI) to distribution operations. Presently the trend for linking many IT and OT applications is the development of Web services in a service-oriented architecture, although a hybrid system architecture in which other interfaces, such as point-to-point, will be economic for particular applications. Application integration technologies continue to advance, further facilitating IT/OT convergence.

Data modeling and integration
Interoperability standards, which are developed by numerous bodies including IEC and IEEE, are starting to be employed. This includes IEC 61968, the Common Information Model (CIM) for distribution management. CIM will cover various aspects of distribution operations, AMI, distributed energy resources, and demand response. The maturation of such standards is crucial to facilitating further IT/OT convergence.

Mobile computing and data access
Extending, inspecting, operating, and maintaining a distributed asset infrastructure means that many distribution work processes are field-based. The escalation in mobile computing, data access, and even digital photography and video will result in substantial changes to distribution activities such as switching, inspections, design, situational awareness, equipment operating history, damage assessment, field resource optimization, and inventory tracking. Field crews will have much more access to operational data, some of which will be in near-real-time.

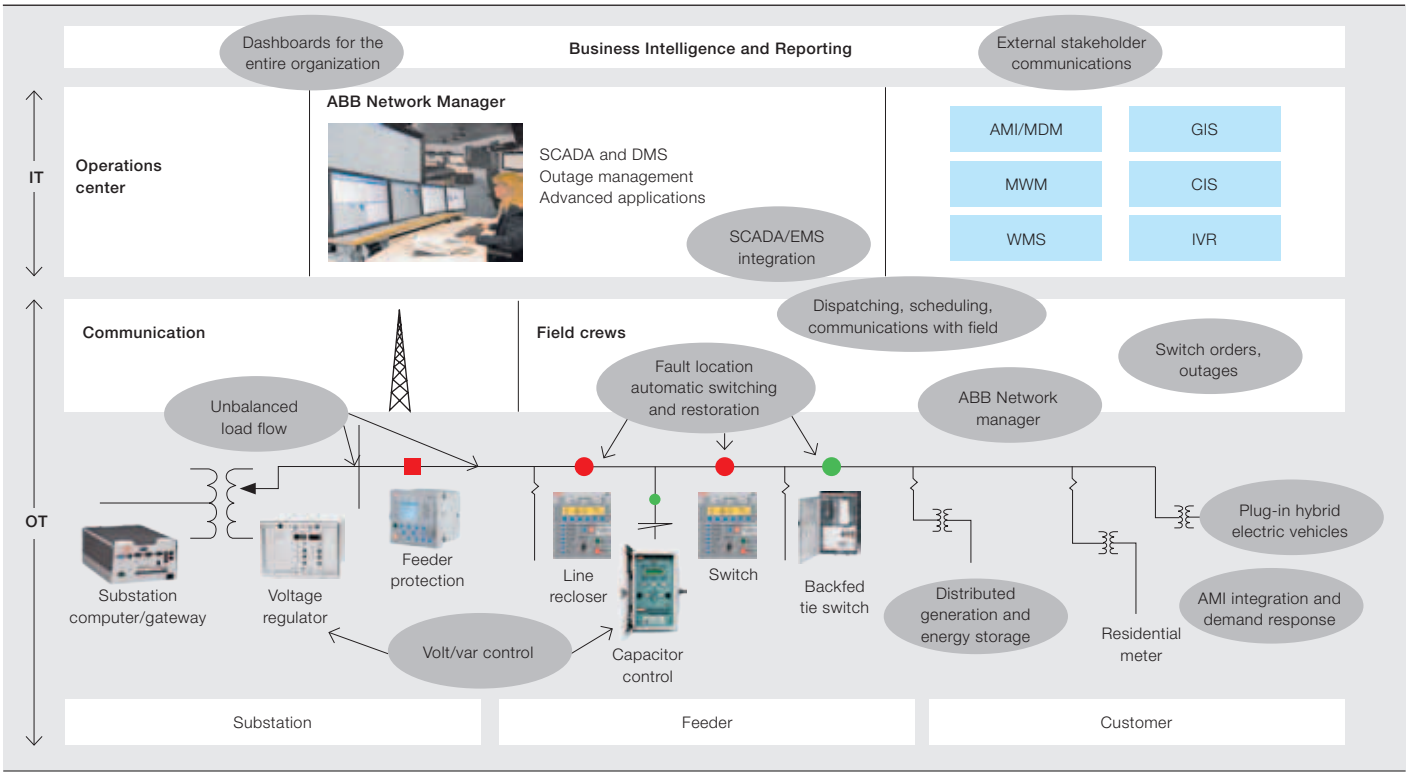
IT/OT convergence enables distribution organizations to keep external stakeholders better informed about their electric service.

4 How typical distribution processes cross over different IT and OT systems



improvements and better decision-making. One example is the process of using a DMS to locate faults that have caused protective devices, such as circuit breakers, to trip. Fault data, including magnitude, affected phases, and type of fault, is extracted from the relay or RTU and sent to the DMS. The DMS uses this data to estimate the location of the fault on the system, and provides this information to the control room operator or dispatcher within minutes. The dispatcher then informs the crew of the approximate fault location. The result is quicker restoration times and improved system reliability metrics. In this case, the data fed to the

5 IT and OT systems used in an electric distribution system



The applications indicated in the bubbles are made possible by IT/OT integration.

DMS system is then processed, enabling the operator and crew to perform their jobs more efficiently.

Data from various OT systems can also be sent to the back office IT systems, such as a business intelligence tool or enterprise asset management (EAM) system, to make better decisions related to longer-term asset management processes. Increasingly, OT data is being analyzed with data mining, pattern recognition, and statistical analysis. Data from sensors and online monitoring equipment, which can include temperature, pressure, historic equipment loading, duration and frequency of short-circuits and through-faults, number of operations, and other OT quantities, can all be used in the IT environment by asset managers to make better decisions about maintenance programs and asset replacement. Potential benefits include the conversion of unplanned outages into planned outages (if economically practical to do so), reduction in the number of catastrophic outages and better allocation of capital and maintenance budgets.

An increasing trend is also the application of business intelligence software (ie, IT) that can extract data from OMS, WMS, SCADA, and other OT systems to provide information dashboards and querying capabilities for the entire workforce. The dashboards, which are now available as cost-effective out-of-the-box solutions, can be customized to the specific job function in the organizations; ie, different dashboards can be created for operations, for customer service representatives, for senior management, etc. Users can drill down and drill across data to get more details. Improved situational awareness results, providing the workforce with the right information at the right time, in order to make the right decision.

Smarter stakeholders

IT/OT convergence is enabling distribution organizations to keep their external stakeholders better informed about their electric service. External stakeholders include customers, government officials, regulators, and others with an interest in the electric distribution system performance. Such information can be related to service outages, power pricing as a function of time or usage, special offers and programs, as well as other information about its electric power service that a distribution organization wishes or needs to share.

A common example is outage maps placed on the utility website that show number of outages, number of customers out, and the general locations of outages. Based on forecasted network loading (of which past and present loads, collected from OT systems, are a key determinant), distribution organizations or power retailers can let customers know if a demand response event, in which power suppliers request customers to reduce demand, either directly through messaging or control signals, or indirectly through pricing, will be held that day. Information portals between utilities and other external stakeholders, such as public safety, regulators and local government officials, are becoming more common.

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