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Electric Utilities IT and OT Convergence

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SUMMARY

Grid modernization (i.e. SmartGrid) has seen the expansion of new digital technologies for monitoring and controlling the Electric Grid. As a result, the traditional operations, security, and maintenance of the Operations Technologies (OT) have stretched the resources of Utilities' traditional operations staff. One strategy utilities are using to help alleviate the resource issue is to use their Information Technology (IT) organization for support. This has resulted in some conflict between OT & IT organizations, making the convergence effort difficult. This paper will examine the issues and benefits of IT and OT convergence and a few steps to help make it a successful transformation.

KEYWORDS

Operations Technology
Information Technology

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Overview

Grid modernization (i.e. SmartGrid) has seen the expansion of new digital technologies for monitoring and controlling the Electric Grid. As a result, the traditional operations, security, and maintenance of the Operations Technologies (OT) have stretched the resources of Utilities' traditional operations staff. One strategy utilities are using to help alleviate the resource issue is to use their Information Technology (IT) organization for support. This has resulted in some conflict between OT & IT organizations, making the convergence effort difficult. This paper will examine the issues and benefits of IT and OT convergence and a few steps to help make it a successful transformation.

IT and OT Historical Roles

Traditionally, electric utilities information technology supported corporate functions like: billing, customer information systems, finance, human resources, supply chain, order management, sales, and email. These services were typically provided enterprise-wide, on a corporate supplied network.

The applications were usually batch or transactional oriented and did not normally require 24/7 technical support. Some of the applications were tagged as "Business Critical" (i.e. billing, customer information system, etc.) and are provided today by large software vendors. Much of the software was originally run on mainframes from the major hardware vendors. As PCs and servers became more prevalent, the applications or their functions were then migrated to individual servers from various hardware vendors, with various application clients running on desktops from the same vendors. As the industry shifted to this model, it became a problem to support the mainframe applications, but it was much easier to find support for the client/server model.

The support staff was educated in computer science and could apply their learned skills in a short period of time bringing useful knowledge about the latest technologies. The corporate IT department usually had no problems locating new support personnel from the local job market. The IT organization typically reported up through the CFO or other non-operations corporate executives.

Operations Technology for Electric Utilities traditionally supported the generation, transmission, and distribution processes. These systems typically were "individual" process-oriented and were often vendor hardware proprietary. The applications were real-time, required 24/7 support, and were tagged as "Mission Critical." The systems were usually located on isolated proprietary communications networks that attached to the processes they were controlling. These systems usually had direct automated control over the machine operations and processes. One example is the Generation Distributed Control System (DCS).

It is an automated control system used for direct monitoring and control of an individual electric generator at a power plant. Depending upon the age of the system, it could consist of individual embedded computers distributed throughout the plant that monitored and controlled all aspects of process to generate electricity. A DCS typically uses custom designed processors as controllers and uses both proprietary interconnections and communications protocol for communication. Input and output modules form component parts of the DCS. The processor receives information from input modules and sends information to output modules. The input modules receive information from input instruments in the process (or field) and the output modules transmit instructions to the output instruments in the field. Computer buses or electrical buses connect the processor and modules through multiplexer or de-multiplexers.

Buses also connect the distributed controllers with the central controller and finally to the Human–Machine Interface (HMI) or control consoles. Figure 1 below shows the functional levels of a typical distributed control system. [1]

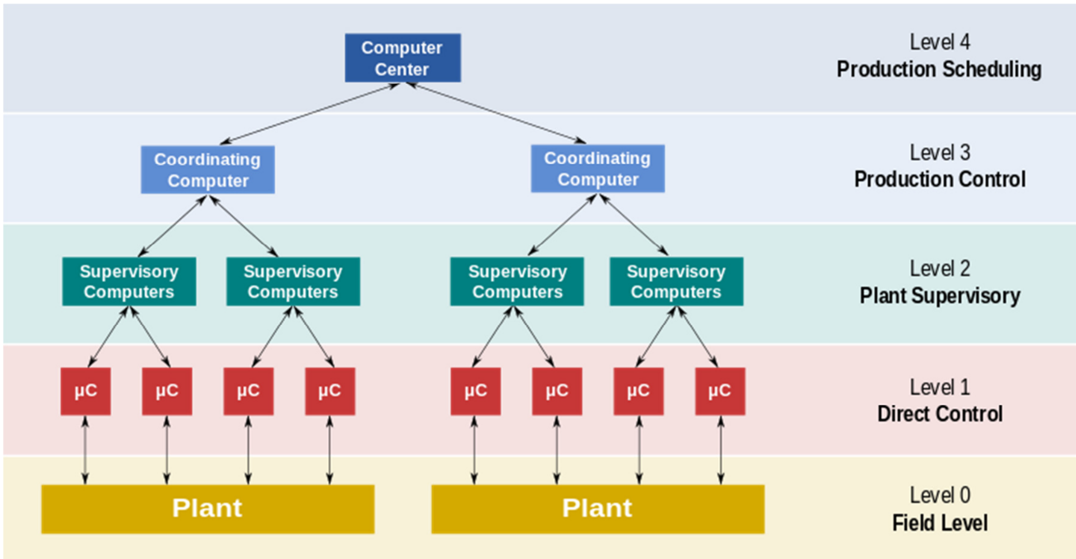

Figure 1. Functional Levels of a Typical Distributed Control System [2]

Another example is the Energy Management System (EMS) used by Electric Utilities.

The EMS oversees the designated electric grid control or service area for a utility. It is used to monitor, control, and analyze all aspects of the utility's portion of the electric grid. The technologies used for these systems were originally analog computers developed to monitor and control frequency, tie-lines, and generator output. This also included the Supervisory Control & Data Acquisition (SCADA) function. In the 1950s, the computers were enhanced to add Automatic Generation Control (AGC) and Economic Dispatch Control (EDC). In the 1960s, digital computers and software began replacing analog EMS functions. Vendors modified computer supplier's OS to meet real time design criteria. Each customer's needs were typically unique, thus each system delivered was unique. When upgrades/enhancements were needed, total system replacement was required. This continued into the 1980's and 1990's until more open standard systems were able to support real-time applications. UNIX became the so-called open OS.

The typical architecture for control systems requires high availability. As a result, vendors provided redundancy with automatic failover designed in from the start. Figure 2 below depicts a high availability example.

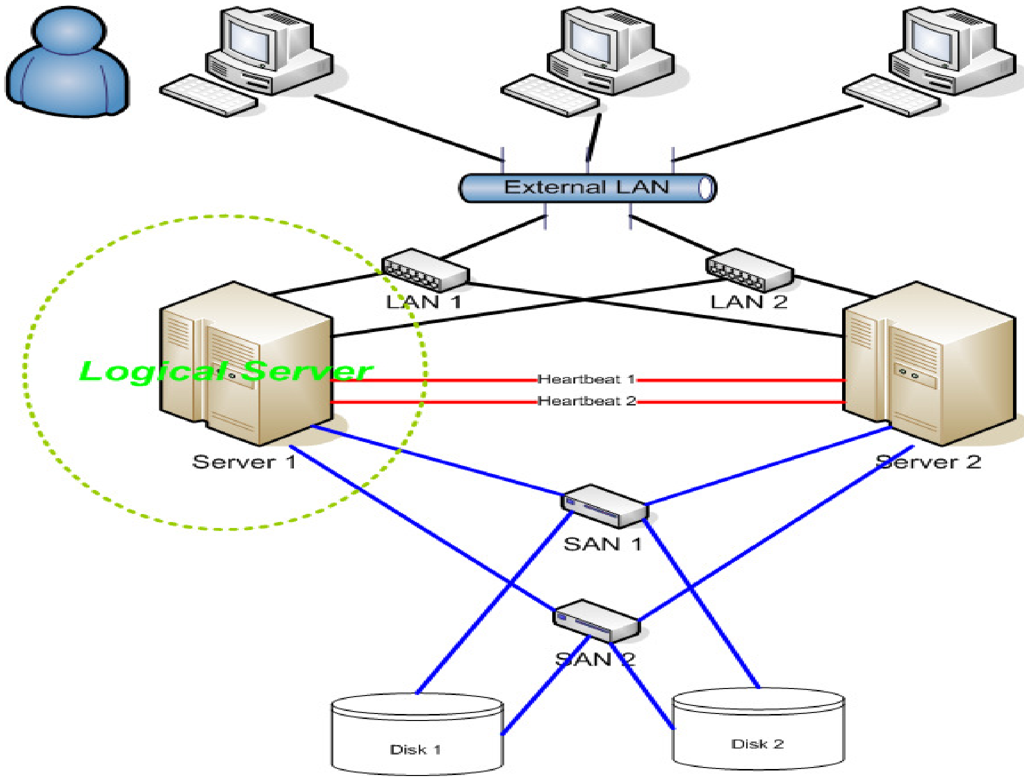

Figure 2. High Availability Architecture Example [3]

The master-to-remote device communications technology varied and included many proprietary hardware/software designs. Figure 3 below shows typical EMS to remote devices communications.

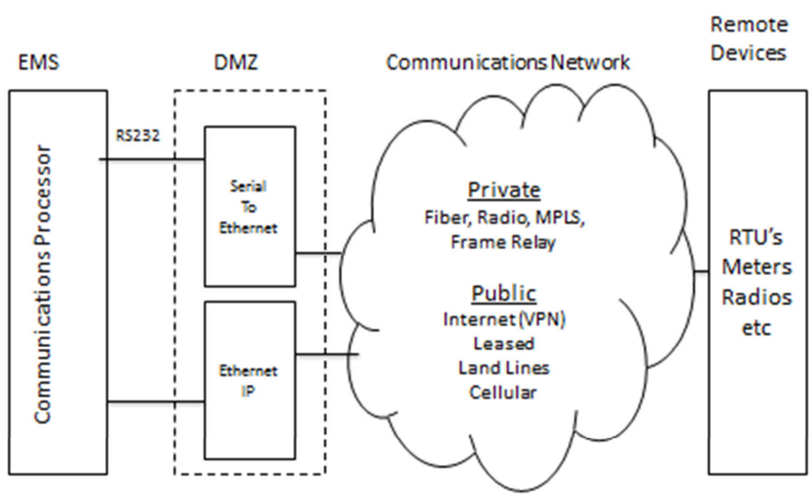

Figure 3. EMS to Remote Devices Communications

The OT systems were designed to be used for many years without upgrades and the utility employees were typically trained at the vendor's factory to maintain them over a long period of operation. Today, standard systems architectures are more commonly used but the systems are still designed to remain in place for many years.

Each OT technology usually had its own support team that directly supported the system. For example: Metering Systems technologies were supported under the Meter department. The Generation Distributed Control Systems (DCS) were supported under each Power Plants operations department. The SCADA/EMS/DMS for the Generation, Transmission, and Distribution systems were under either an overall System Operations department, or were individually under the Generation, Transmission, or Distribution operations departments. The support staff was typically Electric Engineer/Technician educated and would require some years of on-the-job training before they could support the technology. Personnel with specific OT knowledge typically stayed with their current employer until retirement which meant the market for these types of personnel were scarce. These departments normally reported up through a line of business operations management who then reported to an overall operations executive.

IT and OT Changing Environment

Historically, the OT architecture lagged behind current technology implementations and innovations by many years. The utilities would implement the latest that the OT industry providers had available for each project. That technology implementation would remain in place, unchanged, as long as it served its purpose and had no major problems. Utilities usually had long term maintenance contracts with vendors or equipped their own staff with training and parts to self-maintain the equipment. Technology upgrades and replacements would only be implemented if the major assets that they were controlling and monitoring were also being changed. This mode of operation started to change as vendors began using standard off the shelf hardware and software products to save costs and make upgrades and replacements easier. With these changes, OT equipment began to look more like standard IT equipment. IT management began to wonder why this equipment wasn't part of their responsibility. After all, they had spent much time and effort establishing needed governance around corporate IT assets, and here were multiple departments within the company not adhering to these policies and procedures with much of the OT equipment. IT was tasked with providing and maintaining all corporate IT assets and business applications and from their perspective, OT should be included in that directive. On the other hand, the OT realm didn't see any need for IT to manage their technology assets. After all, corporate IT doesn't manage and support the flight control systems on an airplane. Why would they need to manage real time OT Electric Grid systems?

Smart Grid

The advent of the Smart Grid brought more drivers for IT and OT convergence. The new systems required to implement the Smart Grid model in many cases needed to interface with the current OT systems to realize the full value of these technologies. Also, systems such as Advanced Metering Infrastructure (AMI) were implemented using the business IT department to procure, install, and support. The current OT staff most often did not have the training or enough resources to accomplish this type of initiative with the latest technologies. In some cases, OT staff was not included in the process and weren't consulted until after problems arose when systems needed to be integrated.

Cyber Security

As cyber security came to the forefront of critical issues, utilities began to see the case for merging OT and IT. NERC CIP was directed toward the OT world which lagged behind the corporate IT world on applying security to their environments. The OT environment previously did security by isolation. Historically, the OT systems were physically isolated from the corporate network and the internet. Also the staff didn't always have the necessary security training or enough resources to apply security as required. In some cases, the business brought in IT to add proper security to the OT systems but, what was not understood is that the application of standard security practices and solutions didn't work in the OT environment on some of the systems. In some cases, applying security tools to a real-time application rendered the application unavailable. For example, an experience at one utility applying standard anti-virus to a Windows based Digital Fault Recorder at a substation didn't allow the fault recorder application to run as designed. These types of issues added to the dissonance between IT and OT.

The above issues all helped create the dilemma that made the convergence of IT and OT difficult. Because of the way the technologies are used, what their purpose is, and how they are supported, the two organizations had difficulty agreeing on how to manage the systems. A summary of some of the functional differences between the two technologies inside electric utility organizations is depicted in table 1.

	IT	OT
Roles	Manages Business Information	Manages Electric Grid Assets
Purpose	Automates Business Processes	Automates Electricity Production and Delivery Processes
Architecture	Batch, Transactional, Relational DB's	Event-Driven, Real-Time, Embedded Software
Human Interfaces	Web Browser and Terminals	Coded Displays or keypads – becoming Web based
Support	Computer Science Grads, IT Technicians, CIO	Engineers, OT Technicians and Operations Managers, COO
Communications	Corporate Network, IP-Based	Proprietary Control Networks - becoming IP-Based
Applications	Billing , CIS, HR, Finance, Accounting, email	DCS, SCADA, EMS, DMS, PLCs, Control Systems

Table 1. Electric Utility IT and OT Functional Differences

Both areas of responsibility were at odds and both believed that they were right. Battle lines were formed and there didn't seem to be an easy way forward. Executives didn't have time for this kind of dispute and wanted a quick resolution. They would need to make an executive decision if the individual management teams could not come to terms. In the aftermath, utilities chose various paths. Some decided to leave things as they were with some minor concessions. Some decided to organize into two separate organizations reporting up to the CEO. In this case, they created an Operations Technology Department that oversaw all the company's OT systems and kept the Information Technology Department as is. IT and OT then both reported up to a Chief Technology Officer (CTO) or Chief Information Officer (CIO) who reported directly to the CEO. Some companies decided to create a single technology organization under a CIO and merge the IT and OT staff so it resembled a typical IT organization. This last organizational structure became the most prominent because this lined up with many other businesses and their IT support model.

The Road to Convergence

The road to IT / OT convergence became a rocky one. The general trend was for IT to assume the OT responsibilities and transfer the OT staff to the IT department. The approaches used in many cases were by brute force, which caused employee stress and disillusionment for the OT staff and confusion for the IT staff. Although from senior managements' perspective, this may seem to be the fastest way forward, but may not be the best strategy for the long term. Even with a more gradual approach the real benefits of IT / OT convergence may still not be realized.

The best way to move forward is to begin by working to get everyone's "buy in". This means including representatives from both areas in developing a plan. The first step needs to be an education and understanding of the current responsibilities of both departments. The various group representatives should cover possible issues that may cause problems going forward. For example: the OT personnel might provide information about how a common IT procedure, like changing passwords, could break interfaces between some systems in an Industrial Control System. This action could actually shutdown a production process. In addition, enhancements to the operations that each area can provide should be presented. For example, an Active Directory Server provided by the IT group may able to assist password management for some of the OT systems. Also, as any new technology gets added to the OT environment, the IT resources may already be trained and ready to assist in the deployment. Lastly, forming teams made up with members from IT and OT to integrate new systems helps to establish common goals and a cooperative environment. These types of efforts go a long way to help make convergence of IT and OT easier. The team members can create the plan and schedule going forward rather than having it dictated to them.

The long term benefits for the company, and for all parties involved, need to be presented as part of these discussions. This will help everyone gain understanding of the overall common goals for them and the company. Some of the possible benefits are as follows:

For the Individuals

- IT and OT staff become a team instead of adversaries
- IT and OT staff gain knowledge and experience to add to their resumes
- IT and OT staff feel more empowered
- IT and OT staff feel they are vital part of company success

For the Company

- Business decisions based upon Real Time operations
- Operational Efficiency
- Reduced Costs
- Improved Environmental Friendliness
- Improved Reliability
- Improved Electric Asset Health
- Improved Customer Service

Conclusion

For Electric Utilities to remain successful they will need to continue implementing Smart Grid solutions which will help make the Utility more efficient and reliable. The implementation of the Smart Grid requires the introduction of new technologies into the operations environment and integrating the IT and OT technologies is vital for the success of this effort. The people that historically have made IT and OT [individually] successful need to be fully engaged and supportive to help integrate the two technology areas, which will help make the merged organizations successful. Bringing the two teams together to formulate the plan going will help identify possible obstacles and enhancements before merging. This will allow the individuals to have a stake in the plan and thus, be a part of the decision moving forward. Using this type of strategy will help to implement a successful convergence of IT and OT for Electric Utilities. The Smart Grid requires Smart People making Smart Decisions.

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