Nature's Medicine

Using centralized monitoring, distributed intelligence, and a healthy dose of change management to create a truly smart grid.

In 1534, François Rabelais famously observed that nature abhors a vacuum. He could have added that software and data, like nature, rapidly expand to consume the vacuum of available network bandwidth. At Duke Energy, we understand that as the smart grid expands, new communications networks can be immediately overloaded with new traffic from additional devices. Our employees have long been concerned that existing communications networks will be unable to support tomorrow's new applications. With that in mind, we carefully plan for current and future scenarios so we can "future-proof" technology decisions and acquire solutions that have the most flexibility and scalability to adapt to likely developments.

UTC Journal

THE OFFICIAL PUBLICATION OF THE UTILITIES TELECOM COUNCIL

Special Edition 2013

- Unlocking the Potential of Unlicensed Spectrum for Private Utility Networks
- Can TV White Spaces Solve the Last Mile Wireless Communications Puzzle?
- CII Spectrum: Bits And Pieces
- UTC TELECOM Program Guide

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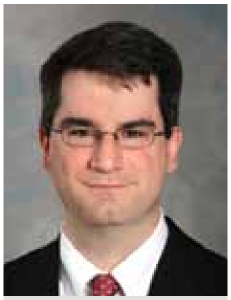
Unlike nature, we cannot grow a modern grid in a haphazard manner. We are replacing analog mechanical devices with intelligent assets that have new communications capabilities and varying latency tolerances and quality of service (QoS) requirements. Utilities are planning and deploying substation fiber rings, advanced metering infrastructure (AMI) networks, intelligent distribution assets, and hybrid public/private wireless networks—solutions that require careful planning and an understanding of the limitations and needs of each system. Historically, each application had its own proprietary network, management system, and display to report status, alarms, and system performance. The end result was multiple panes of glass to manage each system and rapid proliferation of data that has challenged our existing systems, processes, and resources. Seeing these challenges, we have been pursuing an innovative smart grid emerging technology strategy to overcome these hurdles by accommodating not only the laws of physics, but the laws of human nature, too.



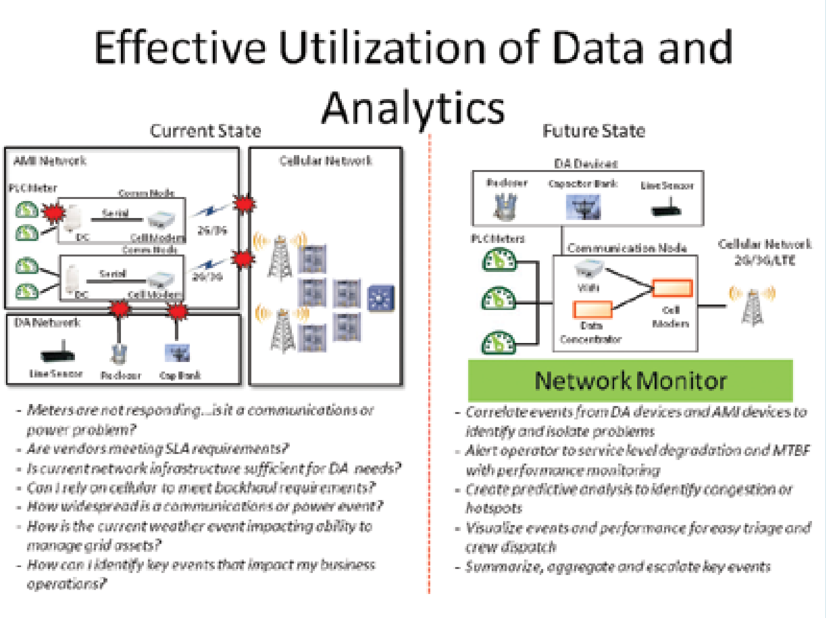
By Raiford Smith

By Paul Moon

For example, networks are investments in finite resources that must be carefully planned. When investing in a network solution, we consider wired and wireless solutions as well as private versus public carrier networks. Every application, network, and frequency comes with a unique set of rules that define its effective use for power grid applications. As such, network investments are never “deploy and forget” solutions, particularly wireless networks, as the operating conditions and environment can impact their performance on a minute-by-minute basis. Managing our use of these networks becomes increasingly critical as the only way to increase our capabilities to cost-effectively manage assets and deliver results. As our business and operational processes change, we will most likely see increases in the volume of data our networks support and the complexity of those networks. Despite this, physics and network management will continue to dictate our ability to meet these demands.

Duke Energy power grids and communication networks contain a smorgasbord of vendor technologies and applications. The test bed in Charlotte is a representative subset of the range of new and existing products in the field.

- Line sensors
- Solar PV: field and roof-mounted for grid and microgrid applications
- Energy storage: batteries for home, community, substation, and microgrid applications
- Electric vehicle charging, smart appliance, and in-home energy management
- DERMS and DMS
- Intelligent switches
- AMI metering
- Communication Network components
- Network transport: WiFi, PLC, Gobi 3G, LTE, 900MHz RF, Ethernet, Serial
- Integrated network management



Effective Utilization of Data and Analytics

- *Meters are not responding...is it a communications or power problem?*
- *Are vendors meeting SLA requirements?*
- *Is current network infrastructure sufficient for DA needs?*
- *Can I rely on cellular to meet backhaul requirements?*
- *How widespread is a communications or power event?*
- *How is the current weather event impacting ability to manage grid assets?*
- *How can I identify key events that impact my business operations?*

- *Correlate events from DA devices and AMI devices to identify and isolate problems*
- *Alert operator to service level degradation and MTBF with performance monitoring*
- *Create predictive analysis to identify congestion or hotspots*
- *Visualize events and performance for easy triage and crew dispatch*
- *Summarize, aggregate and escalate key events*

Planning for Complexity Means Managing Change

Recognizing a need to address the opportunities and risks from new technology, Duke Energy set up the Emerging Technology office to focus on three different parts of the electricity value chain: generation technologies, power grid technologies, and customer premise/distributed energy technologies. My group, the power grid emerging technologies team, is the enabling bridge between demand and supply-side technologies. As an amalgam of seven different utilities, our company’s power and communications infrastructure contains a little of everything, and we can reasonably forecast that our infrastructure and desire to offer new services will continue to grow. It was clear that no single communications network would suffice to meet our needs, and we needed to bring together a diverse set of stakeholders to develop a new vision of our future communication needs.

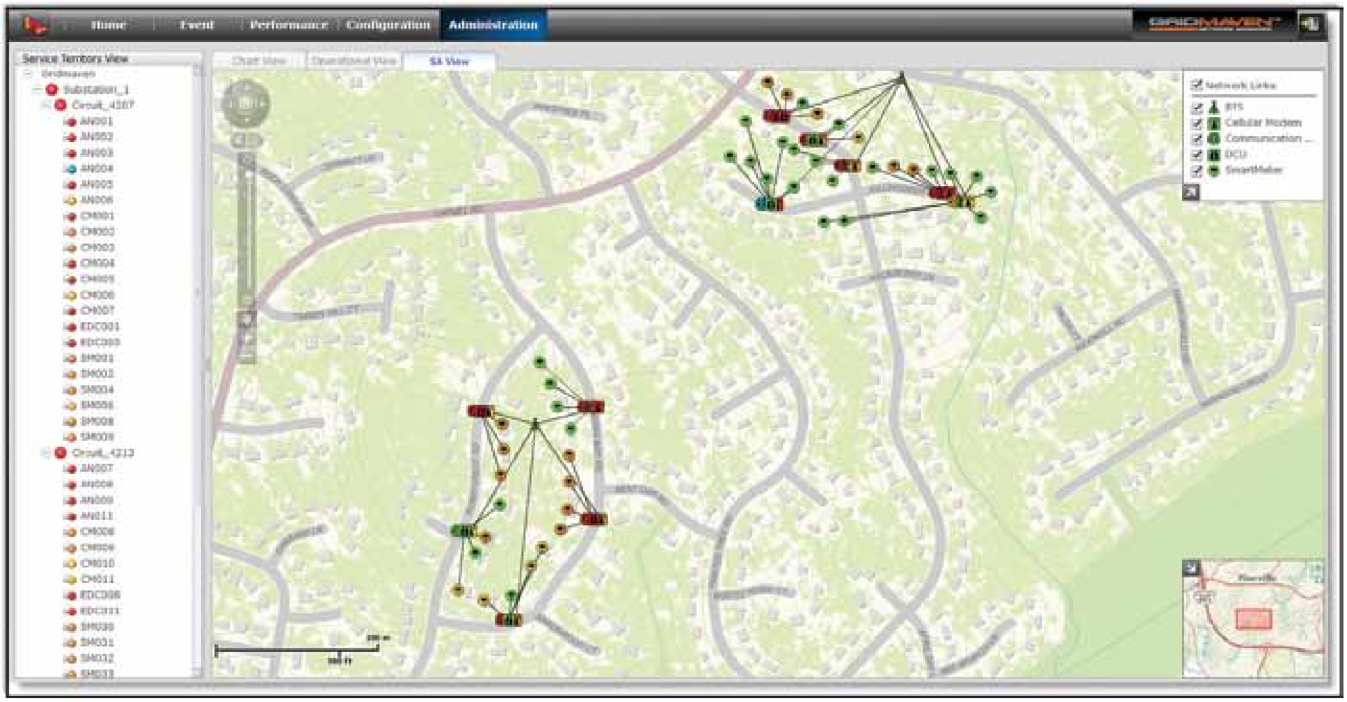
Beginning in 2006, we worked with staff across IT, grid modernization, customer service, and other organizations to develop a thorough list of requirements and future needs. We established a vision to utilize a common communications and logic platform to connect all smart grid-enabled devices in order to improve utility operations, reduce costs, provide inter-operability, and offer additional value-added customer products and services. We call this device a communications node. It is our "Swiss army knife" for the smart grid and is integral to our results.

This vision has helped the organization realize the convergence of demand and supply sides would require changes in business processes and employee skills as we implement new technologies. It also allowed us to articulate many of those changes and initiate a comprehensive, ongoing change management process. It is easy to underestimate the scope (or difficulty) of change when it comes to people and processes. Thus, it is vital to select technologies and solutions that optimize not only operations, but also people's abilities to manage greater numbers of inter-related and integrated solutions.

The team eventually settled on five key attributes for technologies that support our vision. First, communications and grid-related assets have to be based on published standards and must be modular in order to provide inter-operability, reduce costs, and accommodate dynamic network and grid requirements. Second, many of the typical smart grid solutions combine communications with hardware and software, so without a requirement to eliminate functional duplications in solutions, it would be easy to rapidly engineer a virtually unmanageable system that does not work together. The third attribute is effective use of data and analytics, with an emphasis on distributing intelligence and leaving the data close to where it's needed on the power grid. Next, technologies need to have enhanced telecommunications capabilities to enable higher reliability in addition to coordination and control with other solutions. Finally, we need to enhance Duke Energy's security capabilities as we implemented a modern grid. After establishing the vision and key technology attributes, we created a field test bed in Charlotte, N.C., across three substations, six circuits, and 17,000 customers in order to deploy and integrate new transmission, distribution, customer, telecom, and I/T technologies with Duke Energy's legacy systems. The sidebar on page 52 shows a partial list of technologies that are being evaluated for performance and interoperability.

Functional Roadmaps Manage Multiple Moving Parts

Our field test bed lets us familiarize ourselves with new technology on a small scale and really kick the tires before deploying it on a wide scale. We want to ensure we un-



Situational Awareness of Communications and Power Networks derstand the scope and limits of interoperability between new components, so we know what happens when we mix new and existing technology together. This allows us to test things to iron out any hiccups before we deploy new technology in scale. You wouldn't want to get on a plane if you heard the pilot asking the copilot, "What happens if we push this button?" We use the field test bed to answer that question (and others) before deploying a new technology out in the field. Because there are many elements being tested and we need to understand how the technologies continue to evolve, we rely on three separate roadmaps to forecast technology evolution and to inform our strategy. The roadmaps are organized by function to represent the power grid, telecommunications, and the software/logic to tie the components together (which includes security). Additionally, we are building a robust data mining and analytics back office in order to collate and examine baseline data for operational performance. This will give us a "before" snapshot of our operations, so we can then compare it to new data for the "after" snapshot. Like change management, the importance of benchmarking is sometimes overlooked or underestimated. The value that quantitative data delivers is project credibility—the numbers won't lie about whether or not the anticipated benefits from a new technology deployment are realized.

The Pain of Panes

Utilities faced challenges in managing communications networks before the introduction of smart grid technologies, which added 1) new volumes of traffic on existing networks; 2) management of new networks proprietary or not, privately owned and public carriers; and 3) new communications-enabled devices in power grids as well as communications networks. Like many other utilities, Duke Energy had siloed views of grids and networks. Each communications or power application has its own management system, communications, hardware, and visual display, offering up tunnel-vision views and no context about the impacts a change in status in one component might exert on the performance of another component. This lack of situational awareness and the need to correlate data across power and communications networks with outage and weather data is the primary reason why we chose to implement a network management solution. With it, we gain a holistic view of our communications networks and devices, plus the added benefits of correlating communications network operations with power grid operations.

For instance, at our Charlotte test bed, meters transmit customer usage and communication status via PLC (power line carrier) or 900MHz RF that is aggregated at another vendor's communication nodes. Power line sensors, weather sensors, streetlights, reclosers, regulators, and capacitor controls also send data to the communication nodes via Wi-Fi, serial, or Ethernet. The communication nodes connect to fiber, Ethernet, or a common carrier's cellular network to backhaul customer usage, telecommunications performance, and grid performance data to various head end systems. In addition, distribution assets are integrated into Duke Energy's supervisory control and data acquisition (SCADA) system. Our network managers have limited visibility into how our communications and power networks interact because each has multiple management solutions that look at a slice of the system. Our power, telecom, and cybersecurity managers typically work in different locations, so they have difficulty gaining visibility quickly into the status and performance of these operations. So if, for example, we have a problem collecting meter data, where is the problem? Is it on the line from meter to communications node? Is the node experiencing a device fault or a network fault? Is there an issue with the backhaul network? Or, is it altogether different—a power issue?

Visualizing the Convergence of IT and OT

Today, it is difficult to quickly answer that question unless we have a way of seeing data from across all of our networks. Taking a page from the telecommunications industry, which has solved this issue for its own infrastructure decades ago, we chose to adopt a "manager of managers" approach. We needed to be able to expedite root cause analysis by integrating operational status of devices and various networks to identify the problem sources and provide the necessary information to dispatch the right team the first time to quickly resolve the problem at the lowest possible cost. As supply-side and demand-side convergence continues, many issues could require coordination of network, grid, and cybersecurity groups. We will use our network management solution to aggregate critical data from disparate systems into a single pane of glass, so our operators can absorb and synthesize the data for better and faster decision-making. We anticipate that our asset management capabilities should improve as we decrease the time expended to locate, diagnose, and repair faults that could arise in networks or the grid. We also expect that as our asset management improves, so will our reliability metrics because we'll be helping to improve power delivery through this faster diagnosis to resolution cycle.

We're also looking at using the data and network management capabilities to do proactive maintenance. Current run-to-failure practices can incur avoidable costs with regard to labor and shipping and freight charges for rushed deliveries of replacement gear. Unplanned outages and interruptions caused by equipment failures could also have negative impacts on our customers' satisfaction with our services. The network management tool we are implementing can provide analytics and real-time monitoring of failure-related indicators that can move us toward proactive troubleshooting and reduce our operational costs. Correlating data from disparate systems gives us the ability to identify patterns and anticipate trends to failure before they occur. Similarly, pattern recognition from the network management tool is also very useful to track Service Level Agreement (SLA) performance. With the large number of vendors we have, the ability to track performance at a granular level means we could hold them accountable for deviations from performance guarantees, including QoS on networks. That's critically important as we continue to need more reliable systems and overlay new devices and networks on our power grid.

Despite the convergences impacting electric utilities, our overall mission remains as always to deliver safe, reliable, and affordable electricity and gas. The smart grid helps us do that but, if not managed properly, can increase the complexity of our operations in terms of communications networks, power grids, and cybersecurity. It is essential to find solutions that help us manage this complexity while improving reliability and reducing costs. Situational awareness of our network and grid performance provides invaluable knowledge that helps us improve reliability, reduce costs, and even improve safety. We look forward to providing more information about our experiences with network management and the benefits we expect to realize with this manager-of-managers solution.

About Duke Energy

Duke Energy is the largest investor-owned utility in the Americas with operations in six states and throughout Latin America, 104,000 square miles of service territory in its franchise gas and electric companies, over 50GW of generation capacity, and more than 7 million electric and gas customers.

Raiford Smith is director of smart grid emerging technology for Duke Energy. In this role, his team is responsible for developing and assessing new power delivery and telecommunications technologies for the smart grid, including business case development and global project management for joint-venture technology development initiatives in the United States, China, South Korea, and Japan. Smith has 21 years of experience in the energy industry, including various roles in legal, customer management, energy efficiency, pricing and rates, product development, wholesale deal structuring, mergers and acquisitions, and technology.

Paul Moon is the vice president of corporate development and strategy at SK Telecom Americas and the head of GridMaven. He is a founding member of GridMaven and has led SKTA's entry into the utility industry. Moon has more than 15 years of leadership, business development, and management experience in the communications industry. He has been focused on bringing new technologies and innovation in his role as head of business development at Helio and director of carrier relations for SK Telecom in the U.S. Prior to SK Telecom, Moon was a senior investment banker at Piper Jaffray, leading the wireless communications investment banking practice.