SIERRA ENERGY GROUP
The Research & Analysis Division of Energy Central

Communication Network Challenges and Solutions in the Utility Industry

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Executive Summary

Today, utilities face the challenge of using information and communication networks more effectively to manage the demand, generation, transmission, and distribution of their commodity services. Information flow, made possible by emerging network solutions, is a key enabler for increased competitiveness, improved reliability of energy supply, and enhanced business and operational responsiveness. To realize these benefits, utilities need to modernize their network information and communications infrastructure.

Utilities continue to meet fluctuations in electricity demand and capacity that occur locally, regionally, or nationally by cost-effectively increasing the peak capacity of their power generation and delivery infrastructure. However, utilities' network communications infrastructures are also being increasingly strained by a wide range of challenges, and this trend will only intensify. For example, interconnection of utility networks into regional supplies has created the need for fully interoperable system management to maintain local reliability. The competitive free-market environment created by deregulation has further emphasized the need for more fluent exchanges of information in higher amounts. At the same time, there are concerns at a local, regional and national level about infrastructure and services availability, reliability and security. These concerns amplify the need for improved information flow in utilities' communications networks.

While their communications networks may be meeting current demands, most utilities know these networks have a limited lifespan. Existing infrastructures are not built to handle large increases in traffic or to provide rigorous security safeguards. Currently, increases in communications traffic are driven by applications such as interval metering; operational systems for managing power generation, outages, and flows; two-way communications for energy efficiency initiatives and other customer programs; transmission interconnectivity; and network security monitoring and reporting. This means that utilities need to upgrade just to keep their existing communications networks fully functional and compliant.

This paper describes the effects of these new pressures on utility network communications infrastructures, such as upcoming demands for smart grid technologies, regulatory changes, and increased competition. It also summarizes communication network options and key considerations for utilities when addressing these pressures.

Current Issues — Moving from Today to Tomorrow

Before it is possible to chart a path to the utility network infrastructure of the future, it is of vital importance to understand the challenges of the present. These challenges can be broadly divided into two categories of need: outward-facing and inward-facing.

Utility Outward-Facing Needs

The outward-facing needs of utilities are those that are visible externally and that affect a utility's relationships with other entities such as customers and regulatory agencies. Reliability, competitiveness and compliance with regulations are the keywords for understanding these needs.

Maintain High Levels of Reliability.

The primary task of utilities is to maintain high levels of service reliability. Service reliability, in turn, depends in part on a reliable communications network infrastructure. Any enhancement to this infrastructure must therefore be made with reliability uppermost in mind.

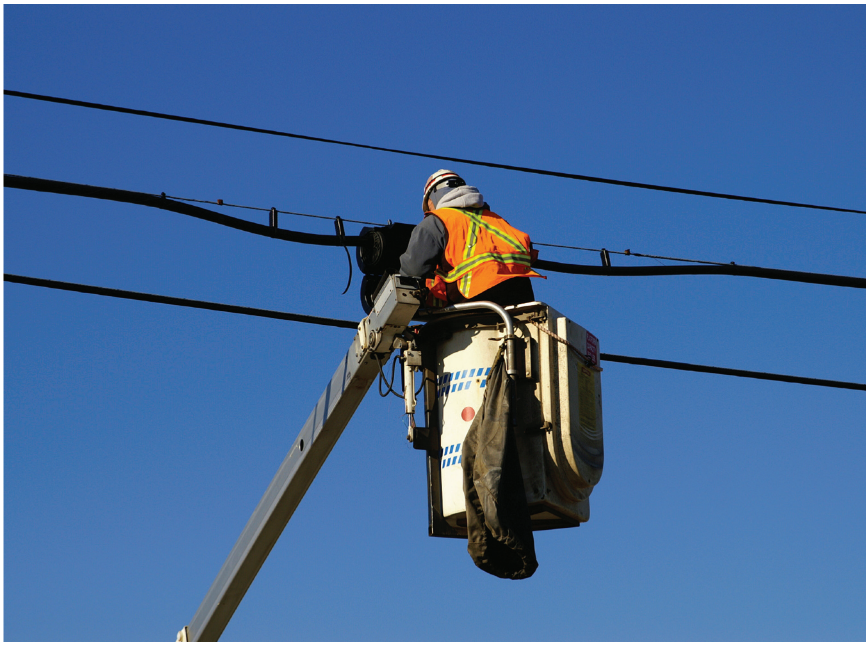
Ensure Regulatory and Standards Compliance.

In conjunction with the Federal Energy Regulatory Commission (FERC), the National Institute of Standards and Technology (NIST) was tasked with identifying needs and crafting standards to meet the objectives of the 2007 Energy Independence and Security Act for building a smart grid. This includes developing a framework for interoperability of smart grid devices and systems. The newly developed standards for data exchange (IEC 61970 and IEC 61968) and substation automation and communication (IEC 61850) require utilities to move toward standardized telecommunications protocols and architecture. However, legacy Supervisory Control and Data Acquisition (SCADA) systems, for example, generally use proprietary, rather than standardized protocols. In many instances, only a select few utility personnel understand these protocols. Gas management systems and energy management (EMS) systems present similar complexities. Each of these systems may run on a separate network, and each may use a variety of backbone networks and technologies for backhaul.

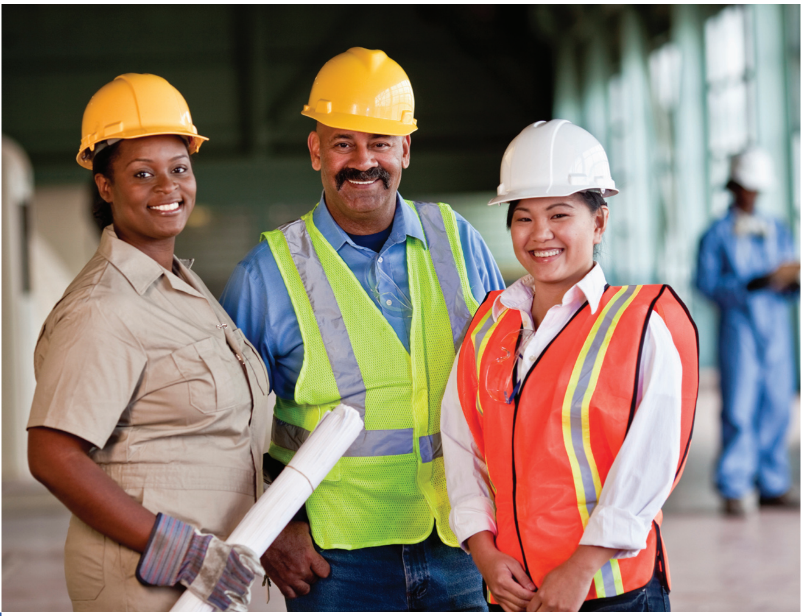
Reduce Cost Inefficiencies.

Upgrades to network communications infrastructure mandated by regulatory standards or selected for competitive reasons may incur unnecessarily high costs unless implemented efficiently. Risks associated with the current proprietary systems include:

- Lack of vendor availability for emergency fixes
- The retirement of utility personnel and concomitant loss of institutional knowledge, and
- Ongoing maintenance and upkeep or replacement of aging equipment.



The NIST standards will support interoperability of both smart grid devices and systems, and consequently address some of these issues. However, the task of shifting from a manual switching operation within each substation, for example, to an automated operation for a utility's grid is a challenging one. One reason for this is that the group responsible for the SCADA systems may be either part of information technology (IT) units or operational technology (OT) units. Also, the group may be split among several different OT groups. If the various OT and IT groups are not



closely coordinating with one another, they may produce contradictory efforts or may require the use of systems that are more expensive than necessary. This is because duplication of equipment and lines, which in addition to being inefficient of itself, often leads to duplication of staff to maintain the communications links.

Enhance Customer Satisfaction.

Utilities can retain and increase customer loyalty by taking advantage of the technologies to modernize their communications networks and by moving further along the smart grid path. This involves ensuring full availability of utility resources, allowing distributed customer generation, providing net metering benefits to customers, and optimizing energy efficiency and demand response programs.

Utilities' Internal Operational Needs

The internal operational needs of utilities are those that, while not directly visible to external entities, nevertheless hamper utilities' ability to fulfill their purpose.

Balance Upfront Costs with Long-Term Benefits.

Utilities often need to balance upfront costs for new equipment, lines, and systems with the resultant long-term benefits. Yet they are often faced with shrinking budgets as they weather the current economic conditions. Even determining the true price tag involved may be difficult. Expenses such as equipment, engineering, installation, business continuity, and life-cycle costs can be quantified. However, other expenditures are more difficult to quantify. Examples are technology obsolescence, changing regulatory standards, and actual utilization of assets. Increased usage of the same lines based on newly implemented smart grid projects can also create costs that are challenging to quantify.

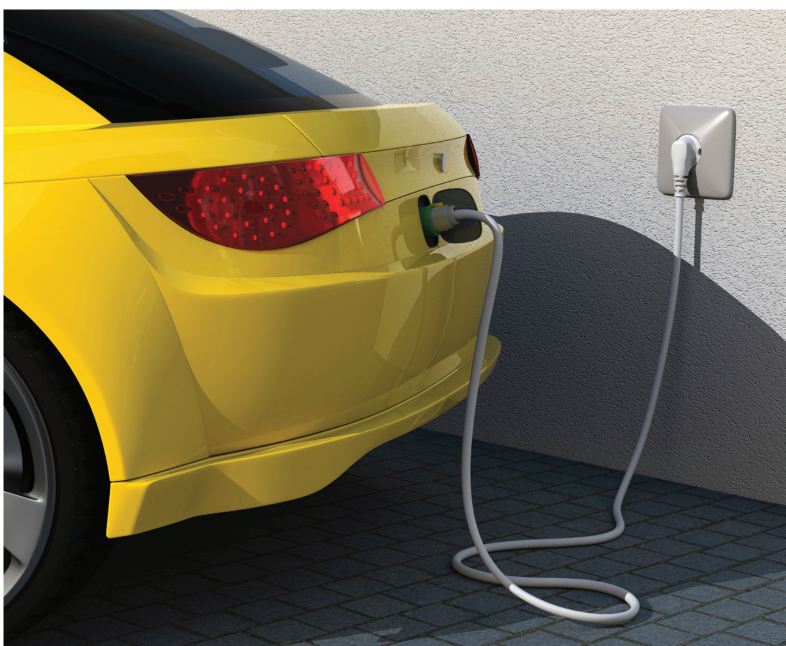
Address Legacy Issues.

Utilities have very large investments in legacy communications systems and architectures - measured in terms of both financial and human resources. Utilities need to address legacy financial issues such as locked-in rate cases, regulated revenue and fixed operating margins, and lack of available private investment.

From a human resource standpoint, change management for new processes and technologies takes a toll on staff. In some cases, limitations of legacy technology require personnel to use online auction sites such as eBay to locate replacement parts. When changing out systems in their entirety, some legacy systems require multiple applications and extensive effort to update network information. Also, the additional skills needed to install and maintain new systems may result in needing new employees.

Address increased public and regulatory scrutiny over the safety and security of the operation and supply chain.

The NERC standard for Critical Infrastructure Protection (CIP) calls for utility personnel to exercise increasing vigilance over substation and network assets. Further, NIST continues to release guidelines and frameworks for risk assessment of the effects of security breaches on the smart grid. This will affect a variety of system types. For example, remote video surveillance requires large amounts of bandwidth to effectively deliver surveillance data to a centralized monitoring hub. Many of the newer video systems can help a utility reuse existing corporate communications lines as long as the bandwidth is sufficient.



These regulations raise other issues as well. For example, new areas of consumer concern include the ability to encrypt individual usage and payment data to maintain consumer privacy.

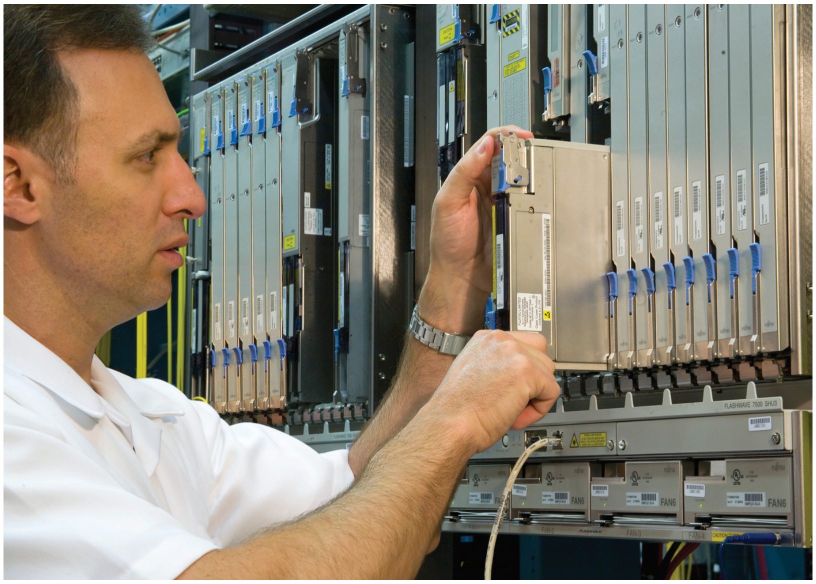
Enhance infrastructure to accommodate new and expanded initiatives.

Utilities are undertaking a broad array of customer and internal projects, which as a group, require an upgraded communications infrastructure. These include demand-response systems, advanced metering infrastructure (AMI), water leakage and overuse prevention, distributed grid operations, gas pipeline monitoring, and grid automation. Energy efficiency improvement initiatives have been enacted in every U.S. state and most Canadian provinces, and many are being expanded as home automation networks are becoming more widespread. At the same time, net metering is becoming the law in more service territories in North America. Water usage monitoring in drought-stricken states is also becoming the norm. Photovoltaic and electric vehicle programs are in pilot stages now, but will eventually become large-scale, mainstream initiatives. The two-way communications required for such programs require higher capacity bandwidth, low latency (or minimal delay in sending or receiving communication packets), instant availability of information (e.g., to optimize demand management), and high security.

Improve Field Maintenance and Repair Processes.

A variety of factors complicate maintenance and repair of utility communication networks. These factors include diverse topography and geography, population density, local regulations, local rights of way, network ownership and co-ownership, and environmental concerns. The latter range from national parks to protected Indian historical and religious sites.

These activities present communication challenges as well. For example, field staff needs to be able to contact supervisory and emergency personnel at all times. They need to be able to access geographical and system information to ascertain asset locations and update records after task completion.



Communications Networks — Utility Options

Utilities have several areas where it is prudent to assess the available options carefully before making decisions. Vendor relationships, technology choices, and available services, are all examples.

Utility Network Management: In-house, Outsource, or Hybrid

There are several options for utilities with regards to communications network management. Some utilities prefer managing and building their own networks with help from third-party vendors for supplemental staffing, design expertise, and equipment. These vendors can help utilities segment networks, provide virtual private networks (VPNs), augment or segregate bandwidth, and provide additional value for dollars already invested in networks.

Other utilities are choosing industry vendors that specialize in communications networks, allowing them to outsource most of the network modernization effort. Some utilities use a hybrid of the two approaches. In these cases, using external carriers in certain geographic locations but maintaining most of the utility network under internal control makes sense.

Utilities that retain or expand private networks should aim to minimize the disruption of core operations and keep operational personnel focused on the delivery of communications service. The best solution to a business case for enhancement is often to use existing networks with newer equipment to leverage and extend the life of legacy technology.

Network Management Technology

New intelligent electronic devices (IEDs) implemented in today's substations gather essential information required to perform outage management, load balancing, and facility operations. To support these new devices, utilities need to develop a standards-based, integrated network architecture that enables the gathering, processing, and distribution of information in a timely, efficient fashion.

Utilities need to develop a networking technology strategy that enables them to efficiently support current applications and new, emerging packet-centric applications. Their Synchronous Optical Networks (SONET) have served them well over the years providing the highest network reliability but do not efficiently transport packet-centric information. Packet optical networking platforms with Connection-Oriented Ethernet (COE), provide the best of SONET and packet-based network architectures. COE is a high performance implementation of Carrier Ethernet standardized by the Metro Ethernet Forum (MEF). It provides networking capabilities similar to SONET; fast network fault isolation, 50 ms network protection/restoration, continuous network performance monitoring with scalable and guaranteed bandwidth. Packet optical networking platforms create a single transport network infrastructure that utilities can use for IP services, site-to-site program controls and IED communications, and cell tower backhaul infrastructure. The platforms enable emerging packet-centric applications to efficiently co-exist with legacy applications over the existing SONET network.

As utilities plan to migrate from their SONET-based network to a more Ethernet-based architecture, compatible communication products are available that provide fail-safe infrastructure options for SCADA systems. These products support the new NIST IEC 61850 standard for substation automation. This enables utilities to move step-by-step to ensure reliability and implement Ethernet in successive phases, while maximizing usage of the new equipment.

Network Management Technology Services

Industry communications partners can provide services that enable a utility's internal staff to make informed decisions or supplement existing knowledge and skills in the following areas:

- Network design and planning
- Prequalification of fiber-optic cables
- Engineering
- Providing, installing, and provisioning equipment
- Actuating, testing, maintaining, and repairing networks
- Providing network operations centers (NOCs) to manage your network 24x7

These technologies and services help to consolidate existing infrastructure, simplify and speed data access, and ensure overall network security.

Incorporating internal OT and IT groups into the network management process can be a challenge for any organization, and a third party can help ease the transition. For example, a network solution partner can provide the integrating link between the groups in both verbal communications and technical specifications. Alternatively, the third party can assume responsibility for the entire transition, including training and a subsequent turnover of the project to utility staff. An industry partner such as Fujitsu can keep the project moving and ensure that the resulting infrastructure and systems are fully reliable and operational.

Future Outlook

The future holds advances in technologies and applications for the information infrastructure. On the technology side, Ethernet has been used for local area networks (LANs) for decades, and Ethernet is a de facto standard for personal computers, servers, storage devices, and similar equipment. Carrier Ethernet is an MEF-standardized implementation of Ethernet used by communications service providers for metro and wide area deployments. It augments this ubiquitous Ethernet LAN technology by defining wide-area networking (WAN) attributes and requirements that enable Ethernet-based technologies to extend from the LAN to across the WAN. Unlike Ethernet LANs, Carrier Ethernet networks can be built using non-Ethernet transport technologies such as SONET (Ethernet-over-SONET), OTN, WDM or bonded T1s (Ethernet-over-PDH). This enables utilities to achieve savings by sharing a common infrastructure for the different applications or services they need to support. Connection-Oriented Ethernet is a high performance implementation of Carrier Ethernet. When used on a packet optical networking platform, COE is ideally suited to meet the stringent requirements of utility networks giving SONET-like performance with Ethernet's cost and bandwidth efficiencies.

More utilities are considering high performance implementations of Carrier Ethernet like COE, because of its flexibility, cost effectiveness, and optimization for new IP-based applications when compared to traditional private line implementations. Migrating to COE also allows utilities to more quickly and efficiently increase bandwidth as they deploy new applications. Furthermore, when using COE on a packet optical networking platform, utilities can significantly increase bandwidth efficiency over their current SONET network. This enables them to transition their network from SONET to native Ethernet at a pace which best aligns with their budget objectives.

On the application side, market-based pricing and dynamic pricing rates for electricity are likely to proliferate in the future, as a means to encourage load shifting from peak to off-peak periods. These pricing models will require greater dependence on two-way communications for utility customers, and a higher level of service availability.

Actions for Utilities to Consider

As bandwidth demand strains existing communications infrastructure, a variety of converging factors are presenting opportunities for utilities. The confluence of evolving regulations and standards, opportunities to create new service offerings and implement business and operational programs, suggest that now is the time to act. Upgraded communication network systems can be the underlying enabling technology for many other systems — both customer-facing and internal.

To help successfully navigate through the communications structure changes and opportunities, utilities should consider the following actions:

- **Plan now for the future.** Careful planning for upgrades to utility communications networks should take an integrated approach that thoroughly analyzes all relevant corporate and technology resources, requirements and goals.
- **Build bridges internally.** Optimal planning endeavors include representatives from a variety of departments. Incorporate network growth in any operational discussions and planning. Continue to bring operational and information technology groups together to gain synergistic insights.
- **Learn from others.** Utilities that did not receive smart grid funding as part of the American Recovery and Reinvestment Act of 2009 (ARRA) can analyze other utilities' ARRA projects for ideas on how to maximize their own investment in communication network upgrades.
- **Work with experts.** Consider partnering with communications and networking vendors for guidance, planning and implementation. Consider the following criteria when evaluating vendors:
    - History of projects in the utility industry and UTC organization
    - History of product and service excellence
    - Leadership and ranking within the optical networking industry
    - Level of technology advancement proven to date through development or controlled acquisition
    - Sustainability in operations areas such as R&D, as well as financial stability
    - Robustness of its technology (e.g., security, scalability, and reliability of its optical transport networks).

Conclusion

Developing a forward-looking strategy for building tomorrow's utility communications network infrastructure requires careful analysis of the network in its entirety. Effective planning for the future depends upon comprehensive assessment of current and future IT, OT and business applications. This is particularly important for addressing interoperability issues and improving coordination among various IT and OT groups to ensure unified, efficient modernization efforts.

A solution-focused vendor partner with proven excellence in communications network applications can bring essential capabilities to the table during every phase of network modernization. The selection criteria set forth in this paper provide valuable benchmarks for selecting a vendor, such as Fujitsu, with the right credentials to help utilities meet the challenge of building truly effective, unified communications networks that support the smart grid.