The New Face of Electric Utility Communication Systems:

A framework for addressing increasing communications system complexity

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Abstract

In their ongoing efforts to optimize electric grid operations, utilities have made great strides in improving efficiency and achieving better customer satisfaction. As grid modernization continues, we face a situation where the volume of operational and customer-related data will increase dramatically. In addressing these challenges we see the emergence of new communications infrastructures overlaying the physical power delivery grid.

This white paper details the complexity of the new communications systems and describes how utilities can proactively manage their communications infrastructure to ensure it is reaching its full potential.

Introduction

Electric and gas utilities are in the business of providing reliable, affordable power to all customers within their service territories. With so-called "smart grid" initiatives, utilities are finding ways to meet this goal more efficiently, with lower costs and increased environmental consideration. The basic systems utilities have used for decades are being replaced with a myriad of technologies that allow increased flow of data, grid control and automation to unlock the power of the smart grid.

A truly intelligent grid is capable of self-healing, optimizing the flow of electricity, seamlessly integrating renewable generation resources, and improving overall efficiency of delivery. To accomplish this grand vision, utilities need more than just smart meters. A modern grid has intelligent electronic devices (IEDs) throughout the transmission and distribution infrastructure and facilitates constant exchange of data through control signals between these points and the utility operators. Distributed generation resources on residences and commercial buildings and the growth of electric vehicles are further transforming the grid. These capabilities are all enabled by connecting legacy with next generation communication networks.

New Communications Requirements: One Size Does Not Fit All

Communications networks are not new to utilities. Over the past century, utilities have put in place networks ranging from simple telephone lines to fiber optics to advanced mobile radio. Most legacy communications systems were built for a single purpose; networks were often low bandwidth and experienced high rates of delay of data transmission (latency). As the need has grown for more rapid information flow between utilities, customers and third parties, more network types and topologies have emerged. Table 1 illustrates the wide-range of characteristics commonly found among communications technologies deployed by utilities.

Table 1. Performance Characteristics of Common Communication Networks

Communications Technology	**Bandwidth Range (per second)**	**Latency Range**
Wireline		
Fiber	1 GB to 100 GB	<2 ms to 10ms
DSL/ADSL	256 MB to 24 MB	<20ms to 50ms
BPL	256 KB to 135 MB	10 ms to 75 ms
Wireless		
Satellite	1 MB to 40 MB	>250 ms
Microwave	10 MB to 10 GB	<5 ms
Radio-licensed spectrum	10 MB to > 1GB	< 15 ms
2G and 3G cellular	200 KB to 1 MB	>15 ms
4G cellular	100 MB to 1GB+	5 ms to 15 ms
Mesh (WiFi) (multi-radio)	<5 MB	>25 ms

Source: Adapted from research from Newton-Evans Research Co, as shown in "Communications: Questions and Concerns" by Cathy Swirbul, *Transmission & Distribution World*, April 2011

Given the range of application and performance utilities are seeking as they build out their communications infrastructure, they must first consider the specific application when selecting a network technology. In 2010, the Department of Energy surveyed utilities across the country about new smart grid communications requirements. The results confirmed that emerging smart grid applications have distinct data network needs and that no one technology will suffice for all purposes, as illustrated in Table 2.

Table 2. Network Requirements by Application

	Network Requirements		
Application	**Bandwidth**	**Latency**	**Reliability**
Advanced Metering Infrastructure (AMI)	10-100 kbps/node, 500 kbps for backhaul	2-15 sec	99-99.99%
Demand Response	14kbps- 100 kbps per node/device	500 ms-several minutes	99-99.99%
Wide Area Situational Awareness	600-1500 kbps	20 ms-200 ms	99.999-99.9999%
Distribution Energy Resources and Storage	9.6-56 kbps	20 ms-15 sec	99-99.99%
Electric Transportation	9.6-56 kbps, 100 kbps is a good target	2 sec-5 min	99-99.99%
Distribution Grid Management	9.6-100 kbps	100 ms-2 sec	99-99.999%

Source: Department of Energy, "Communications Requirements of Smart Grid Technologies", October 5, 2010

Trying to fit an application to a network or overextend existing networks to new applications with different performance needs is not only inefficient but will also likely restrict the benefits of the intended application. The choice of technologies is further complicated by factors like topography, climate and customer density. These factors affect the data transmission quality features of certain technologies and also may drastically change the economic considerations of a new communications investment.

In addition, some utilities have begun to find that even the AMI local area network (LAN) alone may necessitate multiple technologies. While RF mesh networks have emerged as a leader in AMI in the United States, they may not be able to resolve the "last mile" issue of connecting customers at the edge of utility service territories. In those cases, meters may need to connect to the utility network operations center via another existing network such as fiber, PLC, cellular or satellite.

Consequently, as smart grid initiatives expand beyond AMI, it is inevitable that hybrid, heterogeneous communications networks with become the norm, not the exception (see Box 1). Utility network operators will need to bring coherence and management principles to systems with multiple vendors and network technologies.

Keeping the lights on: Best practices for communications network management

Once a utility determines its current smart grid communications needs, chooses the best vendor and installs the system – the work has only begun. Just as utilities place high importance on monitoring, triage and maintenance of the T&D grid, they need to expand this mindset to the communications systems as well. As John LoPorto, special project manager with Pepco, notes: "You can't just set it and forget it".[1] Rather, utilities must manage their communications networks with the same rigor and sophistication as their power delivery networks. This will be increasingly important as utilities more aggressively implement distribution automation and distribution management applications.

In the telecom world, ensuring optimal operation of telecommunication networks rests upon the following basic building blocks: fault, configuration, accounting, performance and security (FCAPS).

- **F**ault Management: Identifying and alerting function through alarms when problems occur on a network. Responses can be automated or manual, and often follow a series of diagnostic tests. Fault logs compile statistics and identify areas that require further attention.
- **C**onfiguration Management: Used to track network inventory, device locations and other key indicators

Box 1: Large & Small Utilities Employ Multi-Network Architecture

Burbank Water & Power, a municipal utility in southern California, is relatively small utility with only 52,000 customers and 17 square mile service territory. Its small service territory and urban setting impacted its choice of technologies. The utility has fully deployed smart meters and put automated switches on 90% of its distribution circuits. A RF mesh network creates the meter LAN, with data collectors throughout to aggregate neighborhood data. These networks interface with a WiFi Wide Area Network (WAN), which is also used to communicate with smart devices, like the automated switches, throughout the distribution system. The WAN integrates with an existing fiber optic ring that links Burbank's 20 substations back to the utility's office.

Duke Energy, despite being one of the country's largest investor owned utilities, has chosen a similar hybrid approach. With 4 million customers reaching over 50,000 square miles in 5 states, Duke has decided to focus its communications architecture on "communications nodes", which act as the main point of contact between the LAN and the WAN network back to the utility's home office. These nodes are capable of managing data locally or routing it to another location for analysis. The utility plans to use a combination of RF mesh and PLC for its LAN, connecting customer meters, sensors throughout the distribution grid, and distribution automation equipment back to the communications node. A public cellular WAN sends data from the nodes back to Duke's office.

Sources: Burbank Water and Power Smart Grid Investment Grant Project Description, US Dept of Energy, June 2011; "Duke Energy: Developing the communications platform to enable a more intelligent electric grid" by David Masters, Duke Energy, February 2011

[1] "With Modernization Comes More Frequent Maintenance, Experts Say", *Smart Grid Today,* September 27 2011

of device health. Examples include pushing firmware upgrades, re-syncing clocks, performing auto-discovery of new devices and adding new devices to the network.

- **P**erformance Management: Real or near-real time monitoring of key indicators that affect network usage and Quality of Service such as signal strength, number of hops, link quality, etc. Used to maintain network health and prevent degradation over time. Passive monitoring can also be done through alarms based on performance and baseline thresholds.

- **A**ccounting/Inventory Management: Tracking the hardware and software inventory associated with a network, including device types, models, firmware versions et al. It also includes analytics such as tracking which network device types experience the highest number of severe alarms.

- **S**ecurity Management: Controlling access to devices in the network and protecting flows of data. Data protection basics include authentication and encryption; access to network devices can be monitored and controlled at the network level or software management level to protect against tampering.

Each of these functions is critical on its own and how best to perform each is specific to individual networks. With only a few thousand devices across all networks, it was once relatively easy to manage these parameters. However, this is no longer the case with tens of thousands to millions of devices now being deployed across two-way communication networks. A centralized systems approach will greatly reduce human error and enable the network operator to effectively monitor and prioritize management actions.

Doing Network Management Well: A Centralized Platform

Never requiring large numbers of telecom experts in the past, electric and gas utilities are already spread thin in this expertise. This will be further exacerbated by a retiring workforce -- up to 30% of workers in the power sector are expected to retire or leave by 2013.[2] Utilities are struggling with institutionalizing the knowledge of current telecom experts while preparing for more advanced systems coming in the future.

Most smart grid deployments involve working with multiple vendors to build out communications networks. Typically network vendors provide software that allow operators to perform basic fault and performance monitoring for its own network. These tools neither monitor other networks nor integrate with one another. Consequently, the network operator must learn multiple independent management systems and lacks a view of overall network health.

In other areas of the power grid, a systems level approach is already becoming more common. For example, Outage Management Systems (OMS) evolved to enable a grid operator to better visualize, monitor, manage and administer distribution circuits. Operators can view real-time status and get detailed information on devices and circuits. The OMS interface is integrated with other utility

[2] *Task Force on America's Future Energy Job: Executive Summary and Policy Recommendations*, National Commission on Energy Policy, June 30 2011.

applications providing the operator with a high level of functionality without needing to switch to secondary applications.

With communications infrastructure now resembling a grid unto itself, utilities are in need of a solution that presents data from across networks for a "one-glance" view of system health. With a centralized interface, operators can view real-time alarm status of all network nodes, whether meters in the AMI network or other IEDs throughout the grid. As communications networks expand to include electric vehicles, their charging stations, and distributed generation resources, the ability to monitor and correlate issues across networks on one platform will become even more important.

A centralized management solution should emphasize correlation of alarms and events across different networks. With alarm correlation, network operators can more easily identify patterns and trends that would otherwise be lost in mountains of data or impossible to spot when using multiple interfaces. The network operator will be able to quickly determine the root cause of an alarm and reduce time to respond. The value of a centralized approach is not just in reaction to communication network events; in the near future, utilities will want to share communications monitoring data with other advanced applications, such as OMS, DMS, DA and Volt/ Var systems, to improve the quality of data and functionality of those applications.

Conclusion

Utilities are deploying a sophisticated portfolio of communications technologies to realize their smart grid visions. The end result is an increasingly complex system of communications networks that must be managed with the same rigor and sophistication as the power delivery grid. If network operators rely only on the management tools from each individual network vendor, the result will be fragmented, inefficient decision-making. A centralized management system will enable operators to institutionalize telecom expertise and automate analysis and processes, resulting in more efficient operations and improved situational awareness.

GridMaven Network Manager is a centralized 'manager of managers' that provides network operators with an intuitive interface and robust performance monitoring, fault management and configuration functionality for new and legacy utility communication networks.

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