Network Infrastructure Considerations for Smart Grid Strategies

By Jim Krachenfels, Marketing Manager, GarrettCom, Inc.

The Smart Grid is having a decided impact on network infrastructure design and the equipment that supports it. For one thing, the Department of Energy is pumping money into U.S. Smart Grid infrastructure. In October 2009, 100 Smart Grid projects around the country were awarded $3.4 billion, to be divided among installation of smart meters and related customer programs, network infrastructure to support smart grids, transmission line modernization and development of smart device manufacturing capabilities. The lion's share, $2 billion, was for infrastructure development. In November 2010, another $19 million was awarded to five projects to "apply technologies, tools and techniques that are capable of transforming the electric grid into a system that is cleaner and more efficient." Reports indicate that the DoE expects that the projects combined may reduce peak electricity demand by more than 1400 megawatts (the equivalent of several power stations) as power delivery transfers from a one-way pipe from distribution station to user to an informed distribution of resources.

Key components of Smart Grid technologies include remote control and automation, two-way communications, and enhanced information technology targeted to both utilities and their customers. In addition to upgrading and hardening the power utility infrastructure, Smart Grid is designed to help consumers—and power companies—make smarter decisions about how they use power. That requires a lot of information, and a lot of data analysis.

The implications for infrastructure providers are huge. As in other information-intensive markets before Smart Grid, data creep is well underway. According to an SBI *Energy* study published in December 2010 (*The Smart Grid Utility Data Marke*t), the volume of Smart Grid data moving through the infrastructure network will grow from 10,780 terabytes (TB) in 2010 to more than 75,200 TB in 2015.

It is clear that the infrastructure in the substation and distribution segments of the Smart Grid will have to undergo changes to accommodate this dramatic increase in data. First, it is easy to predict that Internet Protocol (IP) technology is a key enabler of the Smart Grid because it is standards-based, flexible and scalable. Second, the switches and routers deployed throughout the infrastructure will need to adapt to the demands for increased data by supporting greater throughput and also by assisting in intelligent, bandwidth - protective routing of information through protocols such as IGMP. Third, new software applications and protocols that support security, optimize routing, and simplify and streamline data management will need to be developed. To make Smart Grid work, it will be necessary to automate much of the managing, analyzing and visualizing of all that data—allowing humans to deal with the exceptions.

There is no single "right" way to implement a Smart Grid. Solutions are as disparate as the types of utilities and the regions in which they operate. A municipally-owned utility in the Northwest, a public/private collaborative venture in the Southwestern desert, and a rural cooperative in the mountains of Appalachia all have different operational challenges as well as differing political and financial considerations.

As power utilities contemplate their strategies for data collection and management, they need a variety of options. Some critical considerations are

- Standards-based implementation
- Bandwidth scalability
- Redundancy
- Wireless communications
- Powerful and robust software

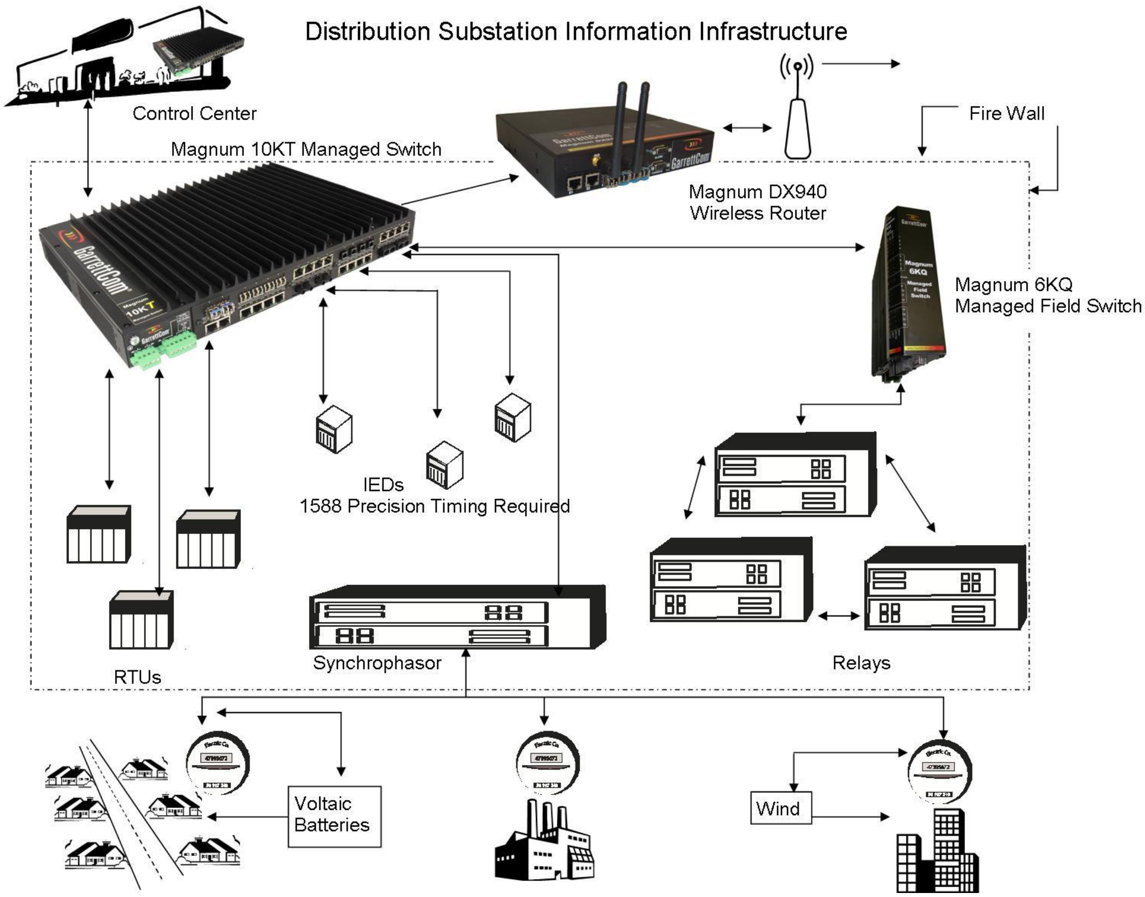

Figure 1 illustrates the increased requirements placed on managed switches within a power distribution substation for Smart Grid system implementations.

Standards-based implementation.

It almost goes without saying that Smart Grid network infrastructure needs to be 61850-3 compliant to support interoperability and scalability, and needs to be substation-hardened to withstand challenging environments in remote locations. IEC 61850 is an international standard for communication in power generation facilities and substations. By integrating key functions within a substation such as protection, control, measurement and monitoring, and by providing the means for high-speed protection applications, IEC 61850 simplifies power management and paves the way for other initiatives, such as Smart Grid.

IEEE 1588 v2 is a breakthrough timing protocol that offers, for the first time, sub-microsecond synchronization for clocks in various substation and power delivery devices such as sensors and actuators over an Ethernet network. It is a critical component for allowing utilities to offer the precision timing required to support the control algorithms required for modern power management and delivery systems. While sub-microsecond synchronization is of value in and of itself, increasing automation is likely to require synchronization at tens of nanoseconds rates in the near future, and it is incumbent upon equipment suppliers to develop and market and support the standards-based hardware and software required to support that level of precision, based on the IEEE 1588 v2 standard.

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Bandwidth scalability

In the Smart Grid, there is an emphasis on distributed energy sources, some of which will be consumer supplied, such as solar panels and small wind farms. (See Fig. 2) These distributed energy sources place even more pressure on the utilities to track and manage load. Most “green” power sources are intermittent in nature, requiring more communication along the grid to ensure that power is supplied when and where needed. At the same time, Automated Meter Reading (AMR), with its potential not only to measure power use at a customer site in real time but also to provide feedback on power usage, generates enormous amounts of data. On the physical security side, developments in surveillance provide streaming video information, often in high definition, which can threaten to overwhelm a network that is not sufficiently scalable and intelligent in its transmission of data through the use of routing tools such as IGMP at the router level, and even switch-based Layer 2 IGMP-based data management tools.

Switches and routers are able to support greater numbers of ports—particularly fiber ports with the introduction of small-form-factor fiber ports. Small-form-factor fiber ports for both 100Mb and Gigabit provide the bandwidth to accommodate the increased video security demands for the power utility industry, and the reduced cost of fiber media has made IT physical security more affordable. The increased port density also increases network reliability by providing fewer points of failure.

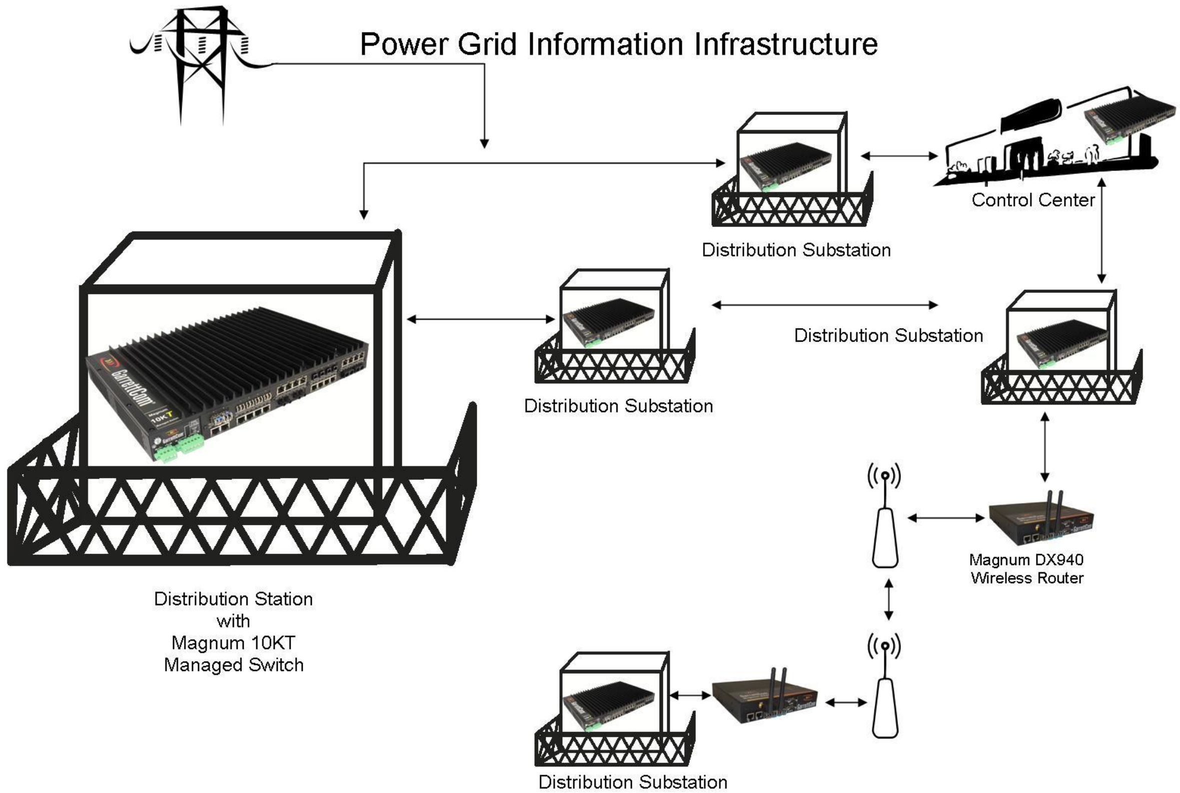

Fig 2 shows the expanded requirements placed on substation-to-substation capabilities as well as the importance of redundancy

Redundancy in connectivity *and* power

Reliability is a leading driver for Smart Grid. The impetus for redundant network paths to enhance reliability has been in place for years. With security threats and increased power demands, redundancy can no longer be considered a luxury. In addition to an insatiable need for continuous flows of data to monitor and manage the Smart Grid, the industry is also contemplating a surge in demand for energy. Consider, for example, mass-market electric cars, each of which can draw as much power as everything else electrical in some homes. A neighborhood or two plugging enough cars in at the same time could tax power delivery and possibly bring a utility to its knees. The impending electric-vehicle power demand is on top of the growing demand for electricity from communications devices, industrial facilities, and even gadgets at home and at work.

Switches, routers, and other networking products for the Smart Grid will require redundant power supplies along with network-path redundancy to ensure that data keeps flowing. For example, security concerns and increasing demand suggest that even 1U rack-mount switches need hot-swappable power supplies to reduce the chance of downtime. Networking software that incorporates features such as RSTP-2004 is also key in minimizing downtime for critical utility applications. Designing redundancy into network paths to every important device is critical to maintaining uptime in power substations and distribution systems in Smart Grid communications networks.

Wireless
Wireless extensions to Ethernet networks have been gaining in popularity as the power industry has embraced distributed data collection, monitoring and control. Wireless communications technology is a major enabler of the installation of AMR devices on the consumer side, where fiber cabling would be cost-prohibitive. Wireless has also made it possible to bring remote substations, particularly in rugged terrain, cost-effectively into Smart Grid management systems.

Routers, hardened to meet the demands of substation conditions, must offer reliable cellular communication to quickly and economically support AMR applications and to reach dispersed power facilities—even those widely distributed “green” power generation sites. There is still work to do in this area as wireless technology brings its own challenges into the development of a Smart Grid infrastructure with both security and regulatory concerns. As wireless deployments increase, wireless functionality continues to be reviewed and refined by equipment vendors and the power industry.

Powerful and robust software
Smart Grid systems require extensive software support for success. Substation switches and routers are at the heart of data collection and management activities, thus switch and router operating software must support the latest precision timing (IEEE 1588v2) and fault recovery (RSTP-2004) protocols. Security is also an issue, with security protocols and standards driven by mandated NERC CIP regulations, and by other security initiatives that are helping to drive increased-tools and protocols for insuring that critical Smart Grid installations can withstand cyber attacks and reliably manage and direct huge volumes of data.

Vendor-supplied software is providing increasingly sophisticated ways of sorting and managing data to support the overall Smart Grid infrastructure. Equipment providers must look to provide increasingly sophisticated and standards-based network management and network operating systems. In addition, systems vendors such as Industrial Defender and SUBNET Solutions supply integrated security and management systems that use interoperability standards to ensure smooth flow of data and infrastructure management information among the variety of equipment from different vendors that make up the Smart Grid infrastructure.

Firm Foundation
A firm hardware and software foundation that provides security *and* multiple options for power utility network designers will ease the way to network implementations that meet the varying needs of utilities as they roll out Smart Grid solutions. Because new power systems also bring increased security concerns and government regulations, and because evolving standards and increasing precision packet timing demands are the norm today, it is imperative to identify equipment, software and network protocols that can be adapted to changes. Flexible solutions, built on industry standards, provide the best platform for Smart Grid data movement and manipulation, as they will provide a platform capable of evolving over time.

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About the author

Jim Krachenfels directs the GarrettCom marketing efforts. His has more than ten years experience in marketing programs and product management in the networking industry, including positions at Cisco Systems and SPEEDCOM Wireless. Jim holds a B.A. in Economics from Northwestern University and an M.B.A. degree in Marketing/Computer Information Systems from the University of Michigan. He can be reached at jkrachenfels@garrettcom.com