Implementing Smart Grid Communications

Managing Mountains of Data Opens Up New Challenges for Electric Utilities

By James G. Cupp, PE, and Mike E. Beehler, PE

Electric utilities faced with the prospect of increasing customer rates are seeking solutions to challenges presented by rising global energy demand, aging infrastructure, increasing fuel costs and renewable portfolio standards in light of climate change. Many consider Smart Grid to be one such solution.

If we define the Smart Grid as "the convergence of information and operational technology applied to the electric grid, allowing sustainable options to customers and improved security, reliability and efficiency to utilities," then we must focus on deployment in ways that address rate and bill impacts. The previous issue of *TechBriefs* provided an analysis of the political landscape, sustainability factors and project justification points. Here, we will outline the technical implementation of technologies that enable Smart Grid practices.

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Communications for Data Transport

Electric utilities continue to be among the largest users of privately owned and operated wide-area networks (WANs) for communications. These networks include a hybrid mix of technologies including fiber optics, power line carrier systems, copper-wire line, and a variety of licensed and unlicensed wireless technologies. The utility WAN is designed to support applications vital to the safe and reliable operation of the electric utility mission-critical infrastructure: protective relaying for high voltage lines, SCADA/EMS, mobile fleet voice and data dispatch, generating plant automation, distribution feeder automation and physical security. Rather than relying on public communication carriers (AT&T, Sprint, Verizon, et al), utilities justify the costs of building and operating their own private WANs because of the highly critical nature of these applications for maintaining a reliable and secure power grid. Less-critical business applications such as corporate voice and data networks are also supported, but are not normally the driver for private WAN deployment.

A typical electric utility WAN consists of a high-bandwidth transport backbone network that backhauls large numbers of channels and applications from the utility service territory to the control center(s). Lower-bandwidth segments, or spurs, connect individual or small groups of facilities to the backbone. Fiber optics and/or digital microwave radio are usually the technologies of choice for backbone transport, whereas the spurs may combine these technologies with less robust alternatives such as copper twisted-pair wire lines, power line carrier, VHF and UHF radio links, and unlicensed wireless systems. Common carrier leased services are used only sparingly in most cases, for low-criticality applications in locations where privately owned alternatives are cost-prohibitive.

These utility WANs have served traditional applications like SCADA/EMS, distribution automation (DA)/demand-side management (DSM) and automatic meter reading (AMR), now popularly encompassed as part of the Smart Grid (see Figure 1). The number of locations requiring communications service increases and the criticality of each location to the integrity of the overall grid decreases as these applications are pushed deeper into the distribution system (i.e., farther out from the primary substation and closer to the customer). Historically, this combination of increasing costs and decreasing benefits has been the primary obstacle to deployment of more feeder-level and customer-level applications such as DA/DSM and AMR/advanced meter infrastructure (AMI). When such applications were deployed, costs were controlled by limiting communications to one-way systems like broadcast radio signals or narrowband, high-latency systems such as power line carriers or dial-up phone lines.

Networks for the Future

Today, the political and regulatory impetus for wider deployment of Smart Grid applications, especially their deployment all the way to the customer premises, has resulted in pressure on utility engineers to solve the problem of establishing robust data transport WANs to the distribution feeder and customer level. The proliferation of information technology utilizing Internet protocol (IP) transport over Ethernet has made IP the de facto standard for data transport. What is needed is a nearly ubiquitous IP transport network operating at bandwidths robust enough to handle traditional utility power delivery applications along with vast amounts of new data from the Smart Grid. These networks need to be scalable enough to handle future applications as they come.

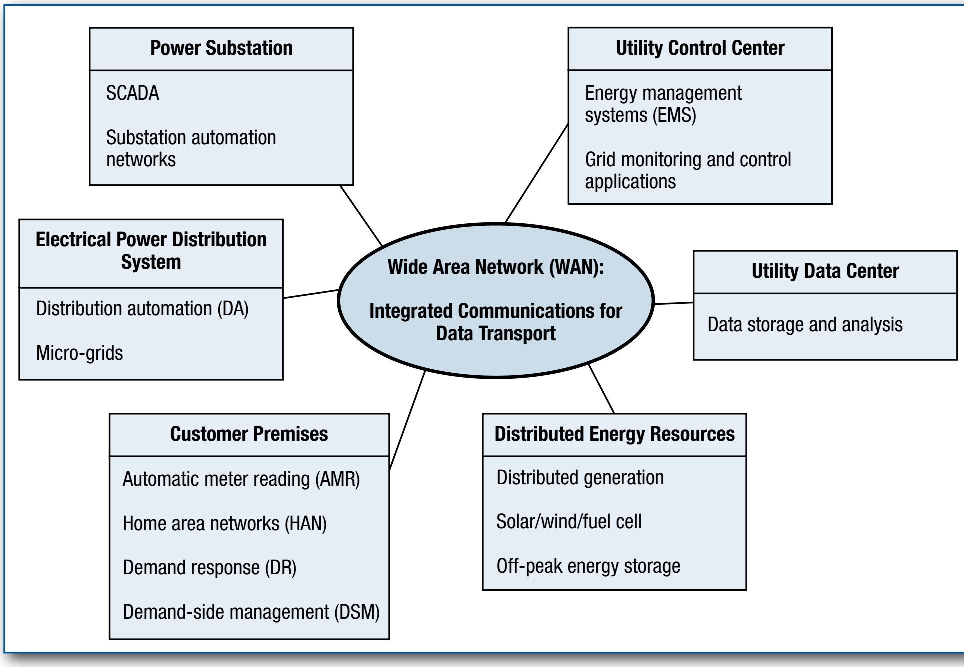

Figure 2: A utility WAN under Smart Grid applications is required to handle more robust data transport.

Communications for Smart Grid data transport require that utilities address both the backbone and the spur segments. Most electric utility communications backbones today are based largely on traditional time-division multiplexing (TDM) digital architectures. TDM technology, while highly reliable, was originally developed for the transport of point-to-point constant-bit-rate voice communications and is not necessarily suited to cost-effective transport of point-to-multipoint “bursty” data traffic required in an IP environment. The Smart Grid will require that these backbones be upgraded to backhaul Ethernet/IP data traffic at speeds ranging from one to 10 gigabits per second in a highly reliable manner. Rather than replacing their legacy TDM networks, many utilities will opt initially to overlay these existing networks by overbuilding gigabit Ethernets on unused fiber, and licensed or unlicensed broadband wireless networks over existing microwave paths.

Last-Mile Challenges

The deployment of spur or last-mile communications for the Smart Grid, typically from a backbone node to the customer premises, offers additional challenges: First, the network must cover a large area, especially if coverage of residential customers is to be provided. This has prompted some utilities to take a phased approach, deploying the Smart Grid to large-load industrial and commercial customers initially, since the bulk of the benefits of Smart Grid follow the bulk of the electrical load, while residential applications may remain on the back burner, waiting for a clearer quantification of benefits. This balanced approach may make sense economically but may have broad ramifications politically as rates rise and residential customers (voters) demand relief.

Second, the proper balancing of performance and cost is less clear for these last-mile applications. Losing communications with a small percentage of the DA or AMI for at time, while undesirable, would pose no real threat to the safe and reliable operation of the overall power grid. Communications with a single customer or residence do not require the bandwidth and performance needed in the backbone, so low-speed communication devices with marginal signal strength that may require multiple retransmissions to complete a message can be tolerated. These issues raise questions like, “How reliable is reliable enough?” “How fast is fast enough?” and “At what cost?”

The relaxed performance and reliability constraints in the last mile also mean that the number of technology options available for this portion of the WAN are more plentiful. Technologies like meshed Wi-Fi, packet-based store and forward radio networks, and broadband-over-power line (BPL), not considered reliable or robust enough for the mission-critical infrastructure backbone, are viable options for the last mile. Likewise, public

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Look for part one of this Smart Grid series in the 2008 No. 3 issue of *TechBriefs* at www.burnsmcd.com/techbriefs.

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carrier and CATV-based services like broadband cable modem, digital subscriber line (DSL) and cellular-based wireless data networks may also make sense where utilities can negotiate bulk service rates.

Data Integration and Management

Once the DA or AMI data is efficiently transported, a completely new set of data integration and management issues will challenge utilities technically and culturally. The Smart Grid will generate billions of data points from thousands of system devices and hundreds of thousands of customers. Data must be converted to information through a knowledge-management life cycle in which the data from meters and appliances or substations and distribution systems are analyzed and integrated in a manner that leads to action. A data-to-information-to-action plan will develop as a better understanding of load factors, energy usage patterns, equipment condition, voltage levels, etc. emerges through analysis and is integrated as functional information into usable customer programs and/or operation and maintenance algorithms that identify, trend and alert operators to incipient failure.

The first phase of the knowledge management effort and a key component in the system of information ecology is data conservation in a data warehouse. Data storage needs will explode. Data security will be important, but some of the best system or customer programs may result by allowing engineers and operators the opportunity to freely analyze some or all of the data. IBM, Oracle and Microsoft recognize the huge growth potential and are visibly promoting their solution concepts.

The Smart Grid is expected to be fully functional by 2030. Data collected, analyzed, visualized and warehoused from the Smart Grid will contribute to many new ideas and inventions that can improve lives.

Dennis M. Klinger, vice president of information management services for Florida Power & Light, calls this "moving at the speed of value." In an era of serial rate increases, customers will demand value, and utilities must deliver that value. This will be the future of electricity.

Customer Programs

The future of electricity begins with the customer. Integration and management of system and customer data can lead to the ability to analyze warehoused information in a manner that improves operational efficiency and reliability, but most importantly, provides sustainable options for customers. Sustainable options will include demand response and demand-side management programs for all customer classes that include a home area network (HAN) plan for residential customers, allowing prices to devices supported by ultra-simple rate plans. Data will become information used for action.

Scheduling Savings

The HAN is a computer automation system for the home (or small commercial business) that integrates devices through the Internet and with the electric utility to allow the user to be proactive in the use or generation of energy. The HAN will play a major role in making the grid more efficient and in moderating rate impact for the customer. The HAN begins on the customer side of the meter and will be made up of plug-in hybrid electric vehicles, renewable and/or distributed generation, HVAC systems, pool pumps, intelligent appliances and plug-load consumer devices like MP3 players, cell phones and iPods authenticated to the electric utility on a secure network owned by the owner. The owner will have the ability to control the operation of devices on the HAN from a computer to maximize the advantages for demand response (DR) or DSM rate structures offered by the electric utility.

Improving Load Factors

DR is a voluntary rate structure that typically lowers a customer's general rate per kilowatt-hour in return for the utility's option to curtail power as needed during system peak loading events. DSM is the effort to incentivize customer use through simple time-of-use rates that generally correspond to the cost of producing electricity. DR and DSM shift electric load and improve the electric utility's

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load factor and should not be confused with energy efficiency programs that reduce load and, therefore, sales. The current regulatory construct allows utilities a reasonable rate of return, or profits, on prudent investments and the cost to operate and maintain those investments. Some utilities seek to decouple their sales from profits since energy-efficiency programs lower sales as less electricity is consumed. Decoupled sales and profits theoretically make the electric utility indifferent to energy efficiency programs and distributed generation but remain a controversial issue in the industry. Cyber security, ownership of customer data, standardization of device protocols for low-power personal networks, customer acceptance of DR and DSM programs and other issues are also sources of controversy in HAN build-out.

Where Next?

Regulators and lawmakers are not passively waiting for utilities to offer solutions to the serial rate increases that are coming. Regulatory action is being taken and the desired result is clear. The Smart Grid must provide sustainable options to customers. Allowing customers to make sustainable decisions on the use of electricity and, ultimately, satisfy regulators will provide for full rate recovery and return on investment. That done, utilities can move at the speed of value to confidently use the Smart Grid to achieve other security, reliability and efficiency objectives.

These other objectives may include more efficient meter reads and billing, better customer service, theft/tamper detection, turn-on/turn-off service, advanced pay services, load forecasting, asset management, transformer sizing, power quality improvements, and a myriad of other efficiencies and services that will be developed in the years to come, when today's electric grid becomes the Smart Grid.

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