Real-time Open Decisive Network Infrastructure for Smart Grid

Sanjeev Puri, *Member, IACSIT*

Abstract—A growing recognition of the need to modernize the grid to meet tomorrow's challenges has found articulation in the vision of a Smart Grid; a vibrant market is needed between supply and demand. IP addresses of running multiple applications and devices on the same network focused on interoperability. Smart Grid success depends on supervisory control and data acquisition in open decisive architecture (ODA). ODA improves operational efficiency, promotes transparency, and enables business insight and automatically produce plans to respond effectively. Smart grids will integrate communication networks with the power grid to create a real-time view of the electric network capable of monitoring its own health at all times. To meet specific energy standards for reliability, utilities are actively seeking out technologies that will address these concerns.

Index Terms—Smart Grid, IP addresses, Interoperability, ODA, Energy Standards, Utilities

I. INTRODUCTION

The Smart Grid is a vision of a better electricity delivery infrastructure. Smart Grid implementations dramatically increase the quantity, quality, and use of data available from advanced sensing, computing, and communications hardware and software. As a result, they help utilities address two of today's most important business drivers: environmental concerns and power delivery constraints and disturbances.

The effective use of smart grid technologies helps utilities to optimize grid use, improve grid efficiency and security, better align demand with supply constraints and grid congestion, enable distributed generation (especially from renewable sources) and empower customers to manage their consumption and take advantage of pricing and supply options. In Smart Metering, an Advanced Metering Infrastructure (AMI) of interval meters and two-way communications systems serves as a gateway for utility/customer interaction. Smart appliances and near-real-time usage displays or messaging enable customers to participate in a variety of utility programs for conservation, peak demand reduction, load shifting, and carbon footprint reduction.

Smart Metering has the potential to reduce both customer and utility costs. It helps customers reduce overall use and better respond to price incentives. It reduces such utility costs as meter reading, turn-on/turn-offs, and contact center responses to bill estimations. In a larger context, Smart Metering will enable deferral of new electricity generation plants. It will also help utilities avoid building new transmission and distribution infrastructure by reducing peak-demands and the related capacity constraints. That

reduces not only the huge infrastructure costs but also such negative environmental effects of energy use as greenhouse gas emissions and landscape-damaging transmission.

Smart Grid success depends on the successful handling of two major IT issues: integration and data handling. Integration and data handling are components of what some refer to as enterprise information management (EIM). EIM is an integrative discipline for structuring, describing and governing information assets, regardless of organizational and technological boundaries. It improves operational efficiency, promotes transparency; enables business insight. Smart Grids require integration among appropriate applications so that Meters act as grid nodes. Smart Grid integration brings with it an exponential growth in the amount of data that must be gathered, verified, stored, and transformed in near real time for intelligent responses and decision support.

The service industry has enacted a number of initiatives with a common goal – improving the quality value and long-term sustainability of electricity delivery with improves customer services. Today the focus has broadened to a number of related applications leveraging the same technology assets. Dynamic pricing programs hold great promise for flattening the load curve, but require more sophisticated and granular measurement. This expansion of demand response creates significant opportunities in both commodity hedging and customer services, but it may also change the economics of distributed generation. The convergence of these varied and interrelated applications is creating exciting opportunities to reshape the nature of electric delivery.

Utility leaders are developing comprehensive strategies to implement and support a variety of new applications that move well beyond meter reading. To create a "smart grid"-The right network brings smart devices "on line" and allows for real-time command and control of the entire distribution system. Utilities ability to realize the vision of a smart grid is largely determined by their choosing the right network infrastructure: one that is functionally capable and cost-effective. Today, yet it will support future (and often unknown) requirements. Advanced networking from the substation to – and into – the premise creates the fundamental platform on which smart grid initiatives are built. The right network infrastructure provides secure and seamless connectivity, supporting any utility application. Innovative, standards-based applications can leverage smart grid assets, turning new concepts into new products. The practice of a common network infrastructure supporting a number of applications is not new. For example, consider the

Ethernet system installed in most offices. When the

network was installed, it was intended to support a variety of applications, including email, Web browsing, video delivery and more. However, it was not necessary to decide up front all of the computers, printers or applications that would ever run over that network. By choosing standards based network with the right performance characteristics, new technologies are easily and seamlessly incorporated onto the network.

II. OPEN DECISIVE INFRASTRUCTURE

As in complex as electricity market, the value derived from that exchange will depend in large part on how the interactions of supply (utilities) and demand (household and commercial customers) are carried out. The process of designing an appropriate marketplace will require an exploration of how these elements overlap, and where the exchanges of information, money and energy are best carried out. The Three Pillars of the Smart Grid are:

A. Smart Customer: The set of technologies that exists or are under development by which electricity consumers will be able to observe, directly control, or allow local intelligent devices to control their electricity consumption.

B. Smart Utility: The utility that is implementing sophisticated monitoring, digital controls, and location pricing; reaching out to its customers with programs/plans for “smarter” consumption.

C. Smart Market: The structure of the market that allows for the integration of the technologies, decision logics, and information at the customer and the utility end to create an economically efficient solution. The industry brought to bear in computing, communications and devices has obvious applicability in energy distribution, monitoring and management.

The first step in implementing the right network requires a utility to develop a strategic plan and define the technical, performance and price characteristics needed to support both current and future applications. Input from all areas of the utility operation should be included, as all departments are affected by – and can benefit from – the smart grid. Operational use cases that consider both current and anticipated needs should be reviewed, including representation from customer service, metering, distribution operations, information technology, revenue protection, regulatory and rate making.

Next, technical requirements of the advanced utility network need to be defined to support the operational requirements of the business. Given the variety of devices and interrelations between several applications, use of single-purpose or proprietary networking should be avoided. Implementing these technologies increases complexity and cost, while simultaneously decreasing long-term flexibility. Standards based networking is the safest, surest route when specifying the network infrastructure of the smart grid.

The technologies required to improve utility performance can be understood by reviewing the conceptual goals of a smart grid. This network management solution should be capable of detecting abnormal conditions, analyzing the magnitude and extent of network problems, and automatically reacting. Each step requires modern

technologies. In some cases, these technologies are partially in place and have been used for decades. One example is field devices that can operate to protect other network components. Some emerging technologies, like automated meter reading, also can be used as a technological component of a smart grid.

Monitoring and detection technologies will use bi-directional communication to maintain this healthy network. It will alert officials when problems arise and automatically take corrective action. The sensing technologies will communicate status of analog and telemetry data from the field devices to monitoring systems. These monitoring systems will analyze the data and automatically generate switch plans, work orders, or take immediate actions to self-heal grid components or network sections.

The smart grid software application is a single application that presents a variety of information to system operators. Consider combining all the daily activities performed by system operators today. Often these operators use the Supervisory Control and Data Acquisition (SCADA) system to initiate switching procedures. It is also common within the SCADA system for users to place tags on the network to present information to other system operators. With Smart Console, the operator will no longer perform these switching and tagging procedures in a separate application.

The dominant standard in networking is Internet protocol (IP). Beyond the World Wide Web, IP is the networking standard used in managing nearly all telecommunications, cable and information technology applications. The IP suite delivers proven technologies for addressing, routing, quality of service and a host of related networking functions, all demonstrated at scale. With IP, vendors can compete to develop best-of-breed products for a variety of applications, yet share a common network infrastructure to minimize cost and complexity.

Figure1: Smart grid systems detecting abnormal conditions, analyzing the magnitude and extent of problems, automatically producing plans to respond effectively

III. SECURITY TECHNOLOGY IN SMART GRID

Historically, security in many remote utility applications consisted solely of “obscurity” created through the use of proprietary products or the use of simple passwords that were rarely changed. The move to sophisticated command-and-control applications mandates significantly more proven and robust security across the entire grid.

A number of proven IP security technologies (for example, IPSEC or SSL) are available to address this need. These technologies are widely used in a number of industries, including securing financial transactions over the web, to manage a range of security concerns. Most

importantly, these technologies are constantly improving due to the collective efforts of countless vendors. IP suite security technologies allow utilities to effectively address concerns of spoofing, denial of service and unauthorized access without computers that connect using a variety of transports, it should be possible for a utility to choose the physical transport that best achieves the business case for any particular part of its service territory (for example, wireless for urban or suburban, power line for rural). Such flexibility can be achieved by utilities in the same way that it is achieved by enterprises: by deploying standard, interoperable, IP-based products rather than proprietary, transport specific ones.

IV. SOLUTIONS VS. PERFORMANCE

Two critical issues when developing the technical requirements of the smart grid network are those of available bandwidth and latency. Bandwidth is the volume of data per unit time that can move through the network. The first step in determining your requirements is to scope how much data is required from each device and application. Add them up on a time sensitive basis. Where are the peaks?

Where does it break? Does the solution allow you to add bandwidth if needed in the future? Although smart grid applications generate significantly more data than monthly meter reading and historic low-density, one-way demand response applications, it is not a large volume of data relative to modern IT systems. Take the very familiar example of a manual meter read: Manual meter reading generates approximately 30 bytes per month of data, per customer. A new smart meter, collecting multi channel, 15-minute interval data with event logs, security logs, power quality and other measures might generate over 10,000 times as much – perhaps 50 to 60 KB of data per meter, per day. In an environment of application specific, low-bandwidth solutions, it may seem that this much data could never be supported, nor would ever be necessary.

Solutions from the traditional IP-based networking world, deployed in utility networks today, render it possible for utilities to move and manage much larger amounts of data than heretofore possible. It is no longer necessary for utilities to constrain their business operations – or for that matter, their

Imaginations – based on the limitations of their vendors' technology. Latency is equally important. Many smart grid applications, including distribution automation, outage alarming and load control signaling, require very low latency, while others, such as metering, are more latency-tolerant. Smart grid networking needs to support end-to-end and device-to-device latencies not of minutes or hours, but of seconds and milliseconds. To manage traffic appropriately, networking technology must support message prioritization, allowing critical, and latency intolerant messages primacy to other network traffic. For example, meter-reading acquisition is generally expected only within a time window measured in minutes or hours, while some DA applications require that remote devices talk "across" the network (without routing through the back office) in less than a second.

Since SCADA is just one of the applications a smart grid

combines, consider other workflows that have once required duplicate work. Many utilities are manually creating and maintaining several network models. With a smart grid solution, there is a single network model. This master network model will be exposed to network analysis tools and SCADA. This is particularly useful when utilities create and execute switching procedures. The result is a single operator console that will permit network management, order creation and assignment, network analysis, and crew management.

Balance Drives Value Hardware economics historically limited the deployment of multi-application networks, forcing utilities to implement vertically integrated, application-specific solutions. While these solutions often solved immediate needs, they also created significant back-office integration issues, increased operational complexity and increased long-term costs. Many utilities hoped that solutions offering greater bandwidth, such as broadband over power line (BPL) would address this need. Current hardware economics now make it possible to deliver high-bandwidth, low-latency networking at reduced cost.

It is now possible to deploy a system wide networking infrastructure delivering hundreds of Kbps and sub-second latencies at a fraction of the cost of broadband. Specific pricing varies based on utility specifics, but can typically rival traditional AMR/AMI network pricing. This results in the utility realizing significantly greater benefits from a variety of applications while simultaneously saving 30 to 40 percent in operational costs versus operating separate communications solutions for each application.

Regardless of the applications or devices that emerge, a standards-based network ensures that they can easily be incorporated into the smart grid. As exhibited in other industries, including cable, IT and telecom, a robust and flexible network is the basis for competitive advantage. An IP-based network allows a utility to network devices not yet invented, if they are built on IP. Product development cycles for devices are much faster than the life cycle of the network, so one must expect new devices will become available and utilities will need to connect them.

V. CONCLUSION

The Right Network Utilities around the world are now leading the drive to capture energy efficiency as the "fifth fuel." Smart grid applications including advanced metering, demand response, distributed generation and distribution automation offer utilities all the tools to capture this value. By specifying and implementing the right networking infrastructure, utilities are building a strategic technology platform that enables a wide range of policy and business initiatives for years to come, avoiding concerns of near-term obsolescence or functionally bridling technologies. IP-based networking is really the only choice when building the network infrastructure for the future.

VI. RECOMMENDATIONS

The Smart Grid development life cycle should assume successful penetrations and attacks from external sources as well as disgruntled insiders. SCADA systems manage the

ongoing operations of transmission and sub transmission lines and equipment between the generator and substation. The Smart Grid should have the ability to isolate large grid segments from compromised segments in near real time to prevent a contaminated section from infecting other large areas of the grid along with algorithms to validate positive intrusion indications.

REFERENCES

- [1] The NETL Modern Grid Initiative, "A VISION FOR THE MODERN GRID," Conducted by the National Energy Technology Laboratory for the U.S. Department of Energy Office of Electricity Delivery and Energy Reliability, March 2007
- [2] 'Grid 2030: A National Vision for Electricity's Second 100 years', July 2003, United States Department of Energy, Office of Electric Transmission and Distribution, <http://www.ferc.gov/eventcalendar/files/20050608125055-grid-2030.pdf>
- [3] 'The Smart Grid: An Introduction', US Department of Energy publication, http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages.pdf
- [4] Rand Science and Technology Report. 2004. Estimating the Benefits of the Grid Wise Initiative.
- [5] Order Code RL34288, Congressional Research Service Report for Congress, Smart Grid Provisions in H.R. 6, 110th Congress.
- [6] Sentec Presentation. 2006. Smart Meters for Dumb Markets: TheGlobalExperience. <http://www.sentec.co.uk/pdfs/ceftalkv1.pdf>.

A. Author: Sanjeev Puri, Member of IACSIT, MSc. (CS) & MCA from MD University, Rohtak, India-passed in 2001-02, MPhil (CS) from VMU, Salem, PhD(CS) perusing currently from Integral university, Lucknow, U.P., India. The author's major field of study is grid computing. He has the 8+ yrs academic experience worked as Ass. Professor as well as industrial experience as SE of C/C++ platform in Goyal computers, Lucknow Now He is ASS. PROFESSOR, SITM, Deptt. of Computer Science & Engg., UP Technical University, Lucknow, U.P., India. His articles have published in many international journals. Mr. Sanjeev Puri is associate organization member of AIMA, New Delhi, Best faculty award at SRMCEM, UPTU, Lucknow, India in 2003. Best Course Coordinator by NIEC in 2006. E-mail:purispuri_2005@rediffmail.com