Session Six:

Industrial Wireless Ethernet Systems: Implications & Applications for the Smart Grid

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Abstract

Electrical systems worldwide are being upgraded and/or expanded by the introduction of demand-response systems, alternative energy sources (wind, solar, etc), and home metering. The net result is a wide cross-sections of technologies that are intertwined into what is being called the Smart Grid. Potential applications for industrial wireless ethernet systems in this arena abound - and will be reviewed.

Introduction

Vendor advertisements and public policy statements from various governments would lead the casual observer to believe that the "Smart Grid" is a shiny new effort. While the government efforts in the USA and elsewhere brought attention to the realization that the electrical grid needs updating, thankfully a great deal of thought, planning, technology development and integration has been underway throughout this decade. Such efforts have culminated in large and small demonstration projects being conducted around the world on various aspects of what is now lumped together as the "Smart Grid".

The components of the Smart Grid (SG) may be viewed as fitting in the generic areas of Figure 1. Therefore your perspective of the Smart Grid could be that it is providing the customer with information about your electricity consumption and usage patterns via smart meters.

Customer Side of the Meter	**At the Meter**	**Distribution System**	**Bulk Grid**	**Generation**

Figure 1. Elements of the Smart Grid may be generalized into these areas.

The role of communications within the information exchange between each box of Figure 1 is fundamental to the efficient operation of the electricity delivery system. The change to the existing paradigms for power delivery and billing lie in devices in each area that are able to provide data to the customer/consumer as well as the generating utilities. Consider simply the meter itself: millions of electromechanical meters based on Thomson's design where approximately 2W are used to rotate an aluminum disk where the total number of revolutions are proportional to the current that has passed through the device. Millions of such electromechanical meters are installed worldwide. Advancements in this design have concentrated on embedding techniques for monitoring other electrical parameters (power factor, reactive power, etc) coupled with methods of communicating in both directions from the meter.

The SG requirement for allowing the customer/consumer to have visibility – and potentially some level of control – into their electrical power consumption implies that the installation process and information relay/visualization be easy. When distilled, this leads to numerous organizations touting their methods of displaying the information to the home user. The typical method involves some application running within a device that is installed on the customer premise, then the customer accessing the application (webservice) for the presentation of the values. The need for ease of use and installation necessitates a high level of integration of the components and communication protocols – most notably IP.

Body

Another view of the elements to provide the underpinnings of the end-to-end communications of Figure 1 shows the various technical elements that are involved. Such a view of multiple components that make up the Smart Grid is presented by Figure 2.

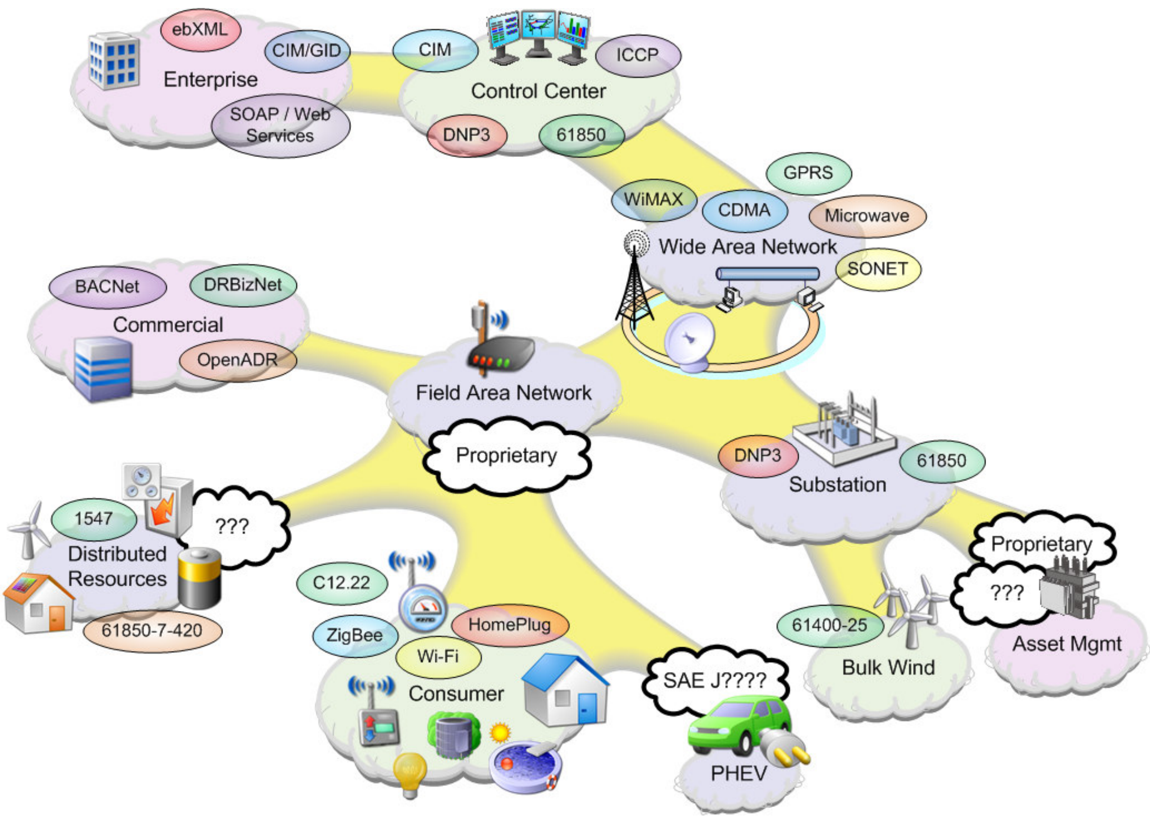

Figure 2. Representation of components of the "smart grid".

Individuals with emphasis on certain areas within the Figure 2 components can see how addressing, security, and communications in general may be enhanced by relying on Ethernet for the data transport method.

A further refinement of the smart grid areas of Figure 2 can be made along different types of networks. Consider the situation where the "consumer network" - also referred to as a home automation network (HAN) - connects into the utility's Field Local Area Network (LAN) which then connects to some flavor of wide area network (WAN). The data flow from the home then reaches the enterprise network for activities such as centralized billing. The communication path doesn't end there for the utility corresponds with power generators (etc) in the External network. There are a wide range of users and organizations that rely on this data communication path – with some manner of reliably of this data transport network dictated by a maze of regulations. The U.S. National Institute for Science and Technology (NIST) has coordinated a "crosswalk" through the numerous standards and regulations that are applicable for the various Smart Grid sectors. The situation is shown in Figure 3.

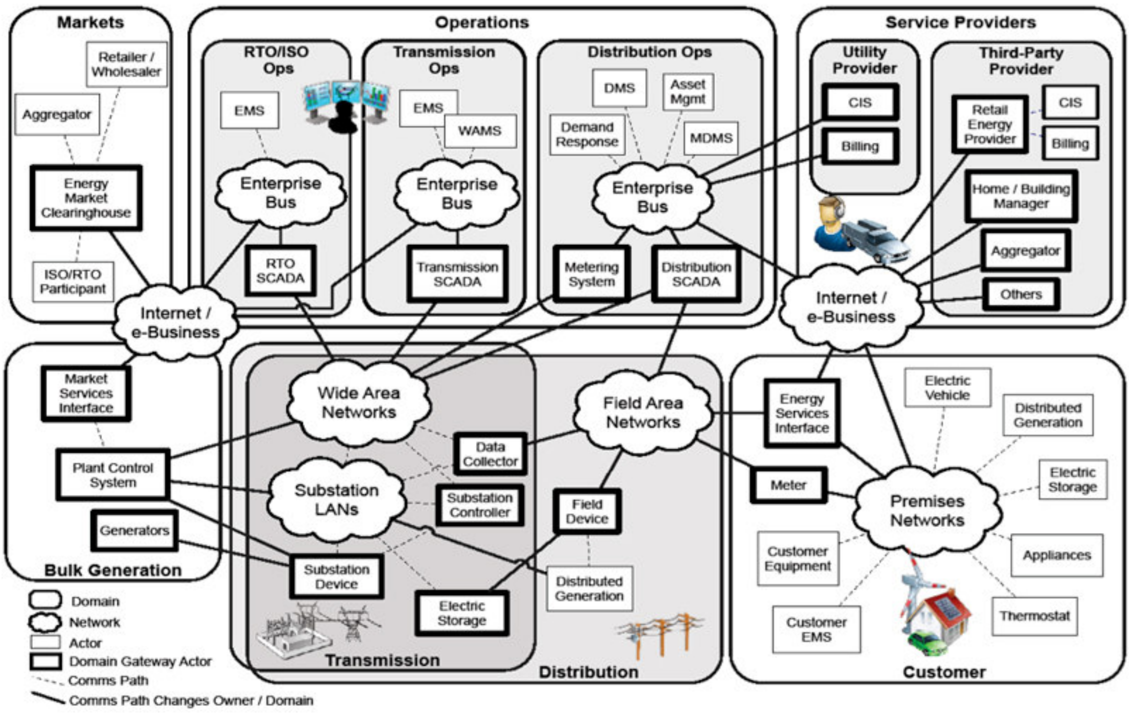

Figure 3. NIST diagram of the Smart Grid.

With such areas identified, it becomes easier to delve into the groups that are depicted in Figure 3. An attempt to illustrate the standards and possible technologies is shown in Figure 4.

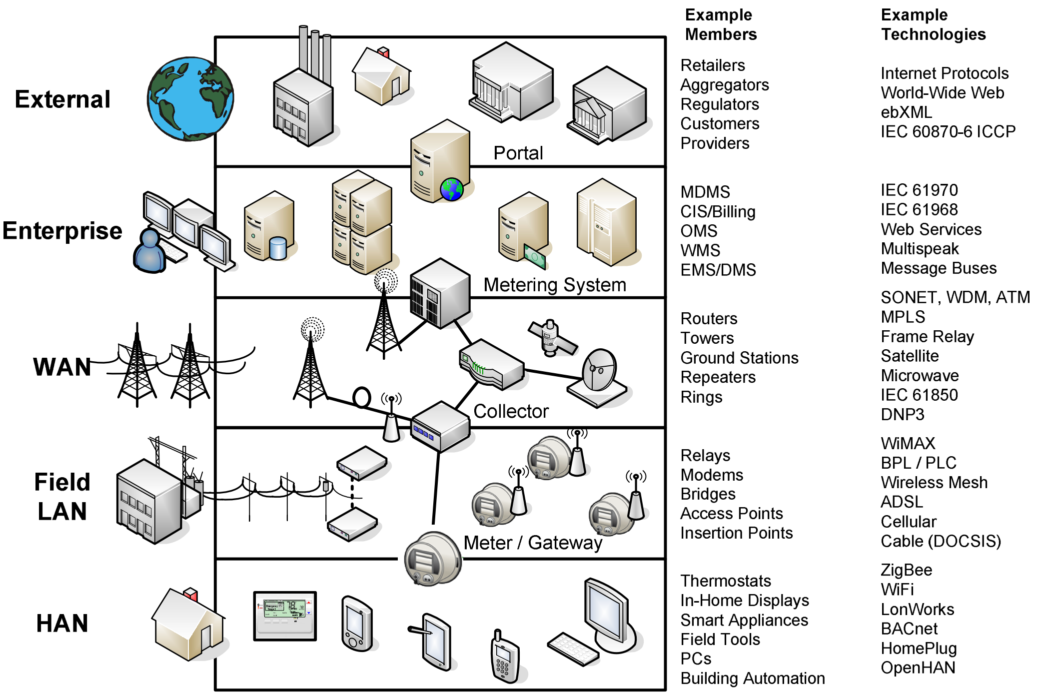

Figure 4. Vertical look at the integrated communications networks used in smart grid.

A more detailed look into the communications aspects of the smart grid may lie in the examination of Figure 4. Organizations such as the ISA Power Industries (POWID) group have stipulated that in order to meet the demand response aspects of the SG, the communication system must have a latency that is less than 100 ms. This operational requirement provides a method of sorting through the various technologies that could be used. The understanding that IT-"friendly" technologies must be deployed has led to detailed examination of using TCP and/or UDP for transport protocols. This type of detailed analysis looks at complex application interaction with real-world utility systems such as that of the Long Island (NY) Power Authority's which is shown in Figure 5.

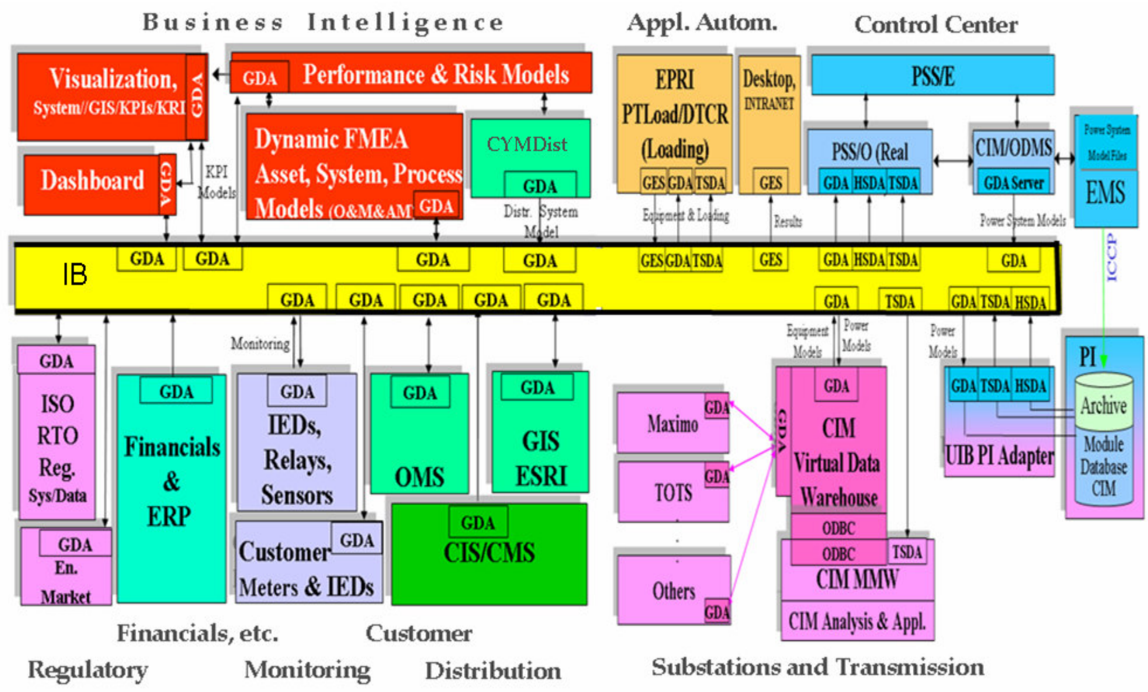

Figure 5. A bewildering array of applications intersect and interact within a utility's integrated system such as this provided by the Long Island (NY) Power Authority.

Summary

The multiple aspects of the Smart Grid cross a wide array of technologies and utility needs. The U.S. Department of Energy's sponsorship of the NIST/EPRI efforts in Smart Grid technology assessment have yielded the Priority Action Plan shown in Figure 6 – with the #1 item being the role of IP in the communications aspects of the Smart Grid.

	NIST Priority Action Plan	Climate	Economics	Reliability
1	Role of IP in the Smart Grid		x	
2	Wireless Communications for the Smart Grid		x	
3	Common Price Communication Model		x	
4	Common Scheduling Mechanism	x	x	
5	Standard Meter Data Profiles		x	
6	Common Semantic Model for Meter Data Tables		x	
7	Electric Storage Interconnection Guidelines	x		x
8	CIM for Distribution Grid Management	x		x
9	Standard DR Signals		x	
10	Standard Energy Usage Information	x	x	x
11	Common Object Models for Electric Transportation	x	x	
12	IEC 61850 Objects/DNP3 Mapping			x
13	Time Synchronization, IEC 61850 Objects/IEEE C37.118 Harmonization			x
14	Transmission and Distribution Power Systems Model Mapping			x

Figure 6. The NIST Smart Grid prioritized list.

References

1. "Smart Grid Research Highlights", Angela Chuang, EPRI, Presentation to ASERTTI, October 2009.

2. "The Smart Grid: An Introduction", prepared for the U.S. Department of Energy by Litos Strategic Communication under contract No. DE-AC26-04NT41817, Subtask 560.01.04, www.energy.gov.

3. Report to NIST on the Smart Grid Interoperability Standards Roadmap, Prepared for NIST by EPRI under Contract No. SB1341-09-CN-0031—Deliverable 7, June 2009.