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Advanced Metering Infrastructure: A Survey

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Abstract

This article is a summary of a larger research project on Smart Grid (SG) and the function of AMI in SG. The poll was taken as part of research on the viability of establishing a Net-Zero neighbourhood in a city in Ontario, Canada. SG is not just one kind of technology but rather an amalgam of several disciplines across engineering, communication, and management. As the backbone of SG, which is in charge of gathering all the data and information from loads and consumers, this article presents AMI technology and its current position. Along with DSM, AMI is in charge of creating control signals and directives to carry out the required control activities. In this work, we provide an overview of SG and its characteristics, clarify the connection between SG and AMI, describe the three primary components of AMI, and address relevant security concerns.

Introduction

As new problems and concerns arise in the 21st century energy industry, upgrades to the electrical infrastructure are unavoidable. Alterations to the traditional methods of electricity production, transmission, and distribution have resulted in some unexpected difficulties. Introduction of Distributed Energy Resources (DER), enhancement of delivered power quality, environmental concerns over conventional and centralized methods of power generation, consumer data privacy and system security against external cyber or physical attacks, the economics of power systems, ranging from maintenance costs to equipment renovation and network expansion, and the need for reliable and affordable power are just some of the challenges facing the power industry today. The established control methods must be adaptable to a wide range of uncertainties arising from the interconnection of electrical storage systems with the grid, as well as the distribution of loads and the incorporation of new energy sources [1]. While reliability and cost-effectiveness in the electricity grid have long been priorities for utility companies, the introduction of new technology has introduced new threats to data security and privacy. DER's importance in the system's sustainability as a renewable energy source cannot be overstated. Although distributed energy resources (DERs) contribute to the answer, they are not simple to implement since they increase the control system's complexity. In response to these issues, several countries in Europe and North America have implemented Smart Grid (SG) technology into their power infrastructure. Power grids have been around since the late 1800s, but the 1960s were their heyday in the industrialized world.

Centralized power production in fossil, hydro, and nuclear facilities was technically and commercially booming throughout this time period, while distribution networks had high penetration rates and load delivery capacities. Electricity consumption rose in the latter part of the twentieth century as a result of the proliferation of new end-users, such as the entertainment sector, and the widespread use of electric heating and cooling systems. This last result was caused by the ever-increasing cost of fossil fuels. In addition, the rate of energy use varied widely. More power plants were needed to keep voltage from dropping and electricity quality from deteriorating as peak demand rose. The price of the additional facilities was high, however. However, because of reduced consumption rates throughout the night, the facilities' output capacity was idled due to an imbalance in consumption. Therefore, the energy business modified its approach to Demand Side Management (DSM) in an effort to persuade customers to better control their use via the provision of incentives. In the 21st century, breakthroughs and developments in several fields have allowed the Smart Grid idea to be improved. Adaptive billing mechanisms can now financially incentivize consumers to shift their consumption to off peak times, thanks to advancements in IT and communication industries, as well as the introduction of smart sensors, which previously posed a barrier to accurate measurement of individual consumers' consumption. Decentralized generation is the result of the incorporation of renewable energy like wind, solar, tidal, or geothermal into electrical networks in response to both technological advancements and environmental concerns. Power management problems inspired the creation of electrical storage systems [2].

Advanced Metering Infrastructure (AMI)

A series of sub-systems must be realized in order to complete the intelligent grid. Overall SG performance relies heavily on the sound installation and operation of its many sub-systems, since the output of one layer feeds the input of the next. This connection is shown in Fig. 1 along with a brief summary of the part played by each subsystem in the evolution of the grid in [4]. Instead of being a single piece of equipment, AMI is a system of interconnected components that work together to accomplish a goal.

Fig. 1. An overview of Smart Grid sub-system sequence.

goals. Meter data management systems (MDMS) and the ability to incorporate the data into software application platforms and interfaces are all part of the infrastructure [4]. Smart meters and communication networks at various tiers of the infrastructure hierarchy are all part of the infrastructure. Figure 2 shows the customer's high-tech, solid-state electronic meter, which logs information in real time. Broadband over Power Line (BPL), Power Line Communications, Fixed Radio Frequency, and public networks like landline, cell phone, and paging may all be used to transfer data gathered by these meters. The AMI host system receives the consumption data from the meters.

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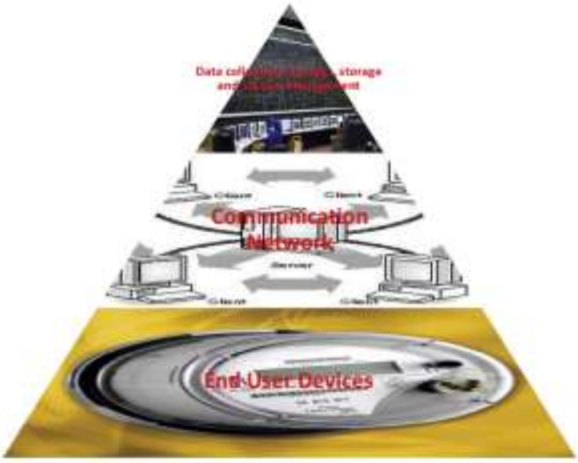

Fig. 2. Schematic representation of AMI.

The data is then sent to a meter data management system (MDMS), which handles data storage and processing before delivering the results to the utility service provider. Since AMI allows for two-way communication, the utility may also provide commands or price signals to the meter or load regulating devices [5].

AMI security issues

Both internal and external threats to SG and AMI are growing in significance with the exponential growth of the number of smart meters. Understanding a customer's lifestyle requires accurate consumption data. Data may be compromised during transmission over vast distances or when stored in many locations before being re-transmitted or analysed. Cybercriminals and terrorists may target the consumer end's price signal and orders for espionage, infrastructure damage, or power theft. In addition, consumers' confidence in smart meters and the growth of AMI is crucial to their success. Consumers may oppose the use of AMI if they fear that their private information will be used without their consent, or if they have to deal with subpar service or electricity as a result of intrusion by hackers or other unauthorized users. Consumers' choice will also be influenced by concerns about health risks and increased utility costs resulting from the installation of such smart meters. The government is concerned about these problems and is developing protocols to protect the personal data of its citizens. The government is also running initiatives to educate the public about smart meters and allay their valid health and financial worries. Technicians in the field of installation and utility provisioning also contribute significantly.

Keeping personal information private, protecting the system from cyber or external assaults, and preventing power theft are all discussed in this article to illustrate the breadth and depth of the security problem and to emphasize its significance.

Compatible subject matter

Protocols and standards

To effectively communicate inside a network, a common language and set of norms are essential. Bringing all the players under one roof may seem like an impossible task, but a lot of preparation has already been done. ZigBee, ZWave, BACnet, Lon Talk, Modbus, C-Bus, 1-Wire, xPL, xAP, x10, VSCP, oBIX, and a few more are among the most popular protocols now in use for building automation. ZigBee, Modbus, M-Bus, DLMS/IEC62056, IEC61107, and ANSI C.12.18 are the most used protocols for Automatic Meter Reading (AMR). In AMR/AMI, or Demand Side Management more broadly, DLMS/COSEM serves as the universal language for all involved parties. The Device Language Message Specification (DLMS) is a high-level framework for representing abstract communication elements. Data communication with energy meters is governed by COSEM, or the Companion Specification for Energy Metering, which is based on previously established standards.

DLMS/COSEM's purpose and role are best described as:

- First, an object model of the meter's interface(s) and the functions they expose.
- All metering information must have a unique identifier.

- Third, a means of exchanging messages with the model and encoding information as a string of binary digits.
- A transit mechanism for transmitting data from the meters to the data aggregation system

DLMS is supported by the DLMS User Association, which also created it. The worldwide Electrotechnical Commission (IEC) TC13 WG14 has taken up the development of worldwide DLMS standards as the IEC 62056 family of documents. COSEM comprises a collection of specifications that specify the Transport and Application Layers of the DLMS protocol [29], while the DLMS User Association handles the new standard's upkeep, registration, and conformance testing. DLSM includes four categories of requirements:

Book of Green:

detail the structure and processes in your description. The conformity testing questions are answered in the "Yellow Book." The COSEM meter object model and object identification mechanism are detailed in the Blue Book.

Blank Volume:

includes the definitions in the glossary. If a product is DLMS Yellow Book compliant, it implies it complies with the IEC62056 standard. "Electricity metering - Data exchange for meter reading, tariff, and load control" is the umbrella term under which the DLMS standards are organized by the IEC TC13 WG 14.

IEC 62056-21: Direct local data exchange (3d edition of IEC 61107) describes how to use COSEM over a local port (optical or current loop).

IEC 62056-42: Physical layer services and procedures for connection-oriented asynchronous data exchange.

IEC 62056-46: Data link layer using HDLC protocol.

IEC 62056-47: COSEM transport layers for IPv4 networks.

IEC 62056-53: COSEM Application layer.

IEC 62056-61: Object identification system (OBIS).

IEC 62056-62: Interface classes.

Sub-metering

With bulk metering, the whole facility's or site's energy use is tracked, not just that of individual units. The sum is subsequently allocated among the building's occupants according to certain predetermined criteria, such as the square footage of each unit. Since one person may occupy a bigger unit yet have lower energy usage than another, this manner of invoicing is unjust. In contrast to bulk-metering, which measures utility use for an entire building or campus, sub-metering measures utility consumption for individual dwelling units or HVAC systems. correct utility usage is essential for correct invoicing. This arrangement is beneficial since customers pay only for the energy they really use. The sub-meter readings may also be indicative of the efficiency and comfort level of the apparatus. Sub-metering offers consumption data in a lateral direction, improving the data's resolution, whereas smart meters provide data in a longitudinal direction. To better prepare for operational demands, fine tuning, and consumption comparatively, this is ideal for O&M staff and tenants.

Sub-metering in multi-family buildings has lowered average power usage by 34% in non-electrically heated buildings and by 27% in electrically heated buildings, according to a research by Navigant Consulting Ltd. [30]. Few technologies and strategies exist that can cut this much usage without significant network upgrades or financial outlays. According to the National Science and Technology Council [31], the following are some of the advantages of sub-metering: Finding ways to boost efficiency and directing upkeep efforts. If the meters are connected to a BMS or an EMS, maintenance may be sent immediately to fix broken parts. Assisting in long-term budgeting by amassing data for trend research. Facility managers are being incentivized to reduce energy and water use by shifting responsibility for building operations to them. Calculating and verifying cost reductions resulting from infrastructure upgrades. Providing assistance in establishing a baseline energy consumption rate for use in negotiating with an energy service provider. Facilitating building-wide energy and water efficiency improvements via peer-group benchmarking. Allowing departments or other campus entities to be charged for energy and water savings achieved via efficiency initiatives. Giving building tenants access to information may raise their consciousness about the impact they have on the building's energy bills. Using virtual aggregation of several sub-meters to reduce peak demand rates on electricity bills.

Conclusion

Distribution and use of electrical energy have benefited greatly from the technical advances of the 21st century. These breakthroughs are fraught with difficulty and need for cutting-edge resources and strategies to overcome. One such instrument is the Advanced Metering Infrastructure. An infrastructure has been realized that can execute real-time data collection from consumers, communicate the data, and return the executive orders to the loads as a result of advances and improvements in electronics, instrumentation, communication, and data processing. With this helpful resource, operators and utility firms may get first-hand data on the health of their network to better plan for and optimize its performance. The collected information may also be used to control consumption from both the supplier's and the buyer's perspectives. AMI's diagnostic and notification capabilities may save energy providers and customers millions of dollars in damage prevention and maintenance costs via measures like detecting leaks in water and gas networks or cyber or physical assaults. The public's interest in the SG and AMI was piqued by the prospect of adding value to the networks via the incorporation of sophisticated services like fire detection or warning and monitoring through mobile applications. The transmission of information and the delivery of electricity are both made safer with AMI. Additionally, AMI enables customers to better manage their energy use. In addition, the power quality and stability are improved. Based on our research, we know that there is room for development in the areas of communication, data analysis, and control systems for Advanced Metering Infrastructure. In spite of this, the prospects for AMI appear positive when considering the state of the global energy market and the environmental concerns that encourage governments, businesses, and consumers to fuel AMI research and use.

References

[1] Momoh JA. Smart grid design for efficient and flexible power networks operation and control. In: Power Systems Conference and Exposition, PSCE '09. IEEE/PES; 2009. p. 1–8.

[2] The History of Electrification: The Birth of our Power Grid, Edison Tech Center. [accessed November, 2013].

[3] SAIC Smart Grid Team for The Energy Policy Initiatives Center. San Diego smart grid study final report. University of San Diego School of Law; 2006.

[4] National Energy Technology Laboratory for the U.S. Department of Energy. Advanced metering infrastructure, NETL modern grid strategy; 2008.

[5] Electric Power Research Institute (EPRI). Advanced metering infrastructure (AMI); 2007.

[6] Silicon Laboratories, Inc. Smart metering brings intelligence and connectivity to utilities, green energy and natural resource management. Rev.1.0. [accessed August, 2013].

[7] Depuru SSSR, Wang L, Devabhaktuni V. Smart meters for power grid: challenges, issues, advantages and status. Renewable and sustainable energy reviews; 2011. p. 2736–42.

[8] US Department of Energy. Communications requirements of smart grid technologies; October 5, 2010.

[9] Agilent Technologies. Introducing LTE-Advanced; 2011 [accessed May, 2014]. [10] Navigant Research. LTE Networks for Smart Grid Applications; 2013.

[11] Fischione C. Toward a development of LTE for smart energy systems. Scandinavian workshop on test-bed based wireless research, Stockholm; November, 2013.

[12] Deign J, Salazar CM. Data management and analytics for utilities. FC Business Intelligence Ltd.; 2013.

[13] Anderson D, Zhao C, Hauser C, Venkatasubramanian V, Bakken D, Bose A. A virtual smart grid. IEEE power & energy magazine; December 13, 2011. p. 49–7.

[14] Cohen R. Is cloud computing really cheaper? Forbes; 2012 [accessed August, 2013].

[15] Cavoukian A. Privacy by design. Take the challenge. Information and privacy commissioner of Ontario, Canada; 2009.

[16] Murrill BJ, Liu EC, Thompson II, RM. Smart Meter Data: Privacy and Cyber security. Congressional Research Service; 2012.

[17] Information and Privacy Commissioner of Ontario, Canada. Building Privacy into Ontario's Smart Meter Data Management System: A Control Framework; 2012.

[18] Molina-Markham A, Shenoy P, Fu K, Cecchet E, Irwin D. Private memoirs of a smart meter; 2010.

[19] Kalogridis G, Efthymiou C, Denic SZ, Lewis TA, Cepeda R. Privacy for smart meters: towards undetectable appliance load signatures. In: Proc IEEE.

international conference on smart grid communications, Gaithersburg, Maryland; October 2010.

[20] Pfitzmann A, Hansen M. A terminology for talking about privacy by data minimization: anonymity, unlinkability, undetectability, unobservability, pseudonymity, and identity management; 2010.