Smart Grid

Indentifying and Resolving Major Problems within the Smart Grid System

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Abstract- The term cyber –physical systems (cps) refers to a new generation of systems with integrated computational and physical capabilities that can interact with humans through many new modalities. The ability to interact with and expand the capabilities of physical world through computation, communication and control is the key enabler for future technology developments. Throughout this research paper we will focus on the impact cyber-physical systems have on the smart grid system which is both a present and future technology. We will then introduce fundamental security techniques, whose integration is essential for achieving full protection against existing and future sophisticated security attacks on the smart grid system.

Introduction

Older electric grids were design to meet the requirement of power systems centuries ago; however with today's demands and requirements for both present and future planning, the capability of older electric grids has become limited. In order to meet the demands and requirements the idea of combining power systems with networking to provide a much more intelligent system has been one of the main goals within the area of energy**.** To accomplish this goal, the design and integration of the smart gird was brought into existence. Smart grid is define as a modernized electrical grid that uses information and communication technology to collect and act on information to provide an automated, reliable, efficient and cost effective way to produce and distribute electricity. The overall vision of the smart grid was divided into several areas in which the grid must be effective. These areas include:

A) Intelligent: the smart grid has the ability to respond intelligently to various problems that arise within the system. For example, detecting overloads and reroute power to prevent or reduce potential outage in a faster response time than humans.
B) Efficient: the system is capable of meeting the demands of consumer both presently and in the future without requiring additional infrastructure.
C) Green: the smart grid must work in favor of improving the environment. The grid must reduce the effect energy production and distribution has on climate change.
D) Accommodating: the smart grid must be accepting of all forms of energy production and distribution. Also capable of integrating current and future energy technologies.
E) Motivating: the grid will allow two way communications between consumer and utility in real time to enhance consumer's ability to preferences in energy consumption.
F) Opportunistic: an opening of new opportunities and markets for new innovations.
G) Resilient: serves as a firewall to attacks and natural disasters as system becomes decentralized and reinforced with smart grid security protocols.
H) Quality- focused: provide clean power which is free from disturbances, sags, spikes and interruptions to supply a digital economy and data centers, computers and other electronics.

Figure one below shows the changes to existing grids to redevelop or redesign them into a smart grid.

	Existing Grid	Smart Grid
Information flow	Unidirectional	Bidirectional
Electricity generation	Centralized generation	Distributed generation
Grid topology	Radial	Network
Integrating DERs	Seldom	Often
Sensors	Few sensors	Lots of sensors
Monitoring ability	Usually blind	Self-monitoring
Outage recovery	Manual restoration	Self-reconfiguration
Testing	Manual check	Remote check
Control ability	Limited control	Pervasive control
Control type	Passive control	Active control
Overall efficiency	Low	High
Environmental pollution	High	Low

Fig 1 Smart Grid vs. Existing Grid

To understand the design of smart grid fig 2 and fig 3 shows a flowchart of how the system is designed. One can consider the conceptual model to be the physical structure of the system however, to understand how the system is structured internally the term interoperability describes such a structure and can be defined as the ability of organizations to effectively communicate and transfer meaningful data even though they may be using a variety of different information systems over widely different infrastructures, possibly across different geographic regions. To understand meaningful data collected and acted upon as defined by interoperability, the smart grid system is organized into several different areas of applications and technology which are presented below.

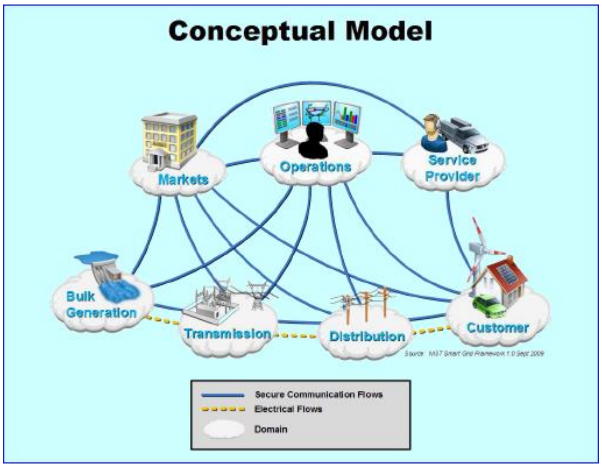

Fig 2 Smart Grid Model

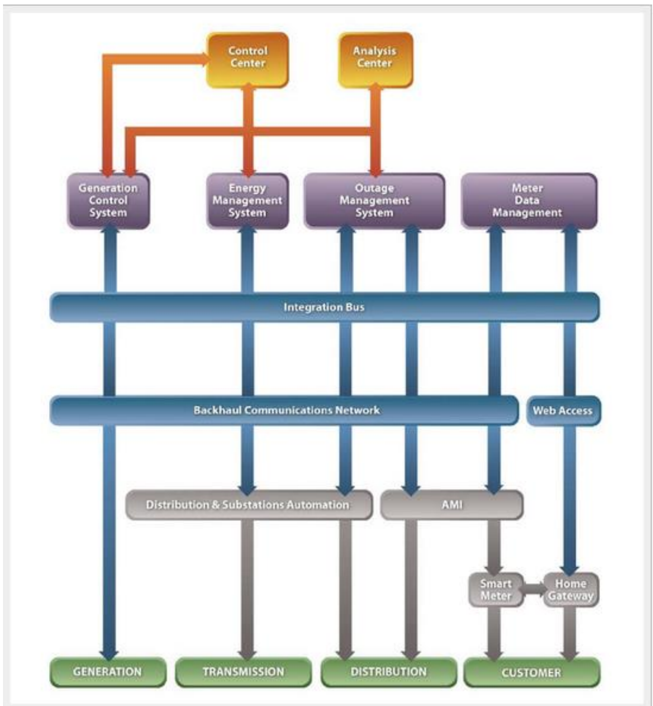

Fig 3 Interoperability

ADVANCE METERING INFRASTRUCTURE

Advanced metering infrastructure (AMI) is a vision for two-way meter/utility communication. Two fundamental elements of AMI have been implemented. First, automatic meter reading (AMR) systems provide an initial step toward lowering the costs of data gathering through use of real-time metering information. They also facilitate remote disconnection/reconnection of consumers, load control, detection of and response to outages, energy theft responsiveness, and monitoring of power quality and consumption. Second, meter data management (MDM) provides a single point of integration for the full range of meter data. It enables leveraging of that data to automate business processes in real time and sharing of the data with key business and operational applications to improve efficiency and support decision making across the enterprise.

DISTRIBUTION MANAGEMENT SYSTEM

The distribution management system (DMS) can be looked at as a technology or application that governs the grid system by modeling the electric distribution network with mathematical software models, acquires the results and predictions from the impact of outages, transmission, generation, voltage/frequency variation. It helps reduce capital investment by showing how to better utilize existing assets, by enabling peak shaving with demand response (DR), and by improving network reliability and efficiency. In addition, the distribution management system takes into account future plans that require the use of the smart grid. These plans include the integration of renewable generation into the system, electric vehicles and charging station management.

GEOGRAPHIC INFORMATION SYSTEM

Geographic information system (GIS) technology is specifically designed for the utility industry to model, design, and manage their critical infrastructure. By integrating utility data and geographical maps, GIS provides a graphical view of the infrastructure that supports cost reduction through simplified planning analysis and reduced operational response times, for example GIS data helps study customer behavior patterns in a specific area along with demand response determining this way the optimal location for smart grid components such as meters, sensors, cell relays. Managing data within GIS ensures the degree of accuracy required for smart grid functionality.

OUTAGE MANAGEMENT SYSTEM

Outage Management Systems (OMS) consist of computer technology that great increases the speed at which outages are resolved. They allow smart grid systems to be more reliable to the customer by providing prioritization methods and predictions to provide the fastest repair possible. OMSs have the ability to quickly recognize where the issue is, how many management crew members are needed and where the exact area is affected. It uses smart grid technologies, such as advanced smart meters, to quickly analyze the data and interpret the issue that is occurring in the affected area.

INTELLIGENT ELECTRONIC DEVICES

A smart grid system is designed with the goal to be an intelligent system that acquires as much information as possible and act base on such information within the electrical grid system. To accomplish this, there are implemented devices known as intelligent electronic devices (IEDs). IEDs are modernized or advance, application enable devices used within the grid system to compute, process and transmit information. IEDs can also be referred to as microprocessors-based controller's that collects data from both network and consumer facilities and enable network reconfiguration locally or on command from control centers. The smart grid uses intelligent electronic devices to replace electromechanical devices with less capability to process more data. These devices include protective relays, sensors. Larger transmission stations usually include digital fault recorders (DFR), sequence of events (SOE) recorders and phasor measurement units (PMU).

WIDE -AREA MEASUREMENT SYSTEMS

Wide-area monitoring system (WAMS) **is** a system that provides a geographical view of generation and transmission conditions through the implementation of PMUs (Phasor measurements Units) which provide precise, time-stamped data, together with phasor data concentrators that aggregate the data and perform event recording. WAMS data is ideal for monitoring and controlling dynamic power system performance, especially in post-disturbance analysis, control verification of devices such as static var compensator and wide area protection schemes.

ENERGY MANAGEMENT SYSTEM

With Energy Management Systems (EMS), having the ability to monitor, control and optimize power consumption can greatly increase the efficiency and reliability of any smart grid system. In EMSs, most of the control and monitoring comes from a control system known as SCADA (supervisory control and data acquisition). SCADA has many different sensors that can collect and transmit data for the EMS. With this data collection, the EMS system is able to determine the best course of action for maximum efficiency and optimization. Recently, many SCADA systems are being replaced within substations, with what is known as substation integration and automation packages or SIA. SIA packages introduce a wide variety of new equipment such as Ethernet switches, routers, GPS time syncing clocks, discrete programmable automation controllers, computers and Human machine interfaces (HMIs). All these new technologies would work with other meters such as Phasor Measurement Units (PMU) and digital fault recorders (DFR), to evaluate the data and provide the most efficient energy management.

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