

Application of Trustworthy Cloud Computing and Advanced Power Electronics in Smart Grid

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ABSTRACT: Increasing complexity of power grid and its management there is an increase in demand and service quality expectations to Smart Grids that use bi-directional communication with the consumer to enable an information-driven approach to distributed energy management. Smart metering is one of the smart grid applications. The main problem with "smart meter" adoption is that trust is lacking in the actual "smart meters". Hence, this paper focuses on proposing the Trustworthy Clouds (T-CLOUDS) on the smart power grid that will prove the simplest way such energy-preserving systems could be migrated to a cloud infrastructure while enhancing their resistance, privacy protection and tolerance, from both hackers and hardware issues. Moreover, Power electronics is possibly the most important element in a smart grid. Therefore, this paper also studied on the application of advanced power electronics in smart grid. The result shows that the security, efficiency and reliability of that smart grid, which had applied advanced power electronics can strengthened and optimize the grid, ensure the safety of power grid stability as well as promote the utilization of renewable energy.

KEYWORDS: Smart grid, advanced power electronics, Trustworthy Cloud computing and smart grid security.

I. INTRODUCTION

With the development of the economy, the progress of the society, and the increasingly prominent global resources and environment problem, grid development is faced with new issues and new challenges. In order to achieve the optimal allocation of resources and promote the economic development, it is necessary to construct smart grid. And more and more researchers try to find some way to improve the properties of the smart grid.

The electric grid provides electricity from generation points to consumers. Electricity delivery network consists of two primary systems. It is transmission system, which delivers electricity from power generation station to distribution substations and the distribution system which delivers energy from distribution substations to consumers [1]. Increasing intricacy of power grid and its management increase in demand and service quality expectations such as greater grid reliability, efficiency and security concerns have stimulated to Smart Grids. It uses bi-directional communication with the consumer to enable an information-driven approach to distributed energy management using the Internet protocols [4]. This enables utilities to supervise electricity utilization as it occurs and offer signals to consumers to minimize their usage if the load on the utility nears its available capacity.

Smart metering is one among the first recent smart grid applications utilized by most of the utilities which covers over infrequent energy measurement. Lots of new smart grid applications need to have continuous power and power quality. This sort of measurements (received from smart meters) may well be required as much as once every 15 minutes to assist energy management applications. Measurements provided by smart meters are also used to support real time pricing (RTP), time of use (TOU) pricing, and critical peak pricing (CPP) features for billing and demand response

applications. Hence, this paper first describes the architecture of trustworthy cloud architecture for smart grid and then gives the application of FACTS (Flexible AC Transmission Systems) and power quality technology in smart grid.

II. LITERATURE SURVEY

The “Power Semiconductor Devices for Smart Grid and Renewable Energy Systems” by Huang reviews the modern power semiconductor devices for applications in smart grid and renewable energy systems. The traditional Si-based devices, such as Thyristors, gate turn-off thyristor, integrated gate-commutated thyristor, integrated gate bipolar transistor, and power metal-oxide-semiconductor field-effect transistor are discussed in the beginning highlighting the comparison of their characteristics. Then, the emerging wide band gap devices based on SiC and GaN are discussed comparing their performances with Si-based devices. This latter class of devices is extremely important in future smart grid applications in terms of higher power rating, higher switching frequency, lower conduction drop, and higher temperature operation. The recent innovation of Si-based power devices is also discussed in the paper. The key applications of today’s devices and the future technology for electric vehicle, energy storage, Photovoltaic, wind, high-voltage direct current, flexible AC transmission systems, and solid-state transformer in smart grid are also summarized in the paper [1].

Gao in [5], made the comprehensive assessment of smart grid construction based on principal component analysis and cluster analysis. They used principal component analysis (PCA) and cluster analysis, the standardization, dimension-reduction and de-correlation of multiple evaluation index system for a smart grid to evaluate the re-weighting among original indices. Dong in [6], studied on the dynamic assessment method for smart grid based on system dynamics. They put out a new method which was dynamic assessment method for smart grid based on system dynamics to meet the different goals and demands for the development of smart grid. This method reflected the relationship between the smart grid construction and intelligent techniques realized. And it had made the evaluation of that model the results showed that the method was effective.

Wang in [7], investigated the information platform of smart grid based on cloud computing. In order to meet the need of the smart grid for reliable storage and effective management, they put up the information platform of smart grid based on cloud computing. The construction of the platform was introduced in detail. In addition, they combined the handoop and smart grid to achieve reliable storage and fast parallel processing of massive data. Cheng in [4], did their research on the homomorphism encryption based security data fusion technology of smart grid. They put up a safe and effective security data fusion scheme of the smart grid to promote the development of smart grid. The security analysis and performance analysis of the security data fusion scheme of the smart grid is performed. The experimental results show that the scheme is feasible, and is suitable for smart grid.

III. PROPOSED SYSTEM

A. Basic Concept and Major Characteristics of Smart Grid

A Smart Grid has been defined by the Smart Grids European Technology Platform as “an electricity network that can intelligently integrate the actions of all users connected to it; generators, consumers and those that do both, in order to efficiently deliver sustainable, economic and secure electricity supply”. In general terms, Smart Grid is referred to as the modern grid technology that covers all the part of electric power industry from power production to transmission to consumption and implements the convergence of electric flow, and information flow and business flow on the basis of information technology, communication technology and computer technology.

From the electric power system perspective, a smart or modern grid should have the following four major characteristics:

- 1) Information, which means that the smart grid should be able to integrate, share and exploit the real time and non-real-time information in electric power systems.
- 2) Digitalization, which makes it possible that the grid objects, structure and states can be quantitatively described.
- 3) Automation, which will require more advanced control systems that construct elastic and flexible grid. Conventional grid is, to a large extent, rigid, which lacks of elasticity and flexibility, and thus fails to properly meet those requirements.

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4) Interaction, which will bring benefits to electric generation systems, transmission systems and consumers. In a smart grid, electric generation, transmission systems and customers need to interact with each other and coordinated operate.

B. SMART GRID TRUSTWORTHY CLOUD ARCHITECTURE

According to this state of affairs and development trend of electric power vision, we design trustworthy cloud architecture for the power enterprise which is suitable for the future grid. Cloud computing operating system is the overall management system of data center behind the smart grid cloud policy. It is constructed on software resources such as stand-alone operating systems and hardware infrastructures like servers, storages and networks. Merely put, our cloud operating system has the following functions:

- It manages and drives huge frame of basic hardware like servers and storages. It integrates physical resources of the data center into a coherent server.
- It provides common and standard AP to cloud applications.
- It is responsible for managing great computing tasks and dispatching resources.

Cloud computing operating system is the important step to realize cloud computing. It streamlines the computing and provides a more efficient computational model. As shown Figure (1), our cloud computing operating system contains four parts as follows: virtualization management, DFS, safety management control, cloud computing services interface. By the way, cloud computing services interface provides an interface to the development and application which will come up with the underlying data centre evidently.

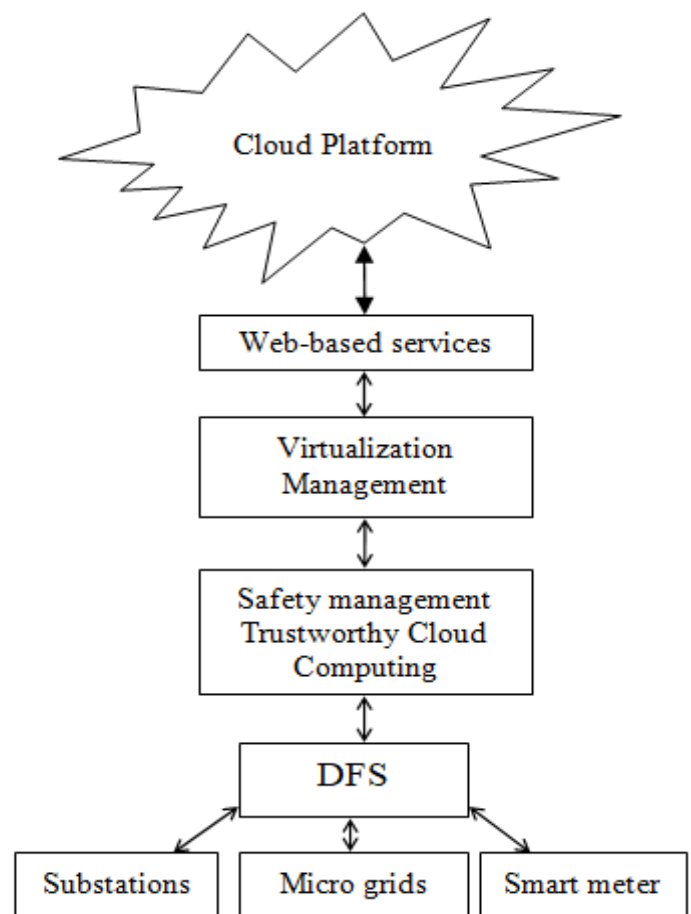


Fig. 1: SMART GRID TRUSTWORTHY CLOUD ARCHITECTURE

1. Virtualization Management

It simplifies the management of primary data center and helps enterprises to reduce the drain and expenses in management, visualization and maintenance of dissimilar storage infrastructures. It monitors each application status noticeably all times. Once found abnormal actions, it will warn the administrator to repair, avoiding affecting the normal operation of the entire system.

According to user's access situation and server's CPU loading condition, virtualization management will call dynamic load-balancing algorithm, and it will assess, configure and source storage resources routinely, to realize the purpose of user shared resources and effective improvement of resources utilization

2. DFS (Distributed file System)

Owing to block based Distributed file system, customer data is deployed redundantly in masses of economy storages. Parallel and distributed computing provides excellent data redundancy. Distributed concurrent data processing technology not only makes high-performance services provided instantaneously to users by storage nodes possible, but also ensures higher efficiency of data transportation. Therefore, block based DFS is more suited to mass through put a cloud computing platform. There is numerous current popular DFS: Hadoop Distributed File System by Hadoop, FastDFS by Google, Iustre by Oracle.etc. FastDFS is modified for Internet Applications. It is aware of redundancy backup, load balance and linear expansion, emphasizes targets like real availability and performance. It is mainly designed for large capacity and high page view of small files. Compared to other Google File System characteristics of FastDFS architecture and design concept mostly reflects in three aspects: lightweight, packet mode and equivalence structure. So FastDFS is much suitable for our cloud computing operating system as it can provide better cloud services to inner enterprise.

3. Safety Management Control Private Cloud Computing

It detached computing from storage and realized multiple users' sharing for the similar basic resources, but at the same time, numerous users sharing the identical resources; it will create higher challenges to data security. Definitely, Trustworthy cloud computing security involves several key features as follows: data access risk, data-storage risk, information management risk, data isolation risk, legal investigation support risk, sustainable development and transfer risk, etc. Security's control in our operating system needs a comprehensive prevention and control of infrastructure security design, cloud computing center operating system architecture, authentication and encryption strategy to ensure information security of the entire system.

C. APPLICATIONS OF POWER ELECTRONICS IN SMART GRID

1. Application of FACT System Technology in Smart Grid

Flexible AC Transmission System technology refers to the technology, which combines the power electronic devices with the most modern control technology to realize transmission system parameters and the original communication, rapid, flexible control of the network structure, so as to greatly improve the transmission capacity of lines and enhance system stability and reliability. With the development of power electronic devices, Flexible AC Transmission System technology has moved from the original static reactive power compensator based on half controlled device (static variable compensator, SVC) and controllable series compensation (thyristor controlled series compensator, TCSC) technology to the synchronous compensator (static synchronous compensator, STATCOM) and uniform flow controller (unified power flow controller, UPFC) technology. The distribution of energy resources and the demand present reverse distribution, so it is necessary to achieve a wide range of energy transfer. During the process, it requires the smart grid should improve the transmission capacity of the lines, and solved the related problems such as system oscillation, voltage instability and other issues. It is known that the Flexible AC Transmission System technology has the ability to control the system rapidly and solve compatibility problems effectively. So, it has large development space in our country.

2. Application of Power Quality Technology in Smart Grid

The application of power quality technology in smart grid should pay more attention on the establishment and improvement of the power quality evaluation method and hierarchy system. In addition, it is necessary to set up internal technical grade evaluation system and user economy assessment system, and relevant policies, laws and regulations so as to achieve "high quality economic operation of the smart grid. When power quality technology applied to the smart

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grid, the related technology includes electrified railway power supply technology, adaptive static reactive compensation technology, continuously tuned filter dc active filter technology, unified power quality controller (unified power quality controller, UPQC), high quality power park, etc. Unified power quality controller can ensure that important users of power quality effectively.

IV. RESULTS

In Table (1), the comparison of different security aspects in smart grid using cloud applications is shown. The smart security features of cyber-physical, data security and privacy are compared. Also from the figure (2), it can be seen that the application of advanced power electronic technology in smart grid can improve the safety, stability, efficiency and quality.

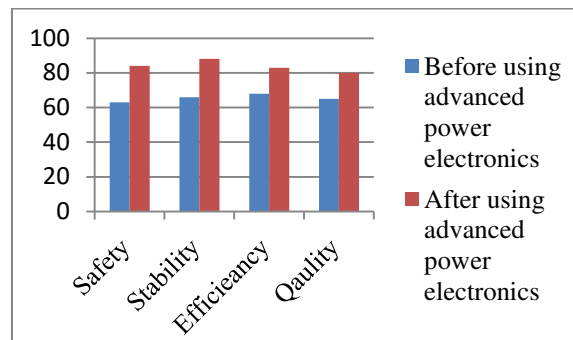


Fig. 2: APPLICATION OF ADVANCED POWER ELECTRONIC TECHNOLOGY IN SMART GRID

Table 1: COMPARISON OF CLOUD COMPUTING APPLICATIONS FOR SMART GRID SECURITY

Cloud Applications	Smart Grid Security Features	
	Cyber Security	Data Security and Privacy
Software platform for server and client's security	✓	—
Power cloud computing	—	—
Distributed verification protocol	—	—
Privacy Preservation	—	—
Software architecture for security and privacy	—	—

V. CONCLUSION

The smart grid can promote the development of economic benefit and improve social efficiency. In this paper, the trusted cloud computing is presented for the confidentiality, integrity of their data, and computation which is a major deterrent for consumers in the smart grid distributed system. In addition, this paper studied on the application of advanced power electronics in smart grid. This paper firstly introduced the basic knowledge of advanced power electronics and smart grid then discussed the application of Flexible AC Transmission System technology and power

quality technology in smart grid. The result shows that the application of advanced power electronics in smart grid will make the safety factor, stability factor, efficiency factor and quality factor increased over 20%, 19%, 15% and 14% respectively.

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