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Cloud Computing Application to Manage Smart Grid System

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Abstract— *With the rapid development of national economy, our demand for power resources has also increased rapidly, associated with such development, the grid structure has evolved in development led to investment in technology and equipment to control the data, store the specifications grid increasingly more complex. Smart grid is one of the new energy systems in which application information technology, tools and technical solutions to the power system operate more efficiently. In this paper the application of cloud computing technology for smart grid to manage the collection and storage of information, parameters of the grid on the cloud system and aims to reduce investment costs of data storage devices of the power sector with purpose reduce the investment costs of data storage devices of the electricity industry, allows the operating can push parameters or update the information of the grid on the cloud system in a flexible and high security. With that application, it will solve the economic problem when investing in storage equipment infrastructure and reduce the amount of calculation application software on the computer system when the power grid structure is increasingly developing. Developed to meet the demand for electricity in each country.*

Keywords— *Cloud; Cloud Computing; Smart Grid; Service; Station Automation; Power System.*

I. INTRODUCTION CLOUD COMPUTING

Cloud computing, as defined by the National Institute of Standards and Technology (NIST), is the model used to access required computing resources (e.g., networks, servers, storage, applications, and services) are shared via the network conveniently, available everywhere [1]. Cloud computing provides two benefits: Infrastructure services and software platforms, which underpins the process of developing large-scale application systems. In other words, cloud computing is based on the capabilities of modern computer systems to provide organizations, computational services and data warehouses on demand. Through low-failure systems and geographically dispersed data centers, cloud computing achieves high reliability.

These cloud services are divided into: Service for infrastructure (IaaS-Infrastructure as a Service), platform-based services (PaaS-Platform as a Service), software services (SaaS-Software as a Service) [2].

- Cloud Infrastructure as a Service (IaaS): The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls).
- Cloud Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.
- Cloud Software as a Service (SaaS): The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- On the other hand, cloud can also be categorized, depending on the deployment models, as - private, public, community, and hybrid [3].
  - Private Cloud: The cloud is owned by a private organization, and information is shared only within the organization. The purpose of this type of cloud application is to serve its own business applications.
  - Public Cloud: On the other hand, public cloud is owned by a service provider, and used by public for their purposes.
  - Community Cloud: Community cloud is similar to the private cloud with some additional features to provide services to a group of organizations who have similar type of requirements.
  - Hybrid Cloud: Hybrid cloud is the extension of cloud computing with private, public, and community cloud computing techniques [4]. The private, public, and community clouds are integrated together to perform several tasks which are capable of handling the requirements of private, public, and community organizations.

Additionally, we also show the categorization of cloud computing application in Figure 1. The advantages of using a cloud computing model are as follows [5]:

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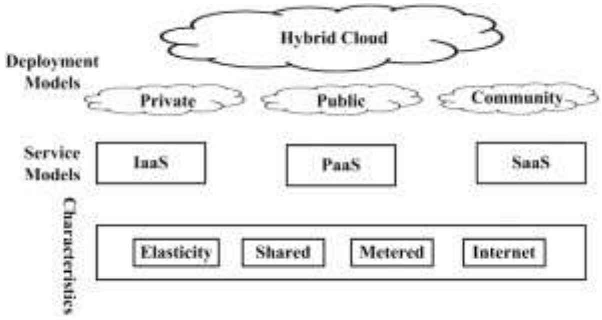

Fig. 1: Classification of cloud computing applications

Deployment Models:

Private cloud. The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise. Community cloud. The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise. Public cloud. The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services. Hybrid cloud. The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

II. Cloud Computing Application To Manage Smart Grid System

2.1 Research and Fast Power System Parallel Computation and Treatment

Smart grids and information platform for the large volume of data to provide stable operation of the power grid data base, but more critical is the analysis and design of each system operating data, planning and decision-making, and even failures and transient stability, state estimation and intelligent a variety of computing and content analysis and decision-making process, its huge computing needs, general computing system can not reach its goal [6]. Cloud computing technology through parallel computing technology has greatly enhanced parallel processing capability of the power system, which provides parallel programming model makes more simple and efficient parallel algorithms. MapReduce as Google made an important parallel programming model, and its role in large data sets in parallel computing plays a very prominent. Parallel processing job results by the client to achieve effective user submitted, via decomposition automated master role, the corresponding task scheduling to working nodes and nodes work completed by the specific calculations and perform the appropriate task. Data management, electrical system specifications for a cloud-based smart home is to monitor the consumption of electrical energy used by customers through intelligent electronic meter system with data volume. big data about the amount of power consumed by the customer so that a load chart can be generated and at the same time, calculate the customer's electricity use tariff so that customers can follow through the message system or Email [7]. Integrating and optimizing heterogeneous resource management [8]. Among smart grid systems, the connection and communication between different vendors' devices is one of the most difficult problems due to different device configurations with different heterogeneous structures and there is a dispersion, disagreement about language, so the operation of the electric system does not ensure high reliability, so it needs to standardize according to a common standard. Therefore cloud computing technology will integrate software with the aim of creating software to standardize the connection of elements in the electrical system in a flexible way. Develop a model of software system to monitor and control the operation and alert the abnormal operation status of the grid with a simple to complex grid structure on the cloud platform [9]. At the same time integrated monitoring systems for renewable energy sources [10].

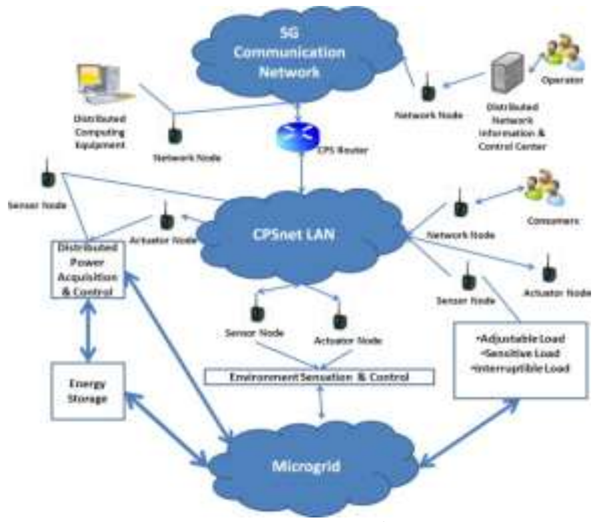

Fig. 2: Cloud computing model for smart grid

With cloud computing technology users can access a single server to get information and update data and parameters of the electrical system without having to purchase licenses for different applications. In the secondary system of intelligent substations (non-personnel stations), to meet the needs of monitoring the working status of the equipment, detecting incidents and controlling power quality and requirements otherwise harmonious, the station is installed a large number of different secondary devices, each device is built according to a standard so compatibility between devices is poor and maintenance and lifting costs senior [11,12,13]. Protection, measurement and control devices, secondary devices with large numbers, so the data on the operation history needed for calculation and analysis is large. In this respect, the relative lack of computational capacity of substation equipment and data transmission will be inadequate, while the amount of information will increase rapidly in the process of operating devices leading to demand. demand for distributed data storage and calculation services.

2.2 Cloud computing application in grid planning

Cloud computing technology also solves a number of planning issues, intensive computing applications and is used to replace the calculation functions of secondary devices scattered in other substations. each other on the electrical system to remove old equipment from the station. In the development process, the complex functions of these devices are implemented in the "Transformer station cloud system" and it will significantly reduce the investment of equipment [14].

2.3 Cloud computing technology is used to forecast load demand

This technology is based on the Amazon cloud computing platform, application of additional load demand forecasting based on modeling with Matlab using artificial neural networks deployed on the cloud and on the system. Local computers have the same computing power as the corresponding cloud cases [15].

2.4 Applications in energy management systems are monitoring, controlling and conserving energy [16]

In the smart grid system, energy system management is the main goal in national energy conservation [17]. It is necessary to conserve resources, environment and climate while saving costs without affecting the working process by optimizing some energy sources such as the governance system. Energy Management (Building Energy Management System-BEMS), Home Energy Management System (HEMS).

2.5 Cloud Applications for Security in Smart Grid

A smart grid can be conceptualized as a cyber-physical system that connects physical electricity systems and cyber-infrastructure, with the integration of the Internet. This service can communicate with the consumer appliances and also provide the backbone for service providers to absorb contents and control operations.

With the presence of online connectivity, it is a big challenge to prevent cyber-attacks in the smart grid that can potentially disrupt the power supply [18]. One of the important issues is power theft by consumers. This can be done by hacking a smart meter or modifying the real-time information through accessing communication channel to change the reported electricity usage. Additionally, data manipulation is also one of the most security concerns in the smart grid. To overcome these issues we need to implement proper security for secure and reliable smart grid architecture. Security can be implemented on the consumer side, transmission side, and generation side. The main security aspects of smart grid are as follows:

- With the increase of the grid system complexity and their integration, it is difficult to track interactions among business systems securely.
- The smart grid architecture is more complex than the one for the traditional power grid. The implementation of a smart sensor network, wireless communication, and smart meters increases the complexity in the protection of the information security system.
- With the implementation of millions of smart meters, the network is distributed to the end-user systems. So, the capacity of the protection at the end-users needs further enhancement.
- The denial-of-service (DoS) attack to affect the stability of the applications for the smart grid.
- Utility and third-party can access the user data as well as private information, thereby affecting the privacy of the users.

The existing information protection systems for electric power are deficient in handling the ever changing and growing nature of security threats [19]. To address these issues in the smart grid development, researchers proposed several security technologies in terms of cloud computing applications [19] - [23].

An electric power information security and protection system, based on cloud security, is presented by Yanliang et al. [19]. The authors classified cloud security into two parts: *server* and *client*. The clients mainly collect data and take action according to the server responses.

On the contrary, the server uses the cloud computing platform to implement the distributed storage, thereby acting as an intelligent decision maker. Then the results are transmitted to the clients through the Internet.

Simmhan et al. [20] analyzed different security and privacy issues in smart grid software architecture operat-ing on different cloud environments. Private cloud platforms are suitable for scaling out and processing millions of data from users. Using the cloud computing platform, the electrical utilities can quickly and effectively deal with malicious software, thereby reducing the overall network damage control costs and improving the overall safety level.

The distributed verification protocol (DVP) proposed by Ugale et al. [21] is focused on guaranteeing data storage security in cloud computing. The authors introduced the merits of the application field of cloud computing to reduce users' cost in the smart grid architecture. Ugale et al. [21] also proposed that the implementation of the DVP protocol is suitable to support data storage and power management mechanisms for smart grid. With the construction of power cloud technology for smart grid development, many security issues are addressed in [22]. Cloud computing expands the trust boundary and makes more stakeholders to join the adoption of the traditional security techniques. Several cloud computing security risks are discussed. For instance, (a) administrator being able to access personal sensitive data, and (b) the location of the cloud required to ensure that information is transmitted and kept securely.

Maheswari et al. [23] focused on the development of a cloud-based software platform for state estimation in a smart grid environment. With the implementation of the public key infrastructure (PKI), issues related to faulttolerance and intrusion detection are addressed. This state estimation method utilizes maximum bandwidth that is available in the cloud, so as to achieve reliable, secure, and fault-tolerant smart grid architecture. This software platform also maximizes the use of cores.

Wen et al. [24] propose a privacy preserving smart metering scheme in the smart grid. In the proposed scheme,

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each individual smart meter stores the real-time information in encrypted form on the cloud platform. Therefore, only the authorized entities are permissible to access the stored data. In such a scenario, users can generate data query upto a possible range. Further, the query is transferred into two query tokens which are used to find the required data, while maintaining the users' privacy.

Cloud computing technology as a new and efficient calculation method, applied with building information platform for smart grid, can significantly improve the efficiency of management and operation platform, set Solid foundation for security system and stability of electrical system operation. Combined with features of intelligent grid monitoring, developing special solutions on the basis of the actual situation of the electrical system to bring into full play the advantages of the intelligent grid information platform, providing great security activities for management and maintenance of smart grid to achieve the rapid development of electricity-using businesses.

III. Application Cloud Computing Technology to Manage and Operate Substation Automation System

With the configuration and control system for the operation of equipment in the 110kV substation, it is currently built with a control system consisting of two parts: hardware and software:

The hardware system includes Intelligent Electronic Devices (IEDs), level control (BCU) controllers, Remote Terminal Units (RTU), Relay protection devices. Digital, distributed control system (Distributed control system - DCS), Local Area Network (LAN), time synchronization device (Global Positioning System - GPS), control system Monitoring and data collection (Supervisory Control And Data Acquisition - SCADA), fiber optic connection system for signal transmission between devices in the electrical system with control and protection devices, systems Information storage including (signals, operating parameters, device status, events, alarms ... will be stored at the host computer and Medical database properties the past).

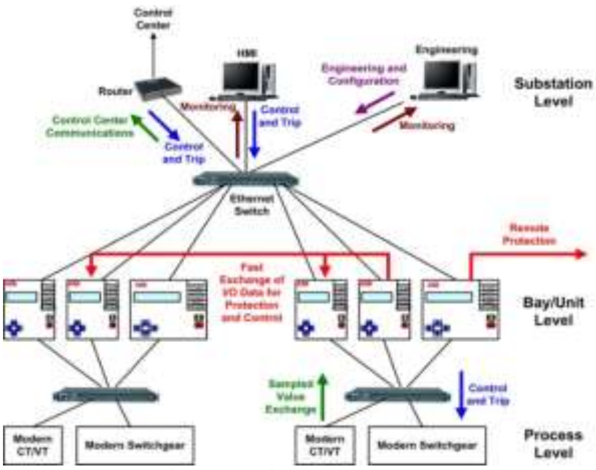

Fig. 4: Configuration of substation automation system

The software system is provided by the device manufacturers to provide adequate technology transfer including original software, installation operation sequence, system configuration, password levels, procedures for connecting devices. being in the station, the ability to change logic functions, add, remove, modify elements in the system ... ensure the investor owns the system, self-operates, self-repairs and lifting grant and expand the system.

Currently the automatic station system will collect information on protection, control and measurement of equipment and electrical systems at high voltage transformer stations. Information will be collected through direct connection to intelligent eel control, protection and measurement devices, communication between IEDs and the control center in the substation will be important when performing functions. automation of the station. Many communication protocols are used in monitoring remote control TBAs, popular protocols like Modbus, DNP3 and IEC 60870. The above protocols are completely interoperability when provided by different vendors, while limiting the processing speed, so building station automation applications on the platform tradition is quite difficult.

In 2003, the International Electrotechnical Commission (IEC) issued the first version of IEC 61850 communication standard [26]. IEC 61850 is the new international communication standard for station automation applications, LAN communication protocols between host computers and smart electronic devices (IEDs). The standard allows the integration of the substation traditional protection, control, measurement and monitoring functions, and it is capable of providing distributed, functional and protective applications. Complex and complex monitoring. This information system design standard is capable of providing similarities between devices from different manufacturers, to coordinate the implementation of the same function.

When cloud computing technology has not been applied to the automation of station control, the whole process of collecting station operating parameters as well as measurement parameters is collected by BCU sets of compartments. The data is collected in real time, processed at the BCU of the compartments. The data is transferred to the server and displayed on the monitor screen so that the operator can manipulate and switch on the electrical equipment and understand the operating status of the equipment in the station. The ability to store similar data, status data, events and calculation results is stored continuously on demand for a certain period of time, the system will generate reports and be sent on request. The operator's configuration or automatically prints to the printer according to the pre-programmed program.

When applying cloud computing technology, it will solve the investment problem for hardware and software equipment in substations. Regarding hardware equipment, it is not necessary to invest in equipment to store and manage data, operating parameters of electrical equipment in the electrical system. Parameters and data will be transmitted to the cloud system via high speed Internet connection to ensure security of network security system. In terms of software equipment,

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there is no investment and cost to buy software licenses to manage and operate electrical equipment in the electricity system with high cost.

Fig. 5: Cloud computing application in substation automation system

On the cloud system will integrate application software and integration algorithms for the calculation and analysis of electrical systems with simple configuration from complex to complex, electrical system parameters will be Regular and continuous updates over time through global positioning system (Global Positioning System GPS). At the same time on the cloud system will integrate, encoding communication language between the control and protection devices of different manufacturers to create a common language to facilitate the connection process between them.

IV. CONCLUSIONS

Cloud computing technology is one of the new technologies with high efficiency in the current engineering industry and is applied to build smart grid system, improve efficiency in operation and electrical system management. Combined with features to control, monitor and store data information with high security level during operation. The application of cloud computing technology will effectively solve the problem of investing in storage devices, software systems on computers and only pay for the managers of system applications on the cloud system. Therefore, users do not have to invest money to buy equipment, technology and software to calculate and analyze electrical systems, but all data and parameters during the operation of the electrical system The technology is transferred to the cloud system to perform the calculation process, the operator can get the cloud system access through the industrial communication network connection to collect data of the electrical system quickly. Fast and effective. Through the article on the author, it is hoped that in the future with technology 4.0, it will apply successfully in the management and operation of smart grid system effectively.

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