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INTERCONNECTION OF ELECTRICAL POWER SYSTEM GRIDS VIA CLOUD METHODOLOGY & APPROACH

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Abstract:

This paper deals with the interconnection of electrical power system grids using cloud. Which provides the way for openness, robustness and reliability. Because achieving secure and reliable delivery of energy is becoming more challenging goal to achieve with increasing demand and declining resources. The ongoing restructuring of the rather older delivery system is an attempt to improve the performance so that the delivery lag and communication between the resources could takes place with higher efficiency and less losses.

Cloud connected grid is modified form of electrical grid where generation, transmission, distribution and customers are not only connected electrically but also connected through strong communication network with each other as well as with market, operation and service provider. For achieving good communication link among them, it is very necessary to find suitable protocol. With the use of Zigbee in conjunction with cloud at front end and Zigbee at back end this automation can take place which will provide the above mentioned benefits.

THE ELECTRIC power transmission grid has been progressively developed for over a century, from the initial design of local dc networks in low-voltage levels to threephase high voltage ac networks, and finally to modern bulk inter – connected networks with various voltage levels and multiple complex electrical components. The development of human society and economic needs was the catalyst that drove the revolution of transmission grids stage-by-stage with the aid of innovative technologies . As the backbone used to deliver electricity from points of generation to the consumers, the transmission grid revolution needs to recognize and deal with more diversified Challenges than ever before. It should be noted that in this paper the word "grid" refers not only to the physical network but also to the controls and devices supporting the function of the physical network, such that this work is aligned with the ongoing electrically and wired connected grid initiative.

In this paper, we summarize the challenges and needs for future smart transmission grids into four aspects.

a) *Environmental challenges*. Traditional electric power production, as the largest man-created emission source, must be changed to mitigate the climate change .Also a shortage of fossil energy resources has been foreseen in the next few decades. Natural catastrophes, such as hurricanes, Earthquakes and tornados can destroy the transmission grids easily. Finally, the available

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and suitable space for the future expansion of transmission grids has decreased dramatically.

b) *Market/customer needs*. Full-fledged system operation technologies and power market policies need to be developed to sustain the transparency and liberty of the competitive market. Customer satisfaction with electricity consumption should be improved by providing high quality/price ratio electricity and customers' freedom to interact with the grid.

c) *Infrastructure challenges*. The existing infrastructure for electricity transmission has quickly aging components and insufficient investments for improvements. With the pressure of the increasing load demands, the network congestion is becoming worse. The fast online analysis tools, wide-area monitoring, measurement and control, and fast and accurate protections are needed to improve the reliability of the networks.

d) *Innovative technologies*. On one hand, the innovative technologies, including new materials, advanced power electronics, and communication technologies, are not yet mature or commercially available for the revolution of transmission grids; on the other hand, the existing grids lack enough compatibility to accommodate the implementation of spear-point technologies in the practical networks. Whereas the innovation of the transmission grid was driven by technology in the past, the current power industry is being modernized and tends to deal with the challenges more proactively by using state-of-the-art technological advances in the areas of sensing, communications, control, computing, and information technology. The shift in the development of transmission grids to be more intelligent has been summarized as "cloud connected grid,".

I. FRAMEWORK

The vision of a smart cloud enabled transmission grid is illustrated in Fig. 1.The existing transmission grid is under significant pressure from the diversified challenges and needs of the environment, customers, and the market, as well as existing infrastructure issues. These challenges and needs are more important and urgent than ever before and will drive the present transmission grid to expand and enhance its functions towards smarter features with the leverage of rapidly developing technologies. As a roadmap for research and development, the smart features of the transmission grid are envisaged and summarized in this paper as digitalization, flexibility, intelligence, resilience, sustainability, and customization. With these smart features, the future transmission grid is expected to deal with the challenges in all four identified areas.

A. Digitalization

The smart transmission grid will employ a unique, digital platform for fast and reliable sensing, measurement, communication, computation, control, protection, visualization, and maintenance of the entire transmission system. This is the fundamental feature that will facilitate the realization of the other smart features. This platform is featured with user-friendly visualization for sensitive situation awareness and a high tolerance for man-made errors.

B. Flexibility

The flexibility for the future smart transmission grid is featured in four aspects: 1) expandability for future development with the penetration of innovative and diverse generation technologies;
2) Adaptability to various geographical locations and climates; 3) multiple control strategies for the coordination of decentralized control schemes among substations and control centers; and 4) seamless compatibility with various market operation styles and plug-and-play capability to accommodate progressive technology upgrades with hardware and software components.

C. Intelligence

Intelligent technologies and human expertise will be incorporated and embedded in the smart transmission grid. Self-awareness of the system

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operation state will be available with the aid of online time-domain analysis such as voltage/angular stability and security analysis. Self-healing will be achieved to enhance the security of transmission grid via coordinated protection and control schemes.

D. Resiliency

The smart transmission grid will be capable of delivering electricity to customers securely and reliably in the case of any external or internal disturbances or hazards. A fast self-healing capability will enable the system to reconfigure itself dynamically to recover from attacks, natural disasters, blackouts, or network component failures. Online computation and analysis will enable the fast and flexible network operation and controls such as intentional islanding in the event of an emergency.

E. Sustainability

The sustainability of the smart transmission grid is featured as sufficiency, efficiency, and environment-friendly. The growth of electricity demand should be satisfied with the implementation of affordable alternative energy resources, increased energy savings via technology in the electricity delivery and system operation, and mitigation of network congestion. Innovative technologies to be employed should have less pollution or emission, and decarbonize with consideration to the environment and climate changes.

F. Customization

The design of the smart transmission grid will be client-tailored for the operators' convenience without the loss of its functions and interoperability. It will also cater to customers with more energy consumption options for a high quality/price ratio. The smart transmission grid will further liberate the power market by increasing transparency and improving competition for market participants

II. BASIC ARCHITECTURE

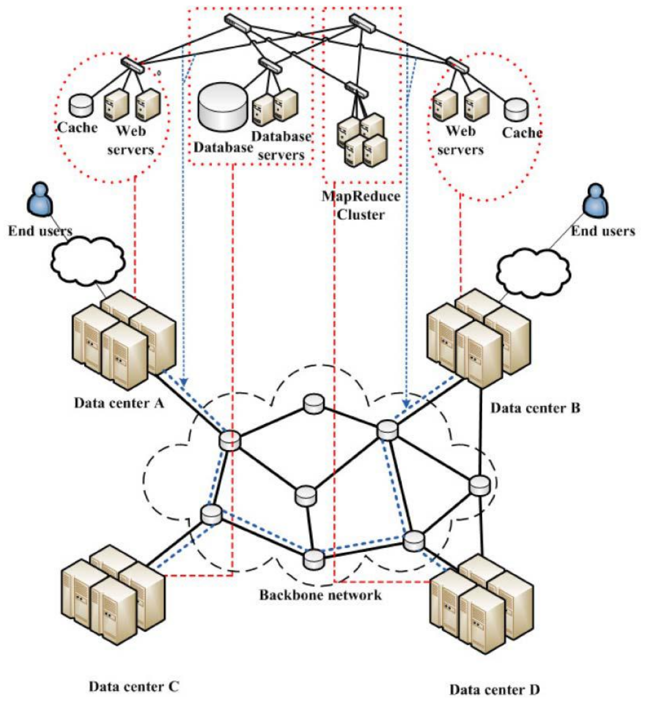

Fig 1. Cloud based Architecture

In a cloud computing environment, an infrastructure provider (InP) partitions the physical resources inside each data center into virtual resources (e.g., virtual machines (VMs)) and leases them to service providers (SPs) in an on-demand manner. On the other hand, a service provider uses those resources to deploy its service applications, with the goal of serving its customers over the Internet.

Electricity is generated at a few central power plants by electromechanical generators. The generating plants are quite large and located away from heavily populated areas. The generated electric power is stepped up to a higher voltage for transmission in the transmission system. The transmission system moves the power over long distances to substations. Upon arrival at a substation, the power is stepped down from the transmission level voltage to a distribution

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level voltage. As the power exits the substation, it enters the distribution system. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).This process covers the basic idea of the bulk generation, transmission,distribution, and customer sub-domains

Bulk Generation: The actors in this sub-domain are responsible for the bulk generation of electricity and the corresponding control, measurement, protection, and recording procedures.Therefore, the information management part in this sub-domain should

1) Record key performance and quality of service issues such as scarcity (especially for wind and solar) and generator failures;

2) utilize the data provided by the market sub domain to schedule generation and simultaneously provide availability data to the markets;

3) Record the history of device operations and maintenance, and analyze the performance and the life expectancy of devices.

Transmission: The transmission system is the carrier of the bulk electricity over long distances. The information management part in this sub domain should provide monitoring information exchange, and control data for operations and control of transmission substations and field devices. This information is generated from widely-deployed measurement and monitoring devices, such as sensors and phasor measurement units. Furthermore, this information should be properly used to manage the operations in the transmission system, including optimizing power flows, improving reliability, and optimizing asset utilization.

Distribution: The distribution system is the electrical interconnection between the transmission system and the customer sub-domain. , the cloud connected distribution system will communicate closely with the operation subdomain in real-time to manage the power flows associated with a more dynamic market sub-domain, and hence promptly adjust localized consumption and generation. A large amount of monitoring and control information, including load management and distribution system reliability, should be managed in this sub-domain

Customers: The customer is ultimately the stakeholder that the entire power grid system is created to support. Customers are allowed to manage their energy usage, generation, and storage. The communication and information systems support the realization of many advanced user features, such as remote control, monitoring and control of distributed generation, in home display of customer usage, automatic reading of meters, and control of new electric devices (e.g. electric vehicles).In addition to the four basic sub-domains above, there are three other sub-domains supporting the cloud based: markets, service providers, and operations.

Markets: The market is the place where grid assets are bought and sold. The information management part of this sub-domain provides information support for the analysis and optimization of the pricing, for the balance of supply and demand, and for the energy trading between bulk generators, utilities, transmission operators, and customers.

Service Providers: The actors in this sub-domain perform services to support the business processes of other actors existing in the grid system. Such services may be performed by the electric service providers, existing third parties, or new participants drawn by the new business models. These business processes range from traditional services such as customer account management and billing, to enhanced new customer services such as management of energy usage and home energy generation . Almost all of these processes need the involvement of the information management system, which

1) manages customer information;

2) utilizes usage data and pricing to encourage load control by the customer;

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3) Provides an effective information interaction interface between the customers and the markets;
4) Provides information support for the emerging services.

Operations: The actors in this sub-domain are responsible for the operation of the power system and the management of the movement of electricity. In order to maintain reliable and safe operation of the grid, the information management part in this sub-domain should support aggregation, validation, editing, estimation, and analysis of the monitoring, measurement, metering, and operation data gathered from the power grid.

The Cloud Computing Domain

In this subsection, we describe the three sub-domains of the CC domain in our model: Cloud providers, service providers, and end users. Cloud Providers: A Cloud provider, the owner of the infrastructure, is responsible for managing physical and virtual resources to host applications and services, such as computing, data storage and management, and user developed applications. A Cloud provider has to assign virtual resources to be hosted on its physical resources and can hence provide maximum flexibility to configure various configurations partitions of physical resources to serve requests with differing requirements
.

Service Providers: A service provider leases resources in the Cloud infrastructure provided by the Cloud providers and provides applications or services that will be utilized by end users. In order to differentiate a service provider in the CC domain from a service provider in the cloud based domain, we call the former one a CC service provider and the latter one ancloud based service provider. In addition, some CC service providers may form a special class of actors, called service brokers. A service broker, as an actor with the expertise on the Cloud, mediates between end users and other CC service providers for gathering end user requirements, locating the best suitable CC service providers, and assisting end users in (dynamically) buying, obtaining, and releasing Cloud services . The idea of service broker is compelling because as the number of services supported increases, end users may have more difficulties in finding a CC service provider that best meets their requirements, such as cost, availability, performance, and service category.

End Users: An end user generates demands for the Cloud to process and is the consumer of the services provided.

III. APPROACHING THROUGH ZIGBEE

To achieve system automation we can create a wireless sensor network having number of nodes which communicate with each other in full duplex mode. The communication will consist of data transfer, controlling node operation. We are using zigbee protocol for the wireless communication. The main advantage of using ZigBee protocol is that the nodes require very less amount of power so it can be operated from battery. And in this way we have managing the available power by using wireless sensor network working on zigbee protocol. Each node is measuring the power, which is being consumed by the appliance. The appliance is controlled by the end device i.e. node. An overall operation of the system controlled by the control device. Main purpose of the project is that the wireless sensor network will differentiate and control the devices in the network on the basis of power consumed by appliances to make the efficient use of power

Fig. 3.1 Concept Diagram.

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Implementation:

The block diagram of the system is shown below. Here controller will wirelessly communicate with end devices to control them. The power threshold will be set by the controller. The end device will compare this threshold with the power being consumed by the device connected through it and will take the appropriate action.

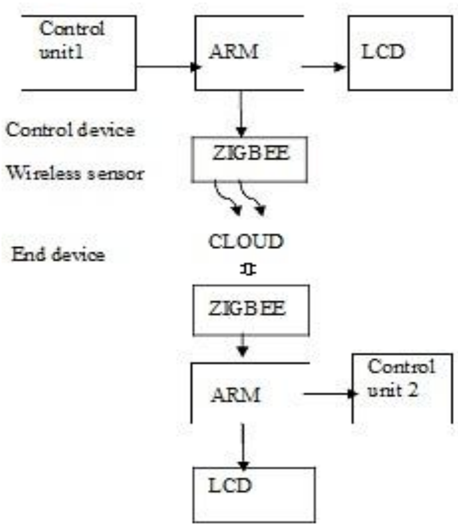

Fig . 3.2 Block Diagram

Utility companies sending the message of power available to the control device unit. Control device unit receive the message and display on LCD then further information from local collection point, central collection point or utility company location or household where it is installed it will intelligently send the information to cloud using GSM network or through LAN if provided to the corresponding IP address so that the data will reach to the destined CLOUD so that it will be arranged automatically and will he hassle free with minimum human effort and will be error free without any redundancy in it . So that the authenticity of data remains very high and can be used for further process like metering in metering stations or at load dispatch centers for further processes.

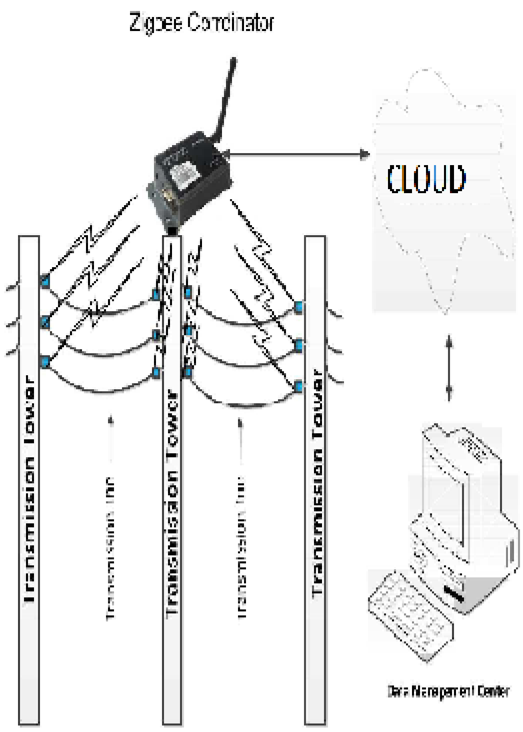

Fig.3.3 Transmission Line Monitoring Using ZIGBEE and CLOUD

Advantages of ZIGBEE

The main advantage of GSM, with its good anti-piracy ability, large network capacity, high reliability and high sensitivity, for that it can provide many data transmission services.

Other advantages of ZIGBEE are as;

- Power saving, as a result of the short working period, low power consumption of communication, and standby mode.
- Reliability: Collision avoidance is adopted, with a special time slot allocated for those communications that need fixed

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bandwidth so that competition and conflict are avoided when transmitting data

- Low cost of the modules and the ZigBee protocol is patent fee free.
- Short time delay, typically 30 ms for device searching, 15 ms for standby to activation, and 15 ms for channel access of active devices.
- Large network capacity: One ZigBee network contains one master device and maximum 65,000 slave devices. There can be as many as 100 ZigBee networks within one area.

IV.CONCLUSION

The most challenges and "green" legislation that utilities are facing today, combined with increased demand from consumers for more flexible offerings and cost savings, make a solution like smart meters both timely and inevitable. ZigBee's wireless open standard technology is being selected around the world as the energy management and efficiency technology of choice. Implementing CLOUD CONNECTED GRIDS with an open standard such as ZigBee helps to keep costs down, ensure interoperability, and future-proof investments made by both utilities and consumers. Consumers and businesses will see changes they never dreamed possible.

This paper has presented a unique vision of the next-generation smart transmission grids. It aims to promote technology innovation to achieve an affordable, reliable, and sustainable delivery of electricity. With a common digitalized platform, the smart transmission grids will enable increased flexibility in control, operation, and expansion; allow for embedded intelligence, essentially foster the resilience and sustainability of the grids; and eventually benefit the customers with lower costs, improved services, and increased convenience. This paper presents the major features and functions of the smart transmission grids in detail through three interactive, smart components: smart control centers, smart transmission networks, and smart substations. Since this initial work cannot address everything within the proposed framework and vision, more research and development efforts are needed to fully implement the proposed framework through a joint effort of various entities.

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