A REVIEW OF SMART GRID: EXPLORING THE INTEGRATION WITH CLOUD

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Abstract

Power system became a complex network as it connects eighty percent of the world population at the end. Power flows from generation to transmission and distribution whereas complexity increases from distribution to transmission and generation. Proper distribution system will reduce the difficulties in transmission and generation. Creating Distributed Energy Resources (DER) near the load center reduces the burden in transmission part of the power system. Two ways power transfers needs a smart technology to lead the effective operation for the imminent power systems. Smart grid encourages the renewable power source for small power producers, DER and microgrids. Solar, Wind, Biomass are some of the well-known renewable energy sources for small scale power producers and the limitations of renewable energy sources depends on the availability, output and conventional method. Renewable energy uses power electronic converters to interface with gird. By controlling and monitoring the output of the renewable energy, the limitations of microgrid can be eliminated and it leads to reliable smart grid network. Increasing the size of the smart grid network includes problems like handling meta or peta data, controlling and monitoring microgrids and communication between end-user to operator or vice versa.

This paper has reviewed about the issues faced by the smart grid in communication and data management field to ensure stable operation of the microgrid. The solution for the smart grid limitations in data management is addressed by the Cloud computing technology. Cloud computing is an emerging technology that handles big data and reduces the cost for infrastructure. The data about customer and microgrids can be stored and made available for accessing for the reliable operation which creates transparency in the power market.

Keywords: Power system, Distributed Energy Resources, Two ways power transfer, Cloud computing technology.

1. Introduction

Electric energy revolutionizes all the technology to the next level. Unfortunately electric power technology stumbles to transform from its earlier state. Edison and Nikola tesla laid a basement for power grid in the 20th century from then power grid has grown exponentially very large physically but the operation remains the same [1]. Initially power production is only for individual requirement and small scale. But during the evolution of machines in mid of 20th century power generation has become large and huge. This led to the separation of generation and distribution and initiated an area for transmission. From the past to few decades, generation of electricity was purely dependent on fossil fuel and was mainly generated from the non-renewable sources like fossil fuels, nuclear etc. This creates an environmental disaster and scarcity for raw materials which led to the increase in generation cost.

In the mid of 20 century renewable energy sources was invented and due to the greenhouse gas effect, renewable energy technology is growing with high intensity. In 1978 and 1997 FERC implemented an act for distributed generation led the power system to rigidly increase the scalability with new technology [2]. Increase in demand has forced the increase in generation and it has led to the emission of greenhouse gases. From the beginning, power system is facing severe problems with regard to the demand response, stability, harmonics and many solutions have evolved in the past two decades which has transformed the power system into a combination of modern and classic model. The solution for the problems faced in the power system is solved by the new technology, smart grid [2-7]. Smart grid can be defined simply as automated control of transmission, generation and distribution and market operation from power producer to consumer and vice versa. Wikipedia defines smart grid as, a smart grid is a modernized electrical grid that uses analog or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.

National Institute of Standards and Technology (NIST) has defined smart grid as "a modernized grid that enables bidirectional flows of energy and uses two-way communication and control capabilities that will lead to an array of new functionalities and applications." According to Department of Energy smart grid means “computerizing” the electric utility grid.

Even though smart grid provides solution for the problems in existing grid, it has in its own problems. One of the main functions of smart grid is two way power transfers by integrating micrograds to the main grid. Structure of the smart grid remains the same as existing grid, if the participation of customer is null. Integrating microgrid with the grid creates integrating problems like controlling, monitoring, protection and data acquisition [8]. Rapidly increasing power demand, reducing fossil fuel sources, complexity in network scalability, monitoring and control are the problems that are effectively addressed by smart grid [9, 10]. Smart grid has become a solution for the existing grid and so every country is moving towards the smart grid. Every country has a smart grid vision, countries like Europe and US is pursuing for Smart grid 2020 [11]. But the limitations like stability, monitoring and data management plays a vital role on implementing smart grid.

Evolution in renewable technology takes us back to early of twentieth century i.e., nowadays everyone can generate their own power through renewable energy. Power conversion using renewable energy source is fully depend on power converters. To get a maximum and stable output fully controlled converters are generally used. When the micro grids number increases, considering a billion people is connected through the smart grid and the result with an existing infrastructure is too complicated. Due to large number of individual power producers and producer cum consumer (prosumer) sit will be very hard to monitor and control all the renewable energy power converters. The consumers in smart grid can also describe in other word prosumer, because they will produce and consume the power [2]. The microgrids below required power rating cannot be connected to the grid to support the demand individually because, many microgrids used for house hold purpose will be below rated power and voltage level, so the power cannot be transferred from microgrid to grid. In order to support the grid, microgrids are combined in groups to meet the voltage standard of the grid. The clustering of microgrid having excess power is called as Virtual Power Plant (VPP) [2]. VPP is dynamic in nature and the structure changes according to the availability of excess power in microgrid. By dynamic algorithm for VPP the output of the microgrid is controlled and the problems like revenue and protection of individual microgrids can be maximized. The revenue for individual microgrids in VPP is based on the participation power supplied from individual microgrid to the grid [2].

To build a reliable network, renewable energy should be continuously monitored. Data’s plays a vital role for various smart grid operations and control. It is used for load forecasting, load scheduling and tariff and it solemnly making data security as one of the main problem in smart grid [12]. At every instant smart grid is going to evaluate huge amount of data and the collected data should be stored properly. At present energy companies are spending 1.1 percent of revenue in IT infrastructure and in regions like Asia/ pacific, Latin America, North America have spent an average of 20 percent revenue on data center [13]. Thus a huge amount of money is being spent on the data centers for transforming the current power system into a smart grid. Power utility companies should invest their money in power system infrastructure to get better service. But due to the requirement of large communication and storage system for smart grid the investments are off the course. To overcome the limitations in data management and market operations of the smart grid new emerging information technology cloud environment provides a better network solution [14-16].

2. Smart Grid

Resource smart grid includes adding two-way digital communication technology to devices associated with the grid. Each device on the network can be given sensors to gather data, plus two-way digital communication between the device in the field and the utility’s network operations center. Smart grid word has evolved after the distributed energy act by FERC in 1997 [2]. The act paved a road map to smart grid by deregulating the centralized power production. Smart grid is a multi-disciplinary sector which integrates power system, power electronics, embedded systems, and information and communication systems. Hence, the technological development in these sectors will have its implications on smart grid. Smart grid structure has been defined by NIST and it is shown in Fig. 1 [17].

NIST standardized the smart grid structure in power and communication along with administration layer. In power transfer layer bulk generators, transmission, distribution and consumers are connected. In the information layer markets, operator, service providers and consumer or prosumers are connected together. The data’s from power transfer layer is carried to information layer through communication layer using Ethernet or wireless protocols [18-20]. The information layer is proposed with a new technology of cloud environment to manage the information between the markets, operator, service provider, prosumer and data.

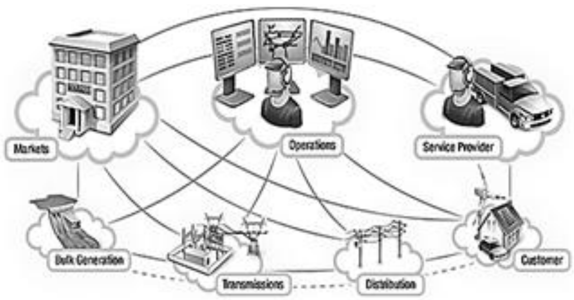

Fig. 1 NIST Smart grid Structure

NIST differentiate the renewable sources into three types

1. Renewable non variable
2. Nonrenewable non variable
3. Renewable variable [21]

The nonrenewable non variable power generation is based on fossil fuel for bulk power production. The plant capacity factor of the fossil fuel plants are ninety percent [2]. Fossil fuel plant is used to serve base load. Renewable non variable energy sources like biomass, hydro, geothermal, pumped storage etc. These sources are mainly used to serve the peak load demand. Solar and wind energy are main source types for Renewable variable energy [22]. The output varies as the input of the source varies hourly and seasonally and the plant capacity factors of the renewable and variable sources are 15 to 30 percent [2]. In renewable variable advanced technology helps to make the output constant and by using storage, the availability and reliability of renewable variable can be improved. From nineteenth century solar energy is positively shaping by new technologies and one of the important sources in the distributed energy resources [23-25]. Solar energy has advantages like large resources, static energy conversion setup, easy to install and no special engineering construction required. There are some disadvantages like resource available region i.e., it can be used broadly in tropical countries, it requires power conversion devices and available only during day time so for reliable usage storage installation is preferred.

In solar energy conversion structure embedded controller will control the MPPT, duty cycle of the DC-DC converter, switching pulse of the inverter and battery status. It can add some properties for reliable smart grid control like load, voltage, reactive power and metering [26]. Likewise in wind energy system embedded controller controls the pitch, yaw, gear and back to back conversion firing angle. For smart grid control it has to send all the data to the operator and respond to the response of the operator. This concludes that solar and wind energy can be controlled efficiently in the smart grid. By controlling the embedded systems solar power microgrids monitoring and controlling is made viable [27-29]. The Fig. 2 shows the single line diagram of the microgrid structure [30]. The wind turbine, solar and fuel cell are integrated with the main grid using inverter.

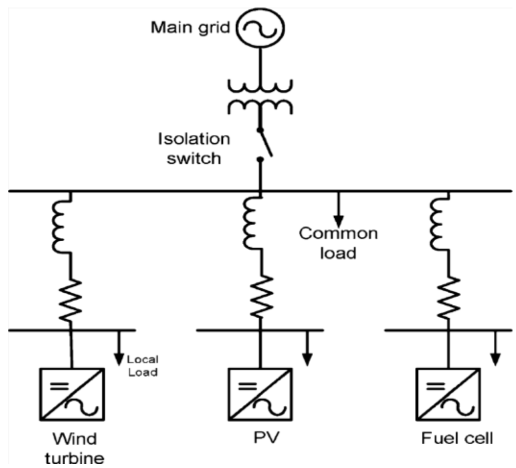

Fig. 2 Microgrid Structure

Integrating microgrid with the main grid induces the problems like harmonics, power flow and stability [31, 32]. Primarily microgrid stability is classified into;

1. Small Signal Stability
2. Transient Stability
3. Voltage Stability

The control scheme for inverter has been defined by Union for the co-ordination Transmission of Electricity (UCTE). It has three levels of control like Primary, Secondary and Tertiary control. Primary control focuses on the control within the DER whereas secondary control tends to maintain the frequency and magnitude fluctuations. Tertiary control helps to monitor the power flow at the Point of Common Coupling (PCC) between main grid and microgrid.

Controlling microgrids indirectly refers to controlling power electronic interfacing devices which is inverter in many case. Remote stabilizing unit for each inverter increases the reliable operation of the microgrid [33]. The instantaneous value of P-F and Q-V values are monitored by the Remote stabilizing Unit. Increasing microgrids, increases the amount of data to be handled and computing power for different processes. Stability is a primary concern of the microgrid during islanding and operating with the main grid. Stability problems occur in the point of common coupling within the microgrid and with the main grid. Different control techniques have been developed to maintain the stability. Nonlinear loads in the microgrid causes transient stability problems which can be addressed by Lyapunov direct method or other methods to damp the disturbances. This paper reviews the future perspective of controlling, monitoring and data management of the microgrid using cloud environment.

3. Recent Advancements in smart grid

From the invention of electricity, it has not changed much from the beginning. Development of grid happens by integrating communication systems among grid using Power Line Communication (PLC) between the substations using the unique frequency through the power line. Now PLC has been standardized and communication has been established by researchers and their developments. The communication of the power system is further reinforced by Supervisory Control and Data Acquisition (SCADA). It has been installed along with PLC to collect data from remote places and also to control the power system from the remote places. SCADA added up data collection, data storage and data management to the power system communication network. Power system requires servers to store the data and information technology is used to manipulate the data. To accompany the Supervisory control and data acquisition system Local Area Network (LAN) and Wide Area Network (WAN) for communication and Storage Area Network (SAN) servers for information technology are added in power system management system. For past twenty decades power systems has been reinforced, till the introduction of DER. Now power system needs special communication and computing infrastructure to provide reliable service.

Automated Metering Infrastructure (AMI) is a starting node point for smart grid. From AMI, data's are collected and sent to metering data management system. The data from AMIs are sent through communication channel like Ethernet or wireless network to the control center. In power system communication systems, technology developed from PLC, SCADA, GPRS, GPS, Ethernet and Wi-Fi or WiMAX. Parallel network communication topologies are developed from LAN,WAN, Home Area Network HAN, Metropolitan Area Network MAN, Internet and to satellite. Similarly various network topologies were developed starting from LAN, WAN, HAN, MAN, internet. Likewise in embedded systems, the memory and processor speed has been increased from 1 to 32 bit. Information system for data management has developed from personal computing, service oriented architecture, grid computing and cloud computing.

Implementing the top new technologies from Communication, network, embedded and information technology sectors will make smart grid very reliable and efficient.

3.1 Communication and Network

Communication between all the components in smart grid increases the reliability and flexibility [34-39]. Communication for smart grid can be established by combining wired and wireless network. For a real-time control internet is mandatory in smart grid infrastructure. Every device operator or electricity producers and consumers are connected through the internet and so speed of the internet is crucial for reliable operation of the smart grid. The data from the micro grid and to the micro grids are transferred through the internet using LAN, MAN, WAN and HAN network. Recently French Telecom Company, Alcatel-Lucent research team tested the network speed in wired network and achieved a speed of one terabyte per second and likewise Chinese telecom company, hauwei has succeeded in achieving 10 Gbps speed for Wi-Fi network. These results enhance a positive scenario for the smart grid communication with high speed interaction between smart grid participants and microgrids through which monitoring and controlling can be carried out efficiently [40, 41].

3.2 Embedded control

Two way power flow and communication between the operator and micro grids are possible through the communication line and at the end embedded systems is going to respond [42-44]. Microcontrollers like Atmega, Atmel, Arm, and Arduino are used to control the switching pulse, relay, send the real time data from the micro grid and receive the control data from the remote end. Internet based embedded control has evolved by the development of different types of compilers. Each embedded is connected in a network through Ethernet or zigbee in different protocol or network internet protocol and these embedded controller is monitored from the remote end by the operator or power producer. The communication between embedded systems and the operator takes place through the web languages like HyperText Markup Language (html), Extensible Markup Language (xml) or php [45, 46].

Controlling embedded system using web pages creates cyber-security concerns in smart grid.

Process of embedded control can also become a utility source, because embedded controller controls the system using the algorithm or uploaded program in the micro controller. The processor memory size depends on the number of processes to be managed by the processor. Every control system has a microcontroller or processor which sends and receives signal and converts digital to analog and vice versa and also manipulates the calculation according to the program uploaded.

Basically programming microcontroller is in op-codes but the revolution in embedded control face lifted the programming language from op-code to C, C++, java and also user friendly open source embedded application [26]. This made embedded system user friendly and easily controllable. Interfacing embedded control with Ethernet network revolutionized the embedded systems to control and monitor the microcontroller from remote place. This also led to the new concept of Internet of Things (IoT) [47]. IoT is defined as monitoring and controlling the embedded devices by the internet network.

In smart grid many sensors are used to collect and send the data to the microcontroller. To process the data from sensor, initially the analog data is converted into digital data. In the beginning microcontroller memory size was based on the Digital to analog conversion and processing size but recently the memory and processing size of the embedded system is developing with higher margin. Embedded systems are integrated with Ethernet, Wi-Fi, Wimax, Zigbee, Xbee and the processing size has increased from 1 bit to 32 bit processor.

3.3 Standards

From installing a microgrid to integrating with grid its operation, protection, communication, architecture, protocol, control and data management, is defined by standards [16]. It helps to maintain reliable, flexible and stable smart grids. IEC 62325 is an information standard and measures the amount of data collected from the IED's, connected with a standard of IEC 61850. IEC/PAS 62559 provides a standard for information technology providers to develop the new system from the existing system. IEC 62351 is a standard concerned with IT security for data communication. IEC 62443 ensures the industrial communication. NERC CIP framed a cyber-security standard for the information layer that includes recovery, response and electronic security [16]. IEC 61850 is also well known for the standards of interoperability of smart grid components. IEEE 802.3 instructs the way to interlink the components using Ethernet [16]. IEEE 1588 precision time protocol advises the communication between the power system components using Ethernet [48]. IEEE P2030 ensures the interoperability of smart grids and within the smart grid. IEEE 1547 series standards the interconnection of resources used in smart grid. Other important standards are shown in Table 1 [16, 49].

Table 1 IEC Standards

S. no	Standards	Purpose
1	IEC 61970	Energy management
2	IEC 62357	Architecture
3	IEC 61968	Application Interfaces
4	IEC 61850	substation automation
5	IEC 60370	Security
6	IEC 62325	Communication for markets [std1]

4. Cloud environment

Due to increasing expansion the grid is becoming the one that is data-intensive, information-intensive, communication-intensive and computation-intensive [50, 51]. To come up with a new paradigm in the field of electric grid a distributed architecture that uses the concepts popularized in internet research is required (The Hindu, May 17, 2010). Cloud computing heavily relies on communication protocols. Standards are implemented openly to aid collaboration between services thereby providing independence between device and software

Cloud computing is defined by National Institute of Standards and Technology (NIST) as "it is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [52]. Gartner defines Cloud Computing as "a style of computing in which massively scalable IT-related capabilities are provided "as a service" using Internet technologies to multiple external customers". The Fast Cloud Group defines Cloud Computing "as a new style of computing in which dynamically scalable and often virtualized resources are provided as a pay for use service over the Internet or an Intranet network. Users need not have knowledge of, expertise in, or control over the technology infrastructure in the cloud that supports them.

Cloud environment has three types namely Public, Private and Hybrid. Environment is defined by the service level agreements and rules between the utility providers and cloud users. In these environments the cloud providers also provide the services like Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service(SaaS) [53]. If a customer is choosing IaaS, customer has to agree with the cloud provider to use the infrastructure besides electricity customer and the cloud provider should pay penalty if they violate their agreements. PaaS includes infrastructure and customer is allowed to use their own software rather SaaS allows to use an application installed on the environment.

Cloud environment reduces the burden for other utility company's information technology oriented application [53, 54]. Like electricity, cloud environment is also a utility service with an objective to pay as per use. The need for cloud is to reduce the expenditure on infrastructure i.e., in an electricity company, the expenditure of the company should be on the electricity infrastructure but currently around 1.1 percentage of investment is spent to maintain the data storage and on information technology infrastructure to maintain communication and data handling [13].

The need for infrastructure forced to develop from network computing, grid computing, and utility computing to cloud computing. Cloud computing is designed to reduce the infrastructure cost and as a solution for problem faced during grid and utility computing. The infrastructure cost is reduced by virtualizing all the existing hardware. Reliable service by elasticity and scalable process i.e. dynamic allocating resources on demand basis and Meta and Peta data handling using Hadoop and Map reduce technique [55, 56].

Amazon eucalyptus, Citrix cloudstack, Apache openstack and Salesforce provides cloud infrastructure as a service. Google App Engine (GAE), Windows Azure is well known for their PaaS. GAE is limited open source environment.

Cloud environment has a participants like cloud consumers, providers, auditors, brokers and carrier. Cloud provider will offer the types of services and the environment as a utility service. Cloud consumers are the network providers in the smart grid who use the cloud environment for the information management purpose. Cloud auditor is like an operator in smart grid, ensuring the security, assessment and information of the cloud environment. Cloud broker operations are similar tosmart grid brokers to act intermediate between cloud provider and cloud consumer to ensure the requested resource has been allocated. Broker also ensures the availability of the customer. Cloud carrier is the medium that creates connectivity between provider and consumers and also transfers the services [48].

The important property of cloud environment is virtualization. Virtualization is defined as integrating and converting the total physical hardware's including networking, storage, server, CPU and desktop. This property intends to reduce the infrastructure cost. The various economical factors to be analyzed to establish Cloud environment for power system are Total Own Cost (TOC), Return of Investment (ROI) and Net Present Value (NPV). Total Own Cost for IT infrastructure pricing includes for Disk storage, Full Time Equivalent(FTE) labor, firewalls, network switch, server hardware, service maintenance and licenses. The return of investment for cloud computing will be higher than the grid or utility computing. ROI is calculated by Eq. (1).

$$ROI = \frac{\text{Gains from investment-cost of investment}}{\text{Cost of investment}} \qquad (1)$$

Net present value for cloud computing is also higher than the other computing technology. The Net Present Value is calculated using Eq. (2).

$$NPV = \sum_{t\text{-}1}^{T} \frac{C_t}{(1+r)^t} - C_o \qquad (2)$$

C_t = Net cash inflow during the period

C_o = Inintial investment

r = Discount rate

t = Number of time period

Considering a premise needs IT infrastructure for three years, only at the first year cloud computing cost will be more than grid computing but for the remaining two years cloud computing price will be comparatively lesser than grid computing as its price will be increasing year after year. For all services like IaaS, PaaS, and SaaS the ROI and NPV of cloud computing is high and reliable.

5. Smart Grid with Smart Network

The bantling smart grid is growing by neutralizing the problems blocking its growth [57-60]. This paper, concentrates on the monitoring, embedded control and data management of smart grid using cloud environment [61-64]. Voltage, power, inverter switching signal, MPPT control and load are monitored for the microgrid to be reliable. The instantaneous control causes handling of several millions of data. Data's are valuable and it has to be secured for revenue, tariff and planning purpose [65]. This makes the data handling and securing as a primary console. Cloud technology is an emerging technology innovated to handle the metadata and sharing the resources.

The vision of all countries is to create a grid which is smarter in all aspects. Developed countries like US, UK, China drafted a vision of smart grid on 2020 and developing countries like Brazil and India also have a vision of smart grid [10, 16]. The future smart city will be fully connected with the high speed internet. The block diagram in figure 3 shows the operation of the proposed future smart grid.

In the proposed control architecture, the data measured by the sensor is sent to cloud environment for the controlling process through high speed internet connectivity. The data from the sensor will be collected by embedded system which is transferred through high speed internet in high level languages and vice versa [66-70]. The control signal will be sent from the cloud environment through high speed internet to the embedded system. This transformation will reduce the dependence on embedded systems and the smart grid components can be monitored instantaneously and effectively. Establishing a smart grid with full high speed internet, the process of embedded systems can be shifted to the Process virtualization servers. Embedded servers evolved to respond directly to the high level languages like xml, Unified Modeling Language uml, java, python, php, html5, C#.

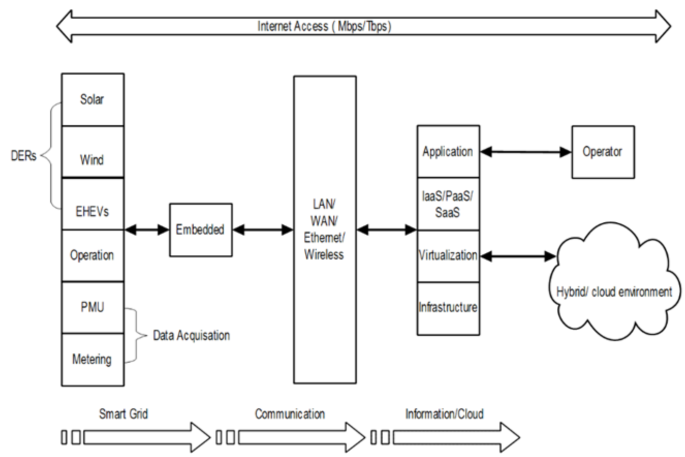

Fig. 3 Smart grid operations in Smart Network

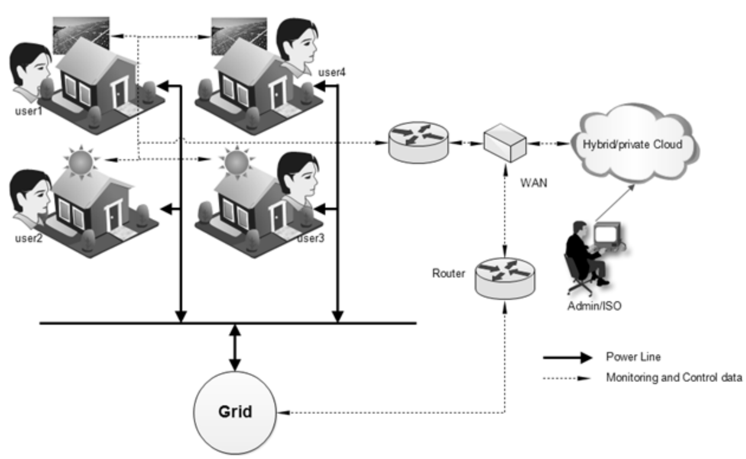

Fig. 4 Structure of microgrid in smart network

Renewable energy sources, AMI and protection system are monitored and control through embedded systems [71-73]. The embedded systems will send and receive the data from the end-user to the operator and vice versa. High speed internet connection is established throughout the smart grid environment. Communication network is succeeded by wired or wireless configuration. The data's from the prosumer or micro grid is collected and manipulated by the cloud environment servers and control signal is being sent through the same communication channel.

The Fig. 4 shows the basic structure of smart grid with microgrid connected with smart network. The control and monitoring data is operated from the hybrid or private cloud environment by the operator. The stability of the microgridis being monitored continuously using the communication lines. The figure represents the local power packet with two solar and two wind energy microgrid connected to the grid. Control and monitoring communication is established between the microgrids and the main grid. The communication network uses WAN network to collect data from the microgrid to the ISO likewise same WAN network is used to send the control signals [74, 75]. The data's from the WAN network is send to the Hybrid or private network and monitored and manipulated by the ISO.

6. Application of cloud in smart grid

Integrating smart grid and cloud environment cause a boon for the power system. The advantages from the cloud environment will tend to nullify the disadvantages and it will reinforce the power system. Application of the cloud environment is widely used to reduce cost, data handling, accessing speed, cyber security and in smart grid environment it creates more entrepreneurship.

6.1. Reducing cost for Information Technology Infrastructure

Using the property of virtualization, the cloud environment will be able to integrate all the available hardware's and use them to achieve highest efficiency. For example, if a smart grid broker requests for 5 GB of ram space to any cloud environment, the cloud provider will allocate 5 GB ram through cloud broker. The allocated 5 GB ram will be in virtual form i.e. the smart grid broker can use the properties of 5 GB ram in a virtual manner not as hardware. The space provided can be either from single location or by integrating available space from the different location similar to virtual power plant property. Cloud utility service provides the required information technology for smart grid brokers and large power producers. Depending upon the ability of fund cloud environment is purchased or created which will reduce the spending cost for nearly 60 percent.

6.2. Data handling

Generally data handling starts from collecting then manipulating the data and storing for various purposes. Monitoring data virtually intends to monitor the microgrid elements. In smart grid data's are acquired from every node and component. Number of elements directly increases the number of data's to be handled and the data's are collected by the embedded systems and transferred through Ethernet. The files can be either html or xml format. These files are collected by smart grid brokers and synchronized with operator. The data's must be aggregated and arranged in an orderly fashion for easy access of files. A unique and large storage space is needed to store the metadata. Cloud environment provides data handling as a service.

6.3. Increasing accessing speed

For proper market operations, the network should be designed to access of data's with high speed. Accessing data depends on the network infrastructure and the information technology. The problem arises when all the participants in the smart grid try to access a same file or domain at the same time. This may lead to website crash which if occurs during the peak hoursit leads to improper market operations. It will reduce the reliability of the market operations. Cloud environment crowned with the property of elasticity and it is the one of the solution for accessing files. The size of the users and network will be increased and decreased according to the usage of the website.

6.4. Cyber security

Security in smart grid is of primary concern that includes security from the each individual protocol on consumer's side to the large producers and also protecting the data's from microgrids, market operations and total accessing network. Hacking or block out in smart grid communication or in information layer could lead to bigger problems like shutdown, erased data, interrupting market operations, instability and islanding. Evolution of smart grid may ignite an idea for hackers or illegal users to create a unique malware or virus for the smart grid services. But smart grid participants may not be aware of these threats and this led to a gateway for hackers to enter inside the network. So it becomes mandatory for the network providers to give security for the whole network including communication and information layer. Smart network once again proves that it is suitable for the smart grid operation by helping to overcome this issue and reinforcing the structure. Cloud environment provides the security for the data stored and the service can be outsourced by the smart grid providers like a utility service.

6.5. Increasing Entrepreneurship

Smart grid is a collection of many small micro grids and large grids. Large sources are controlled by large producers and whereas the small micro grids in the consumer side are dynamic and has to be controlled. Single operator cannot monitor the complete smart grid. The micro grids should be controlled locally and the data's are to be monitored by a local body synchronized with the main data frame. This process can be defined as brokering. The smart grid broker ensures the power available from the region, monitoring the micro grids, protection, revenues and data storage of that region. This scenario encourages many brokers for the local region. The brokers will face the problem on communication and information, so that they can use cloud services for data management and monitoring system.

7. Conclusion

In future, power generation from the microgrids are going to increasing order to satisfy the power deficit. To ensure proper operation, efficient performance and effective communication of microgrid integrated with the grid, smart grid needs high computing and data management power. This paper reviews the various issues faced by smart grid and propose two different approaches to reduce the problems in monitoring, controlling and data management. With a high speed internet, smart grid operations like controlling and data management are instantaneously monitored and the process of embedded systems has been replaced by the cloud servers. Migrating to cloud environment will increase the efficiency of the smart grid and reduces the infrastructure cost.

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