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Energy Monitoring and Routing for Impending Challenges in SMART GRID

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ABSTRACT: This paper emphasis on the scenario of current Power system for the upcoming world i.e. in Power Grid (PG) now a day's Smart technologies playing vital role, Thus the term Smart Grid (SG). The interconnections of the Power Grid(PG) is mingled and complex. The two- way flow of power is caused by the presence of various distributed generation. Therefore, in future it is becoming more composite and a vast constriction to the energy routing, where monitoring of each signal plays a significant role. So, each signal quality must be improved, sensors should be placed and aided to power system. Then Introducing Internet of Things(IoT) to the Power Grid(PG), with respect to the VAN, HAN, WAN each signal is monitored. This paper presents the issues and remedies in design and monitoring of Smart Grid linked with IoT.

Keywords: Smart Grid, Internet of Things (IoT), Sensors, Meters.

I. INTRODUCTION

"The ubiquitous Power grids are outdated" is the correct statement for the scenario of the future power system i.e. it's says that the world is shifting to smart.Traditional grids couldn't make as much as the hastily growing demands of electrical energy. Smart electrical grid system or smart grid is presently developing technology. That is honestly fine over traditional grid in a way that tracking and manage of all components from energy plant to consumers and vice-versa is feasible, which establishes a thorough manipulate. For this form of manipulate and tracking in actual-time, communique technologies are intensely evolved, which might be called "Internet of Things" (IoT), in which the machine permits all devices to relate to the internet service [1]. IoT in conversation networks for smart grid also serves Wi-Fi technology for the increasing call for of Wi-Fi services. IoT is a trending generation which establishes conversation or interplay between one of some kind smart devices in day after day existence, like cellular telephones, sensors, actuators and radio frequency identity tags and so on

"Worldwide interoperability for microwave access" (WiMAX) is one of the latest wireless communication option used in Smart Grid knowledge and technologies. This "IEEE 802.16" series is a 4th generation broadband wireless media with high standards. This offers extensive coverage, rapid data, and enormous service for a plethora of requirements [3]. "Smart Grid Communication Networks" (SGCNs) are model architectures with the US "National Institute of Standards and Technology" (NIST) and also with the IEEE Project 2030. In these following architectures three domains of networks namely "House Area Network at customer side" (HAN), "Field Area Network in distribution section" (FAN) and "Wide Area Network" (WAN) are defined in transmission domain. WiMAX featuring communication and QoS ("quality of service") are implemented with FAN and WANs. WiMAX is now revised as WiGrid [3]. Different nodes in a power grid are connected electrically as it is a complex interconnected system, termed micrograids which operate as per local demand.

Flow of energy becomes bidirectional due to presence of distributed generation plants. There are greater constraints determined in power routing in terms of voltage and present-day alerts and electricity quality. In Power grid, for power monitoring in actual-time, sensors and transducers also play an enormous position. smart sensing systems cause automation in strength measuring and processing of facts. IoT provides top scope for growing smart electricity meters, like multihop communique – information sharing towards complete grid, communication mounted with each sensor and all successive nodes, via internet and internet services and for this reason enhancing grid management.

Continuity of service is also the most critical aspect with the aid of which the performance of Power System is assessed. However, the goal of accomplishing uninterrupted service is hard to be met with because of a plethora of motives, one of which will be, dispensed generation from an arbitrary sustainable source makes the grid preservation hard. the maximum feasible answer for DSO ("distribution System operator") is to upgrade distribution network automation, extending the situation to become smarter. Those automations put into effect Intelligent Digital Device (IDD) hooked up in number one substations. Logical choice of shielding relays is one precise automation approach that results in maximum fault clearing in short clearing time. "IEC-61850" standard serves first-class implementation of automation. IEC-61850 scheme of logic selectivity for public medium voltage distribution networks is laboratory examined with one of a kind faults.

Altogether the above discussion introduces numerous new technologies being evolved /used in cutting-edge day.

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II. "SMARTGRID" TECHNOLOGY

As defined by IEC 2010, "*Smart Grid is a network of smart electricity capable of integrating actions or activities of all users, ranging from power plants to consumers to make efficient, sustainable, economical and supply electrical safety*".

NIST defines 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*".

These definitions portray Smart grid as an intelligent network with communication established between generation, consumption and storage.

Traditional Power Grids face some drawbacks like ageing of infrastructure, renewable energy sources to integrate with existing grid, globalizing of devices, black-outs, deploying variety of loads etc, are the needs or reasons leading to formation of Smart grid.

Phasor Measurement, Intelligent Metering system, Data Sharing and Distributed Energy will be the type of Smart grid technologies / components.

The anticipated features of Smart Grid will be:

- Enhances electricity market
- Asset utilization optimized
- Power Quality
- Enhances the efficiency of Operating Systems
- Self-healing
- Tough against technical and cyber attacks
- Direct engagement of consumers in demand response
- Includes every generation and memory options.

A Smart Grid effectively provides integration between four basic domains:

1. Utility (domestic / industrial / commercial)
2. Ancillary Services (Power Market)
3. Operational Control (Grid Operation)
4. Provision of Resource (Consumers provided with electric power by Utility companies)
5. Power Generation, Transmission System and Distribution.

Self-healing based on sensors, used to predict abnormal conditions is a distinguishing feature of Smart-Grid. It is possible to shift to island mode of operation for the system to become stable and fix the failures. The tedious challenge for smart grid is to provide security against hackers on the internet, the best example is Ukraine attack. Storage options and Big Data management are other challenges. Operational compatibility of communication networks also poses a challenge.

Smart grid is unavoidable for future scenario. IoT should be the prime solution for Smart grid. A change from traditional power grid to smart grid is a difficult task. A greener and smarter energy will be the outcome of Smart-Grid.

III. INTERNET OF THINGS (IOT)

The word "Internet of Things" (IoT) is one of the most prevalent present-day technologies. It has deals with different connected devices, like cars, domestic appliances, medical, roads to smart grids, leading to energy management efficiently [6-7]. Thus, IoT plays a significant role in development of energy consumption at economic levels and energy efficient smart grids. There are various "Internet based communication technologies" like "Radio Frequency Identification" (RFID), different Sensors like Infrared, GPS (Global Positioning System), Laser Scanner, etc which are effectively used for information exchange as regular entente. This helps in managing network with good monitoring and efficient or smart way of communication.

Some of the key technologies involved with IoT:

RFID provides automatic identification of objects without any physical contact. It has feature against duplication, Combine Encipher, data security on card etc.

Sensor Network like "Wireless Sensor Network" (WSN) that it develops a huge network for communication linking diverse fields of application [8].

Smart Technologies includes "Artificial Intelligence", "HMI Interfacing", "Intelligent Control Technology", "Intelligent Signal Processing" etc relating to internet.

Nanotechnology is the study of miniature particles consequential in progression of industrial products like Medicine, energy transportation etc.

The communication network uses various technologies like
HAN (Home Area Network)
NAN (Neighborhood Area Network)
FAN (Field Area Network)
WAN (Wide Area Network)
WSN (Wireless Sensor Network)

Fig 1: FAN and HAN systems

These are some important aspects of IoTs and Smart grid. In coming future, most of the end-users will require wireless communication for data sharing. ZigBee and HAN and NAN networks customarily employ 6LoWPAN protocol; these are specially designed for communication of low speed data within limited range over wireless personal area networks [9-10].

The interconnected power grid becomes more reliable and efficient by implementing Sensor technology in IoT, which creates a live or interactive environment between power grid equipment, consumers and corporation.

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IPV6 is opted in multi-layered smart grid frameworkDomestic, industrial, global, public or private IP address according to the scale of disposition. IoT's IPV6 multi-layered architecture involves OSI layers [11-12].

With the application of IoT, each connected device has a unique IP address which can do status uploading and obtain control commands through the internet. IPV6 can address up to2^128 devices.

One of such addressing schemes in IEEE802.15.4 standards is 6LowPAN communication protocol. The design parameters of 6LowPAN frame size are: 127 bytes, 21 bytes payload for TCP and UDP 33 bytes. This is a nice choice in smart grid appliances based on IoT technology. Some of its applications are described as below:

- ❖ 6LowPAN frame applied in Smart Homes. The data sharing and control utilise payload. With internet provision, all appliances are traced by a unique ID and accessed by the consumer.
- ❖ All usual devices of any substation such as transformers, circuit breakers, switches, relays, cameras, etc are each assigned with a unique IP address. Every device communicates with the personnel via Internet.
- ❖ Distributed Renewable energy sources scheduled during peak hours. An IP address assigned to every device and assigned with payload.
- ❖ Devices attached with Mobile Workforce like smart phones, computers cameras etc each with an IP address and accessed.
- ❖ User information and service / control infrastructure and database services such as DMS ("Distribution Management System"), GIS ("Geographic Information System"), OMS("Outage Management System"), CIS ("Customer Information System"), SCADA ("Supervisory Control and Data Acquisition System"). Every service is assigned with an IP address.
- ❖ Bilateral systems with DG("Distributed Generation") and multiple users are accessed with an IP address.

IoT integrates all these devices in scalable model.

The architecture of IoT is defined by EPC Global "IoT" as in Europe, US,

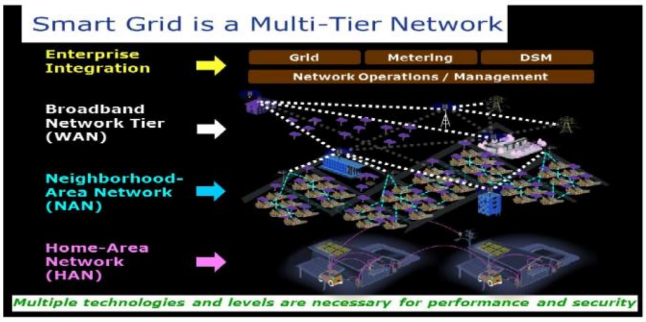

Fig 2: Layers of Communication Network

and the UID (Ubiquitous ID) of Japan IoT system. UID is popularly used for interlinking industries with all suitable data to form an "Internet of Things". The basic three layers of IoT will be Perception – Network - Application Layers.

Perception Layer used for perceiving information using code reader, sensor network, M2M terminal, RFID, camera, etc.

Network Layer used for network operation and information handling.

Application Layer combines IT with industry by data sharing and data security.

Ubiquitous areas of application in IoT: Networking; Information; Operation Service; Security; Management :

Deploying IoT with Smart grid highlights the following:

- ➢ Real time based management of energy consumption of end user.
- ➢ Integration of device energy requirement status with smart meters.
- ➢ Energy consumption scheduled according to consumer requirement and resource convenience.
- ➢ Smart communication established within devices of grid, also with a possibility for islanding.
- ➢ Smart storage devices connect power supply to main grid and vice versa converting a " consumer" to " prosumer" . (Prosumer = Consumer & Producer)
- ➢ Integrating Renewable energy and Power Grid.

IoT also predicts energy forecast using wireless sensors, collecting real time data.

Electric Vehicles act like storage devices. IoT can communicate with these to collect information like identity, battery status, location etc.

A continuous monitoring is done online for the entire grid with power grid, transmission and distribution systems, energy management etc.

IV. CHALLENGES IN SMART HOME BASED ON IOT AND SMART-GRID

Power supply and user-end can be established a communication interface with IoT based Smart-Grid applied to Smart Home. At the same time, it need to face challenges like data security, connection stability, economy etc.

Some case studies of such examples are listed below:

1) The use of USB flash drive, in 2010 was the cause of spreading of STUXNET VIRUS. This lead to attacking of SCADA in Smart-Grid. Statistics prove that 60% of virus was due to this medium.
2) Using of Windows operating system in energy sectors by corporate is also a virus by computer attack to extract confidential data like financial, bidding information etc. This virus is called Night Dragon Virus.
3) Slammer worm virus infected a power plant in Ohio which made the power plant to hang for certain period of time.

Establishing communication with fast response and small latencies among all components is the requirement of a Smart-Grid in real time systems for smooth operation, maximum utility of electric power and high reliability.

Therefore, managing efficiently a smart power system and evolve the same to the existing system is a big challenge.

Fast internet connectivity becomes basic requirement of IoT, a slow internet connection does not lead to optimal electrical redistribution [1].

Smart-Grid with IoT should minimize energy consumption, and also need to face challenges for achieving the goal.

Factors like vast implementing, limited resources, diverse loads challenge the deploying of IoT. First one to mention, IoT applications are featured with overlaid wireless sensor and actuator networks which cannot interconnect and many a time use very limited resources. Second one, accurate sensor technology, information broadcasting and quick adaptability to real time changes are challenging aspects of IoT. In the [2] article by Zhao, et al. [An Event-Driven Service Provisioning Mechanism for IoT (Internet of Things) System Interaction], these challenges are answered by a IoT platform, defined in different levels. The practical possibility of this area is shown through a DHCISS ("District Heating Control and Information Service System"). From the article by Park, et al. ("Learning How to Communicate in the Internet of Things: Finite Resources and Heterogeneity"), applications, benefits, constraints, performance and difficulty of analysis of novel learning frameworks, such as machine learning, Artificial Intelligence and successive learning for IoT concepts are summarized. This work defines a framework based on cognitive hierarchy theory that can manage IoT heterogeneity and highlights the key results in applying cognitive hierarchy. Facts related to energy utility and power quality help the grid in efficient energy routing based on appropriate decision selection. The smart environment modified the method of energy exchange through the grid. The new method of energy flow should adapt to change in flow of direction as per requirement. The transmission distance is not the only measure for energy routing decision. Therefore, energy supply from a distant node can be preferred if it is more standard in quality. From this point of view, the recent smart energy metering supports the Smart-Grid in monitoring power through all nodes efficiently and effectively.

Improved Smart Energy Metering

- remotely controlled and also programmed;
- communication equipped among various power meters;
- flowcharts of decision-making;
- embedded data processing;
- better power quality;
- energy routing based on appropriate decision selected from power quality requirements of end-user.

IoT provides power meters access to internet for communicating information of their parameters like status, position etc. Smart power meters take this advantage to use the internet, making the power grid more advanced. Power meters also do constant monitoring of power line temperature and estimate the line carrying capacity. This method is used for managing dynamic power flow with suitable line ratings.

The Fig 3. Shows Smart Applications in INDIA, 2015 to 2024 and a short time forecast.

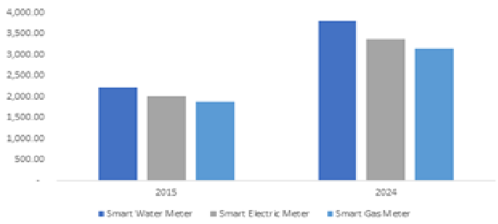

Fig 3. Smart Applications, INDIA , short-time forecast.

V.CONCLUSIONS

Future challenges of Smart-Grid are discussed in this paper. Applications of Smart-Grid with IoT Technologies facilitate and enhance communication between grid and consumer. Efficient Energy Routing based on decision criteria, taking into account the Power Consumption and Power Quality is the main objective of Smart-Grid system. Effective Monitoring by Smart Meters is one good achievement by IoT in Smart-Grid.

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