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An Effective Demand Side Management in Smart Grid Using Cloud Computing

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Abstract**—** *In the present decade, power grids plays a vital role to deliver the growing demand for power, as well as to provide a stable and sustainable supply of electricity to consumers. These complex challenges are driving the evolution of smart grid technology. To handle smart grid dynamically, Active Demand Side Management Scheduling (ADSMS) algorithm is proposed for resolving the electricity demand over online using Cloud Technology. The entire place is divided into grid of geographical area and each geographical grid's power requirements are scheduled and managed over smart grid. Demand response which decreases the power consumption from off peak hours to on peak hours depending on consumers' preferences and lifestyles. From the consumer consumption details, the ADSMS manage and provides suggestion of requirement of power over for smart grid geographical area. The web application which is built within the cloud to schedules the power into three cases. According to the scheduling, the consumer will get the power via smart grid. A smart meter which is built within the smart grid is to record the power consumption and it sends the data to the utilities for the billing purpose.*

Keywords**—** *Demand side management, demand response, cloud computing, smart grid and smart meter.*

I. INTRODUCTION

Inter-disciplinary research is a growing field in the present information age to find the solution for unsolvable problems. Computers and software plays a major role in all the fields in the Internet world. Now, integrate computer technology into electrical to form the power grids to smartly handle electricity requirement of the consumer without any wastage. Generally, to make the traditional power grid to work as an intelligent is known as smart grid. Traditional power grid is one way communication but smart grid is bidirectional communication between the utilities and consumers.

A. Smart Grid

Electricity plays crucial role in development of a Nation. Electricity generation and distribution causes major environmental disorders and affects greenhouse gases. The conservation optimization of power is a challenging work in this present traditional grid system. New innovative technologies are implemented to reduce power consumption in the house hold items, machine in the factories, agricultural fields etc., Even though generation, utilization and distribution of electricity not yet optimized so far in the right direction. In this globalization era, limited power consumption, efficient utilization of existing electricity needs a modern technology to handle this complex situation with proper power saving distribution scheduling. To address this issues a smart grid is introduced.

To making the traditional power grid to work as smart grid is generally called as "smart grid". The smart grid plays a major role in power allocation via consumer requirement scheduling. A smart grid is a combination of electrical, network and communication infrastructure. The smart grid which is bi-directional communication between the consumers and the utilities. The smart grid supplies the power more efficiently and reliably than the traditional power grid. The smart grid is power network with the 'intelligent' entities that can work autonomously to provide a quality power supply. Smart meter and the micro grid are the two main components to achieve the smart grid goal.

B. Smart Meter

The smart meter which is a digitalized meters not an analog meter. It displays the cost of power consumption to the consumers in a detailed manner and also it sends the daily bill to the utilities to verify that the transmitted power and the received power is equal to avoid power theft. It uses the advanced metering infrastructure (AMI) for bi-directional communication for getting the real time power usage at the consumer side.

C. Micro Grid

Micro grid which is consists of electricity resources like renewable energy resources for power generation for a small area or a particular area. The micro grid generally connects to the macro grid. It generally used to provide stable power supply within a particular boundary. Micro grid is described into five categories. Those are off - grid micro grids, campus micro grids, community micro-grids, district energy micro grids and nanogrids.

D. Cloud Computing

In the present information age, networking and cloud computing plays a major role in development and implement new techniques with different fields. The Cloud computing means a type of 'utility computing' that is a shared pool of physical and virtual resources not for deploying the hardware and software.

The cloud which provides on-demand access of data at anywhere and anytime in the world using the internet. The cloud computing provides three main services such as Infrastructure, platform and software as a services. The cloud deploys three models as public cloud, private cloud and hybrid cloud for different usage for client requirement for storing and retrieving the datas.

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E. Demand Side Management

The goal of demand side management is to use less power consumption during peak hours and manages to fulfil the consumer need as per their demand. Peak demand management does not necessarily decrease total energy consumption, it used to manage the power requirement. One of the main goals of demand side management is billing the consumer according to the original cost of power consumption (i.e. tariff plans).In case the consumer gets less bill for using the power in off-time periods, than the supply and demand encourages the consumer to use less power. Then, the goal of demand side management will be achieved.

F. Requirement of Cloud Technology

Smart grid consist lot of smart meters in the consumer side. It needs distributed data centre to manage these smart meters. In this way the cloud computing technique plays vital role in utilizing smart grid. Cloud computing which takes responsibility for the service providing for the consumers at anywhere and anytime. Cloud computing which provides high scalability and on-demand access for getting the real time information retrieval. Cloud based demand response which uses black box information system which takes information from the consumer side and it gives the output to the utility.

II. Related Work

K. Anderson et al. [1] provided a platform for modelling, designing and planning of the smart grid via a cloud based architecture. These are all managed through representational (REST) state transfer application programming interface (API) or through python library.

A.-H. Mohsenian-Ra et al. [2] proposed an optimal, autonomous and distributed incentive-based energy consumption scheduling algorithm to minimize the cost of energy and balance the residential load when multiple users share a common energy source. It maximizes its own benefits in a game theoretic setting.

Y. Guo et al. [3] focused on minimizing the expected electricity cost. Lyapunov optimization technique is used to solve the stochastic optimization problem and it considers about the energy, storage and local distributed generation such as PV modules, small wind turbines.

H. Goudarzi et al. [4] used a task scheduling policies to minimize the electrical cost by setting the Time of Use (TOU) and also it used rank-based heuristic and a force directed based heuristic solutions.

X. Fang et al. [5] explored three major systems namely smart infrastructure system, smart management system and smart protection system. They proposed failure protection mechanism to improve the reliability of the grid.

M. Hashmi et al. [6] explains about various smart grid concepts i.e. virtual power plant development, active demand at consumer side, Domestic Electric Rentals (DER) business, active distribution network and ICT applications for developing the intelligent grids.

To monitor and manage smart grid a web application was created in that real time energy monitoring, prediction and energy trading management has been realized and piloted in tamatis S. Karnouskos et al. [7].

N. Lu et al. [8] approached a multilayer hierarchical information system (IMS) for smart grid. The IMS characterize the states of the smart grid with the help of data collected by the multiple control and communication network. Amir-Hamed Mohsenian-Rad et al. [9] used data centres and cloud computing for the robustness and load balancing in smart grid. They used IEEE-24 bus Reliability Test System for the load balancing improvement in smart grid.

P. Samadi et al. [10] proposed Vickrey-Clarke-Groves (VCG) mechanism to maximize the social welfare i.e. reducing the power consumption and shifting the load from on-peak to off-peak hours. They used Energy Consumption Controller (ECC) in smart meter for the bi-directional communication.

Consumers are asked to report their information about power usage to service provider, then the service provider determines the optimal power allocations and charges for each user based on social welfare maximization. Consumers cannot achieve greater benefit by mis-reporting and social welfare maximization can be achieved in J. Cao et al. [11].

A. Narayan et al. [12] used Auto Regressive Integrated Moving Average (ARIMA) statistical model for calculating the bill based on the load prevailing on the cloud infrastructure for and the calculated bill is submitted to the consumer.

S. Bera et al. [19] discussed about three management systems such as energy management, information management and security. They explained cloud energy storage devices and cloud data storage devices for the smart grid architecture in energy management system. It gives more memory and storage for the computing mechanisms in the energy management system. Additionally, cloud computing provides pure-IP based security than the conventional.

III. Active Demand Side Management Scheduling

The proposed system used for demand side management in smart grid using cloud computing applications. It uses the monitoring sensors for getting real time demand from the consumers. This system uses the ACTIVE DEMAND SIDE MANAGEMENT technique. DSM manages the consumer requirement based on their demand. Demand response is one of the types of demand side management. From the consumer consumption details the power scheduling algorithm is prepared and the smart grid used to channelize the power requirement as per the demand. The proposed system gets the real time consumer consumption details. It manages the demand side requirement and it is cost effective method.

Table I describes the power consumption details for one smart grid area in which it consists of households, industries, agriculture, educational institutions, government offices, street lights and hospitals. The one smart grid area power consumption is divided into 8 categories based on the time such as on-peak, mid-peak and off-peak hours.

On-peak: 9-12 am, 12-3pm, 3-6pm
Mid-peak:6-9am, 6-9pm
Off-peak:9-12pm, 12-3am, 3-6am.

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TABLE I. Power consumption details for one different geographical area

	House in KW	Industry in KW	Agriculture in KW	Institution in KW	Office in KW	Street Light in KW	Hospital in KW	Total Power in KW
6-9am	45	100	37	null	null	null	200	382
9-12am	0.3	200	37	1.2	1.2	Null	300	501
12-3pm	0.3	200	37	1.2	1.2	Null	300	501.5
3-6pm	0.3	200	37	1.2	1.2	Null	300	501.5
6-9pm	45	100	37	Null	Null	1	200	383
9-12pm	1	100	37	Null	Null	1	200	339
12-3pm	1	100	37	Null	Null	1	200	339
3-6pm	1	100	37	null	null	1	200	339

TABLE II. Power consumption detail for 5 geographical areas

	6-9am	9-12am	12-3pm	3-6pm	6-9pm	9-12pm	12-3am	3-6am
Grid1	400	550	550	550	400	350	350	350
Grid2	350	500	500	500	350	400	400	400
Grid3	375	520	520	520	330	370	370	370
Grid4	300	510	510	510	380	335	335	335
Grid5	420	560	560	560	370	420	420	420

Table II describes the power consumption details for five different smart grid areas and the power consumption of each grid is calculated according to the time period such as on-peak, mid-peak, off-peak hours.

Based on the power consumption details of geographical area the power supply for each grid will varies based on their demand. In case one grid will need high power supply and the other grid will requires less power supply. So, according to their demand the grid will supplies or transmits the power to the consumers.

A. System Architecture

The home sensors data are given as input to the system. The datas are saved in database which is connected to the web application mounted on the cloud. From the web application the scheduling algorithm has been prepared for three cases such as on-peak hours, mid-peak hours and off-peak hours. When the scheduling is done the utilities supplies the power to the consumers and the consumers will get the power as per their demand.

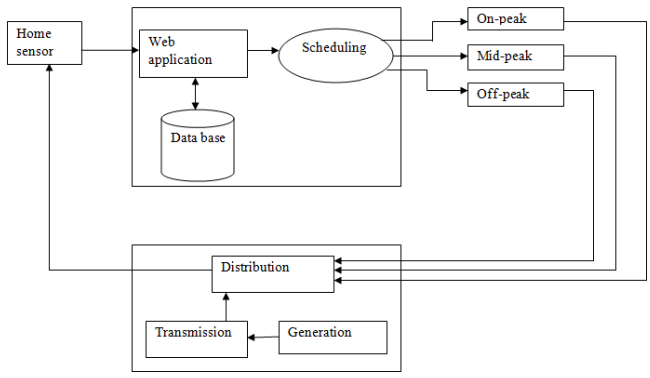

Fig. 1. architecture diagram for the proposed system

B. Algorithm

```
Algorithm adsms (G[i], P)
{
   //G->total number of grids
   //P->total power in KW
   for i=1 to G do
   if (request G[i] < =Need G[i])
     {
       if (request G[i] < = available [P])
     {
       Available [P] = available [P] -request G[i];
       Allocation G[i] =allocation G[i] + request G[i];
       Need G[i] = Need G[i] -request G[i];
      }
     }
   if (available [P] < =0)
     {
     Send message "power insufficient";
      }
   if (available [P] >=100)
      {
      Send message "Power overflow";
       }
}
```

The need of the grid and the available of the power should be greater than the request of the grid. If the availability of the power is less than or equal to zero value then the power is in insufficient condition so it needs a power otherwise the availability of the power is greater than or equal to 100 then the power is overflowing.

IV. CONCLUSION

This system uses the active demand side management scheduling (ADSMS) algorithm for providing the power to the consumers based on their need and the availability of power. Demand side management manages the consumer requirement based on their power consumption details. It uses the monitoring sensors for getting real time demand from the consumers and the smart grid which is used to channelize the power requirement. This model gives better energy management than the existing system. The distributed data management and parallel processing scheme is highly specialized on time series, which is the common type of data that the smart grid will produce. The proposed autonomous demand side load management strategy efficiently reduce the peak demand and energy cost.

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