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Peak load shifting in cloud computing environment using Advanced Metering Infrastructure

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ABSTRACT: In a micro grid (MG), Advanced Metering Infrastructure (AMI) is the main component that collects data of consumer and sends it to the cloud through communication network. In the future AMI interfaced to cloud computing will increase substantially, creating a large data transfer of the load which needs to be efficiently balanced. This paper proposes a load-balance problem in an AMI cloud computing network using Linear Integral Programming (LIP). With respect to monitoring knowledge, we have a tendency to be able to plot the load curves so it will be useful in achieving optimum energy consumption for particular load. Classification of loads is done in terms of shifting priorities. Stochastic control algorithm is used to shift the least priority load to decrease the overall peak of the system.
Index Terms: AMI, Peak Load Shifting, Communication Infrastructure, Cloud Computing, PDN.

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I. INTRODUCTION

Cloud based network paradigm allows real time monitoring and provides a control mechanism in micro grid using secure, reliable communication between consumer and utility by using the standard protocols to perform an end to end communication. AMI is one of the primary components of micro grid which helps to integrate communication network and data management system that allows two way communications among the consumers and utilities. The AMI uses micro grid communication infrastructure to transfer metered data. In micro grid network peak demand management is used to match total demand with the available power. Here, the consumers can make decision autonomously on when and how to utilize electrical energy. Consumers can change their energy consumption as per the energy pricing. Demand side management can be utilized, enabling the load shifting from period of high price zone to period of low price zone. AMI communication infrastructure along with cloud computing can be used to push the energy consumption to the cloud facilitating the utilities to carryout peak response programs. Here [1]-[9] discussion on an AMI infrastructure is done which checks the energy consumption of the consumers thereby controlling the electric energy using the peak response techniques. In [7], micro grid systems consisting of a few sources of energy along with an AMI infrastructure is applied. As per the time of use, the consumer's power loads are scheduled. The information of energy consumed along with price band is passed on to the available AMI network. So, a vital issue in AMI networks is establishing a secure, reliable, and scalable communication network which will meet the required quality [10]. The quality is a desired part of the entire architecture in MG. Real time pushing of metered data from the consumer to the utility's cloud requires a quality communication infrastructure which guarantees minimum delay[12], [13].

AMI services are expanding quickly; all utility companies are developing such services so as to gather power consumption information remotely from the consumers. Where many metering network are located in various regions are employed a large scale data transfers and its related consumption information are stored on to the cloud. The use of cloud with AMI network leads to efficient utilization of network resources [16]. The AMI communication networks currently are limited to small-scale a region locally which does not satisfy the requirements of the utilities for the next generation large scale AMI. Hence, for an efficient management of large data, it is very important to use new technologies of communication systems. Program Defined Networking (PDN) is an upcoming telecommunication technology which can assist the MG networks [17]. In PDN, the data and control planes are logically centralized and separated using the Open transfer protocol thereby meet the communication network requirements of the AMI [18] [19]. Each network terminal forwards the data and enforces activity as per the instructions obtained from the controller which in turn makes the network programmable to be more scalable, secure and flexible. Now, Focus has for developing different PDN for MG applications requiring a high degree of awareness.

II. MOTIVATION

Why do we need AMI with cloud based infrastructure? As discussed AMI infrastructure is a key component in MG, it's critical to develop and design a high performance and reliable communication infrastructure with quality of service support in large data environment. The AMI has been installed to manage the usage of appliances based on time of use tariffs and electricity rates in order to support new services available in the energy market. Also the AMI is largely being utilized in different physical locations. However, for the large scale future AMI, it will be required to collect and transfer power consumption information from each consumer to utility cloud which will lead to a large traffic on the system that should be efficiently managed and balanced throughout the network [7]. Nowadays many AMI of the utilities collect data every minute, which is an improvement as compared to the earlier method that records the meter data monthly, which is a far deviation from achieving the full vision of a MG [26]. Summarizing the MG road map, both the number of AMI as well as the sampling rate will dramatically, hence a huge amount of data will go to the cloud, imposing a great challenge on the scalability of the AMI communication network [26].

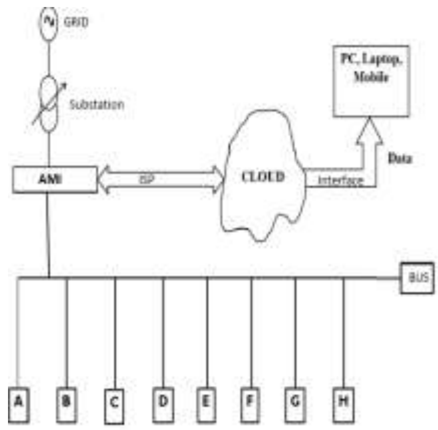
III. RELATED WORK

In this section use of PDN technology in MG is discussed using AMI architecture. Application of PDN technology in MG has received considerable attention over the past couple of years.

[13] Proposes PDN platform based on cloud technology to support real-time monitoring techniques of MG presents the potential of PDN for strengthening the MG under any circumstances. In [17]-[19] the types of configuration, content-based cross-domain networking, virtualization, and isolation offered by PDN in MG networks are mentioned. Molina et al. [20] propose to integrate PDN in IEC-61850 based substation systems. In [21], Sydney et al. use PDN to facilitate an automatic fail over method for MG networks. Dorsch et al. [24] develop a test set up based on PDN for communications in IEC-61850, hence investigate the use of PDN in heterogeneous MG in order to create an infrastructure based on different technologies, such as IEEE 802.11 and Ethernet. The AMI load balancing problem is a challenging issue because of the limitations of resources. We introduce a load balancing procedure for performance evaluation based on PDN. In [28], a load balancing routine is introduced in the for AMI using cloud networks.

IV. PROPOSED METHODOLOGY

In an AMI system the communication essentialities are provided for a scalable secure, reliable system for which relevant protocol are utilized. We are proposing to use Initiation Session Protocol (ISP) for transferring data packet among the consumers and utilities.



F**igure1**. Block diagram of System

The ISP protocol features some novel benefits so as to be used in AMI, it has mature protocol which is compatible with all the available standards as well as architectures requirements of device communication. Hence an ISP based cloud computing communication interface is proposed with the AMI network.

V. SYSTEM ANALSIS AND RESULTS

Peak load shifting is one of the most lifeline peak demand management & has attracted increasing attentions from both researchers & engineers. When peak load shifting is applied the energy consumed in market is as same. The impact of peak load system on generating power station is reduced & hence reducing cost at same time. A cyber physical that is the MG for which is the opportunity of energy efficiency improve and is reliable through big data. In now-a- days the information and communication technologies running in market through the fields of energy management .which has developed the electric grid as a cyber physical system. Applications such as bidirectional communication of AMI, automation etc has also developed .measurement & recording of electricity consumption and two way communication between the electric meter and the energy consumption pattern and hence achieving economical benefit.

Fig.2. Real Time Data from AMI

Legacy grid is electromechanical due to which it needed many components for its operation. In this grid one way communication which means there is one way connection from distribution to consumer side due to which power can only be distributed from main plant to consumer side. Legacy grid has few sensors due to which it gets difficult to detect failure, so often it causes delay in failure detection. Legacy grid has normal manual restoration due to which in case of any malfunction, the technicians have to physically go to the location of the failure to make repairs. Legacy power grid system infrastructure is not properly equipped to give customers to choose the way they receive their electricity. In this system equipment checking is manually possible due to time required to restore system is more. Here is radial topology is used. This grid uses many sensors' so failure can be detected very faster than legacy grid. Whereas MGs have self-healing restoration, sensors can detect problem on the line & can start working to do simple troubleshooting & repairs. These points show that how MG be more advantageous than the legacy grid which is currently used. If we use MG, then we would be able to overcome many of the limitations that are present in legacy grid & obtain energy management. Data shown Fig 2 is for the month of June this also same consist real time monitoring of current, voltage power factor, and energy consumption for the whole month .This system allow user to track and manage data from all facilities. Using online platform data, programs and controlled are stored over the internet from any computer.

Stochastic control algorithm is applied to shift the pumping load to decrease the overall peak of the system.Here the energy management issue is looked at from a stochastic viewpoint. A finite horizon stochastic optimization problem is formulated. The power demand from the cloud is modeled as a random Markov process. The optimal control strategy is then obtained by using stochastic programming.

Fig. 3 Simulation Results using Stochastic Method and LIP

TOD Tariffs(in addition to base tariffs)	**Energy charge incentives (Rs/unit)**
2200Hrs-0600Hrs	-1.5
0600Hrs-0900Hrs & 1200Hrs-1800Hrs	0
0900Hrs-1200Hrs	0.8
1800Hrs-2200Hrs	1.1

Table 1 Rate of Incentive/ Penalty as per TOU

In the case study, the existing method and proposed method are compared to measure energy consumption. Energy consumption of the MG system is measured and compared for a period of one day. The analysis depict that the proposed method has a lower consumption of energy as compared to the conventional method. The peak value of the proposed method has been shifted and the conventional method peak values are high in the 13 hour. Hence, the proposed method has a higher efficiency leading to the power saving.

VI. CONCLUSION AND FUTURE SCOPE

In traditional AMI network of MG substantial exponential increase of data transfer rate has constraints, to form a scalable, secure communication system is the prime challenge to balance and route the large amount of data measured by AMI. Peak load shifting program was considered to balance out the load using stochastic method using the data obtained from the cloud. Implementation of PDN based test setup including an AMI architecture in cloud environment was carried out, whose performance was extensively evaluated. The results show that the proposed architecture leads to substantial saving of resources and overheads besides the advantage of being flexible in design that can be accessed from any geographical distance. A more advanced cloud system with higher communication transfer rate will make the AMI architecture safer, secure flexible and scalable in MG.

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