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Next Generation IP Based Metering for Monitoring and Control of Power Consumption

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Abstract—*In recent years, real time monitoring of power consumption in home appliances is needed to save electricity usage. An automated IP base metering system can record real time power consumption information and communicate that information to the utility provider and facilitate real time monitoring and control electricity consumptions for various appliances by sending feedback on each appliance to the user. This solves many issues of traditional meter reading system like need of human resources, reliability, security, efficiency, accuracy, latency etc. This paper not only focuses on the next generation smart metering by using internet services for reducing the cost and energy consumption in the households but also provides an overview of standards and protocols to realize the Inter of Things (IoT) based approach to smart metering.*

Keyword*: Smart Meter, AMI, communication Protocols, IoT.*

1. INTRODUCTION

Now-a-days, the number of electricity consumers are increasing in great extent. The demand of electricity has also increased in households with the use of different electronic appliances. It became very hard task in handling and maintaining the power as per the growing requirement.

In order to meet each user's electricity demand, it focuses in the implementation of smart grid technology in power sector [1]. The application of ICT infrastructure in the electric utilities helps consumers to lead an easier life. A new concept of next generation IP based metering in electric power system plays an important role in smart grid infrastructure for improved efficiency, reliability, security, interoperability etc. and usually the first milestone in smart grid implementation.

In traditional meter reading we face lot of problems like error in reading, inaccuracy, external conditions affecting readings and billing process, delayed work etc. They have designed for unidirectional flow of electricity.

IP metering system is one way to avoid these problems that provides more information than a traditional meter. It is an electronic system that can measure energy consumption, transmit and receive data and can process data for billing. This system provides the services like real time monitoring of electricity consumption, automatic control, data storage, data processing and exchange, making estimation of the next bill etc. to the consumers. The IP metering system uses the Advance Metering Infrastructure (AMI) technology that allows a two way communication between the meters and the central control station and to monitor and control the power flow in the smart grid to the consumer end [2]. The AMI technology involves the placing of smart meters, collecting consumption data from smart meters and transmitting it to the meter data hub. This new technology offers value added services to their customers.

IP metering is one of the important applications of Internet of Things (IOT) for electric issues of accessibility, interoperability and power consumption. The Internet of Things is a phenomenon in which physical consumer products connect to the web for machine to machine communication to collect data of energy usage [3].

The availability of communication media like the internet, GSM network, etc. has made the exchange of information fast, accurate and secure between the utility and electricity consumers and this allows utility to better regulate supply.

The technology developed to IP metering system is allows Machine to Machine (M2M) communication with the devices of same ability in which the captured information is relayed through a network to an application software program. And the measured data reads from a remote server automatically using existing GSM or WiMAX network [4]. The remote server then stores the information in database for analysis and sends the bill to the consumer. It is a bi-directional data communication system in which data can be collected quickly and efficiently after regular interval of time like hourly, daily, weekly or monthly basis.

By using such kind of smart meters to measure the energy consumption of households, it becomes possible for consumers to obtain accurate and update electricity consumption data.

2. IP BASED METERING SYSTEM ARCHITECTURE:

IP based metering is designed to measure the power consumption during peak and normal hours separately and send these power consumption data regularly to the utility provider through wireless communication network. These data are acquired at utility provider server and process the data for generating responses. The key benefit of IP based approach is that it is based on open standard protocols suitable for large scale deployments [5]. In the proposed architecture every meter can have an IP address.

The key elements of the architecture are: smart meters, a communication system for data flow, and a centralized management and control system.

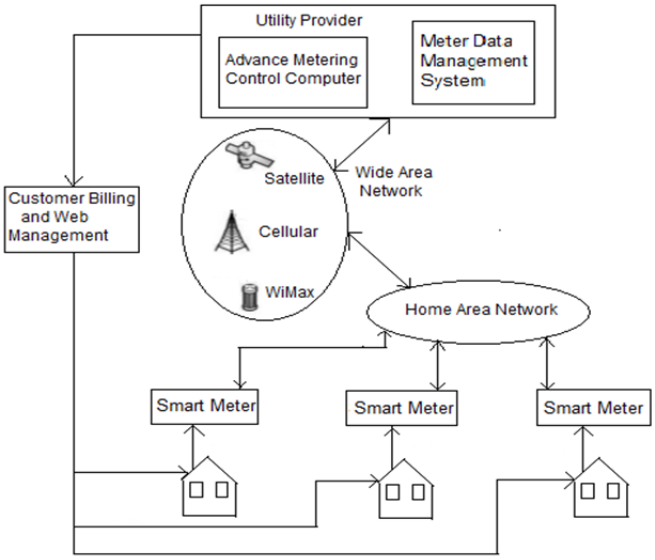

Fig. 1: IoT enabled IP Metering Architecture

A smart meter measures the amount of energy consumed by a customer and sends the recorded readings of energy consumption periodically to the Home Area Network (HAN) via wireless communication to a PC or a remote device where monitoring and analysis of the data will be made. This meter can be used by residential, industrial or commercial customers

The HAN is a mesh network of smart meters communicating through wireless technology such as 6LoWPAN, ZigBee, Wi-Fi, Bluetooth which are characterised by low bit rates, low power consumption and low cost [6]. The HAN connectivity may be further extended to include smart devices like In Home Display Unit (IHDU) to help consumers to monitor power consumption, smart thermostat that can respond to peak-load-signaling form utilities, smart plugs that can control power usage of electric appliances etc.

The Wide Area Network (WAN) connectivity enables end to end IP connectivity between smart meters to utility provider using WAN infrastructure such as GSM, GPRS, 3G, 4G cellular networks.

The utility provider performs functions like Network management system, Meter data management system and billing information. Software upgrade, parameters updates etc. are performed by Network management system and addresses to all meters. The transmitted data is collected by the Meter Data Management System (MDMS) that manages the data storage and analysis to provide information in useful form [7].

The central server stores the information in database and generates the bill to send to the consumer via SMS. The smart meters can be made to incorporate with smart phones and a number of IoT enabled devices using the standardized protocols [8][9]. The consumer is aware of his energy usage and any abnormal change in electricity consumption can alert the customer to reduce the power consumptions at peak hours. The SMS based data collection can be done regularly and efficiently. In the entire process there is no human intervention so no possibility of human error and corruption and there is no chance of error due to environmental problem.

Every smart meter installed at the consumer end has a unique meter ID. The IP metering system has the feature of remote turn on/off the supply. If theft is detected, the IP metering is capable to alert the utility provider and automatically can disconnect the supply to such consumers. Once meters are connected on the internet, the meter data can be aggregated on a remote server in utility's control room or on the cloud [10][11].

3. IOT COMMUNICATION PROTOCOLS FOR SMART METERING:

A meter with IP-based communications should have the ability to leverage a variety of networks. In wireless communication, Wi-Fi, ZigBee, 6LoWPAN, Bluetooth technology can be used for short range connectivity of devices and GSM, 3G/4G or WiMAX for connecting M2M gateway to server. The use of these Internet Protocols (IP) enable successful integration of resource constrained networks into existing IP based infrastructure [12][13].

Table 1: Comparison of Communication Protocols

Technology	Frequency Bands	Data Rate	Coverage Range	Limitations
6LoWPAN	800/900/ 2400MHz	250 kbps	10-1000 m	Low reliability, Low bit rate
Bluetooth	2.4-2.4835 GHz	721 kbps	1-100 m	Low data security, Low reliability
Wi-Fi	2.4 GHz	54 Mbps	Up to 100 m	High interference from other sources

ZigBee	868/915 MHz/2.4 GHz	20-250 kbps	10-100 m	Low reliability, Not interoperable with non ZigBee devices, Low data rate, Short range
GSM	900-1800MHz	14.4 kbps	1-10 km	High cost, Moderate bit rate
GPRS	900-1800MHz	170 kbps	1-10 km	Low data rate
3G-4G	2.4 GHz	240 kbps-2 Mbps	Up to 50 km	High cost, Moderate bit rate
WiMAX	1.8-3.65 GHz	70 Mbps	30-50 km	Higher cost than similar technology, Not wide spread.

The ZigBee network to collect all meter data from remote households is shown in Fig. 2. ZigBee is specifically designed to operate on low-cost and low-power consumption. ZigBee technology is a new up-coming technology following the Bluetooth. It is a short range wireless communication device with the features of low power consumption, low cost, low complexity, and low data rate. This device works on a unique identification method that means the data transmit by one ZigBee device can be received by only that ZigBee device which is having its decoding address. Hence data is secured in this device. In case of Bluetooth and Wi-Fi technology anybody can transmit and receive data. ZigBee has a maximum packet size of 127 bytes. This device can interface with the computer via USB/RS232.

Bluetooth allows the packet size of 47 bytes with point-to-point and point-to-multi-point configurations. 6LoWPAN (IPv6 over Low power Wireless Personal Area Networks) that realize to assign an IP address to every node and supports packet size of 127 bytes.

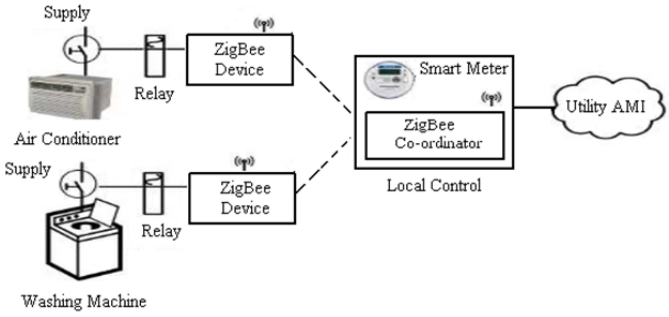

Fig. 2: ZigBee technology for Home Area Network

4. SMART METERING DEPLOYMENT IN INDIA:

The main drivers for encouraging a smart metering in India are energy efficiency, reliability, security, monitoring of power quality, peak load management, interoperability, etc. In India, IP metering is still in the early stage of deployment. The launching of IP based metering system in India has been delayed due to many obstacles. Some of the main obstacles facing in the deployment of the system are listed below.

- Lack of required knowledge among the people who are directly involved in the implementation process.
- Utilities and IT systems are not implemented as per the requirement.
- Lack of awareness among the common people.

The Government of India is planning to invest up to $21 billion in smart grid technology by 2025. At the present stage, India has 200 million legacy meters and it is expected to install 130 million smart meters by 2021. As per the plan, the smart meters will be rolled out for all consumers consuming 500 units per month by 31st December 2017 and all customers consuming 200 units and above per month by December 2019. At present, smart meters in India are deployed only for the pilot projects [14].

The ISGTF allocated 14 smart grid pilot projects in various states of India to implement the smart grid technology. These pilots are mainly concentrates on the following functionalities.

- AMI for residential and industrial consumers
- Peak load management
- Power Quality Management
- Outage Management System
- Distributed Generation
- Microgrid

In Assam this pilot is conducted by APDCL (Assam Power Distribution Company Ltd.) and about 15,000 numbers of consumers will be providing the facility of smart metering including cellular phone operation tower, apartment buildings in pilot area, hotels in pilot area, and other few identified bulk customers.

The communication architecture for smart metering deployed in Assam is shown below.

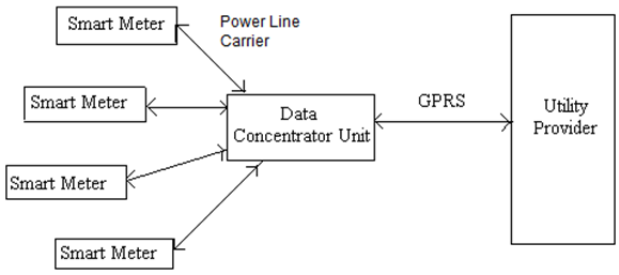

Fig. 3: The architecture deployed by APDCL

The Data concentrator unit collects all meter reading data from remote households through ZigBee network and sends acknowledgement back to the corresponding meters. It is usually located at substations and acts as a link between meters and the rest of the components of the Advance Metering Infrastructure [15]. In addition, it can also functions as monitor the operation of the power grid and smart meters, reporting interruptions and failures and detecting and reporting of theft and tampering attempts.

5. CONCLUSION

This paper has been addressed an overview of the general architecture of IP metering and various communication standards relevant to the smart grid. An IoT enabled use case provides end to end connectivity with automated meter reading which can be adapted for usage profile, control and billing for Indian context though the development cost of IP base remote meter will be higher than traditional meter. As in the entire process, there is no human intervention, so there is no chance of human error and corruption. For customers, daily monitoring of power consumption is better than monthly monitoring because customers have exclusive information about their electricity usage. An abnormal change in consumption can alert the consumers to take action and they will know whether the abnormality is false or not. Moreover, IP network can be monitored in real time which is a good measure against cyber attacks and theft of electricity.

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