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Smart metering worldwide deployment scenarios and IoT based approach for India

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***Abstract*—Smart meters are being deployed worldwide on a pilot basis by various utilities. Often conventional electronic meters implementing Automated Meter Reading using proprietary protocols are faced with inegration and interoperability challenges. In this paper, we present an overview of some of the smart metering deployments in progress worldwide. An overview of standards and protocols to realize the Internet of Things (IoT) based approach to smart metering in the Indian context and how emerging Internet Engineering Task Force (IETF) Constrained Application Protocol (CoAP) can be utilized for smart metering are also discussed.**

***Keywords:* Internet of Things, Smart Meter, 6LoWPAN, RPL, CoAP.**

I INTRODUCTION

With the advancement in Telecom & Information & Communication Technologies (ICT), Power utilities are adopting various levels of automation in the power systems network. One such recent adoption is in Smart Grid applications and Smart Metering plays a vital role in this context. Various communication technologies are being tried out for successful Advanced Metering Infrastructure (AMI) pilots that are highlighted in this paper and an IoT based approach for Smart Meter is also presented.

Internet of Things (IoT) is expected to drive many internet standardization efforts and shape how future real world internet communication happens. The impact of IoT is increasing as more and more devices seamlessly integrate into the internet infrastructure. The combination of technology with industries/utilities leads to innovation in solutions, market efficiency and sophistication in business prospects. The era IoT will enable new approach to internet application development in fields such as structural monitoring, health monitoring, agriculture automation, home/office automation etc. The smart grid is also expected to be one of the key application driver of the IoT. IoT is a twenty-first century phenomenon in which physical consumer products connect to the web and start communicating with each other by means of measuring and controlling mechanism [1]. Internet of Things can be viewed from three different perspectives: "Things Oriented", "Internet Oriented" and "Semantic Oriented" [2]. The IoT devices such as RFID tags [3], sensors, actuators, NFC are emphasized in "Things Oriented". In "Internet Oriented" approach the focus is on the protocols such as IPv6 for low-rate personal area networks (6LoWPAN), Constrained Application Protocols (CoAP) and Routing Protocol for Low power Lossy Network (RPL). While the "Semantic oriented" approach looks at semantic descriptions and representations of sensors / devices, device discovery and service compositions for application development enabling "a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols"[4]. According to the Cluster of European Commission projects [5] on the IoT, "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts."

IETF is developing protocols such as 6LoWPAN, RPL and CoAP to enable IoT applications based on open standards based approach becomes possible and these protocols will address many of the interoperability challenges. In this paper, we look at how smart metering application can be realized based on some of these protocols. Smart Meters can compute, store and communicate the energy meter data to the head end system upon request or can initiate a communication based on specific configuration settings. Also, it can receive information from the head end system and act upon it. For example, utilities can communicate time dependent tariffs in order to incentivize customers having lower utilization during peak-time. In India, Electric Utilities are planning for deployment of Smart Meters on a pilot basis. There are various forums including Bureau of Indian Standards (BIS), India Smart Grid Foroum (ISGF), India Smart Grid Task Force (ISGTF) that are working to bring standards in Smart Metering to help in utilities' compliance. Also, it is understood from the utilities experience that in most cases the conventional electronic meters supplied by various vendors use proprietary communication protocols, and implementing Automated Meter Reading successfully and integrating with the entire system is going to be a challenge.

The rest of this paper is organized as follows: Section II highlights some of worldwide deployment of smart meters in progress. Section III presents the different standards /protocols that can be used for smart metering. Section IV provides the detailed IoT based approach of smart metering application requirements. Section V describes about smart metering in Indian context, challenges with ageing infrastructure and an android app using CoAP. Finally, section VI presents the conclusion.

I WORLDWIDE SMART METERING DEPLOYMENT

With recent advancements in ICT, the Global power utility companies are focusing on deployment of smart meter technology. Smart meters are energy efficient, easy to operate with real time monitoring help in Demand Response along with various other features like remote connect/disconnect, two way communication, recording of bi-directional flow of electricity, remote programming capability etc. Table-1 provides summary of the technology and smart metering infrastructure challenges in some of the major countries.

TABLE I. OVIEW OF SMART METER DEPLOYMENT OF DIFFERENT COUNTRIES

Country	Major Utilities	Technology		Challenges & Features
		HAN	WAN	
Italy	ENEL	PLC	GSM/GPRS/PSTN	Energy consumption, control system, homogenous and distributed Multi-level Policy and rules (user, utility, authority) sustainability, optimization and reduction of energy consumption
France	ERDF	PLC	GPRS	Standards for a common architecture and Interoperability of the various Communication technologies
UK	EDF	ZigBee	PLC	Cyber threats, Security, Over The Air (OTA) wave coordinating stakeholders services and investment
Brazil	APTEL	PLC	FTTH	Regulated or liberalized meter market
Ireland	ESB	ZigBee/ Wi-Fi	PLC	Quality of Service (QoS), smooth transition to future technologies and cost reductions
U.S	Southern California Edison	PLC/BPL	WIMAX/ 2G/3G	Reliability and sustainability, Revolutionize energy management and grid reliability

A. Italy

Italy is considered to be the first country to deploy smart meter. ENEL utility has begun its project “Telgestore” in 2001[6] with the first commercial installation of smart grid technology. ENEL has rolled out about 32 million meters over the last decade, linked with PLC technology for the backbone communication and GSM for the last mile connectivity[7]. Major countries have begun smart metering projects subsequent to the successful deployment under this project [8].

B. France

ERDF has executed "Linky" pilot project with the plan to modernize electricity meters nation-wide and a strategic supplier[9] fulfilling the requirement. France aims to deploy 35 million smart meters for 30 million consumers at a cost of about €5 billion by 2020. It is estimated that up to 80% of the meters will be made in France [10]. So far, about 30,000 smart meters have been deployed as part of the pilot project. ERDF has planned to use G3-PLC technology for last mile connectivity and the GSM interface for the backend connectivity to the utility network. The main focus of this pilot is to reduce the CO_2 emission with the target to achieve between 5 to 15% savings on the electricity bills.

C. UK

In UK, Smart Metering implementation programme is introduced by “Energy Demand Research Project” (EDRP) in 2007. As a part of this project, electricity suppliers EDF, Scottish and Southern energy, Scottish Power and E.ON are installing over 50 million smart meters in about 30 million homes and small businesses with *"In home display units"* in households. This smart metering initiative is expected to complete by 2020 [11].

D. Ireland

Ireland’s Commission for Energy Regulation (CER) announced its plans to rollout smart meters between 2014 and 2019 [12]. It has initiated the implementation of National Smart Metering Programme (NSMP) involving stakeholders from the energy sector to “digitalise” the nation’s electricity

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and gas metering. ESB deployed 10,000 smart meters in Irish homes so far.

E. Brazil

Along with Brazilian government APTEL, one of the utility association is conducting trials using narrowband power line carriers. Various utilities are conducting smart grid pilots including “Ampla”, the Spanish utility “Endesa”, “AES Eletropaulo”, that are deploying smart meters. There are also attempts to use existing fibre-optic backbone in order to ensure secure networks while deploying smart meters.

F. United States

In the U.S, utilities have installed about 49 million smart meters that use 2G/3G cellular for last mile connectivity with BPL, PLC used for Home Area Network (HAN). Institute of Electric Efficiency (IEE) provides a deployment estimate of about 65 million smart meters by 2015 in the U.S[13].

In all, we could see major countries have already begun their smart metering pilots using various communication technology options based on the local demands. To the best of our knowledge, utilities yet to adopt Internet of Things based approach to smart metering considering that some of the IoT standards are still emerging.

III IOT STANDARDS/PROTOCOLS FOR SMART METERING

A. IEEE standards

IEEE 802.15.4™-2011 standard [14] offers Medium Access Control (MAC) and Physical Layer (PHY) control layers for low cost Low-Rate Wireless Personal Area Networks (WPANs) with consumed very less power require personal and operating range of 10m. The standard uses carrier sense multiple access with collision avoidance (CSMA-CA) medium access mechanism and supports star as well as peer-to-peer topologies. LoWPAN physical layers (PHYs) are defined for devices operating in the license-free 868 868.6 MHz, 902 928 MHz, and 2400 2483.5 MHz bands. WPAN consists of set of devices communicating on the same physical channel. The WPAN network should include at least one Fully Functional Device (FFD), which operates as the PAN coordinator and other devices can be Reduced Functional Devices (RFD) is an end device that provides short set of services. The raw data rate supported by this standard ranges from 20 kb/s or below (suitable to the needs of ultra low power devices) to 250 kb/s to satisfy specific applications needs. IEEE Std 802.15.4f™ 2012 [15], is an amendment defining two alternate PHY layers and the changes required to MAC layer to support Active Radio Frequency Identification (RFID) System. IEEE Std 802.15.4g™ 2012 [16] amendment specifies three alternate PHYs and MAC modifications needed to support principally outdoor, low-data-rate, wireless, smart metering utility network (SUN) applications under multiple regulatory domains.

B. DLMS/COSEM & ANSI

Device Language Message Specification (DLMS) is an application layer protocol supporting multiple transport layer options including Ethernet, PLC and IPv4. Companion Specification for Energy Metering (COSEM) specifies the data model with their attributes and methods. DLMS/COSEM are open standards managed by DLMS user association [17] and it was published as a series of IEC 62056 & EN 13757 standards. ANSI C12.22 [18] standard provides set of application level messaging services for end-devices and enterprises of an Advanced Metering Infrastructure (AMI). ANSI C12.19 defines data structures for metering data and the list of functions exposed by a smart meter to a client device. IETF RFC 6142 provides a framework for transporting ANSI C12.22 application layer messages over an IP network. There are also attempts implementing Simple Network Management Protocol (SNMP) for low power wireless network.

Figure 1 shows the relevant open protocol standards for smart metering applications. At the physical and MAC layer, IEEE P1901.2 Narrowband Power Line Communications (NB-PLC) system enables transmission of data over power lines and its MAC layer aligns with IEEE 802.15.4 making 6LoWPAN layering possible. IEEE 802.15.4g Smart Metering Utility Networks is a PHY amendments to Low rate WPAN standard supporting multiple data rates in bands ranging from 169 MHz to 2450 MHz. IEEE 802.15.4e MAC amendments incorporates several new techniques to support various industrial applications. The Internet Protocol 6LoWPAN, RPL and CoAP application layer were discussed in the following sections. These new IETF protocols for low power, low rate wireless environment enable successful integration of these resource constrained networks into existing IP-based infrastructure.

C. PRIME

PRIME[19] stands for PoweRline Intelligent Metering Evolution that defines lower layers (PHY, MAC and convergence layer) of a narrow band PLC. PRIME subnet work consists of base node (root of the tree) and service nodes (all other nodes). PRIME supports OFDM multiplexing in CENELEC-A band with a raw data rate up to 130 kbps. The PHY layer transmits and receives MAC PDUs between Neighbors Nodes.

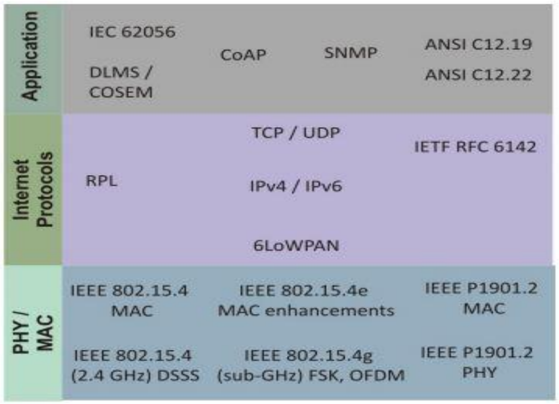

Fig. 1. Open Protocol Standards Stack for Smart Metering

D. IETF PROTOCOLS

I. 6LoWPAN & Mesh Networks for Smart Grids

The IETF 6LoWPAN working group has defined specifications [20, 21] to efficiently transport IPv6 datagram over IEEE 802.15.4 links. The Internet Protocol (IP) is predominantly used over Ethernet links that offer increasingly high throughput. The transmission of IPv6 packet over LoWPAN links are faced with several challenges due to the resource constraints of 802.15.4 devices. Figure 2 shows the 6LoWPAN adaptation layer defined by IETF specifications [20, 21] works between IPv6 and 802.15.4 MAC layer to support IPv6 packet delivery in LoWPAN networks performing fragmentation, header compression and layer2 forwarding considering that the minimum IPv6 MTU (1280 bytes) is much larger than the largest 802.15.4 frame size (127 bytes).

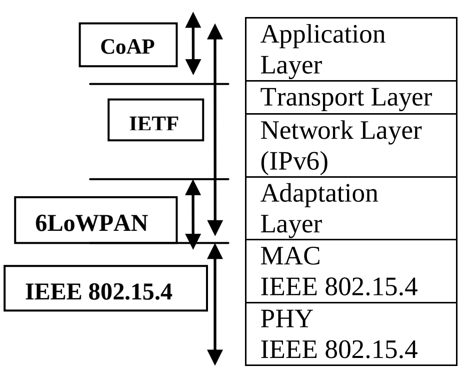

Fig. 2. 6LoWPAN Protocol Stack

6LoWPAN based Mesh Networks are being actively used in Smart Grid applications which go beyond metering and quantitative usage related information. These 6LoWPAN Mesh Networks are also being used for power qualities monitoring [22] which are parameters such as continuity of service, variation in voltage magnitude, transient voltages and currents, harmonic content in waveforms, etc. Currently, large commercial network analyzers are being used to detect power fluctuations which can cause damage to consumer equipment. It is possible to substitute the centralized and expensive power analyzers by a number of smart meters which are distributed over a large geographical area forming an IPv6 based mesh network. Such a smart meter mesh network can provide sufficient information of power quality while keeping the upfront capital investments at a minimum.

II. Smart Meter Mesh Networks using RPL DODAG Topology

In a typical urban Smart Meter deployment, the number of meters in a single smart electric mesh network could be in the order of 5,000 to 10,000 meters. In an Urban or Smart City IoT solution, besides the smart electric meters, smart metering can also involve the smart water meters and smart air pollution monitoring devices. Hence, in a typical IoT enabled Urban Smart Metering solution which is built on standardized protocols can end up involving tens of thousands of wireless endpoints. While the smart electric meters can use the power available from the same electric feed that it is monitoring, water and air pollution meters would be running on modest sources of stored energy (e.g. batteries, energy harvesters, etc.). In the context of two-way wireless communication, data from all of these smart meters would need to be routed from the source to sink in unicast (point-to-point), multicast (multipoint-to-point and point-to-multipoint) and broadcast manner, keeping in mind the power constraints of some of the low powered smart meters.

IETF ROLL Working Group has published an informational RFC that is focussed on the routing requirements for urban Low-Power and Lossy Networks (LLNs) [23]. Also, there is a standards draft that is getting defined to discuss the applicability of Routing Protocol for LLNs (RPL) in AMI and Smart Metering networks [24].

RPL uses ICMPv6 messages to build an IPv6 based Mesh Network. The topology used to build these networks is that of a Destination Oriented Directed Acyclic Graph (DODAG). As described above, Smart Meter based mesh networks can consists of several thousand wireless nodes (each node can be a Smart Meter). In order to transmit Smart Meter data in a multi-hop environment, the algorithm utilizes pre-determined routing metrics and optimization functions to give ranks to the various nodes.

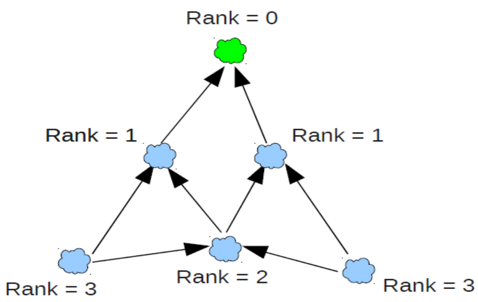

Fig. 3. DODAG Smart Meter Nodes with Ranks[36]

The RPL algorithm uses three key ICMPv6 control messages, as described in [25]. The wireless routing table is then built and propagated based on minimizing the path cost to the DODAG root. In Figure 3, node rank 3 uses node rank 1 to send data to the sink (node rank 0).

Smart Meter DODAG Mesh Networks built with this topology allows for great deal of flexibility and dynamicity in the way smart meter nodes may associate, disassociate or disappear from the smart grid network. The dynamicity of the smart meter functioning does not impact the routing of the data in the rest of the smart grid network.

III. CoAP

IETF Constrained RESTful Environment (core) [26] working group is defining Constrained Application Protocol (CoAP) that is a generic web protocol designed to meet the requirements of the resource constrained network environment. CoAP resources are organized hierarchically and they are identified by Uniform Resource Identifiers (URIs) using a scheme similar to HTTP. The CoAP request methods that act on the resources are GET, POST, PUTand DELETE.

IV IOT APPROACH TO SMART METERING

1. Internet Protocols based Smart Metering Architecture

The major objective in the IoT based approach is to leverage Internet Protocol standards end-to-end for smart metering. The key benefits of IP-based approach are that it is based on open protocol standards suitable for large-scale deployments. While many physical, data link and applications layer protocols relevant for smart grid are defined by IEEE, IEC, DLMS/COSEM and ITU, the core internet protocols in network, transport and application layers such as 6LoWPAN, RPL and CoAP are being defined at IETF. These new IETF protocols for low power, low rate wireless environment enable successful integration of resource constrained networks into existing IP-based infrastructure.

Commercial Smart Grid technology vendors are building end-to-end IPv6 enabled solutions which are built on open-standards based protocols. These include not only Smart Meters but also Mesh Networks and Distribution Automation [27].

Figure 3 shows the architecture that leverages open internet protocols for Smart Metering application. The components and the functions of each in the design is explained below.

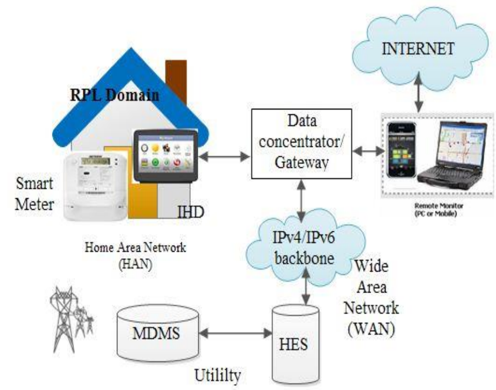

Figure 3: IoT enabled Smart Metering Architecture

Home Area Network (HAN): The HAN is a mesh network of smart metering nodes communicating through 6LoWPAN / RPL protocol over IEEE 802.15.4 LoWPAN or PLC. Multiple IP border routers help in connecting to different WAN technologies. The Home Area Network connectivity on customer premises may be further extended beyond Smart Meter to include smart devices like In Home Display Unit (IHDU) to help user monitor power consumption, smart thermostat that can respond to peak-load-signaling from utilities, smart plugs that can control power usage of electrical appliances etc.

Wide Area Network (WAN): The WAN connectivity enables end-to-end IP connectivity between smart metering nodes to the Head-End System (HES). IP border routers connecting to WAN is required to be configured with dual stack supporting 6-to-4 tunneling when it connects IPv6 HAN network to a IPv4-only WAN infrastructure such as GPRS/3G cellular networks.

Utilities: The Utilities end administers functions such as Network Management System (NMS)/Head-End System, Meter Data Management System (MDMS) and billing information. The head-end system in addition to collecting customer electricity usage data, performs functions like addressing group of meters simultaneously using multicast, for e.g., to perform software upgrade, parameters updates by network

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management system (NMS) to all meters, and meter reading queries to subsets of the meters.

Security: Smart meters can join the system by using authentication mechanism defined in IEEE 802.1 xs, PKI X.509 certificate or AAA/RADIUS before they communicate with the AMI head-end systems using their link local IPv6 address. The smart meter node can join the RPL domain and obtain the global IPv6 address using DHCPv6 and make use of DNS services.

2. Smart Meter Interoperability with IoT enabled Smart Devices

Smart Meters which can communicate over standardized protocols such as CoAP can be made to interoperate with Mobile Smart Phones like Android using the Californium CoAP framework [28]. A number of IoT enabled devices have their control interfaces available via Android Smart Phones. Companies manufacturing IoT enabled devices like Nest (now acquired by Google), Philips Hue, GE Wireless lighting, etc. provide Android apps to control these devices. These apps also know the usage profile of the devices they control. Energy utility companies would be interested in knowing the usage profiles of energy consumption of individual households, as that can help them better manage the demand-generation of the electricity that they supply. Smart Meters can be enabled to send their usage profiles (the duration for which they were on and the amount of electricity that was consumed by the device). This device usage information can be communicated back to the Smart Meters using the CoAP protocol. This could be done directly by the device or sent via the Android Smart Phone. Smart Meters can be enabled to receive this information from the IoT devices and send it back to the Utility companies along-with the periodic Meter Reading data. Electricity/Utility companies would be immensely benefitted by having fine-grained and detailed data of electricity usage patterns of their consumers.There are attempts already to use CoAP for eMeter framework [35] for designing over the web.

V SMART METERING IN INDIAN CONTEXT

As we have seen in section II, there are different smart metering approaches worldwide providing insights for smart metering solution in the Indian context. Considering that smart metering still in its early stage of deployment in India, an IoT approach to Smart Metering will enable better integration with existing internet infrastructure.

According to recent industry reports, distribution utilities globally are expected to spend US$378 billion in smart grid technologies by 2030 where India is estimated to install 130 million smart meters by 2021 [29]. Government of India has taken initiative to develop a cleaner energy supply that is more efficient, affordable and sustainable. In this regard, The India Smart Grid Task Force (ISGTF) is focusing on all activities related to smart grid.Under the ISGTF, in March 2011, a Smart Meter Task Group was formed to discuss the development of cost-effective metering solutions that can be applied within the Indian context. The ISGTF initiated 14 smart grid pilots in the nation with specific inclusion of smart meters. These pilot project forecasts the challenges for a large-scale rollout in the following years. The pilots will focus on addressing three key issues: 1) Reduction of aggregate technical and commercial (AT & C) losses, 2) Peak load management, and 3) Integration of renewable energy like wind and solar into the grid.The number of installation of smart meter in India will be huge considering that, the growth of data volume, managing the deluge will become increasingly challenging in smart metering. A network infrastructure having local computing to empower decision making at the edge of the network will save time and cost. It is neither feasible nor desirable for utilities to invest in super computers or to transport all data to a central location. Some applications require central data presentation, processing and command while others do not [30].

Government of India has exempted certain frequency bands from licensing requirement (Table 2). The sub-1Ghz frequency offers number of advantages over 2.4 GHz for low-powered devices in applications that require simple point-to-point communications and low data rate. Sub GHz RF modules consume less energy for communication as compared 2.4 GHz, achieve longer communication range (for e.g, at 434 MHz signals can reach 5.5 times greater than 2.4 GHz providing communication between two nodes beyond 1 Km), offer less interference compared to 2.4 GHz that is crowded with WiFi devices, Bluetooth, microwave ovens etc. The newly formed 6Lo working group at IETF is extending 6LoWPAN to various technologies including sub-GHz, Bluetooth low energy, DECT Ultra low energy in addition to supporting IEEE 802.15.4 PHY/MAC. 6LoWPAN compliant RF link running at sub-GHz considering its range will suit the WAN/NAN connectivity while the 2.4 GHz is suited for HAN. Also, wired communications such as Power Line Communication is required where wireless technologies are faced with various issues like interference, line of sight due to environment factors.

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Table 2 License free bands in India [31]

Unlicensed Frequency Ranges in India	**Application/Specifications**
50-200 kHz	Very low power devices
13553-13567 kHz	Very low power radio frequency devices, indoor only
433-434 MHz	Low power short range devices may be considered with a power output of 10 mW with a channel bandwidth of 10 KHz on non-interference, non protection and non- exclusiveness basis.
865-867 MHz	Use of low power RFID equipments or any other low power wireless devises with a maximum transmitter power of 1 Watt (4 Watts Effective Radiated Power) with 200 KHz carrier band width has been exempted from licensing requirement.
2400 MHz - 2483.5 MHz	Low power wireless equipment (e.g. Wi-Fi) (max. transmitter output power of 1 watt-4 watts ERP) with spectrum spread of 10 MHz or higher
5150 MHz-5350 MHz	Low power equipment for Wireless Access Systems (max. mean Effective Isotropic Radiated Power of 200 mW and max. mean Effective Isotropic Radiated Power density of 10 mW/MHz in any 1 MHz bandwidth) indoor only
5725 MHz-5825 MHz	Low power equipment for Wireless Access Systems (MMEIRP of 200 mW and MMEIRP density of 10 mW/MHz in any 1 MHz bandwidth) indoor only
5825 MHz- 5875 MHz	Low power equipment with spectrum spread of 10 MHz or higher

A standards driven and non-proprietary approach to building smart grids will address significant interoperability issues among various stakeholders such as smart meter companies,, utilities, consumers while ensuring easy consumption of smart metering data by IoT applications for big data analytics.

The use of standards compliants hardware platforms (802.15.4, etc.), open protocols (6LoWPAN, RPL, CoAP, etc.) and license exempt frequency bands will engage large number of application developers and device specialists in Smart Gird Research & Development in India. Further, this could substantially lower costs while providing opportunities for creating number of standards driven solutions for smart grid implementations that are already underway in India.

Smart Metering Deployments in India

Tata Power Delhi distribution has become the first Indian power utility to launch an automated demand response (ADR) project with smart meters in the capital. It is one of the first projects in the world where ADR and AMI (advanced metering infrastructure) for smart meters are conceptualised together. The project is implemented in partnership with IBM, Honeywell and Landis+Gyr, with the participation of select industrial and commercial consumers of Tata Power Delhi Distribution, and has been rolled out post approval of the Delhi Electricity Regulatory Commission (DERC) [32].

Electricity Department of Puducherry and the Power Grid Corporation of India Ltd (PGCIL) have launched Puducherry smart grid pilot project. This is the India's first smart grid pilot project, involving installation of smart meters in households, aiming to ultimately covers a total of 87,000 households in Puducherry[33]. The pilot project would enable Advanced Metering Infrastructure (AMI)/ Smart Metering as well as improves the quality of distribution management system applications. Currently more than 1300 smart meter with one control room for Puducherry is in place.

Bangalore Electricity Supply Company (BESCOM) is responsible for power distribution in eight districts of Karnataka [34]. It is also coming with new smart meter macro-scale project with lots of features not intended for consumers at early stage.

Challenges

There are various challenges in migration from existing energy meters to smart meters such as the cost of deployment, various last mile connectivity issues (rural, urban etc.), management of metering data and realtime events, security. We can expect a transition phase in moving from the traditional metering system to smart metering..

The smart metering systems cannot be effective unless all the appliances and devices in the distribution and metering network become part of the communication network. In a highly populous country like India, we can expect the future smart metering network to connect large number devices. The process of data collection by smart meter at regular intervals is automated by the utilities and is subject to certain security and privacy issues. In this context, customers may have privacy concerns on the data collected by utilities automatically without their knowledge.

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VI CONCLUSION

In this paper we have discussed the deployment status worldwide for smart metering infrastructure. An IoT enabled use case provides end-to-end connectivity with automated meter reading which can be adapted for Indian context for usage profile, control and billing; with more enhancements CoAP can be embedded in smart phones as a user friendly android app for smart metering.

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