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Energy Management using Catalog model in IoT for Smart Homes

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Abstract—**In IoT applications energy management to be considered one of the most important issue that affects the consumers, power system feature and the global environment. The high energy consumed by home appliances, lighting and air conditioning makes homes to be considered as one of the most significant area for the impact of energy consumption. Smart home technology is a good option for people not only care about security, relieve, comfort but energy saving as well. In this paper, a smart home energy management method based on catalog model. The proposed catalog model is established in reference to the three IoT layers (i.e., network layer, sensor-actuator layer, and application layer), and IoT energy management is deals with from the perspectives of supply and demand side to achieve good communication, effective perception and efficient computing. A smart home scenario is represented which involves the main enabling technologies with demand-side and supply-side**

***Index Terms*— internet of energy, energy management, smart home, ommunication, catalog model.**

I. INTRODUCTION

The Internet of Things (IoT) has provided with inference regarding replicated interaction, physical perception, social relationship and cognitive thinking for the establishment of a ubiquitous and intelligent cyber-physical-social thinking space. The IoT concepts are looking forwarded to provide consistent communication, intelligent computing, and high efficiency considered by interconnection, intelligence, and greenness. Energy management techniques are important because of the limitations in communication networks, and infrastructure and also for maintainable development of IoT.

"Ref. [1]" Smart home technology has introduced for more than a decade to give the concept of device and equipment networking in home. Smart home has internal network and intelligent control on different home's services. The internal network can be built via networking technologies through wire or wireless communication between sensors and actuators. If the whole house is managed or monitored or controlled by internet services then that type of home is called as smart home or also called the home is under the center control unit.

"Ref. [1]" Smart home is the incorporation of technology and services through internet networking for a modern quality of living. Smart home with integrating the services inside home as shown in figure 1 allows

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them to communicate with each another through the smart home device controller, which enables single button to manage the various home systems according to preprogrammed conditions or operating modes. Smart homes have the probability of improving home comfort, convenience, safety and energy management. Moreover it can be used for age old people and those with disabilities, hence provide the safe and secure environments. A smart home is a good choice for the community who cares about security, healthiness, energy saving, convenience and comfort. The benefits of smart technology at home could be observable to each and everyone if this prospective is carried out

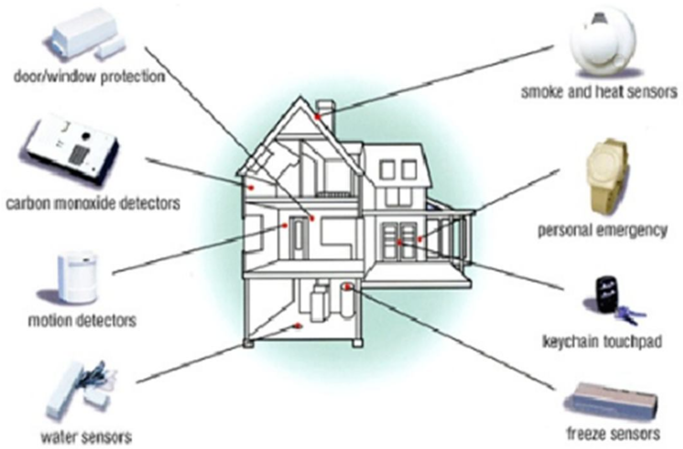

Figure 1. Integration services of smart home

“Ref. [2]” In wide variety of industries and applications based on IoT uses different power sources. For each of the identified application areas in IoT based companies has the specific use case to make use efficient power. Table 1 identifies the related edge devices with their typical power. Smart home may have the application like smart lighting, home automation, and smart appliances, each of having different power supply modes

TABLE 1. SMART HOME APPLICATIONS WITH EDGE DEVICES

Application Area	Application	Edge Device	Power Source
Smart Home	smart lighting	smart LED bulb	mains
		gateway	mains
	home automation (security, comfort, energy)	battery powered sensors (e.g. smoke, window, …)	battery
		mains connected sensors (e.g. light buttons)	mains
		camera	mains
		gateway	mains
		actuators	mains
	smart appliances (convenience, energy)	washing machine, dish washer, clothes dryer, coffee machine, oven, refrigerator, etc.	mains
		gateway	mains

II. ENERGY MANAGEMENT

Energy management is a long-standing issue, and main objective of energy management to achieve long network lifetimes by reducing and harmonizing the energy utilization in diverse networks. “Ref. [3]” In the IoT, because of global greenhouse gas (GHG) emissions energy supply and demand will become unprecedentedly complex. For instance, it is estimated that the network energy consumption in Japan in

2025 will be 13 times compared to the 2006 level and equal to 10% of Japan's total power output. With the ever-present connection of things to the Internet, an increasing rate in energy consumption. When considering protract able energy strategies, IoT energy management has became a noteworthy research topic, because of complexity in issues such as energy supply, energy demand. The evolution of energy management can trace the significant strategies in the development can be divided into four stages: the primary energy management stage, the secondary energy management stage, the effective ICT stage, and the efficient IoT stage.

Primary energy management stage: in this stage the communication technologies are primarily focused on device design and testing. Energy management is not a primary design target because it has restriction related to device manufacturing process. The main target of communication and networking technologies is to develop system presentation. In small scale networks energy management is not major stage.

Secondary energy management stage: the secondary stage is characterized by vast deployment and coverage of networks and communication infrastructures. In this energy management stage, the primary purpose of energy management is to ensure continuous power supply to the communication and networking infrastructures.

Effective ICT stage: in this stage mainly concentrated on a rapid increase in data traffic due to user-centric applications. Techniques of Energy management are mainly focused on reducing the energy consumption of network terminal devices.

Effective IoT stage: in this stage builds and results in the evolution of the Internet of Energy (IoE). Effective communications, networking and information exchange technologies are useful to achieve energy conservation and emission decrease. Throughout the power cycle, including production, conduction, distribution and utilization the energy flow and information flow are traced.

III. Catalog Model For Energy Management

The presented catalog model for energy management which briefs out the classification of energy management in the IoT. Catalog model shown in figure 2, in which two-dimensional mapping is done based on the IoT layers and their equivalent energy aspects. In one dimension, the energy management issues related to the, network layer, sensor-actuator layer and application layer are presented in one dimension. In the other dimension, energy management issues are analyzed based on considerations related to the supply side and demand side. The main objectives of effective perception, good communication, and efficient computing are sequentially focuses the individual layers from bottom to top. Based on the energy interactions and information interactions involved in IoT energy management. These two dimensions restructure the issues correlated to IoT energy management into a consistent mapping framework and this structure can communicates to customer.

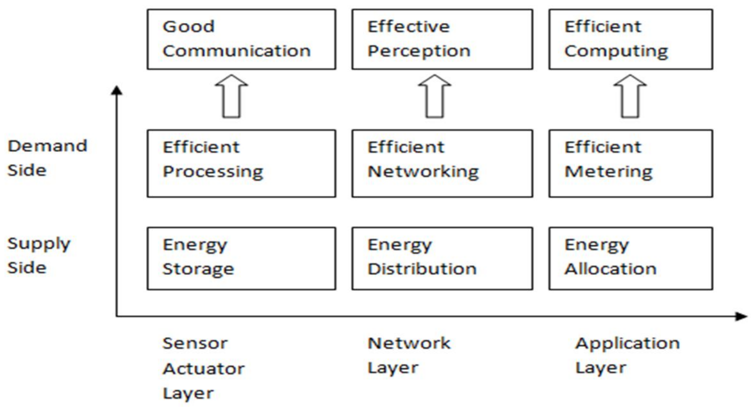

Figure 2. The catalog model for energy management

A. Sensor-Actuator Layer

The conversion of physical objects into cyber entities and comprises the widespread sensors used to perform target identification of physical objects is done in sensor and actuator layer. "Ref. [3]" The sensing techniques adopted in this layer mainly includes radio frequency identification (RFID), ZigBee, infrared induction, Wi-Fi, radar, the Global Positioning System (GPS), and Bluetooth. The identified mechanical and electronic actuators (e.g., valves and switches) can be connected to the sensors to produce issued instructions based on the sensed data. Energy storage, capable sensing and processing, and energy buffering are the main tasks of the sensor and actuator layer, corresponding to the supply side, and demand side respectively.

Energy Storage and Producing

The sensor-actuator layer should tackle the heterogeneity arising from the omnipresent collection of resources, on the supply-side. Distributed and hybrid energy harvesting and storage become the biggest energy supply trends. Energy harvesting means capturing minute amounts of energy which would be dissipated in the forms of such as heat, light, sound, vibration, electromagnetic waves, and others.

a) Renewable energy: “Ref. [4]” renewable energy is an important source of power which is generally managed by ultra-low-power management circuits for nourishing sensing and actuating operation. This energy is very important for unattended sensors and actuators.
b) Solar energy: solar energy is an unlimited power source that can be converted into electricity or heat via the photovoltaic effect.
c) Wind energy: wind energy convertor contains two types of devices such as inconsistent-speed devices and consistent speed devices. The earlier occupy indirect interfaces of electronic components for connection to the network, and the final rely on magpie-cage induction generators for direct grid connection. Analyses of power and wind speed data are useful for wind energy prediction.
d) Radio frequency (RF) energy: RF energy is a ubiquitous source of power for electromagnetic devices. Radio signals are constantly transmitted into the surrounding environment to facilitate the wireless charging of lower power devices with high usability, mobility and reliability.

Efficient Sensing and Processing

Demand and supply sides energy management can reduce energy utilization, enhancing energy protection, increasing energy minimization, and improving energy processing efficiency done on. Efficient sensing and processing depends on the sensing components, operating principles, and manufacturing developments of the applied sensors. Energy consumptions can be reduced based on dynamic energy processing methods such as energetic voltage and frequency scaling (EVFS) and forceful power management (FPM).

B. Network Layer

Multiple network components (e.g., hubs, routers, interfaces and gateways) and various communication channels are included in network layer. Heterogeneous network configurations are established based on WSNs, the Internet, communication networks of mobility, telecommunication networks, and other network technologies. The different tasks of network layers are energy distribution and allocation, efficient networking capabilities, and energy load balancing, corresponding to the supply side and the demand side.

Energy Distribution

Energy distribution can be achieved using distributed algorithms relating to online procedure that consider factors such as power grid load smoothing, dynamic price strategies, and energy provisioning costs.

Efficient Networking: Energy management in the demand-side can achieve good communication plans by reducing energy utilization in the network layer. In the network layer of IoT includes multiple network interconnected components (e.g., boundaries, routers, and gateways) and network channels to transmit related data.

Energy Load Balancing

The goal of supply-demand side in the network layer is to accomplish energy load balancing during communication and networking. Bunch of cluster main heads are usually subject to deep traffic loads for assembling and transmitting information, and they may reduce energy resources, which results in service interruptions in WSNs.

C. Application Layer

The application layer offers provision to support practical IoT developments involving different networks areas, of which allocation of energy, efficient data metering, and energy calculation match up to the supply side and the demand side.

Energy Allocation
Energy allocation can be organized as an infinite-horizon program in order to achieve throughput increase. In renewed WSNs, the sensors are subject to time-dependent energy collecting rates, battery accessibility, data buffer availability, and channel disappearing, in this manner presenting challenges in efficient energy allocation for energy storage and harvesting applications.

Efficient Metering
Smart meters are expecting to support bi-directional information communications between residential customers and power providers to allow real-time energy utilization information collection. It may necessary to realize the efficient energy metering and remote observation of energy nodes in the network, in that end a smart meter is an advanced metering device for recording the utilization of electrical energy and other electrical related parameters for mechanical meter readings.
"Ref. [5]" Energy theft detection has become a important concern in the implementation of efficient metering in home networks area, neighbourhood network area, and wide networks area. There are two main classes of energy stealing detection techniques: classification-based detection and state-estimation-based detection.

1) Classification-based detection adopts artificial intelligence algorithms and machine learning to achieve a appropriate classifier based on data sample that are frequently collected by power meters.
2) State estimation based detection adopts additional checking mechanisms (e.g., WSNs and RFID) to advance the detection rating and reduce the occurrence of false positives.

IV. Perspectives On IoT Energy Management

In this section, energy management for smart home is presented from the supply side and demand-side perspectives, as shown in Figure 3. The main enabling technologies, including power generation using photovoltaic concept, the micro-grid concept, virtualization concept, software-defined networking, data metering infrastructure, response demand, and vehicle-grid technology, are individually discussed with regard to the challenge to achieve high efficiency and effective energy conservation.

A. *Supply Side*

The problems related to energy management in a smart home by supply side are deals with the concepts of power generation using photovoltaic and micro grids concepts.

Photovoltaic Power Generation:
"Ref. [5]" The consumption of solar energy is exactingly suitable for self-sufficient, mobility, wireless, portable electronic devices. Considering the relatively high power solidity and correctness of outdoor applications, solar energy is the most available source of power for resource-confined systems. Photovoltaic power generation technology is main leading technology used to supply power for smart house hold facilities, capability and facilitates the prolong development of the efficient IoT applications.

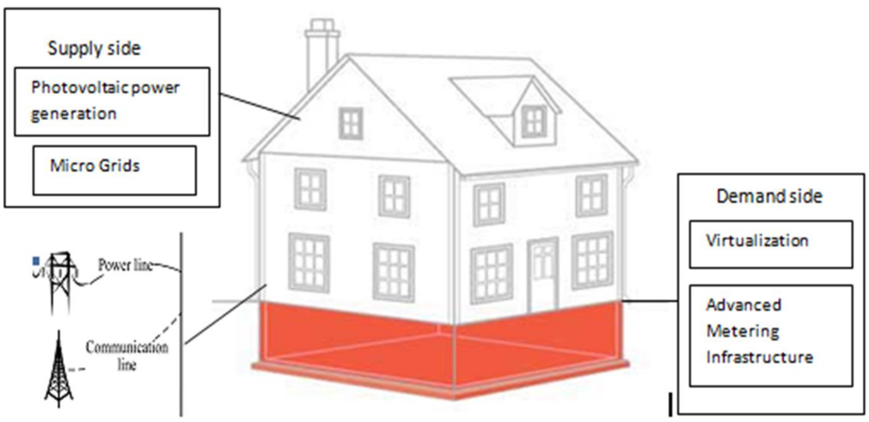

Figure 3. Energy Management of Smart home

Micro-Grids

Micro-grids offer the major benefits of flexibility in functioning and operating, during either interconnected with the influence grid or disconnected in islanded method, and they principle rely on distinguished encoding rules(DERs) or DER method for encoding a data object, including public key infrastructure certificates and keys systems for decentralized energy supply. The incorporation of DERs into the micro-grid architecture enables the organization of a power plant virtualization.

B. Demand Side

The problems related to demand-side energy management of IoT applications like smart home are addressed through the concepts of virtualization, software-design networking, and data metering infrastructure.

Virtualization

Virtualization concerns to the design of virtual entities representing physical objects for resource organization and optimization of logical objects. It can be classified into three main types, such as full virtualization, para virtualization, and partial virtualization.

Virtual machine (VM) movement has generated as an essential tool for data collector and storage systems for service conditioning and energy sensitive consolidation.

Data Metering Infrastructure (DMI)

A data metering infrastructure (DMI) is an intellectual cyber-physical system, which is going to replace traditional analog metering devices for automatic measuring, collection, storage, and analysis of power information for supply or demand side. A DMI creates high-frequency two-way communication to facilitate information to be transmitted between power utilities and the consumers in a smart home. A typical DMI system includes smart meters, communications infrastructures (e.g., routers, edge aggregators, operational & functional gateways, and a utility head-end), networks, and meter data management systems (MDMS).

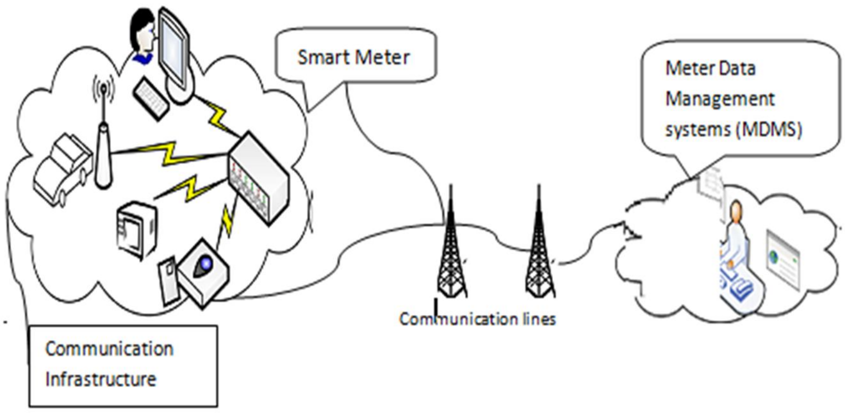

Figure 4: A typical DMI system model

V. CONCLUSION

In this paper, the established catalog model for energy management considers three layers of a IoT, including the network layer, sensor-actuator layer, and application layer. IoT energy management is from supply side and demand-side the related energy issues were individually discussed. The sensor-actuator layer is accountable for efficient sensing and processing, energy produce and storage and energy buffering for the achievement of effective perception. The network layer centres on energy distribution, network efficiency, and energy load balancing to accomplish good communication. The application layer mainly deals with energy allocation, efficient infrastructure, energy metering and forecast for efficient computing. A smart home scenario was considered to provide an overview of the enabling technologies for energy management. The union of communication, computing, and the Internet of Energy were discussed as new perspectives on IoT energy management.

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