A Survey on Efficient Energy Management SystemFor Smart Homes Using IoT and Big Data Analytics

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Abstract-The home automationhas taken a rapid growth in industrial, commercial and public sector such that it became the origin of smart home technology. The smart home concept is an emerging technology which is used at wide range. The smart home concept is mainly focused on monitoring, controlling, analytics and energy management system. The energy management system plays very important role into smart home where main focus is on to use energy efficiently. The smart home energy management system concept can be implemented by using IoT technology. The IoT technology provides a ubiquitous platform to monitor and control home appliances. Where the IoT technology is not sufficient to manage/handle the EMS for smart homes, hence Big Data analytics is get added in support of IoT technology bygathering, storing and performing analytics on the data which is generated by IoT devices. The paper presents the survey on efficient energy management system for smart homes. The various EMS are implemented across the globe to monitor, control home appliances are get proposed in this paper and also calculated, analyzed and compared them with each other to get efficient energy management system.

Index Terms-IoT, Big Data Analytics, SHEMS, EMS, Arduino, Wi-Fi, Bluetooth, Smart Home

1. INTRODUCTION

The EMS stands for Energy Management System and it can be implemented by using technology like IoT, Big Data Analytics, Cloud, communication meduim. The IoT technology is having various network devices, edge devices, sensors and actuators for monitoring and controlling [1]. The sensors are the devices those calculates the change in environment and convert physical entity into electrical signals by which we can measure the amount of change is happened, in a particular environment where sensor device is present [5]. The examples of sensors are DHT11, LM35, ACS712 current sensor, etc. The DHT11 is a temperature and humidity sensor [1]. This sensor calculates the change in the temperature and humidity; they became very general sensors used in smart home [5]. The ACS712 current sensor is used to calculate the amount of current passing through the electrical wire and mostly used for calculating energy consumption of home appliances [6]. The actuators are the devices those are converting electrical energy into physical change like servo motor. The electrical energy is a input to servo motor and arm movement is becomes the output given by servo motor [5]. These devices can be connected with each other to send and receive the data by using communication medium like Bluetooth, Wi-Fi or radio signals. The communication needs two terminalsand they are transmitter and receiver [6].The transmitter terminal send data in the encrypted format where receiver terminal receives data and decrypt the data.The survey comprises various energy management systems for smart home by using parameters like efficiency, scalability, availability and throughput [5].

2. ENERGY MANAGEMENT SYSTEM FOR SMART HOME

The energy management system monitors the energy consumption of home appliances and comprises it with the standard rate of particular home appliances. When home owner purchase home appliances for example bulb. The standard power usage is given on the bulb cartoon [1], [5]. Then the real time energy usage data of bulb is compared with standard energy usage rate. The standard EMS consists of four operations sense, monitor, control and analytics. Variety of sensors are being used to calculate physical change in the environment by using these sensors system gets real time data [5]. For controlling the home devices like fan, T.V., relays are used to make ON and OFF by using any networked device based on ubiquitous platform. As shown in fig. 1 the home appliances are connected to energy consumption monitoring module where energy consumption of home devices is calculated [5].The module consists aequation of power is a product of voltage and current, unit of power is Watt or KW.To calculate energy consumption we need three parameters voltage, current and time.

Energy ConsumptionFor 1 minute$= \sum_{i=1}^{60} V \times I \times t$

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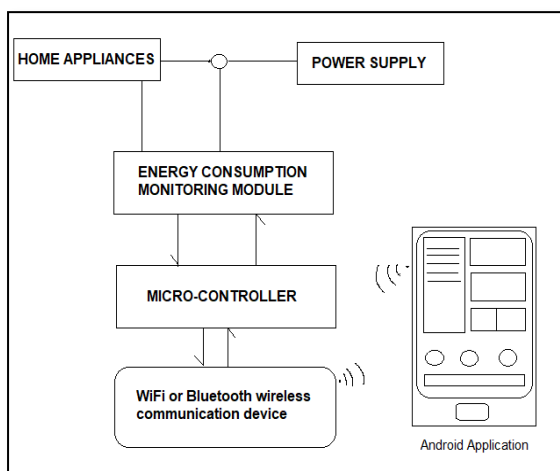*26th & 27th February 2019*

Fig. 1.SHEMS block diagram

The calculated energy consumption details are then passed to the android app by using Bluetooth or Wi-Fi module [5]. The issue in such type of EMS is scalability and network range is present. The author A. R. Al-Ali proposed a EMS for smart home by using IoT and Big Data [1]. The paper presents EMS by using wireless sensor network (WSN) where system consists of home devices connected to data acquisition module and it having a unique IP address [1], [6]. The proposed EMS system utilizes business Intelligence server to meet consumer demand and to better manage energy consumption [1]. The paper presents EMS for smart home in residential, commercial and industrial sectors.The system architecture consists of home owner, community owner, state owner, country owner and administrator. The system provides different privilege of home owner is restricted to his home only [1], [5]. The administrator can be able to control, monitor devices of home owner, community owner and country owner respectively [1], [6]. The system architecture consists of hardware as well as software architecture. The hardware architecture consists of three building blocks:

1.*Sensors and Actuators*

The temperature and humidity sensor DHT11 is get interfaced with micro-controller for monitor and controlling the air conditioned units [5]. The relay is used to control home appliances by interfaced with micro-controller to turn ON/OFF home appliances accordingly.

The AC current is calculated by using the ACS712current sensor [1].

2.*Micro-Controller*

The micro-controller is act as data acquisition module that manages heat, ventilation and air conditioning units. The table 1 represents the specification of micro-controller used in system [1].

Table 1. Micro-Controller Specification.

Component	Description
Digital Ports	13 I/O pins
Analog Ports	5 I/O pins
Memory	32K Bytes

1. Servers

The servers are high end personal computers which are deployed on cloud for scalability and accessibility [1]. The system consists of four servers MQTT server, storage server, analytics engine server and web server [4]. The result of the proposed system are in the form of graphs and chart by using android application [1]. The home owner can able to view monthly power consumption for each device, community owner can able to view annual power consumption of each house in community-x [5].The author SouvikChatterjee and Rajarshi Gupta presented a real-time wireless temperature measurement and logger system [2]. The system uses LM35 temperature sensor for calculating temperature and the real-time temperature result are can be observed by mobile application [2]. The alert messages are sent to pre-assigned mobile number by using global system of mobile (GSM). The system is designed in such a way that it alerts the operator by messaging at a pre-designated mobile number whenever a system recognizes the threshold value is crossed. It improves reliability and security of measuring scheme [2].

The system uses hardware components as sensors, signal conditioning, voltage divider circuit, arduino board, Bluetooth HC05 module, SIM300 GSM/GPRS module [2]. The LM35 is a temperature sensor used in system as it's output voltage is linearly proportional to the Celsius. The LM35 generates 10mV for each degree centigrade temperature as it does not require any external calibration [2]. The OP07 precision operational amplifier is used to amplify the output of LM35 also to adjust range and span. The voltage divider circuit is used for Bluetooth and arduino boards. As arduinouno board works on 5V power supply and Bluetoothmodule work on 3.3V power supply, hence to provide proper input, voltage divider circuit is used [2].

3. ARDUINO BASED MICRO-CONTROLLER

The arduino is a open source platform and the open source gives us privilege to modify and design the board as per one's requirement. The arduinouno uses ATmega 328 micro-controller [6]. The arduino board is then connected to Bluetooth HC05 module to send data to mobile application.
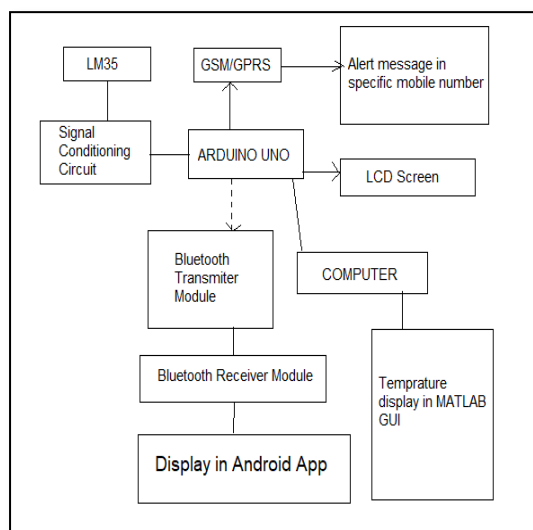
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Fig. 2.Arduino and GSM based EMS

As figure 2 shows the arduino board is connected to GSM/GPRS module which sends the alert message, LCD screen is also connected to arduino board [2]. The Bluetooth transmitter module is connected to arduino board for connecting mobile application and data will be displayed on android mobile app [2]. The GSM and Bluetooth is used to design a stand-alone system for considering harsh environment where wireless PC connectivity is not feasible to implement.

The author SiriwatWasoontarajaroen presented an IoT device which is designed and developed for monitoring energy consumption in building [3]. System uses arduino boards as aIoT platform. Arduinonano micro-controller and ESP8266 serial-to-Wi-Fi board is used [3]. The electrical energy sensor PZEM-004t is used for calculating and monitoring energy consumption of home appliances in building [3]. The presents a system in which the energy consumption monitoring sensor PZEM-004t is connected to electrical power supply between power supply and electrical home appliances which calculates voltage difference and at other end is connected via UART to arduinonano mini [3], [5]. The arduinonano mini is connected to ESP8266 via UART [3]. The ESP8266 is connected to thingspeak.com cloud. The energy consumption data is stored at thing speak cloud and

the data is get access by using mobile application [3]. The result of the proposed system is to develop an IoT device used as a energy consumption monitoring and calculating voltage, current, power and energy of a power line [3].
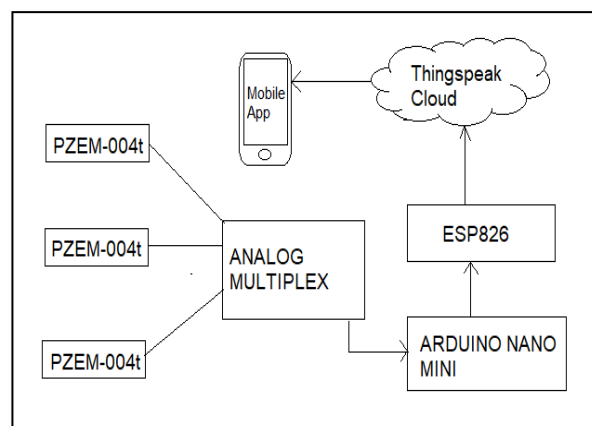

Fig. 3. EMS using PZEM-004t

4. CONCLUSION

The survey paper presents various energy management systems across the globe as they comprises by their level of efficiency, throughput, scalability. The EMS is consisting a issue of networking, as each and every EMS consist of monitoring operation. While monitoring energy consumption by edge devices sends the sensed data to the remote server or cloud for every 1 second to 5 second range. This requires high bandwidth to transfer data but if edge devices are able do computation locally and sends the generated result after 1 hour then usage of network bandwidth will get reduced which will result into better and efficient EMS for smart home.

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