IOT and Energy Monitoring and Management

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Abstract

IoT based Energy Monitoring and Management system is recently trending with the development of IoT. Lot of work is reported in regards to energy management and monitoring the electrical parameters towards hazard. Also, work reporting in controlling the appliance for energy consumption. In an industry or commercial building, significant losses of energy take place. It is important for engineering teams to minimize these losses and hence, a section of engineering workforce is deployed do note energy readings from various energy meters. This results in collection of large amounts of data, which is difficult to interpret and at the same time does not provide clear guidelines to engineers to take real time corrective action. This paper examines a real time energy monitoring system is where in the data is hosted at the cloud which provides actionable task for engineering team. This study is a part of research on applications of IoT and Energy Monitoring in industries and commercial areas, but can be used independently in other applications as well.

Keywords: IOT, Energy Management, Automation, Real time data, Cloud computing

1. INTRODUCTION

Increase in the economic growth and energy consumption patterns has led to ever growing demand for energy. Since most of the energy supply is from burning of fossil fuels, the resources are depleting thus increasing costs of energy. Burning fossil fuels has also increased concentration of CO2 in the environment, hence leading to extreme weather patterns. Therefore, it is imperative that Industries and commercial enterprises take steps to reduce energy wastage, become conservative and reduce costs.

Industry in India consumes 45% of the 900 billion Units of power produced. 35% of electric power produced is lost, and the losses are due to Transmission & Distribution (16%), theft (10%), Inefficiencies among users (10%). The 10% inefficiencies are largely among the industrial and commercial users who have high KVA HT connections. Inefficiency can also arise due to harmonic problems, faulty wiring, feedback from sub systems, and neighbouring electrical systems [9]. This leads to a drop in power and higher usage of energy leading to higher rate slabs and penalties. Some organizations like Data centres measure Power Usage effectiveness where units consumed per annum is much higher than that required to power their total equipment. Researches [1][2] have been carried out using Arduino microcontrollers and Raspberry Pi for monitoring the Temperature and light intensity data and controlling the same in an Automated temperature and humidity control using IoT.

The increase in the usage of energy will disturb the sustainability due to the presence of raised level of greenhouse gases such as CO2. The primary aim of energy monitoring and management is to ensure optimum energy utilization, hence minimizing energy costs and extenuating environmental effects. Energy monitoring and management in real time assist consumers to overcome the burden of energy surcharges and dependence on secondary energy sources like the generators and inverters in residential buildings [2].
This paper develops an IOT based energy management system with integration of meters and sensors for electricity computation in any HVAC system.

So, there was a need for a system which can do the following;

- Easy of Install & Operate.
- Hybrid Data acquisition (Automated & Mobile)
- Vandalism Proof (Data cannot be managed).
- Cloud Based Central Dashboard on NOC.
- Operational in Offline (Mobile Network) Mode.

- Auto Alerts in NOC in 2-5 Seconds.
- Deploy nearest Support Engineer.
- 24x7 Assisted NOC Support.
- Managed Expert Support for Corrective Action.

2. INTERNET OF THINGS (IOT)

Internet of thins is an emerging technology which is using the "Internet" and has a goal to provide connectivity between physical devices around us. Examples of physical devices include home appliances such as the washing machine and refrigerator to any industrial equipment like the cooling ducts, BTU meters, sensors, etc. Using appropriate communication networks, these devices can provide valuable data and enable offering varied services for people. Let us take an example of controlling energy consumption of buildings in a smart fashion enables reduction of the energy costs. IoT has a wide range of applications from manufacturing to logistics and construction industry. IoT is also widely applied in energy monitoring and managing, healthcare systems and services, efficient management of energy, locations sensoring and many others [6]. When planning an IoT application which is the first step in designing IoT systems, the selection of components of IoT such as sensor device, communication protocol, data storage and calculation needs to be appropriate for the intended application. This IoT based platform planned to control HVAC i.e Heating, Ventilation and Cooling in any building, requires utilizing relevant environmental sensors and using suitable communication technology [7]. IoT devices which are the components of the IoT based platforms, can be used in the form of sensors, actuators, gateways or any other device that joins the cycle of data collection, transmission, and processing.

An IoT gateway enables of sending the data into the IoT system and establishing bi-directional communications between the device-to-gateway and hence the gateway-to-cloud. The communication protocols that are the third component of the IoT platform, enable the different devices to communicate and share their data with the controllers or the decision-making centres. IoT platforms offer the flexibility to select the type of the communication technologies, according to the needs of the application. The examples of these technologies include Wi-Fi, Bluetooth, ZigBee, LTE-4G and 5G networks. The data storage is the fourth component of the IoT platform which enables management of collected data from the sensors. In principle, the data collected from the devices is very large and disperse. This necessitates planning an efficient data storage that can be in cloud servers or at the edge of an IoT network. The stored data which is used for analytical purposes, forms the fifth component of the IoT platforms [1]. The data analytics can be performed off-line after storing the data or it can be, in form of real-time analytics. The data analytics is performed for making of any decisions about the operation of the application. Based on the need, the data analytics can be performed off-line or real-time. In off-line analytics, the stored data is first collected and then visualized on premises using visualization tools.

3. CLOUD PLATFORM

A SQL Database with streaming capabilities is used to store data on the cloud in real time and then connected to the user gateway. In my implementation, the Database is selected in real-time due to libraries available for all the Web platforms and the NodeJs platform. The streaming feature of this Realtime Database is used to send commands to cloud at the time when any changes occur. Any cloud that allows real-time communication between the NodeJs and the cloud will also work [14]. Cloud computing is a data processing method which offers services, applications, storage, and calculation throughout the internet and allows calculation of data. In cloud computing, cloud refers to the "Internet" and computing refers to calculation and rectifying services offered by this approach [14].

Cloud computing consists of all the application services which can be accessed via the Internet and the hardware systems. Using these characteristics, cloud computing enables processing of any kind of data, and provides complex calculation capabilities [13]. The main benefits of using cloud systems relies on (i) significantly reducing the cost of hardware; (ii) enhancing the computing power and storage capacity; and (iii) having multi-core architectures, which eases the data management. Moreover, cloud computing is a secured system, which provides resources, computing power, and its storage. These features of cloud computing, enable the data which results from the growing applications of IoT to be easily analysed and sorted efficiently [13]. In addition, cloud computing reduces the costs needed for purchasing hardware and software for processing the IoT data, resulting in considerably deduction of electricity needed for local data calculation.

4. METHODOLOGY:

The given system uses the Wi-fi in the user's PC or smartphone with any specifications. It is not necessary that the user's phone should be in the discoverable mode for functionality. When any of the user is out of reach for a certain time, the system immediately turns off unnecessary devices. Multiple Wi-fi devices can also be used in case of multiple users.

With the upcoming technology of wireless communication where all appliances can be wirelessly enabled using Wi-fi, I have tried to develop a small IoT based system interfacing sensors to give the Temperature, moisture and light intensity of the environment. The readings are given to Arduino board microcontroller which in turn is communicated to Edge level processors, Raspberry Pi. The proposed system is a smart Energy Management system consisting of a Raspberry, Arduino boar, Wi-Fi shield and modules like Hall sensor, LUX Sensor and ambient temperature sensor [4]. The Arduino board will vary the appliance usage i.e. fan speed and light intensity based on the conditions of the environment resulting in reduction of energy usage[10]. These amounts of current consumed by the appliances are captured and same sent to Raspberry Pi3 using Wi-Fi which ultimately calculate periodically the power and plots a graph on the power consumption and same uploaded in cloud server. This way I have tried to achieve the total consumption in energy usage of appliances. This gives the user's knowledge on power consumption of the appliances in real time.

This system allows the measurement of the electrical energy of a building, where the main power has been divided into several sections for individual analysis [1]. Measuring electric energy in sections helps in the identification of higher consumption areas and detection of abnormal conditions in the building [1][3]. The consumption of electrical energy parameters can be shown by means of a graphic interface. Technicians who know exactly when energy consumption occurs and where it takes place can actually take more informed decision about how to lower energy consumption.

The temperature is obtained via the real time environment. The Arduino controls the transistor on which the value is obtained from the sensor. After developing IT Specifications of the application, identify the number of points where data needs to collated and IT interface protocol of various types of meters and sensors available in the market and understand their communication protocols and possible synchronization of data. Estimate necessary data storage required at the Arduino board, assembling of the gateway. And after Testing of assembled gateway, develop data exchange code on Note JS and configuration of SQL file and gateway to receive and synchronize data. Lastly, receive data on cloud on SQL format / file and design and customize energy MIS and using Note JS. The head of the project is an ESP8266, SQL and NodeJs which are used to develop an IOT based system; it has internet access capability and supports several peripheral protocols. A load is connected to a voltage and current sensor module and the load has an external power supply which is separate from 5V supply that is applied for functioning of the measuring circuit. One LCD adapter module is used for driving the display which shows real-time voltage, current and power measurements. The wireless technologies, e.g., Wi-Fi for IoT applications in the energy sector has been widely studied. In the energy sector, the cases of using Wi-Fi include energy measuring & calculating and building energy management systems [4][5]. Calculating and analysing the data generated allows gaining deeper insight, accurate response to the system, and helps making suitable decisions on energy consumption of the appliances in any HVAC. The data can be accessed in real-time on any PC/ smartphone of any specifications.

Figure 1. Sample hardware model embedded on Arduino with GSM sim and Wifi module

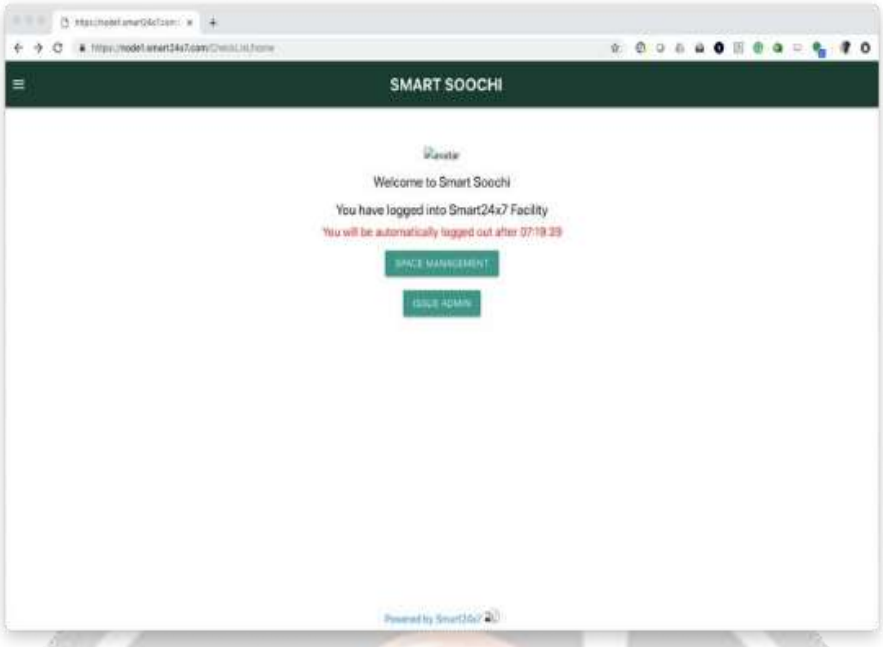

Figure 1. Web Admin Portal

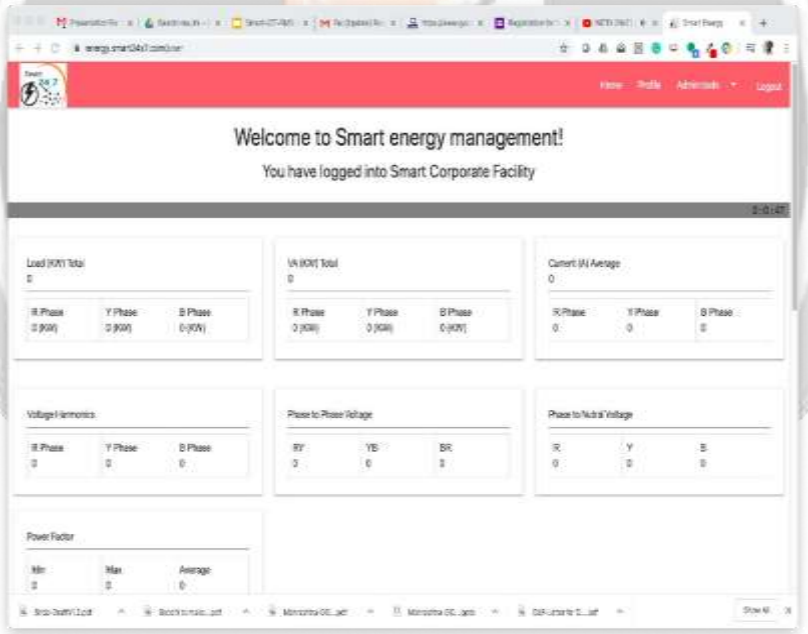

Figure 2. Energy Dashboard 1 with numeric data

The hardware prototype of IoT based Energy Management system is developed interfacing Arduino and Raspberry Pi as microcontroller and the processing unit. In addition to that, Temperature and Lux Sensors deployed and same connected to Arduino microcontroller. Also, the Arduino unit joined using Wi-Fi Module from Reliance Jio to the Raspberry Pi for getting information about the current drawn from each appliance for calculating total power consumed and same plotted as graph using MySql database and the cloud developed. The results is updated in Cloud in real time. I am thinking to implement an algorithm that can change in the weather based on season and detect any kind of change in season based on the temperature, moisture and brightness.

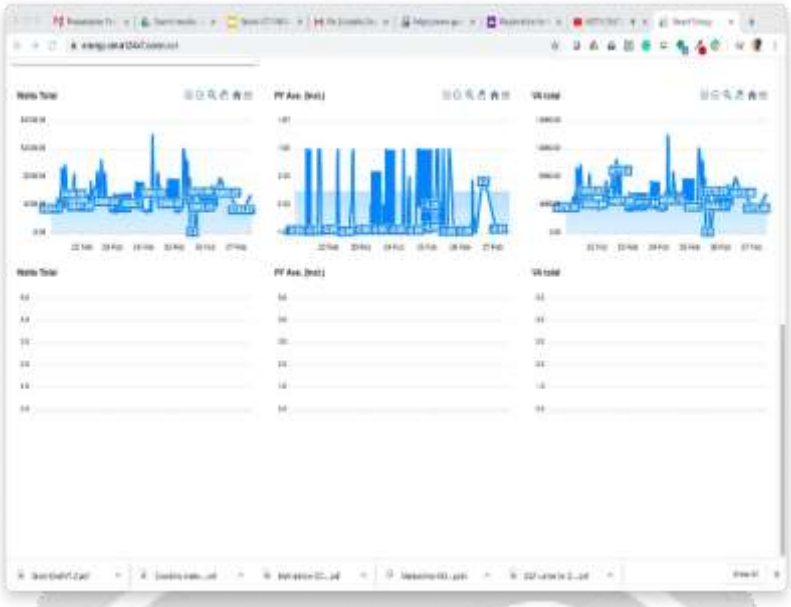

Figure 3. Energy Dashboard 2 with graphical representation

5. CONCLUSIONS:

I have tried to develop an IoT based system for Energy Management routing with Arduino Microcontrollers for controlling the usage of appliance intensity rather than just. Also, the prototype calculates the current(I) drawn from each appliance based on appliance usage and sends it to Raspberry Pi where total power consumed of appliances calculated against time. This information is calculated all through the day and then uploaded in cloud server that too in real time. This eventually achieves in energy calculation resulting in Energy Management using an IoT based system.

The system is not fully finalized as I have developed a prototype only for controlling energy usage in HVAC. In future, I propose to develop a similar system for controlling appliances like Refrigeration, machinery, etc. More amount of power can be saved by the lowering the usage of appliances. We can take over the appliances manually and this can eventually help in achieving employment. I also considered energy issues related to the supply and demand side of IoT energy management, demand, and energy balance. The sensor-actuator layer is culpable for the acquisition and capacity of energy, capable of detection and management, and energy support. The system layer is focused on energy penetration and energy load to achieve an eco-friendly response.

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