Smart Monitoring System for Home Energy Consumption (SMEC)

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The issue of environmental protection and related issues has become a major concern for many people. Despite this concern, electricity consumption continues to pose several environmental pollutions. Electricity consumption leads to the need for natural gas, which in turn leads to many devastating consequences for the environment. Electricity, in itself, does not necessarily pose environmental damage, but on the contrary, it offers many benefits, such as lighting and the operation of many devices; but the problem with power consumption is the gas needed to produce it, which can be damaging to the environment. Indeed, natural gas is currently the most important sources of energy used to produce electricity, which is, create an enormous amount of carbon dioxide, which the environment cannot tolerate. Regardless of the method used to generate electricity, environmental issues related to the use of electricity will help to ensure that the method used is best suited to the environment as a whole. The best way to reduce environmental problems from electricity consumption is to minimize this use. In this research, we will try to solve this problem by developing a new application titled Smart Monitoring System for Energy Consumption (SMEC). SMEC will provide a management of power's consumption within the building anywhere and anytime in which users can see how much of electricity they use while power's consumption report would be provided automatically. The main advantages of SMEC is to avoid some problems like decrease consumption of electricity, help to detect abnormal use and controlling unneeded devices, save effort and time for monitoring and reading the amount of uses and finally such a new application will be more reliable and good for employee to check meter's reading online. All this will be displayed in a friendly interface, which will have graphs and text to make the use of such application more efficient and simple to use. SMEC application will be developed using different languages such as C++, Java script, PHP, html and MySQL. Moreover, the proposed energy detection device uses Arduino UNO with some sensors such as ACS712, electric meter, GPS, LED and Wi-Fi adapter. The information is received by reading the power meter consumption and then handled through the Arduino device to perform the objectives of the research. By reading electricity's consumption online, SMEC can analyze collected data that will help to make better decisions using Internet of Things.

Introduction

Recently, our world is suffering from several problems, which is come from different sources and affect the ecosystem. One of these problems is electricity consumption. Recently, researchers and developers are seeking to develop application to solve this problem, which is considered as one of the main causes that affect environment. Developing such application is more reliable for consumer for many reasons for example, the ease of use and availability. This study is seeking to develop an application titled Smart Monitoring System for Home Energy Consumption (SMEC). SMEC is used to help the environment from excessive use of electricity. SMEC is a smart application that allows the consumer to control and monitor the use of electrical devices. The main features of SMEC are able to control the power and knowing the amount of the power's use remotely. The main idea of SMEC is support energy consumption and for monitoring, recording and controlling energy consumption remotely. Comparing with already exist, SMEC will help society and the environment

in different fields and it will solve many drawbacks, which are:

- Controlling electricity use.
- Reduce the cost of use.
- Knowing the cost of using.
- Decrease electricity consumption.
- Companies may use such application to save their devices by knowing which device consume more.
- Detecting abnormal use.
- Easily control with unneeded devices.
- Saving effort and time for reading the amount of use.
- More reliable and good for employee to check meter's reading online from their workplace.
- Able to take some intelligent decisions taking into consideration the collected data by IoT devices of SMEC.

Problem Statement and Objectives

The power meter is a measuring device with a rotating disk that calculates the electrical quantities or electrical energy that are consumed. Given the growing energy demand, developing SMEC are needed in which such a new application will help people to monitor the electricity of their house remotely to decrease power consumption. Most of the power meters that currently installed at houses display the total real time usage of the power and the amount of electricity available. There is no way to see what the day, week's or month's consumption. Moreover, these power meters are placed in an inconvenient location, which makes regular viewing more difficult, and it lack the ability to monitor this meter easily. The comment problems that might be occurred with the current system are:

- The chance of human mistake while recording the manual meter reading is very high.
- Consumer is not updated about current house's electricity usage.
- Consumer may not easily get the bill information with accurate information.

As mentioned earlier, SMEC (Smart Monitoring Electricity consuMption) aims to monitor and control house's electricity consumption using a new smart application to avoid errors that might be occur by using traditional meter. The main goal of this application is to save the environment by reducing the use of electricity and keeping it green.

Moreover, this application will benefit customers to reduce their electricity consumption costs, which will encourage the government to reduce the usage of gas and fuel when providing energy. Less usage of energy will minimize the pollution that is caused by extracting fossil fuels from the ground. This system will help to keep the environment clean and healthier to live. Therefore, the aim of our paper is to develop a web application, which has specific, measurable, achievable, realistic, timely objectives, which are:

- Real-time consumption monitoring.
- Full control of house electricity.
- Limiting the usage of house appliances, as users prefer.
- Application will have a friendly interface for better and easier interaction with users.
- Remote control of house devices.
- Analyze electricity consumption data in the house.
- Getting readings such as voltage, current and active power.
- Arduino device can connect to an application and the gathered information can be uploaded and processed by the management system.
- Data (i.e., electricity consumption) can then be displayed online.
- Allows users to access their data easily and notifying them in case any abnormal levels of electricity consumption are detected.
- Retrieved sensed data in the form of tables and graphs.
- Avoid employers' mistakes that occur in manual bill reading.

Related Work

Many traditional power meters currently installed in households only display the maximum real-time use of their energy and the amount of usable electricity. There is no way to see what the output of the day, week or month on these meters and often these power meters are mounted in an awkward position that makes it somewhat difficult to monitor regularly. Project in (abhishek7xavier,2019) proposed a new smart meter system that can monitor multiple devices, receiving readings such as voltage, current, active energy, apparent power, reactive power, power factor and frequency. The Android smartphone will connect to a central gateway with the aid of a wireless connection and the collected data can be downloaded and processed by the gateway management system. The app allows users to access information from any phone that is allowed by Android. It is also important that the latest data about the devices can also be displayed with a menu interface on a local screen. Figure 1 illustrates system diagram of the proposed project.

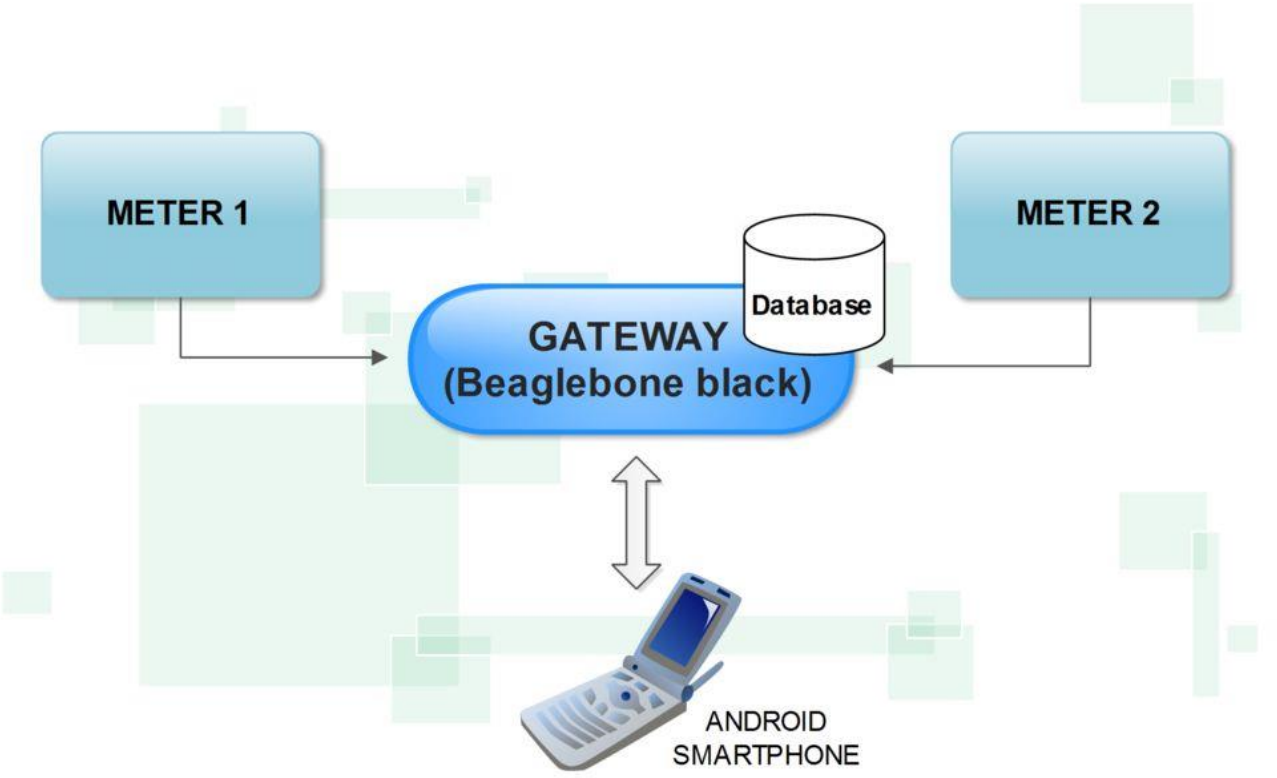

Figure 1. *System design of smart meter system.*

The Energy Management System (EMS) is proposed in (Baig, F., Mahmood,2013) which includes all the load usage information and holds the data in a txt file. The proposed system helps the user to use power efficiently and helps them to reduce bills for energy. The home appliances are controlled by using zigbee from various loads at home. The zigbee allows the life of devices to communicate to each other and send their information to EMS. There are two controls for appliances: one via remote and the other via the EMS software interface. Figure 2 illustrates system diagram of the proposed system.

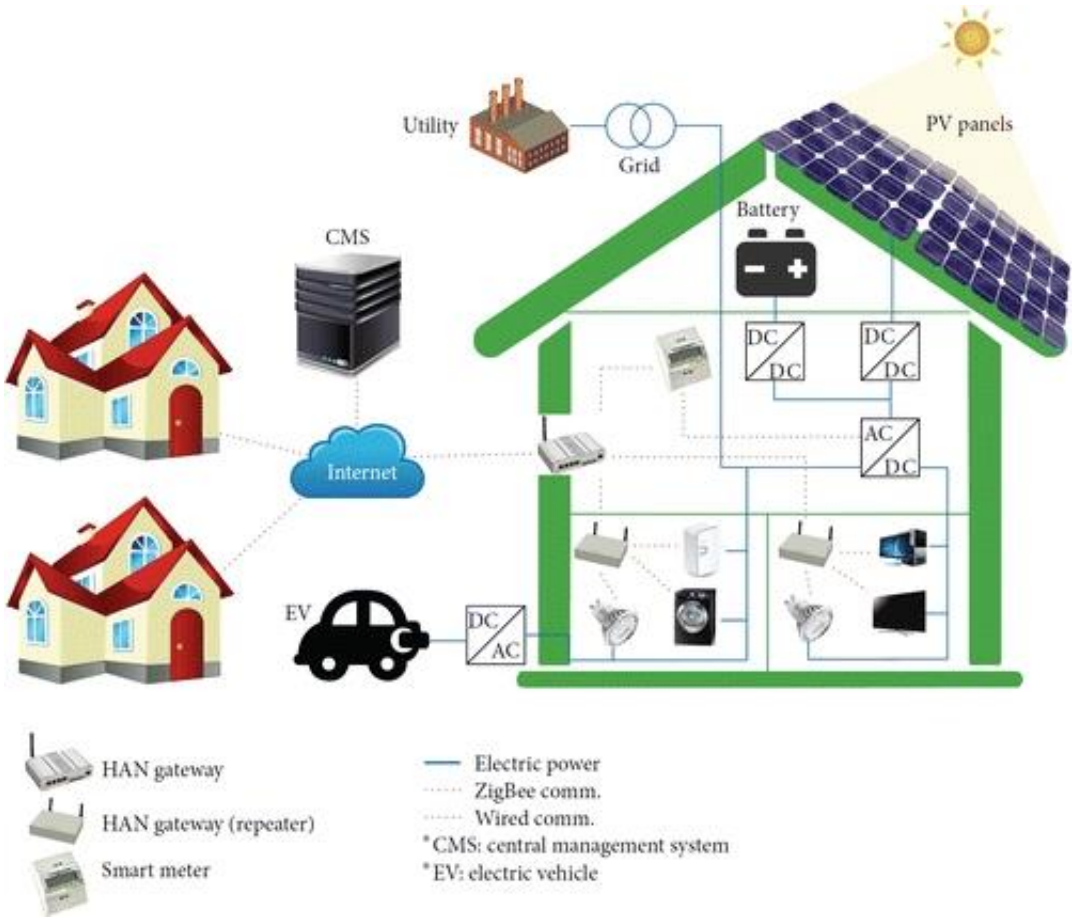

Figure 2. *System design of HEMS.*

Automatic Meter Reading (AMR) which is an IoT based smart energy meter project proposed in (R, A. S., Kumar, 2019). It is an Indian smart energy project which is based on IoT that used to control and monitoring the electronic devices. It contains different control devices and sensors to identify parameters and devices, which are used to transfer data and command signals. It allows user to pay the bill directly without attending the electricity provider company. It also supports monitoring and sending electricity consumption reports within real short times to the user by an application called Smart Meter application. As their comparative analysis, they got a high score result about their device compare with different devices in their county.

In (Pujari , L., 2018) proposed an IoT based smart energy meter monitoring and controlling system. It is a mart energy meter system based on IoT that can be controlled by using Wi-Fi. It aims to save the electricity for a long time, which is considered nowadays one of the important things that has more demands. It also focusses on get the electricity bill, electricity providing days, and the previous bill by using IoT which considered an easy and accurate way for user and the electricity provider company and even for payment process. It is considered and intermediate between user and electricity Provider Company.

Majan and Mazoon (Majan, Mazoon, 2019) are two main companies in Oman which providing electricity service. The main goal of these two companies is to provide electricity for the costumers and provide them with the reports of monthly used electricity, which includes the cost on Kilowatt (KW). However, the current system applied on these companies are not controlling and managing electricity consumption online and remotely as well as we have found these companies don’t have method to afford collected information in a website and displaying them in friendly way such as graphs and texts.

Here in this paper to cope with the above mentioned problems, we will seek to develop application has the following features and activities that the users could interact with SMEC:

- User with SMEC can register online in order to get all the features and to move easily from one page into another.
- The registered user has all privileges to access SMEC's device for controlling and monitoring, analyze electricity consumption, analyze sensor data, and order new device and other services.
- User can ask for help and support or for a complaint.

SEME Methodology

SMEC is a user-friendly system where intelligent paradigm will be integrated into its components. The developed architecture designed under the philosophy of client/server as shown in figure 2. In order to develop SMEC application requires integration of four of the following units:

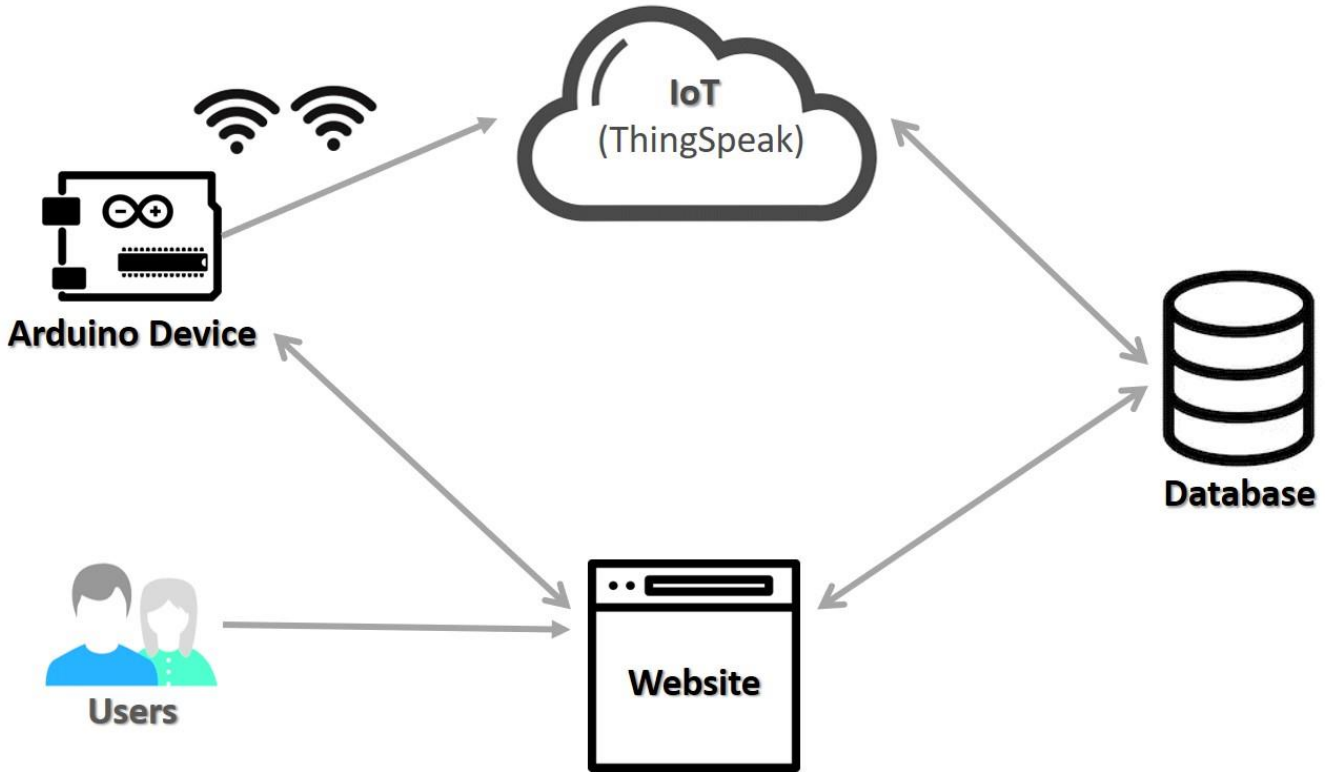

Figure 3. *SMEC Architecture.*

- Data collection unit is consist form smart sensors that are used to capture electricity power consumption data every 5 minutes. Captured real-time data from smart sensors will be transfer to IoT platform (i.e., ThingSpeak). Table 1 presents the required hardware components of this unit. The collected raw data will be analyzed to diagnose ubnormal cases and send an alert message when an actual electricity usage case is identified. By using ACS712 sensor and esp8266, it is easy to collect data in real time. Figure 4 shows the circuit diagram of SMEC device. Table 2 illustrates the type of the sensed data by the suggested device in our application including voltage, current, latitude and longitude data.

Sensor Name	Description

(Breadboard)White Board	A construction place for connecting the electronic devices
Arduino UNO	Control base.
Jumper Wires	Connections
LCD Display (20*d 12C)	View the sensed data
Wi-Fi (ESP 8266)	Controlling and Connection
Battery 9V	Power source
Lamps	Generate Electricity
Current sensor ACS712	Detect Electricity
9V battery connector	Battery connection
GY-GPS6MV2	To identify location
Resistors	implements electrical resistance as a circuit element

Table 1. *Required hardware of data collection unit.*

Figure 4. *Circuit diagram of SEMC.*

Field #	Description
Field 1	Voltage
Field 2	Current
Field 3	Latitude
Field 4	Longitude

Table 2. *Captured Data Description.*

- Cloud Computing unit (i.e., Thingspeak) is responsible for recorded collected data for further analysis and send all the sensed to SMEC's database.
- Database unit: Permanently store all the information from ThingSpeak (IoT) and website and re-share it with the users.
- Data Analysis and displaying unit is responsible for visual massive collected data and posts the results in an interactive web page. SMEM Website allows users to control SMEM device (Arduino) and show all sensed data with their analysis.

Experimental Procedures

In this section, we will combine the suggested hardware parts together including Arduino UNO which consdier the heart of the proposed device, Breadboard for connectivity between the sensors, ACS712 to read the amount of electricity, GPS sensor to give the location, LCD display to display the amount of consumption, and esp8266 WiFi sensor used to read the data from the sensors and send them to Thingspeak so the user can read and understand what is going on remotely.

To get the location we need to connect GPS sensor with Arduino and this can be done by connect VCC pin to 5V pin in Arduino, TX and RX used for reading the data pin to 10 and 11 pin respectively in Arduino and finally connect GND pin to GND in Arduino. Figure 5 shows the prototype of GPS sensor wile figure 6 shows the serial monitor of testing this sensor.

Figure 5. *GPS sensor connected with Arduino.*

Figure 6. *After upload the codes.*

The next sensor to connect and test is Wi-Fi sensor; it has eight pins but we need just to connect five of them. VCC pin will be connected to 3V in Arduino Uno board, GND pin with GND of Arduino, RX and TX with 2 and 3 respectively in Arduino, and the last one is CH-PD which will be connected with 3V pin of Arduino borad. Figure 7 shows the prototype of Wifi sensor while figure 8 shows the serial monitor of testing this sensor.

Figure 7. *Wi-Fi sensor connected with Arduino.*

Now we will connect LCD and ACS712 to read the electricity and display output on the chosen LCD. first we will connect VCC pin of LCD to get the power to pin 5V, GND with GND, SCL with A5, and SDA with A4 to display the data. While VCC pin of ACS712 sensor will be connected with 5V, GND with GND, and OUT which will give the output with A0. Figure 9 shows the prototype of LCD and ACS712 while figure 10 shows the serial monitor of testing these sensors.

Figure 8. *Wi-Fi connected to the netwrok and thingspeak api.*

Figure 9. *LCD and ACS712 connected with Arduino.*

Figure 10. *After uploading the LCD and ACS712 code.*

Finally, all the suggested parts will be connected together to get the final result and prototype of our device. Figure 11 shows the final prototype of the proposed device.

Figure 11. *The complete prototype of the proposed device.*

Figures 12 and 13 show the collected data that were sent from Arduino through wifi. The sensors regularly in real time capturing situational context information from the proposed sensors and processed in its engine. Note that, SEME's engine filters the data to be consumed locally, and sends the rest to the server layer (i.e., SEME's database). SEME engine output has two parts: the first is saving all collected data in SEME's database for long-term behavior analysis and monitoring, while the second is simple and quick feedback if a high electricity usage is identified and an alert message will be sent when an emergency case is noticed.

Figure 12. *Voltage result (Field 1).*

Figure 13. *Current results (Field 2).*

Survey Results

Survey is a type of research methods that aims to collect data from different participants. It is usually disrupted among pre-defined group of participants. A survey was conduct among 20 persons from several categories from the society on 30th of October 2019. Figure 14 shows the

majority of respondents were 23 years old, while others from different years.

Figure 14. *Result of respondent's ages.*

Figure 15 illustrates that 66% of respondents rely heavily on electricity in daily life while 33.3% of them are controlling their usage. In fact, the necessity of start saving electricity usage and get smart with how you use electricity becomes a must.

Figure 15. *Result of the Amount of saving electricity.*

The other part of the survey was discussed the electricity provider of users. Figure 16 shows Majan Company is the top one that is offering the electricity services. Depending on the results, working with Majan Company will help to complete our goals.

Figure 16. *Result of the Electricity providers.*

As a poll question, the result in figure 17 shows that most of the users are agreed that our application (i.e.,SEME) will help them to solve and controlling electricity consumption problem. The obtain value indicates that the extent of people's knowledge on the importance of this application and its benefits on saving their money.

Figure 17. *Result of expectation aims of SMEC.*

In the last part of the survey includes question about the quality of using the current electricity consumption whereas majority of the respondents has negative impact about old system. Moreover, we also found about 50% of respondents are paying their electricity bill by cash while other by credit card as well as we found all respondents could not able to predict the amount of their consumption of electricity using old system.

The survey was used to gather information and to get results from a sample of people from Omanis society as well as we used it to support our idea and make our working depending on their requirements. After analyzing the data, we have found respondents are strongly agreeing to find a new solution to reduce their electricity consumption. Achieving our work in perfect way will help to get customer satisfaction.

Conclusion

In this paper, we have discussed a study about developing a new application that related to monitoring the electricity consumption using IoT platform. The architecture of SMEC is designed in level model including collecting the data by using different sensors like using ACS712 sensor. Providing new application would help users to save them self from paying lots of money and in the same time will save the environment from electricity pollution. In general, the main features of SMEC are:

- SMEC uses IoT as a new technology in its unit.
- Aims to make the user more economical in the use of electricity.

- Notify users in case electricity usage reached a predefined limit.

We conducted a survey to support our idea and we get a many of answer to encourage our idea and we expect SMEC will be using as a main thing in the daily life in Omani's society.

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