A Novel Method for Electrical Energy Consumption Tracking using Internet of Things

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***Abstract* – in big cities everything depends on electricity. Electricity is mainly used for lighting, heating, cooling, cooking, cleaning, personal caring, computer and entertainment.** The **Internet of Things, Big Data services are Energy consumption monitoring in residential houses provides useful information to save energy while reducing CO2 emissions, but also for predictive maintenance and optimization of applications what results in costs reduction. One can monitor the time to time usage of electricity and this data can be sent to a dedicated webpage with the help of raspberry pi. The electricity bill and usage alert can automatically be sent to the dedicated mail id of the person. The methodology is an IoT based, using raspberry pi with the help of programming in python and HTML. With this novelty method efficiency enhances, reliability increases and man power can be reduced and also be used to send alerts to the users if there is over usage which helps in energy conservation.**

Keywords—IoT, Python, HTML, Energy Meter

I. INTRODUCTION

Electricity is one of those discoveries that have changed the daily life of everybody on the planet. Electricity is the key component to modern technology and without it most of the things that we use every day simply could not work, and would never have been created. Our mobile phones, our computers, the Internet, our heating systems, our televisions, and our light bulbs - nearly everything in the home would be completely different. There would be completely different systems put in place in the home to ensure that we can remain warm, and to ensure that we can live properly every day.

For every human being there are basic facilities that are needed i.e. food, clothing and shelter and next in the list comes electricity, it was discovered by Benjamin Franklin in the year 1879 and it revolutionized the world. In the world today there is electricity everywhere without which no one can live even for a second. But we often get a doubt whether we are using it efficiently; this is where this work is helpful.

With this method one will be able to monitor the power consumption time to time with the help of webpage and also if there is an increase in the power consumption it can be sent to the mail of the person. This can be achieved with a Raspberry Pi and by programming it with Python.

Sensing the data from the Digital Energy meter with the help of Optocoupler IC and sending this data (count of number of blinks made by the energy meter) to the Raspberry Pi. Based on this data checking whether the power consumption has crossed the specified limit and sending the alert to the mail id of the user. It sends the billing details time to time to the mail id and also to the webpage.
This system consists of an energy meter which is used to measure power consumption in household and industries interfaced with a Raspberry Pi3. A typical energy meter consists of 4-LEDs one of which signifies power consumptions to this LED an optocoupler is connected to count the number of blinks. This optocoupler is connected to the Raspberry Pi. The Raspberry Pi in response calculates the energy consumed and electricity bill and uploads this data to both the local and global web servers periodically and the end of month electricity bill is sent to the user via email using SMTP (Simple Mail Transfer Protocol).

The meter which is used for measuring the energy utilizes by the electric load is known as the energy meter. The energy is the total power consumed and utilized by the load at a particular interval of time. It is used in domestic and industrial AC circuit for measuring the power consumption. The meter is less expensive and accurate.

II. PROPOSED METHOD BLOCK DIAGRAM

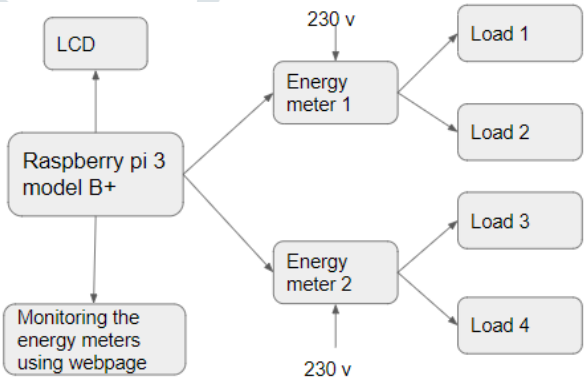

Fig.1 Block Diagram of proposed setup

A. Raspberry Pi3 (RPi) model B+

The Raspberry Pi is manufactured through licensed manufacturing deals with Newark_element14 (Premier Farnell), RS Components and Egoman. All of these companies sell the Raspberry Pi online. Egoman produces a version for distribution solely in China and Taiwan, which can be distinguished from other Pi by their red coloring and lack of FCC/CE marks. The hardware is the same across all manufacturers.
The Raspberry Pi3 is a credit card sized computer that plugs into your TV and a keyboard, it's like a little PC which can be used for many of the things that your desktop PC does, like spreadsheets, word processing and games. It also plays high definition video. The design is based around a Broadcom BCM2837 SoC, which includes an ARM CORTEX 1.2 GHz processor, VideoCore IV GPU and 1 GB of RAM. The design does not include a built in hard disk or solid state drive, instead relying on a micro SD card for booting and long term storage. This board is intended to run Linux kernel based operating systems.

Fig. 2 Raspberry pi model 3 B+

B. Internet of Things (IoT)

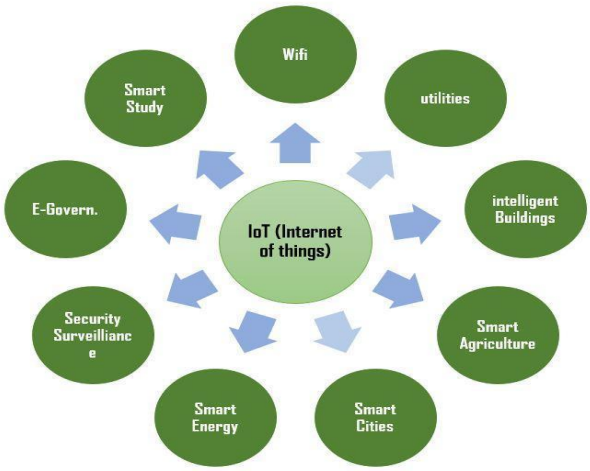

Fig. 3 Overview of Internet of Things

Internet of Things (IoT) is a system of interconnected objects, usually called smart devices, through the Internet. The object can be a heart monitor, a remote or an automobile with built-in sensors. That is objects that have been assigned an IP address and have the capability to collect and transfer data over a network. The objects interact with the external environment with the help of embedded technology, which helps them in taking decisions. Since these devices can now represent themselves digitally.

In other words the globally ruling technology acting as a single key to shrinking this whole universe to a tiny globally connected village, whereas IoT comprises of just two words which precisely depicts its definition.
Internet: Inter connectivity-For global connection

Things: Embedded system devices-sensors, actuators, RFID tags, QR code and so many.
Thus, on the whole, the Internet of Things is the technology which enables everything to communicate by themselves over the internet through the devices without the use of computers. Here comes the most essential and prevalent term in IoT called 'Smart' which means Automation – the process of decreasing human intervention or involvement thereby increasing the machine intelligence to perform every tasks by itself, which could be done by IoT.
IoT makes an intertwined network of artificial things like physical devices, vehicles, home appliances and even to connect with natural living beings like plants, animals and so on. The above diagram speaks about the overview of IoT and what are all the applications in which IoT is used.

There are four main components used in IoT:

1. Low power embedded systems**:**
   Less battery consumption, high performances are the inverse factors play a significant role during the design of electronic systems.
2. Cloud computing**:**
   Data collected through IoT devices is massive and this data has to be stored on a reliable storage server. This is where cloud computing comes into play. The data is processed and learned, giving more room for us to discover where things like electrical faults/errors are within the system.
3. Availability:
   We know that IoT relies heavily on sensors, especially real-time. As these electronic devices spread throughout every field, their usage is going to trigger a massive flux of big data.
4. Networking:
   In order to communicate, internet connectivity is a must where each physical object is represented by an IP address. However, there are only a limited number of addresses available according to the IP naming. Due to the growing number of devices, this naming system will not be feasible anymore. Therefore, researchers are looking for another alternative naming system to represent each physical object.

Characteristics of IoT:

- Massively scalable and efficient
- IP-based addressing will no longer be suitable in the upcoming future.
- An abundance of physical objects is present that does not use IP, so IoT is made possible.
- Devices typically consume less power. When not in use, they should be automatically programmed to sleep.
- A device that is connected to another device right now may not be connected in another instant of time.
- Intermittent connectivity – IoT devices aren't always connected. In order to save bandwidth and battery consumption, devices will be powered off periodically when not in use. Otherwise, connections might turn unreliable and thus prove to be inefficient.

Applications of IoT:

- Smart Grids: Smart Grid and Internet of Things (IoT) are two technologies that become highly developed lately. In the perspective of energy saving, smart grid is an excellent solution to optimize the energy consumption while the IoT can be a solution that offers consumers the convenience of having a real time method to control and monitor energy usage in a home.
- Smart cities: The Internet of Things (IoT) offers new opportunities for cities to use data to manage traffic, cut pollution, make better use of infrastructure and keep citizens safe.
- Smart homes: In IoT enabled Smart Home environment various things such as lighting, home appliances, computers, security camera etc. all are connected to the Internet and allowing user to monitor and control things regardless of time and location constraint.
- Healthcare: Internet of Things (IoT) enabled devices have made remote monitoring in the healthcare sector possible, unleashing the potential to keep patients safe and healthy, and empowering physicians to deliver superlative care. It has also increased patient

engagement and satisfaction as interactions with doctors have become easier and more efficient.

- Earthquake detection: This system helps us to detect the earthquakes by taking the p and s wave readings from the earth and intimating the users if any earthquake occurs.
- Radiation detection/hazardous gas detection: This systems integrates IoT with AGS sensors and detects it if there is any hazardous gas leakage occurs and intimates user if any.

B .Methodology

This system consists of an energy meter which is used to measure energy consumption in household and industries interfaced with a Raspberry Pi3. A typical energy meter consists of 4-LEDs one of which signifies energy consumptions (3200 blinks equal to 1 KWh energy consumed), to this LED an optocoupler is connected to count the number of blinks. This optocoupler is connected to the Raspberry Pi.

III. HARDWARE DESCRIPTION AND WORKING OF PROPOSED METHOD

The Raspberry Pi in response calculates the energy consumed and electricity bill and uploads this data to both the local and global web servers periodically and at the end of the month electricity bill is sent to the user via email using SMTP (Simple Mail Transfer Protocol).

This hardware consists of parts mainly they are:

a) Data acquisition from Energy Meter
b) Data Processing in Raspberry Pi
c) Data display using Raspberry Pi on LCD display, local and global webpage and in the user mail.

a. Data acquisition

This is the most important part in this work. For this purpose we used a two phase digital energy meter to which is connected to the loads and to acquire the energy meter readings the blinking LED of the energy meter is connected to the optocoupler. The optocoupler is an Integrated Circuit (PC817 IC) that provides electrical isolation between the energy meter and Raspberry Pi so that if there are any fluctuations in the power it will prevent damaging of Raspberry Pi and also this also has an IR LED that helps in counting the blinks generated by the energy meter.

b. Data Processing

Processing of the data is the second step of the work the output of the optocoupler IC is given to the GPIO pins of Raspberry Pi (RPi) the GPIO pin acts like a clock i.e. whenever there is a high pulse generated from the optocoupler the count is incremented and for every 3200 pulses generated it is equal to 1 KWh all this is programmed with python. The no of pulses counted is multiplied with the tariff plan to generate bill according to the power consumption. In this work tariff is decided as 2.4/- rupees for power consumption less than 0.005KWh and 4/- rupees for power consumption above it.

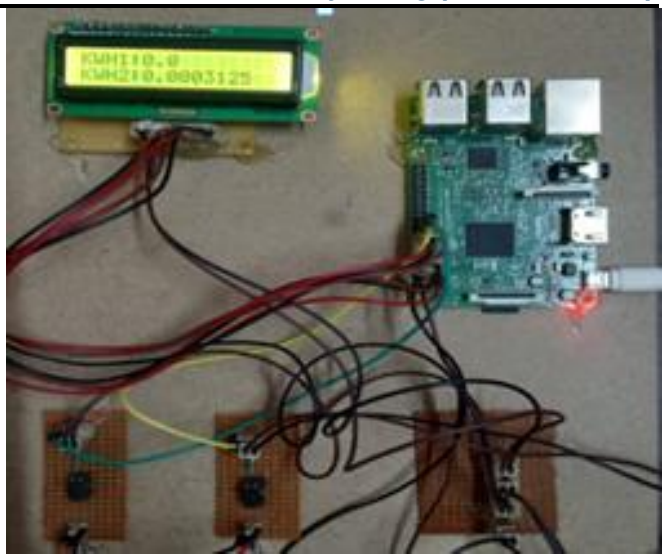

Fig. 4 Hardware experimental setup

c. Data display

Data display is the third and the final step of the work, in this step the data that is processed is displayed on the LCD connected to the Raspberry Pi, in the webpage and also sent to the mail ID of the person. Firstly on the start of the work we see a line “Electrical Energy Tracker” on the LCD screen and as the work runs we see the number of units of the power consumed on the LCD and this is updated as and when the number of units get changed. The same power consumption details are updated in the web pages i.e. in both local and global, to view the data in the local webpage we need to connect to the same wifi connection as that of the Raspberry Pi and the IP address of the raspberry Pi needs to be typed in the browser, similarly to view the data in the global webpage we have used a freeware called Remot3.it that helps us to register the Raspberry Pi as a thing and if we login into that with the correct credentials we will be able to view the contents from anywhere around the world. For displaying is the webpage we used HTML to display the data in the same template every time, to send the mail from Raspberry Pi to the user mail ID we have used SMTP (Simple Mail Transfer Protocol) by which we send mail from the Raspberry Pi to receiver (user) mail ID, the mail is sent if there is any increase in power consumption and also bill is sent at the end of month.

Working flow chart

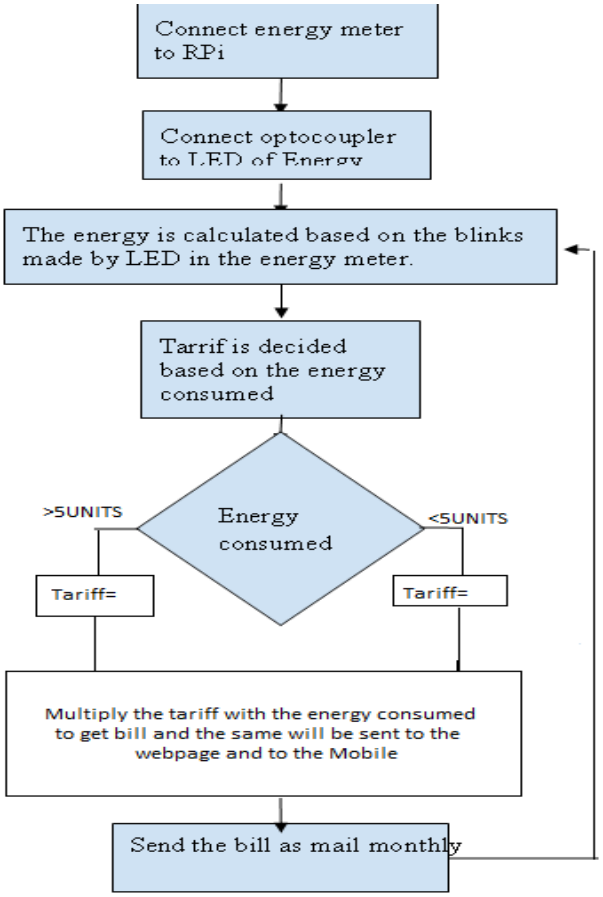

Fig. 5 Flow of information in setup

IV. RESULTS AND ANALYSIS

A. Power consumption bill

Power consumption is obtained by reading the number of LED blinks in the energy meter using an optocoupler and bill is calculated in the raspberry pi. Every 3200 blinks of LED are taken as 1 KWh energy consumed. This equation is used to calculate bill and it is send to the email of the user at the end of every month using SMTP protocol.

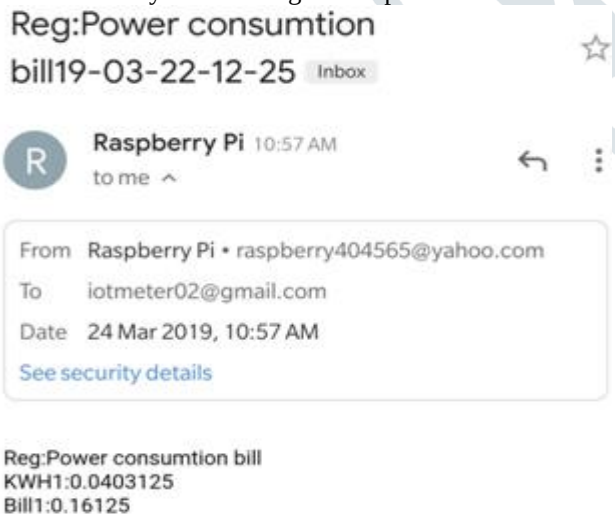

Fig.6 Power consumption bill obtained via email

B. LCD display

The power consumption is updated every second and is displayed on the LCD which is present at the energy meter.

Fig. 7 LCD Display

Fig. 8 LCD display showing Energy Meter 1 Readings

Fig. 9 LCD display showing Energy Meter 2 Readings

C. Webpage display

The power consumed and bill details are displayed in both a local and a global webpage using remot3.it web servers. This web service is protected by a username and password, this webpage is designed in html.

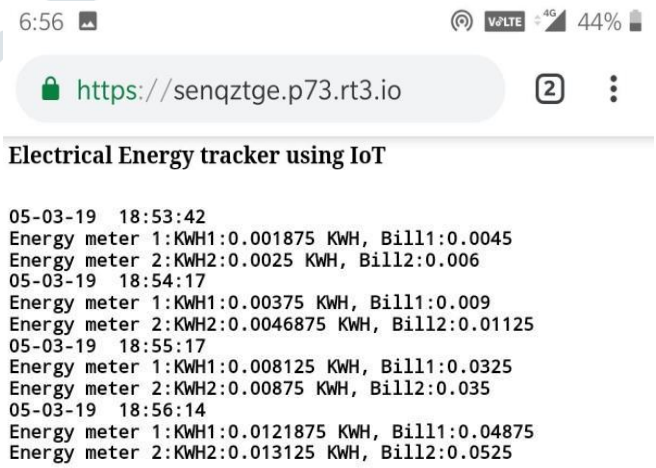

Fig.10. Global webpage

D. Alerts

Once the power consumption is overloaded the user is sent an email alert stating the overload in energy. This is added whenever there is tariff change and the user is notified.

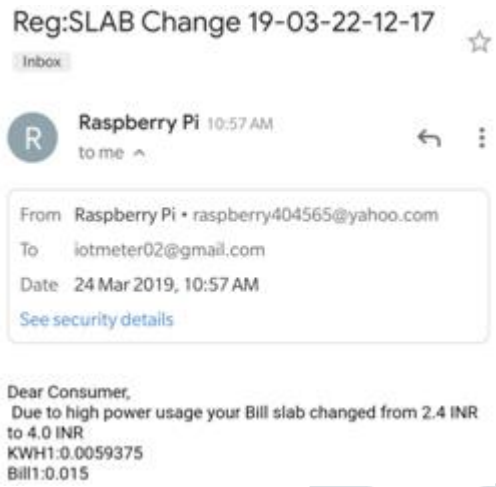

Fig. 11 Slab change alert via email

V. CONCLUSIONS AND FUTURE SCOPE

In this paper, a system is developed that keeps on tracking the electric energy consumed by the person and intimating the person whenever there is a overuse of electricity. This also sends the details of the total energy consumed at the end of the month. The Raspberry Pi is the heart of this work and the whole process of sending the data to the mail id and the webpage is done by that.

This work helps the user to keep the track of the electrical energy consumed and also reduces the workload on the Electricity Department. The tracking the electrical energy and sending the data to user can be further improved by integrating this application with home automation i.e. we can keep the track of power consumed by each device in the house and we can also switch off that particular device from a dedicated webpage. It can also keep the track of the person's bill payment details by collaborating with the electricity department and obtaining the person's details from their database. It can also add payment gateways like paytm, Google pay and other payments. This can also be extended to industry.

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