IoT based Customizable Energy Management System using Cloud Computing

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Abstract

Electricity is an essential need that is mostly utilised in home, agricultural and industrial sectors. In this paper, dynamic power management is carried out by using Internet of Things (IoT) to track and manage home appliance energy consumption. In the current systems, humans must manually keep track of power consumption details, and it is challenging to estimate how much energy various appliances are using. Furthermore appliance status cannot be accessed and it is impossible for home appliances to consume the predetermined amount of energy. The developed system can track home appliance power usage, and the resulting data is saved in IOT. The proposed work provides a system for smart metering and charging on an energy meter. The prepaid energy metre is a device with a chip for assessing how much electricity is used. In remote monitoring of electricity usage, each object's energy metre has been incorporated with a Global System for mobiles (GSM) based wireless connectivity module. This method has the capability to prevent human error, and remote analysis is also feasible. It automatically update information about the amount of energy used, related percentage will be shown on the Liquid Crystal Display (LCD) and transmitted to the base station continuously. The result shows with Energy Meter more automation operations can be performed and Electricity Board (EB) meter is operated automatically. The Energy Meter has intelligence to avoid manual mistakes. The smart controller collects the energy information of the home appliances which saves in cloud platform for analysis. Home appliances accounted for two-third of the Energy consumed in Average home. It also specifies that roughly one third of energy is wasted. The Proposed smart controller can reduce the amount of energy wasted during the idle state of energy consuming equipments.

Keywords: IoT, Intelligent Controller, Prepaid Energy Meter, GSM, Short Message Service (SMS), Electricity usage monitoring.

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Introduction

Now a days, the electricity has become fundamental and its usage has been increasing in a great extent. Home appliances are occupying major role in wasting power during Standby Mode or idle mode and continue to draw the power that technically called electricity leaking. According to the US Energy Information Administration, Home appliance consumes two-third of the Energy generated and it also specifies that roughly one third of energy is wasted. The massive energy waste cannot be avoided until its causes are genuinely understood (Santhosh et al, 2021). Energy waste is not just about having inefficient bulbs and setting air conditioner temperature too low. Recognizing how energy is typically lost is the first step in our society's significant effort to eliminate energy loss. The traditional EB meters can be replaced by smart Energy meter with intelligent controller which saves the energy

consumed by home appliances by monitoring the information in IoT cloud platform.

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The Smart Energy Meter is prepaid, it provides load according to the amount recharged by the user. Once the recharge amount get exhausted, the user can get alert message and this can be easily recharged using GSM Network without internet. With this the theft of electricity can be avoided. The intelligent controller collects the energy information of the home appliances which saves in cloud platform for further analysis. This also serves to control the energy consumption of home appliances with respect defined recharge amount (Nazriya et al, 2020). The home appliances can be ON/OFF by remote station or by using mobile with internet and the analysis of power consumption can be done. This system will send SMS alert to the user when the home appliances are switched ON or OFF. This system's objective is to monitor and manage the energy usage of household appliances using their predetermined recharge amounts. The recharge amount is preloaded to the microcontroller using GSM Modem and Microcontroller will turn on the appliances until the Power Consumption with respect to the recharge amount. The various tariff calculations also incorporated similar like EB Tariff. The status of Load ON / OFF can also be displayed in the LCD. Once units get recharged, the recharge information will be displaced in LCD and also send SMS to pre-defined users mobile showing that Recharge Success (Satheyamoorthy, 2013). The power consumption of home appliances can be estimated with billing system. The current EB billing system charges bimonthly bill on the amount of electricity used by customers with post-paid meter. The post-paid energy meter box in the current system is inaccurate, and readings must be taken door-to-door for calculating bill amount. It is impossible to maintain the consumer's power usage and additionally it takes time and effort to analyse the energy consumption to produce the bill. It is challenging to identify any energy theft the user may have committed to lower the energy meter reading. Some methods rely on prepaid billing have also been proposed, however they need to be recharged using a smart card, which is dependent on an interface or the internet (Mejbaul et al, 2011). In the existing system human need to monitor manually. So it is difficult to perform in automatic operation where it does not require humans. The current EB billing system needs labour and time-intensive, and there is a chance for error. The primary flaw of the current system is that it cannot be maintained automatically. Additionally, the current electricity billing methods are stagnant, expensive and not accurate (Geetha et al, 2018). In existing systems, it is difficult to perform analysis of Home appliances power consumption. The status of appliances cannot be received. The pre-defined amount of Energy consumption of Home appliances is also not possible. The proposed systems monitors and control the Power Consumption of Home appliances and that data's are stored in IOT. In the proposed system can monitor the EB meter remotely and that data are stored using IOT. Regarding remote monitoring of electricity usage, each entity's electronic energy meter has been integrated with a GSM-based wireless module. The key benefit of the proposed technique is that more operations may be carried out using automation. It is intelligent enough to prevent human error and remote areas are nevertheless capable of supporting analysis. The main goals of the proposed prepaid energy meter are: users are not required to pay surplus amount; users ought to pay in accordance with their demands; it can minimise issues with bill payment customers who live in remote areas and it can reduce the need for labour cost to take EB meter readings.

Literature Survey

In this section, the previous works available for energy meter are discussed. To reduce the cyber threats of Intelligent Electronic Devices (IED) presented an intrusion detection system (IDS). The proposed IEDs are capable of identifying interferences, discrepancies, and unusual factors. By using the suggested collaborative intrusion detection technique in IED, it may also find simultaneous attacks. The findings demonstrate that the suggested approaches do not disrupt or add any latency to the defensive IEDs' functionality (Hong and Liu, 2017). Data from light energy sensor is used to solve three issues: i) Offer preliminary validation of a lighting control system's resources. ii) Dissect

energy use and make usage and performance tracking. iii) Track and manage equipment life of lighting system. Utilizing a testbed for experimentation inside an establishment, the suggested procedures are assessed (Wang and Peter, 2018). GSM networks is used instead of the internet. This system's goal is to track and manage energy usage for prepaid users with recharge cards. These cards are preloaded with has values for energy metre usage. Both the energy metre and card are connected to the microcontroller, and the bulb is connected as well (Nithyanantham et al, 2017). A prepaid energy metre that uses a recharging chip was used and keypad is used to recharge and money is added to chip. The amount will be decreased in accordance with power usage. The quantity of energy used is tracked by an Light Dependant Resistor (LDR) component, which also shows the quantity of electricity left over on an LCD. When the recharge quantity is exhausted, a relay system is being used to shut down the energy meter load through main supply. A buzzer that sounds before the recharge quantity drops to a certain level is utilised to alert the user (Ganurkar and Gour, 2015). Designed and developed prepaid energy meter using SMS technology. Energy consumption information is sent to user mobile phone through SMS. The major drawback in the system is recharge done for energy needed only in home using keypad (Subhasiskar et al, 2011). Prepaid energy system is demonstrated in which recharge cannot be done but SMS related to energy information is send to registered mobile phone number (Sheela sobanarani et al, 2008). Developed a smart wireless energy consumption system which calculate power consumption and allow users to view the energy consumed to perform demand management (Okafor et al, 2017). The proposed technology allows use of prepaid recharge cards to monitor and manage energy consumption over the GSM network. The remainder of this paper addresses system design and implementation, results and discussions, conclusions and future investigation.

System Design and Implementation

In the proposed work, the amount for which energy to be used is recharged and loaded using GSM modem to the microcontroller. When recharged the energy unit information is displayed in LCD screen.

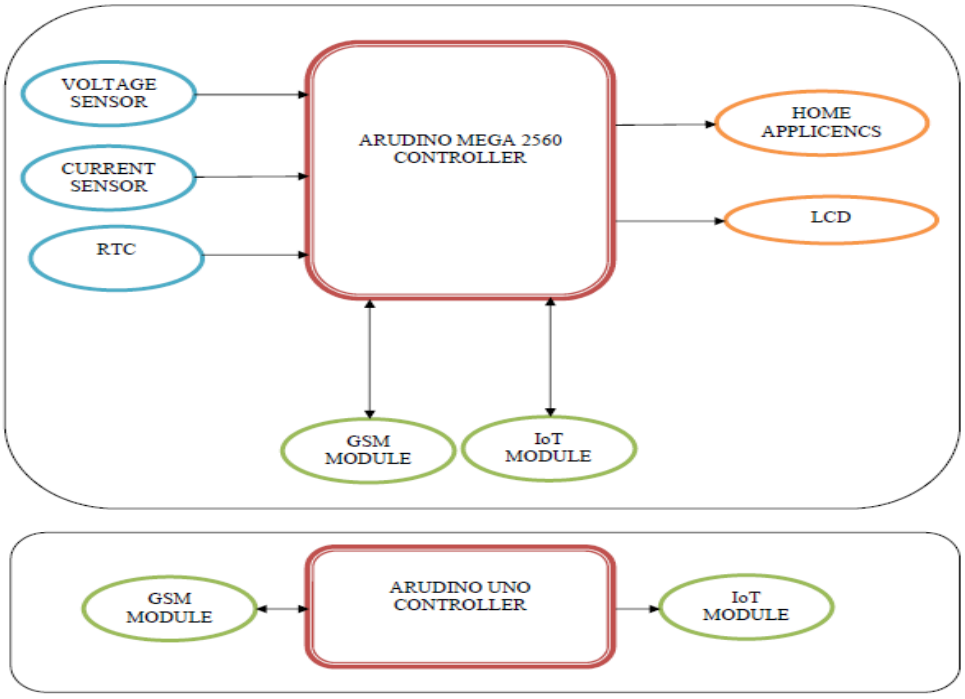

Figure 1: Architecture of Intelligent Controller and Base Station.

Prepaid energy meter is cost effective technique and avoids manpower usage to take readings of energy meter. It reduces errors associated with manual billing of energy usage and provides advantage to both consumer and supplier. The micro controller is used in proposed system to turn on the home appliances according to the recharge amount available, then home appliances energy usage is monitored and controlled. Figure 1 represents proposed system architecture. The hardware components used in this work are Arduino Mega 2562, Arduino Uno, Current sensor, Voltage sensor, RTC (Real Time Clock), IoT wifi module, SIM900 GSM Module. Arduino Mega 2560 Microcontroller board has more memory space and I/O pins. Arduino Mega is used to program and upload the code. Arduino Uno board is a microcontroller and contains required support needed for microcontroller. Figure 2 represents proposed system block diagram. A small step down transformed used in the circuit to reduce the voltage level according to device needs.

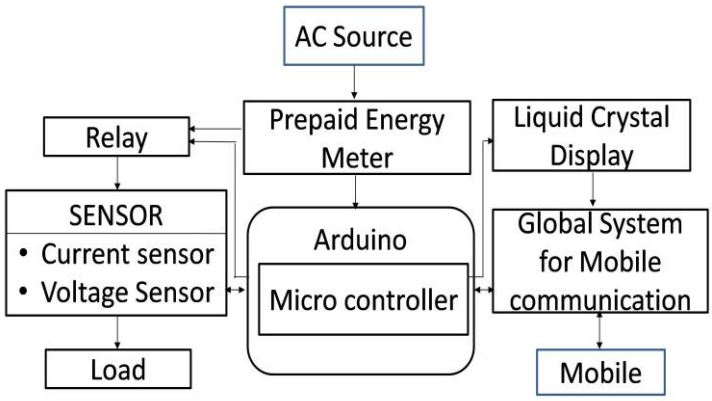

Figure 2: Proposed System Block Diagram

Current sensor is used to detect electrical current and generates a signal proportional to it. voltage sensor monitor and measure the voltage supply. IoT Module receives the information of Home appliances from Arduino Mega controller, communicate to the cloud through wifi and save the information in cloud platform. Home appliances are switched ON/OFF through IoT using mobile phone or computer. GSM Module is a wireless MODEM that connects to the Arduino controller via a Subscriber Identity Module (SIM) card. It functions similarly to a cell phone in that it initiates network contact. For their identification, it also has a special International Mobile Equipment Identity (IMEI) number. As soon as the connection has been made successfully, the Light Emitting Diode (LED) will blink continuously every three seconds. To start the GSM module, insert the SIM card, connect the adapter to the module, turn it ON, and wait until the status LED starts blinking.Based on Attention (AT) commands sent by the arduino controller, the GSM module communicates via serial communication. GSM modules regulate the electricity use of household appliances and communicate with the user. The user specifies how much of an appliance utilization is permitted, and then consumption is controlled at the preset recharge amount. When the quantity utilised goes over the preset limit for a specific household appliance, the customer will receive an SMS (Short Message Service) saying "No balance please recharge". If necessary, the user can recharge the amount using a mobile. IoT is an internetworking of devices, including household appliances equipped with sensors and application that allows them to communicate and share data. Household appliances can be remotely sensed and controlled by IoT to ensure effective use. In this paper, intelligent controller is proposed using GSM network which neglects the need of internet. The proposed controller keeps track of the electricity consumption for prepaid customers using their recharge card. The recharge card which is preloaded with the energy meter usage values and the recharge card is connected with microcontroller as well as with energy meter and lamp is connected to the microcontroller. Load is turned on due to the

electromagnetic radiation while the meter is recharged then the LCD displays the recharged units and SMS message "RC Successful" is sent to customer registered phone number indicating recharge amount. When the recharged units reaches a minimum value a buzzer is given as an alarm to user and SMS "Balance low please recharge" sent to indicate the recharge has to be done to continue the electricity consumption. The flow chart of proposed system is shown in Figure 3. The energy meter was put to the test using a 100-watt electric light bulb that can draw up to 0.5 A of current. The 230 V power source was given and the power used by load was measured using a wattmeter. Then, every ten seconds, energy usage was assessed. Every ten seconds, a total of five pulses were recorded by meter. The LCD is read to determine the calculated energy consumption.

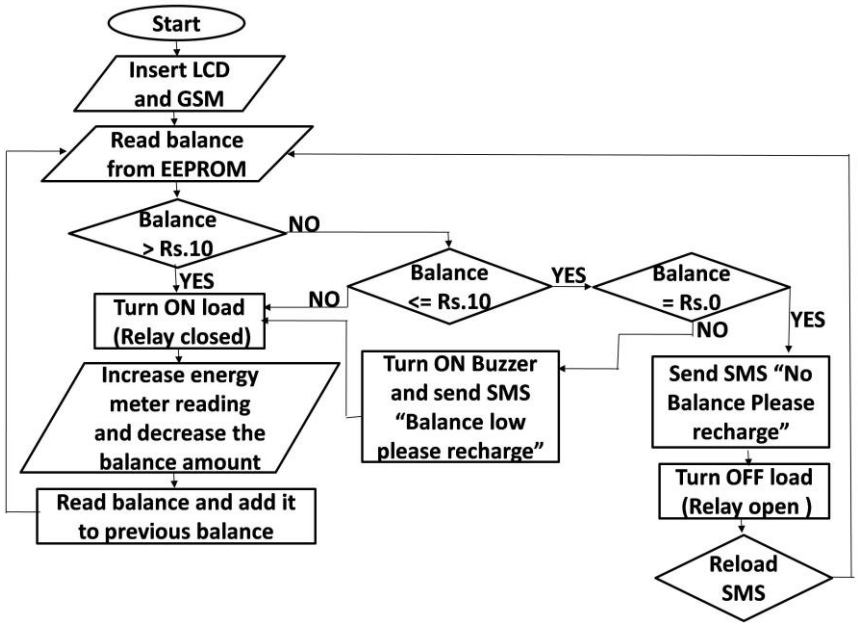

Figure 3: Flow Chart of Proposed System

Results and Discussions

In this proposed system, the microcontroller is the major interface role. Then GSM is interfaced with microcontroller, voltage and current sensor is connected to microcontroller then it flows through the transformer and it produces the electricity. Now electricity generated and display current reading by using the LCD display. The components connected to arduino board are shown in Figure 4. When the prepaid current unit recharge is completed, it prompts the user to the recharge the card and recharge can be done by using the smart card. Arduino Mega controller is used in proposed system to monitor the energy consumed by the home appliances. The current sensors, voltage sensor connected externally collect the information of home appliances. The RTC is used to display the exact time period for calculating the energy consumption, the exact power consumption is monitored by user using IoT. Remote monitoring is performed in Control Station and user can define home appliance power consumption in term of dividing the total energy value to respective appliances. Once the prepaid recharge amount is reached, Arduino controller gives message "Over Consumption" through GSM Controller, and user can recharge the amount to continuously use the load.

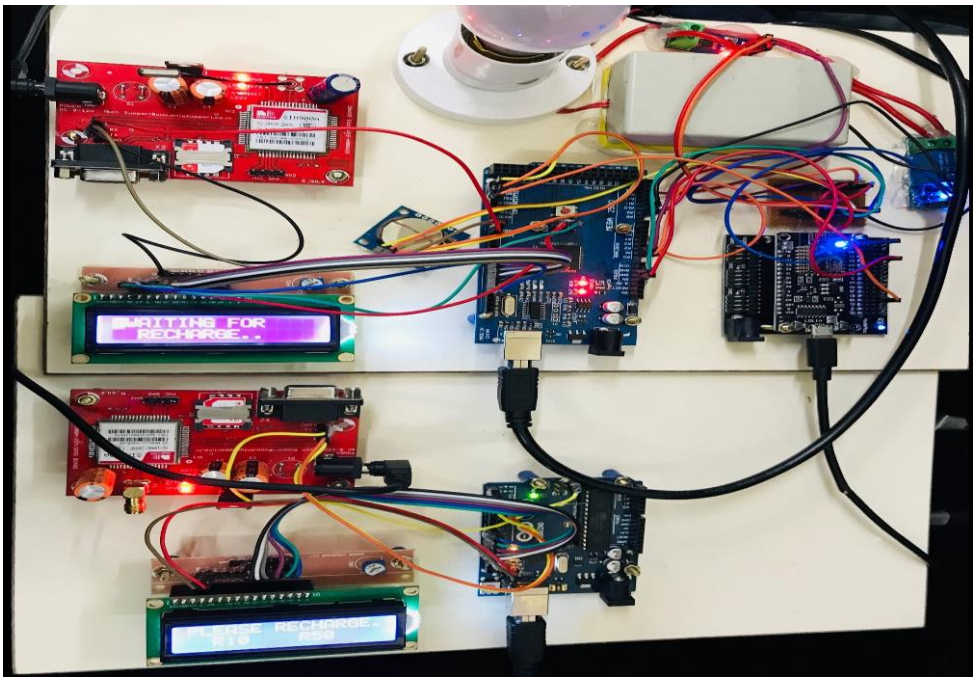

Figure 4: Intelligent Controller for Home Appliances through IoT

When card is recharged, "Recharge Success" message is received by the user through SMS. Internet is not required to recharge the amount for home appliance usage as it can be done using SMS. The control station is able to monitor home appliances in multiple locations and can control from remote station by performing ON/OFF in appliances. Figure 5 represents control section of home appliances through energy management application using mobile phone.

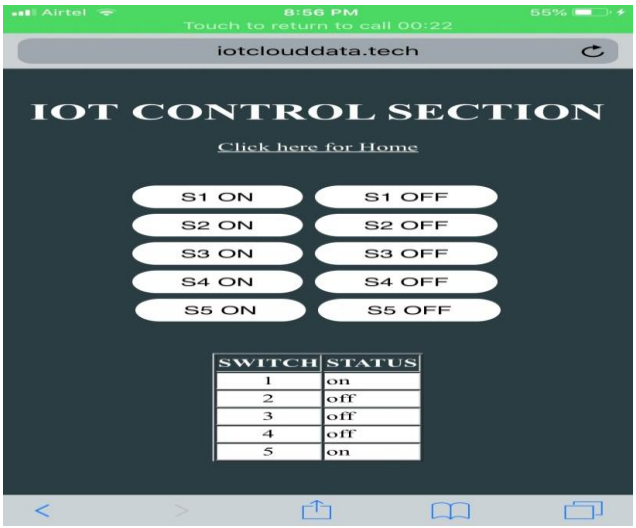

Figure 5: Control Section of Home Appliances

The Electricity Usage can be viewed by user in LCD display and the usage can also be seen in web link provided EB (Electricity Board) for each users. Figure 6 represents the energy consumption data of home appliances accessed through web page. The "Electricity Usage Monitoring web app" is a user-friendly application which allows user to manage our Energy usage.

Electricity Usage Monitor helps to accurately measure daily data usage, and analyze the data to avoid unwanted energy consumption. After recharging the card, it automatically update to the server. Then it shows the cost, units, date, time, etc. By using the data displayed the consumer can able to identify the devices which uses high energy along with the unit of energy consumed and cost by particular device. This data helps consumer to manage and control usage of devices when it is not necessary. The smart Energy Meter has IoT control and monitoring section for user operation. The user can on or off the appliances using mobile phone through IoT. The Actual results obtained from the proposed system shows that the smart controller designed can be used to estimate the electricity usage in home appliances and data will be store in cloud. With the monitoring of energy consumption the wastage of energy can be reduced and create awareness. The proposed system helps user to monitor their home devices energy usage through mobile phone and control it accordingly.

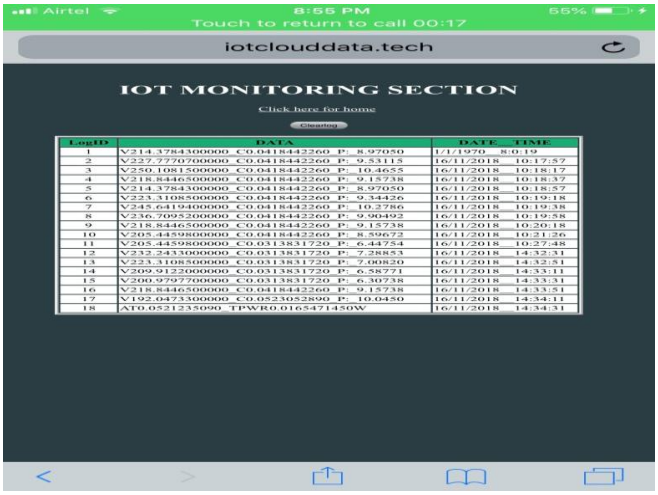

Figure 6: Energy Consumption monitoring using web page

Conclusion

The necessity for dependable and effective Automatic Meter Reading (AMR) systems has increased as electronic metering technology has experienced fast technological improvements in recent years. This paper suggests the development of a simplistic, minimal cost wireless GSM prepaid energy meter and its related web based application for automating billing and managing the energy usage of home appliances. Without the need for a person to visit every home, the system can continually check the metre readings. Smart Home and Automation is growing rapidly to reduce the energy waste. The end user doesn't have time to monitor energy usage in home and user cannot control unwanted running hours of home appliances which cause increase in its power consumption. A system is needed to do the maintenance activities remotely. The proposed low cost Intelligent Meter for Home appliances integrated IoT Platform avoid these drawbacks and allow user to access energy consumption information through mobile or computer anytime. The user can detect reason for increase in power consumption and control the usage of Home appliances through cloud using mobile phone. The proposed system provides an overview of a consumer-friendly, durable prepaid energy meter that can assist to reduce energy usage by allowing users to control their own electricity use. Additionally, it effectively reduces energy theft, making it better for consumers.

Future Enhancement

Multiple smart meters can be interconnected and monitored globally. Smart meter can be connected to smart home and the cost of energy is highly reduced. By using Energy consumption data's in cloud, the home appliance analysis can be done through analytical tool and report can be given to the user. Then alert can be given to user to do maintenance activities of home

appliances to provide the energy efficient usage and power consumption, energy cost of appliances can be reduced.

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