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Smart Energy Meter for Optimized Power Utilization

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ABSTRACT: *Electricity consumption has continued to go up rapidly at a rate faster than energy consumption. The biggest effect of using too much energy is an increase in the so-called carbon footprint. Using electricity more efficiently reduces both the amount of fuel needed to generate electricity and greenhouse gases and other air pollutants emitted as result. In this paper we have proposed a smart, integrated electricity consumption monitoring system that has been implemented with the use of open source standard technology. This monitoring system can be joined with the commercial electric meter so that it can read the electricity consumption of a household. This electricity monitoring meter uses IoT that helps it read the electricity usage and the consumer can read the usage level and the electricity bill from a remote distance via cloud platforms like ThinkSpeak in Computer or in their android mobile using the Cloud Platform Mobile Apps. Using this monitoring system the consumer can also set a limit to their electricity usage and when it crosses the limit, the consumer will be notified by Email. This system helps to reduce the usage of electricity for the betterment of environment and also helps consumer to reduce their electricity bills.*

KEYWORDS: *Carbon Footprint, Cloud Platform, Electric Meter, Internet of Things (IoT), ThinkSpeak.*

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I. INTRODUCTION

Scads of physical devices that are now connected to the internet are collecting and sharing the data is referred as Internet of Things (IOT). This system works on the process of receiving and transferring data over wireless networks without the interference of humans. Depending on the IOT system analysis can be conducted either by humans or by artificial intelligence and machine learning in a whole or long duration. A smart meter is the next generation of a gas and electricity meter. Smart meters measures how much is our consumption and as well as how much it's costing us and also it displays on a handy in-home display like mobiles, tablets and laptops etcetera. Since smart energy meters consumers can regulate the energy consumption simultaneously from anywhere in the world. This meter sends alerts in the form of emails and SMS about the consumption level or any parameters we have put down. This system allows the electricity board to read the meter readings monthly without a person visiting every house. By using Arduino unit, it monitors and records the meter reading in its memory. This system can be used to detach the power supply of the house when ever needed.The ACS712 sensor senses current consumption and gives analog output. The analog output is then calculated abd callibrated and the real-time value of current consumptionn is generaed via Arduino Nano. As we know the mains power supply is 240V AC, so from the equation of **Power = Voltage * Current,** the power consumption is calculated. The total amount of enectrical energy used is calculted by multiplying the total time with the total power consumed by the appliances. Then the real-time values are uploaed to the cloud at regular intervals of time through ESP8266 Wi-Fi module. From the Cloud, the real-time energy consumption can be seen graphically on Cloud Platform and Mobile app from anywhere in the world.This system can also be used to disconnect the power supply of home when needed. This paper mainly deals with smart energy meter, which utilizes features of the embedded system i.e. a combination of hardware and software. The paper discusses how and what type of work is done by IOT based smart energy meter. Also, with the help of Wi-Fi Modem the consumer can monitor its consumed reading and can set threshold value through the webpage. If the consumer is not aware of threshold notification, then meter gets off automatically after that consumer can increment the threshold value and meter will automatically turn on. Moreover, this power cut control system is done by using same website which is used for monitoring. In this project each customer is differentiated using address or Id, this ID are used for identification by the consumer and as well as by office to monitor the reading and payment detail. Live status about power consumption can be viewed by both consumer as well as electric board. The relay in the energy

meter can be controlled by the EB officer using the website created, for turning off the power supply. Another relay is provided to the consumer for turning off the load from the power supply during emergency cases.

II. RELATED WORK

This Paper [1] proposes a GSM Technology Based Smart Energy Meter where billing information is provided through SMS in mobile. This system will provide a remote on/off of the electricity supply based on payment of the bill and it also reduces illegal aspects which takes place due to non-payment bill. This system uses a GSM module which allows the computer to use the GSM modem to communicate over the mobile network while connected to the computer.

The author fromof paper [2] an ATMEGA328 based power consumption monitoring system is proposed that senses the parameters of an electric meter and shows on an LCD display. The meter readings are automatically sent to cloud using IoT. This project supports a GSM module and an IO platform to display the consumed energy.

BirendrakumarSahani, Tejashree Ravi, AkibjavedTamboli, Ranjeet Pisal has proposes in Paper [3], an IoT Based Smart Energy Meter system that creates their own web page to display current unit with cost. When threshold is about to over a message is sent to the consumer. Monthly consumption of power is sent to the consumer with total bill of electricity.

In the Paper [4], the author proposes a Remote Meter Reading System in which the structure uses a virtual instrument programming design that works with IOT. The basic structure shows the quality and the status of the work energy meter does on the screen and send data to cyberspace and SMS is sent through GSM . Monthly consumption bill is sent to the consumer and with proper statistics next month's bill can be calculated. Experts can control gadgets which consume high power through cyberspace which is secured proper username and password keys. This model provides least effort and easy to use process for remote control appliances.

In this certain paper[5], the authors formof a Smart Energy Meter for Economic Energy Usage, in this the system is of the for m of three phase four wire energy meter where all the readings are lodged on the web and with GSM technology transmitted to the users. Proposes Algorithm for power which reduces the requirement of zero crossing detector circuit.

In this Paper [6] real-time monitoring system for residential energy meter is proposed. The system provides an omnipresent and uninterrupted control over the consumption of power to the user with the use of IOT. This system is profitable as only simple enhancement is required in the present meter. SOC used for control and communication and large upgrade can be done for better performance.

Paper [7] describes to measure energy consumption and generates the bill through telemetric communication. Calculation and generation of the bill occurs automatically by using network of IOT. Project design is based on ARM controller. In whole process is based on the web as no manual involvement is required and if any power theft is noticed automatic power is cut off. ARM 7 controllers, WIFI ESP8266 module, LCD display have important part in the project.

Paper [8] introduces a system executed using a GSM shield module on Arduino with an LDR sensor. Connecting an LDR sensor with LED and sending data to the Arduino via a GSM shield. Consumer receives an SMS on the consumption of power, bill payment related details. Power cut off due to due payments or power theft all can be regulated through the web server and mobile. Cost estimation is less than the other available smart meters.

Abdul Kadar Muhammad Masum , Md. Hamid Saveed , Md. Kalim Amado Chy , Md. Tanvir Hasan, S M Taslim Reza has designed in paper[9], the use of a prepaid meter for the calculation of the power consumption. GSM based smart energy meter is developed. Arduino used for measurement of power and cost calculation and GSM module used for the notification purpose to the consumers. In this model prediction next day power consumption makes it different from the others. Easy to install and accurate billing process makes it very efficient.

The authors of Paper [10] has introduced a smart energy meter in which the consumer will be notified daily basis about the power consumption, also the total power consumed by the consumer will be notified to the distributor at end of the month and no manual work is needed in this process.

III. METHODOLOGY

This monitoring system which can not only sends you a Email of your electricity bill but also you can monitor the electricity usage anytime and from anywhere in the world. It also helps the consumer to set a limit to their electricity usage. This monitoring system works in three parts i.e.

- **Electricity Monitoring System** which senses the current and generate the amount of electricity usage and the electricity bill.

- **Cloud Platform Connection** which connects the hardware module to the cloud platform. The electricity monitoring system uploads the data in the cloud platform.
- **User End Connection** which lets the users check their electricity and connect to the system via cloud platform using their laptop or mobile.

3.1 Electricity Monitoring System:

The Electricity Monitoring System consists of ACS 712 Currnt Senser, Arduino Nano and ESP8266 Wi-Fi module. it is very important for us to understand the working of the **ACS712 Current sensor** as it is the key component. **Here's how the ACS712 work:**

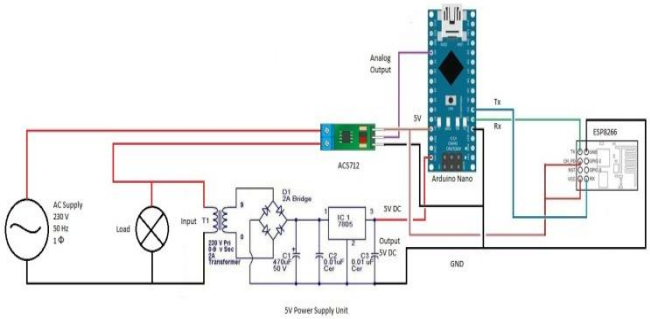

Fig1: Electricity Monitoring System

Current flows through the onboard hall sensor circuit in its IC.The Hall Effect sensor detect the incoming current through its magnetic field generation. Once detected, the Hall Effect sensor generates a voltage proportional to its magnetic field that's then used to measure the amount of current.

After the ACS Currnt Sensor easured the current flowing through the conductor it sends the value to the Arduino Nano as an input. The **Analog pin** of Arduino reads the **output voltage (Vout)** of the module. Each of the 14 digital pins on the Nano can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions.The Nano has 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the analogReference() function. Analog pins 6 and 7 cannot be used as digital pins. The value from the current sensor will reduce as the current flows in negative direction and will increase as the current flows in positive direction. The **ADC** of the arduino gives the value of **0 to 1023** depending upon the input vlotage ranging from 0V to 5V. From the information given in the Datasheet of ACS712 & Arduino Nano we can formulate the equation to measure current.

1) Current Through the Wire (I) = (Vout-2500)/185 A

As we know the mains power supply voltage (V) is **240V 1Ø AC**, from that we can easily compute the power and from that the **energy consumption over time**.

2) Energy (E) = Voltage (V) x Currrent (I) x Total Time (t)

After that, **serial communication** between **ESP8266** and Arduino Nano needs to be started to send the computed value of energy consumption to the cloud so that user end can easily access the required data real time. For this purpose reciever end of the arduino needs to be connected with the transmitter end of ESP8266 and vice versa. But the transmitted digital signal of the Arduino has the peak amplitude of 5V which is out of the range of the reciever end of ESP8266 which is 3.3V. So a **voltage divider circuit** is needed to scale down the peak amplitude of the transmitted signal of Arduino Nano in the range of 0V to 3.3V.

There is two LED attached in the sysytem for the consumer's convenience. One green LED to indicate the data is uploaded successfully in the cloud platfom and one red LED for the indication of crossing the set usage limit. In this manner, the consumer will be enefitted both ways.

Here is the real System image given below:

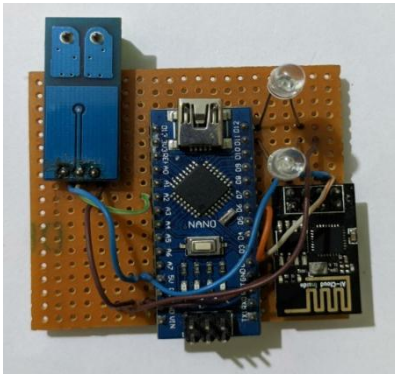

Fig2: Real System Image

3.2 Cloud Platform Connection

The next crucial module of this system i.e. cloud platfrom Connections is responsible for the connection between User End Connections & Electricity Monitoring System. Cloud Computing is the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.

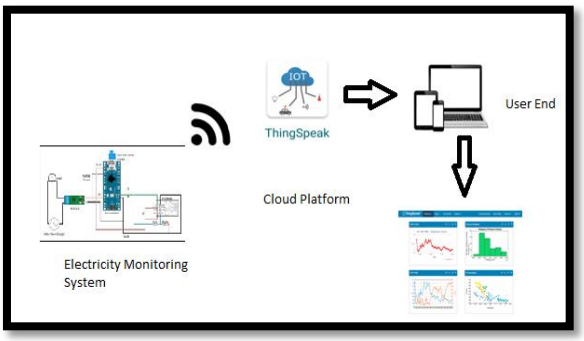

Fig3: Cloud Platform Connection with Other Two Modules

Arduino needed to be programmed so that it can read the value from the current sensor and send the value to the cloud plantform through ESP8266 wifi module. The needed software to program aeduino is called Arduino Integrated Development Environment(Arduino IDE). It is open source software that is mainly used for writing and compiling the code into the Arduino Module. It is official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

In this case **ThinkSpeak Cloud Platform** is used. Any other Platform can also be used (AdaFruit IO platform, MATLAB e.t.c). What makes ThingSpeak different and special is that is uses simple HTTP Protocol to transfer, store and retrieve information from different sensors. ThingSpeak Application allows us to log the sensor data, track locations and even social networking of things. Another important thing (or rather a unique feature) about ThingSpeak is its support from MATLAB. The close relationship between ThingSpeak and MATLAB has lead to integrate several key features of MATLAB into the ThingSpeak Application. The important credentials that we will be using on the ESP8266 code are the server, the user, the password and the port.

In the ESP8266 side, it will be using an ThinkSpeak that supports the ESP8266, called **PubSubClient.** The library can be installed via **Arduino IDE library manager**. A feed is needed to be created ThinkSpeak. Feed stores the data sent by Electricity Monitoing System. Then the data can be seen in the ThinkSpeak Platform graphically. In ThinkSpeak Platform, a channel is need to be created which is public or private which will be the consumers choice. Using an API key the consumer can access it from anywhere anytime using computer or mobile app. In the channel the data will be uploaded and it can be seen graphically with the support of MATLAB. Differents fielda can be created to define different categories like **Current, Voltage, Electricity, Electricity Bill** etc. the limit of electricity usage can be done using **MQTT and IFTTTT**. Next Applet is created in IFTTT for triggering Email for electricity meter. Here user can easily set the limit exceeding which the sytem will send an alert to user via Email. Furthurmore electricity bill can easily be calculated from the energy consumtion data by multiplying the price of per unit with the KiloWatt Hour equivaent of enargy

consumption. This feed containing total energy consumption ammount, realtime power consumption, hourly power consumption graph is easily accessible from user end at anywhere in the world.

3.3 User End Connection

This module is where interaction between user and the system occurs. This lets the user monitor the desired data from the system real time.

Fig4: User End Connections

The Internet of Things (IoT) is an ecosystem of physical objects that are connected and accessible through the internet. The Internet of Things (IoT) is an ecosystem of physical objects that are connected and accessible through the internet. An IoT system consists of sensors/devices which "talk" to the cloud through some kind of connectivity. Once the data gets to the cloud, software processes it and then might decide to perform an action, such as sending an alert or automatically adjusting the sensors/devices without the need for the user. But if the user input is needed or if the user simply wants to check in on the system, a user interface allows them to do so. Any adjustments or actions that the user makes are then sent in the opposite direction through the system: from the user interface, to the cloud, and back to the sensors/devices to make some kind of change. IoT end-user applications are provisioned in cloud settings using PaaS and offered as SaaS. User can access the required data real time from anywhere of theworld via website as well as mobile application.

In this case as **ThinkSpeak** is used, so **ThingView Android Application** is used. This application have the features to monitor **real time electricity sonsumption data, total energy consumtion data** and **real time bill**. Moreover this app also provides higher security, real time troubleshooting feature, management tools etc to make this system more convenient. All the above mentioned features are also available in the website.

IV. RESULT ANANLYSIS

This system allows to approach the current usage, electricity bill via cloud platform.
The following I,age shows the data feed on ThinkSpeak Channel:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	created_a	entry_id	field1	field2	field3	field4	latitude	longitude	elevation	status					
2	2020-05-1	1	0.07	15.93	0.09	0									
3	2020-05-1	2	0.08	17.98	0.18	0									
4	2020-05-1	3	0.08	17.98	0.27	0									
5	2020-05-1	4	0.07	15.93	0.35	0									
6	2020-05-1	5	0	0	0.42	0									
7	2020-05-1	6	0.24	52.88	0.69	0.01									
8	2020-05-1	7	0.24	52.88	0.95	0.01									
9	2020-05-1	8	0.24	52.88	1.22	0.01									
10	2020-05-1	9	0	0	1.22	0.01									
11	2020-05-1	10	0.66	145.24	1.96	0.02									
12	2020-05-1	11	0.65	143.19	4.27	0.03									
13	2020-05-1	12	0.68	149.35	5.01	0.04									
14	2020-05-1	13	0.69	151.4	6.55	0.05									
15	2020-05-1	14	0.66	145.24	7.26	0.06									
16															
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Fig5: Cloud Platform Data Feed In XML File

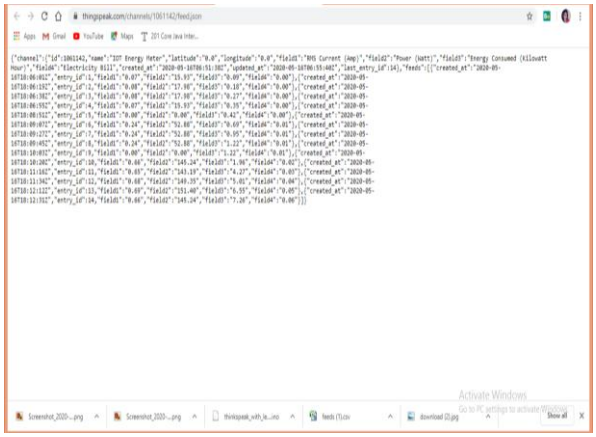


Fig6: Cloud Platform Data Feed In JSON File

In the cloud platform, the consumer can create their own channel and the data of the system will e uploaded there. In the Export data file of the channl, we can find our data feed.

Here are outputs in Cloud Platform to show the usage and electricity bill:

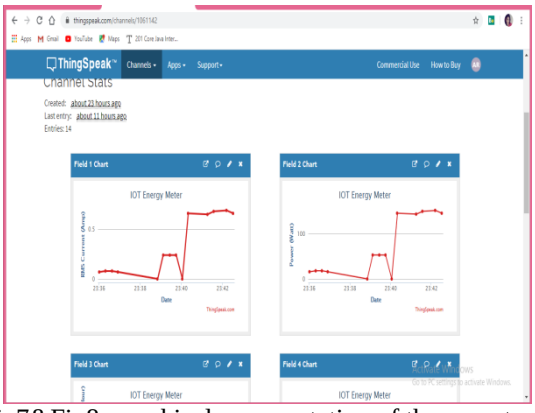
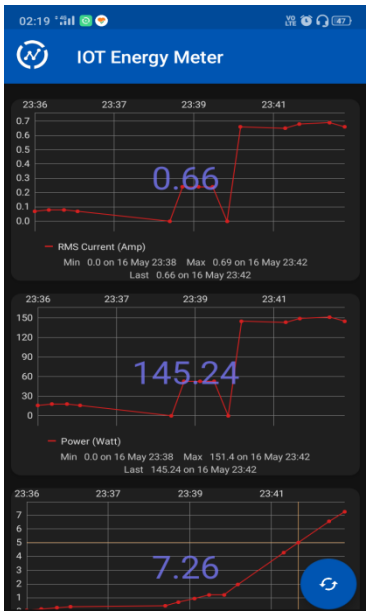


Fig7&Fig8: graphical representation of the curent, power usage and electricity bill in cloud platform
In the graphs, the consumer can check the current , power usage and the electricity bill.

Here is some images of the Mobile app Output of ThinkSpeak:



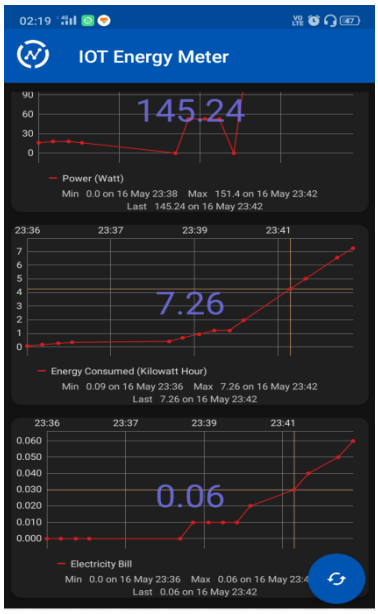


Fig9 & Fig10: Moile App output of the Cloud Platform

This system also sends email to the consumer about the bill amount. The ti,e gap of email can be set according to the consumer's desire.

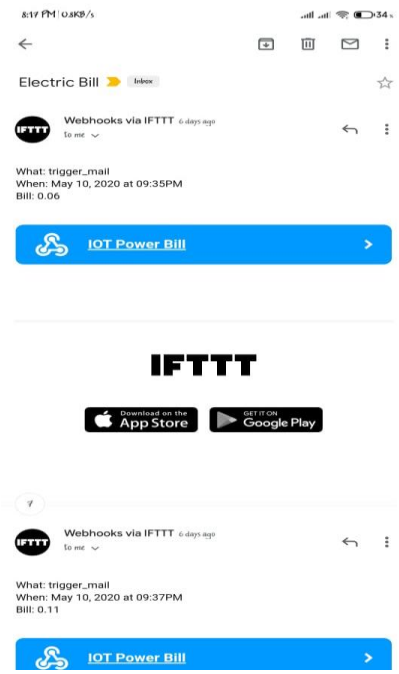


Fig11: Electricity Bill sent to the consumer via email

The consumer can set the limit of their usage and they will get an email if the limit crosses.

V. CONCLUSION

The proposed system awares the consumer to reduce the energy consumption. The benefitial sides of this system are:The IoT Based Energy Meter can record and measure the total energy consumption in small amount of time. By recording total energy at a small interval, this allows the utility to easily calculate the electricity bill.The user will be able to set the limits for consumption. Beyond the limit of user will generate a warning to the user. With the information in mobile, user can see immediately and adjust according to his/her need.By making energy usage more easily understood, the consumer can make smarter decision to save energy and money.The user can calculate his/her own bill according to their total energy consumption. So more accurate bill can be paid and no misunderstanding will be created between the consummer and electric supplier.This system is much smaller than traditional system and also cost efficient to build. With some further modification in the code of the Arduino, user can also obtain scientific data of the power supply like phase angle, power factor e.t.c.This system can be easily modified by simply adding a relay in the system. Some additional code will allow the user to automate the system and have full control over the appliences so that they can turn OFF the applience if it left ON and vice versa from anywhere in the world.The proposed system can only aware the people how to limit their usage y using electricity wisely. But it can not force people to be responsible human being.This paer leads us to a greener environment. When a social awarness is invoked then people will start to realize their responsibity towards the environment. The consumer will realize that they can control their electricity bill and then for their own growth they will utililize the electricity wisely. It will be a good start from their own house, then slowly it wil grow through community and then for better environment. . This will help our impct on climate change while significatently improving customer satisfaction.

REFERENCES

[1]. Vishwa Kotecha, Suchandra Jadhav, Siddhant Bhisikar, Rahul Jangda, Prof. D.M. Kanade ,SSRN, GSM Technology Based Smart Energy Meter. Open Access International Journal of Science & Engineering,03 January 2020.
[2]. Nikhil N. Patil, SumitN. Khamkar, Dileep M. Bind, Vivek R. Kurade, Ganesh I. Sonawane, ,IRJET, Smart Wireless Electronic Energy Meter. International Research Journal of Engineering &Technology.Volume 4, 4 April 2017.
[3]. BirendrakumarSahani, Tejashree Ravi, AkibjavedTamboli, Ranjeet Pisal ,IRJET, IoT BasedSmart Energy Meter. International Research Journal of Engineering and Technology. Volume 4, 4 April 2017.
[4]. A.Subba Rao, Sri VidyaGarige . IOT Based Smart Energy Meter Billing Monitoring and Controlling the Loads. IoT Based Smart Energy Meter, International Research Journal of Engineering and Technology.
[5]. Tejaswini S. Powale, Vrushali B. Shende, Yogesh P. Bawangade, Prof. M. D. Ghatole . Hall Effect Sensor Based Digital Smart Three Phase Energy Meter, International Research Journal of Engineering and Technology.
[6]. Karthikeya S, Bhubaneswar P.T.V, 2017, IoT Based Real-Time Residential Energy Meter Monitoring System, IEEE Trends in Industrial Measurement and Automation.
[7]. Pooja D Talwar, Prof. S B Kulkarni. IOT Based Energy Meter Reading, International Journal of Recent Trends in Engineering and Research.

[8]. Himanshu K. Patel , TanishMody , Anshul Goyal. Arduino Based Smart Energy Meter using GSM , 2019 4th International Conference on Internet of Things: Smart Innovation and Usages
[9]. Abdul Kadar Muhammad Masum , Md. Hamid Saveed , Md. Kalim Amado Chy , Md. Tanvir Hasan, S M TaslimReza.Design and Implementation of Smart Meter with Load Forecasting Feature for Residential Customers, 2019 International Conference on Electrical, Computer and Communication Engineering.
[10]. K. V. Jyothi Prakash ,N S Chethana, Fariya Tamkeen, C S Kala, Kavya. Designing of Microcontrollerbased Energy Meter (Smart Energy Meter) for Energy Preserving , 2019 International Conference on Communication and Electronics Systems. July, 2019.
[11]. Rajesh Bose,Sudipta Sahana,DebabrataSarddar "An Energy Efficient Dynamic Schedule based Server LoadBalancing Approach for Cloud Data Center" in International Journal of Future Generation Communication and Networking Vol. 8, No. 3 (2015), pp. 123-136
[12]. S. Sahana, R. Bose, D Sarddar "Server Utilization Based Smart Temperature Monitoring System for Cloud Data Center" in International Conference of International Conference on Industry Interactive Innovations in Science, Engineering and Technology published on 24-25 October, 2016

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