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IOT-ENABLED ENERGY TRACKING AND AUTOMATIC BILLING SYSTEM

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ABSTRACT
Managing electricity bills can be a tedious task, especially when the energy consumption of household appliances is not properly tracked. With the increasing use of smart devices, it has become possible to monitor energy consumption using IoT-based energy meters. These meters provide a more precise way of tracking energy consumption, allowing users to make more informed decisions about their energy usage. By using a smart IoT-based energy meter, users can monitor energy consumption from anywhereon their smart phones, which is both convenient and efficient. Unlike traditional energy meters, which only display the amount of energy consumed, smart meters provide users with accurate bill generation, which helps bridge the gap in device energy consumption data. The proposed design is minimalistic, cost-effective, and effective, which makes it ideal for consumers who want to track the energy consumption of any electrical appliance. With the implementation of IoT-based energy meters, consumers can reduce their electricity bills and contribute to a sustainable future.

Keywords –
Electricity bills, Energy consumption, Household appliances, Smart devices, IoT-based energy meters, Precise tracking, Smart phones, Efficient, Convenient, Traditional energy meters, Accurate bill generation, Cost-effective, Sustainable future .

INTRODUCTION
Electricity has become an essential need in our daily lives, and its usage has increased significantly over the past few decades. With the growing demand for electricity, there has been an increase in electricity bills, which can be challenging to manage for some households. Additionally, with the rise ofsmart home technology, homeowners can now use various devices that consume electricity, such as air conditioners, refrigerators, and other home appliances.

Introduction to IoT
IoT or the Internet of Things refers to the network of physical devices, vehicles, home appliances, and other items that are embedded with electronics, software, sensors, and network connectivity, allowing them to connect and exchange data. These devices can range from simple everyday objects such as thermostats, light switches, and appliances to more complex machinery like airplanes and medical equipment [13].
IoT technology can be extremely useful in the context of energy tracking and automatic billing systems. By using IoT sensors, devices, and software, it is possible to monitor energy usage in real-time and automatically generate bills based on actual consumption. Overall, the use of IoT technology in energy tracking and automatic billing systems can greatly improve the accuracy and efficiency of the billing process, while also providing consumers with valuable information about their energy usage.

Introduction to Energy Tracking and Automatic Billing System
To manage electricity consumption efficiently and minimize energy costs, an automated electricity monitoring system can be implemented using the Internet of Things (IoT) technology. This system will help homeowners monitor their electricity usage in real-time and generate an auto bill based on

their consumption [14]. Additionally, the system will send an alert message when the consumption reaches the threshold value.
The proposed system uses the Node MCU, a low-cost IoT device that has a built-in Wi-Fi module, to monitor the electricity consumption of each device. The Node MCU will be connected to the main power supply of the house and will measure the voltage and current of each device. The data collected by the Node MCU will be sent to the cloud using Wi-Fi, where it will be processed, and the electricity consumption will be calculated.
The auto bill generation process will use the calculated electricity consumption data, and an automated bill will be generated based on the consumption. This bill will be sent to the homeowner via email or other electronic means.
The alert message feature will notify the homeowner when their electricity consumption reaches the threshold value. This feature will help the homeowner monitor their usage and control their energy consumption to avoid exceeding their budget.
In conclusion, the proposed system is an innovative solution for homeowners to monitor their electricity consumption and control their energy costs. With the use of IoT technology and the Node MCU, the system can accurately measure the electricity consumption of each device and generate an auto bill. Additionally, the alert message feature will help homeowners monitor their consumption and control their energy usage, leading to a more sustainable future.

LITERATURE SURVEY

Smart energy meters are becoming increasingly popular due to their ability to measure electrical consumption at device level and provide users with real-time monitoring of their energy consumption. These devices offer features such as cloud-based data storage, visualizations, and trigger notifications in case of an event. However, there are various types of smart energy meters available on the market, each with their own set of limitations.

[1] M.El-Hajjar, S.S.Sannakkayala proposed “Plug-and-Play Solution for Smart Energy Metering and Billing” .June Smart Energy Module is a plug-and-use solution that uses Narrowband IoT (NB-IOT) technology for energy metering. While it offers cloud-based data storage and analysis, it can only be used for the main electricity switchboard and not device-level monitoring of energy.

[2] I.Yaqoob, M.Arjona proposed “Zigbee based smart energy meter”. On other hand, Smartenit's ZBMSKTI is a remotely controlled outlet that allows users to control their appliances through an accompanying application. While it offers electrical parameter measurements and integrates appliances into a ZigBee-based smart energy management system, it is not a plug-and-use meter and requires non- portable replacement to wall sockets.

[3] N.Nandhini, S.Arumugam, S.K.Srivatsa proposed “Bluetooth-based Smart Metering System Electrical Energy Consumption Monitoring”. Revogi's Smart Meter Plug is a wall socket meter based on Bluetooth that provides features such as automation and parental controls. However, the short range of Bluetooth limits its remote monitoring capabilities.

[4] Jie Zhang proposed “Billing parameters and prepayments” .Aurora by Larsen & Toubro is a single- phase smart meter that offers novel features such as load control and over-voltage and over-current alerting systems. It also provides data logging, billing parameters, and prepayments. However, it is not capable of measuring device-level consumption.

[5] Yuvraj Agarwal proposed “Measures the energy at device level”. P3 International's P4400 Kill, a Watt Meter is capable of measuring energy consumption of appliances connected to it, but the device's timed energy consumption data is reset to zero after unplugging the device or power loss. P3 International has released an enhanced version, the P4460 Kill A Watt EZ, which addresses this limitation by using a built-in memory and backup battery. However, it lacks remote monitoring and does not provide the ability to store previously collected data for analysis without WiFi connectivity.

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PROPOSED SYSTEM

The overall architecture of the system will be as follows:

The current sensor will be attached to the main power line of the building, and it will measure the amount of current flowing through it. The Node MCU will collect data from the current sensor and send it to the cloud platform (Adafruit IO) via Wi-Fi. The cloud platform will process the data received from the Node MCU and store it in a database. The user will be able to monitor their energy usage and billing information through the mobile app (MQTT Dashboard), which will display real-time information about energy consumption. IFTTT will be used to automate certain tasks in the system, such as sending notifications to the user when their energy usage exceeds a certain threshold. Overall, the system will

provide an efficient and automated way of tracking energy consumption and billing, allowing users tomonitor their usage and reduce their energy bills.

Architecture of Consumer Home Automation System

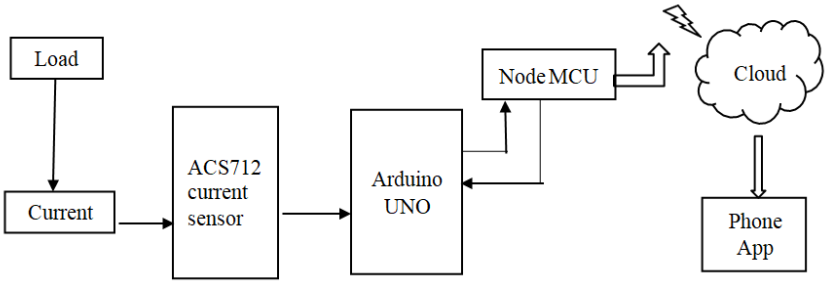

Figure 1. Implementation of Electricity Monitoring System

The architecture of the "electricity monitoring and auto bill generation using IoT using Node MCU and that produces message alert when reaches threshold value" can be divided into two main parts: hardware and software.

Hardware Architecture

Node MCU: Node MCU is an open-source development board that is used to build IoT applications. It has a Wi-Fi module, which allows it to connect to the internet and send data to the cloud.

Current Sensor: A current sensor is used to measure the current flowing through the wires of the electricity meter.

Voltage Sensor: A voltage sensor is used to measure the voltage of the electricity supply.

Wi-Fi Module: The Wi-Fi module is used to connect the Node MCU to the internet.

LCD Display: An LCD display is used to display the current electricity consumption and other relevant information.

Relay: A relay is used to turn on and off the electricity supply.

Power Supply: A power supply is used to power the Node MCU and other components.

Software Architecture

Sure, here is the software architecture for the project "electricity monitoring and auto bill generation using IoT that sends alert message when reaches threshold value and Node MCU module is used" using the cloud platform Adafruit IO, IFTTT, and the MQTT Dashboard app .

Adafruit IO: Adafruit IO is the cloud platform that receives data from the Node MCU and stores it in the cloud. It provides an interface to visualize the data and create rules.

IFTTT: IFTTT (If This Then That) is a service that connects different applications and devices together. It allows us to set up rules that trigger actions when certain events occur. In this case, we can use IFTTT to send a message alert when the electricity consumption reaches a threshold value.

MQTT Protocol: MQTT is a lightweight communication protocol that is used to send data between

devices in IoT applications. In this project, MQTT is used to send data from the Node MCU to Adafruit IO.

MQTT Dashboard App: MQTT Dashboard is an Android app that allows us to view data and send commands to devices that use MQTT protocol. In this project, we can use the MQTT Dashboard app to view real-time electricity consumption data.

Auto Bill Generation Algorithm: An algorithm is used to calculate the electricity bill based on the electricity consumption data stored in Adafruit IO.

User Interface: A user interface is provided to the user to view the current electricity consumption, previous bills, and other relevant information. This can be done through the Adafruit IO dashboard ora custom web application.

The overall software architecture involves the Node MCU sending data to Adafruit IO using MQTT protocol. Adafruit IO stores the data and provides a user interface to visualize the data and create rules. IFTTT is used to create a rule that sends a message alert when the electricity consumption reaches a threshold value. The auto bill generation algorithm calculates the electricity bill based on the consumption data stored in Adafruit IO. The MQTT Dashboard app can be used to view real-time data from the Node MCU. A user interface is provided to the user to view the current electricity consumption and other relevant information.

Energy Calculation

In order to understand the energy consumption of an IoT device during operation, various factors must be taken into consideration. These factors include the amount of data being transmitted, the type of wireless technology and protocol used, the amount of data processing required, and any redundancy mechanisms that may be in place.

A device's operation typically consists of a series of tasks that consume roughly the same amount of energy at each instance. To model an IoT device's energy consumption, we can look at the power consumed by its individual components and processes.

The formulas provided relate to the calculation of power, energy consumed, and electricity bill, and are explained below:

Power, $P=V*I$

Power (P) is the rate at which energy is transferred or consumed. It is measured in watts (W). The formula to calculate power is given by multiplying the voltage (V) and the current (I) of the circuit. Thus, $P = V*I$

Energy consumed, $E= P*T$

Energy consumed (E) is the total amount of energy used over a period of time. It is measured in watt-hours (Wh) or kilowatt-hours (kWh). The formula to calculate energy consumed is given by multiplying the power (P) and the time (T) during which the power was used. Thus, $E = P*T$.

Electricity bill formula:

The electricity bill formula calculates the total cost of electricity consumed during a given period. The formula includes the power consumption rate, which is typically measured in kilowatt-hours (kWh), and the time period for which the power was consumed. The formula is as follows:

*Wh = Wh + P * ((current_time - last_time) / 3600000.0)*

Where:

- Wh: The total energy consumption in watt-hours.
- P: The power consumption rate in watts.
- current time: The current time at which the electricity consumption is being calculated.
- last time: The time at which the last electricity consumption was calculated.

The formula calculates the amount of energy consumed during the current billing period by multiplying the power consumption rate (P) with the time elapsed between the current and the last reading, which is then converted from milliseconds to hours by dividing it by 3600000. The result is

then added to the total energy consumption (Wh) recorded so far. This total energy consumption is then used to calculate the total cost of electricity consumed during the billing period, based on the tariff rates set by the electricity provider.

By understanding the various components and processes involved in an IoT device's operation, we can better optimize its energy consumption and prolong its battery life.

RESULTS AND DISCUSSIONS

The provide a more efficient and accurate way of tracking electricity usage and generating bills, as opposed to the traditional manual methods that are prone to errors and inefficiencies. It also aims to promote energy efficiency by enabling users to monitor their electricity usage and make informed decisions about how to reduce their consumption. The benefits of such a system would be that it could help to reduce energy consumption and lower electricity bills, as well as streamline the billing process and reduce the potential for errors. It could also provide customers with more detailed information about their energy usage.

Overall, the success of the project would depend on the accuracy and reliability of the monitoring and billing systems, as well as the ease of use for both customers and electricity providers.

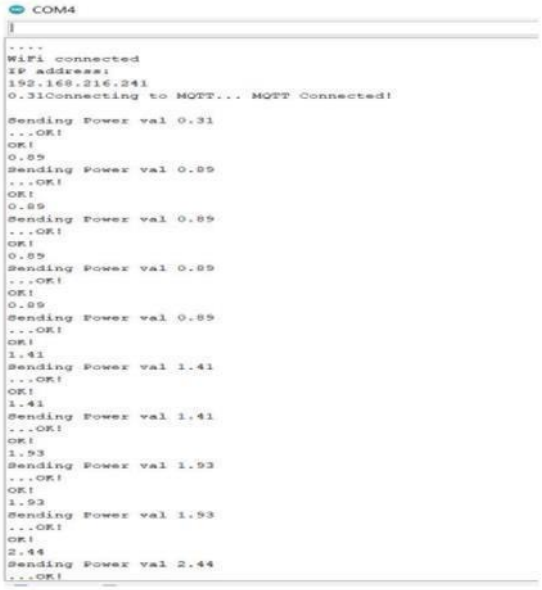

Figure 2. Output at Serial Port

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Figure 3. Publishing Bill and Power Changes

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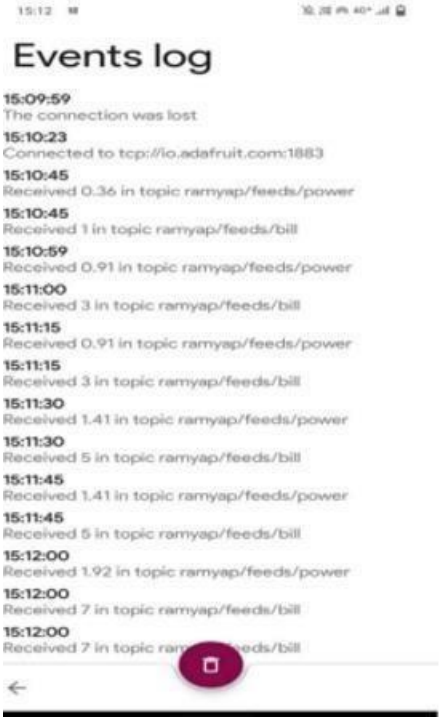

Figure 4. Output at MQTT dashboard

Figure 5. Email Sent to User

CONCLUSION

This paper introduces an innovative Smart energy meter that utilizes the Internet of Things (IoT) technology to measure the power consumption of a single device without interfering with the existing setup of the appliances. The Smart energy meter is designed to be affordable, as it only requires an Arduino UNO, node MCU, and a Current sensor to function effectively. The system utilizes real-time Smart energy meter readings to monitor energy consumption and send notification alerts via email if it surpasses the threshold value. This approach provides an efficient way for users to manage their energy consumption and take corrective actions to reduce their electricity bills.

FUTURE SCOPE

The government has launched a project aimed at transforming major cities in the country into smart cities. Under this initiative, consumers will have access to their energy consumption data and billing information on demand. This platform will enable users to make online payments and keep track of their meter readings. Additionally, the system will include theft detection mechanisms and allow for power disconnection if the user fails to pay their electricity bill. The ultimate goal of this project is to create a more efficient and transparent energy distribution system that benefits both consumers and the government.

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