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IoT Based Development of an Smart Building Applications

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Abstract: **Due to the depletion of energy resources and increased energy demand, there is an increased focus on the energy consumption and management in buildings. Many building energy management (BEM) software platforms are commercially available to monitor and control energy consumption. These platforms are hosted on the physical hardware within the building, due to which the hardware specifications limit their performance. To address this limitation, cloud technology emerged which facilitates software to be deployed at a remote location that has scalable hardware resources. Conventional BEM software can leverage such a cloud platform to offer scalable and maintenance-free installation. Once hosted on a remote cloud platform, BEM software lacks direct connectivity to building sensors/controllers, hence requires a device to support remote accessibility.**

This paper present a smart building automation system based on NodeMCU and Arduino IDE software for programming. The system supports various sensor and its functionality with a very practical and convenient cost system configuration. In various ways, the design and implementation of BMS (Building management system) and fulfilment of many type of green project today, but it uses technology to provide for a superior space. With the help of these system we reduces the human effort. Here proposed system develops different applications like 1.Smart lighting system 2. Smart Plug 3.Smart gate and 4. Smart Power Meter. The key features of our project are to opening and closing gate via Servo Motor, common area lighting, Energy saving and smart plug system. All the hardware sensor and Node MCU components are put into a best demonstration model with the motive of the test of the system and presentation in real-time. With the help of these model, the smart BMS environment is animated and correlated function becomes simple understood. BMS is reliable circuit that takes over the task of controlling various system used in it.

Index Terms:- Building Management System (BMS), Arduino IDE, Embedded System, Automation, Building services, Energy Meter, Smart Plug, Smart Gate etc.,

1. INTRODUCTION

In today's world, there is a persistent requirement for automated appliances. With the expansion in the way of life, there is a sense of urgency for creating circuits that would facilitate the complexity of life. While planning an intelligent building, a Building service engineer, an Architect & Hardware Engineer is required, but in the case of the ordinary building, a Building service engineer and an Architect are enough. For many years, buildings that offer comfortable, a flexible and energy efficient living environment at a minimal cost has been the expectation of building owners and occupiers. To achieve this goal, a variety of advanced building technologies have been developed in the past two decades, aiming to improve the building performance to satisfy a variety of human needs and environmental sustainability. Building automation frameworks are the smart systems that include a combination of suitable software and hardware which are utilized for automation of computer systems. These system ease usage of important functions such as gate opening, door opening, lighting, fire extinction, and security. Some building automation systems can also provide an emergency alert service. However, current building applications have a some common problem, such as comprehensive functions operate in isolation, can't be managed in overall fashion although overall management's tremendous potential in future applications. European Union supported Building as a Service (BaaS) project deals with this various problem which aims to provide a comprehensive software platform for present and future commercial building management and building innovation, with flexible and cost-efficient integration of mentioned services, an overall management idea is targeted. As a rising idea, building automation coordinates numerous applications which can support different usages. For instance; a dc motor engine can be

utilized to control the gate and door; on the other hand, this work has been supported by 9140003 ITEA Baas/Tubitak. it is appropriate for pet sustaining. Essentially, all household exercises can be adjusted to the computerization idea by the assistance of encouraging the electronic component. The remote access renders it progressively down to earth and valuable in the home condition. At the point when the majority of the equipment based administrations and easy to use interface are joined in a framework, the ascent of building computerization framework is inescapable. For such a blend, security is a huge issue. As a commendable arrangement of this issue, in our framework, motion sensor i.e., IR sensors and entryway controls are used so as to get data about strange exercises like a robber at home. In addition; gas, smoke and flame sensors give steady data about exceptional circumstances and raise caution. In this project, building automation system is developed by composing Arduino circuit that involves smart home functionalities which connected with sensors which are controlled by an Android based application. The fundamental controls like lights, door, gate, fire and gas alarms are all included in this project. However, system's functionality is display in real-time by an unique developed demonstration model which shows system properties clearly and possible benefits of smart building automation system in a modled home environment

The organizational framework of this study divides the research work in the different sections. The Literature Review is presented in section 2. Further, in section 3 shown Existing system is discussed, in section 4 proposed methodology is discussed and in section 5 proposed method was discussed in section 6, Experimental Results work is shown. Conclusion and future work are presented by last sections 7.

2. LITERATURE REVIEW

[1] IoT Based RFID Gate Automation System:

The main aim of the system is that it utilizes the RFID framework alongside IOT which is the eventual fate of electronic correspondence. Here we likewise supplant the microcontrollers prior utilized with a raspberry pi 2 which is a mini processor that is both a microcontroller just as a server. The vehicle that should be approved is given a RFID tag with an exceptional number. Presently when the vehicle comes to close to the door RFID tag peruses the code, and send a flag to raspberry pi which checks for the relating subtleties of the one of a kind number and on the off chance that it matches with the spared information in the database, at that point it again makes an impression on the engine which opens the entryway. The IN and OUT time of each vehicle that enters the are is spared in a database and furthermore a web server which encourages us to get to those subtleties wherever we are utilizing IOT.

[2] Automatic Room Light Controller with Visitor Counter:

In these project, they designed and implemented a Bi-Directional Counter & Home Automation utilizing the idea of an Embedded System. The objective clients of the project can be anyone right from a common man to any association. Suppose if anyone uses our project for Seminar Purpose then the track reputation of the persons attending the seminar will give the exact idea about the no. of person attending and leaving the seminar and accordingly the Project Model will control the Electronics Gadget of the room. This type of project is useful in developing countries and this project has a splendid future. In this computerized world, Technology is very advanced and we prefer things to be done automatically without any human efforts.

[3] Design and Implementation of a Digital Code Lock using Adriano:

Digital code lock system is totally depends on arduino. Arduino has been the brain of thousands of embedded projects. We can set the PIN and reset it without using external device. It is useful. It is 90% working and can be easily developed. The project explain here is based on Arduino and is more simple and reliable than simple microcontroller based digital code lock. Here is an LCD display which is used to interface with the project to output lock status. In this project, we have an additional advantage that the user can change the PIN. The user will be prompted to set a password at installation. This password inputted at installation will continue to serve the lock until it is changing. The program will check for the current password and allows the user to change Password only if the current password is input correctly. Applications: It can be used in places where we required more security. It can also be used indoor, lockers, offices, main gate of the house, ATM etc.

[4] Intelligent Building Automation System:

The intelligent building automation technologies are an interconnected network of hardware and software that monitors and controls the building facility environment. An intelligent building, according to the Intelligent Building Institute (IBI) is one that provides a productive and cost-effective environment through optimization of its four basic elements: structure, systems, services and management, and the interrelationship between them. The European Intelligent Building Group defines an intelligent building as one that 'incorporates the best available concepts, materials, systems, and technologies.

3. EXISTING SYSTEM

The existing literature generally discusses building automation systems (BAS) and building management systems (BMS) for the management of different building parameters. Most of the solutions in the existing BMS do not provide the automation feature, except a few of the papers discuss the automation with limited goals or as future work. The existing solutions leave the decision-making to the end-user. Similarly, building automation systems (BAS) as discussed in provide only limited energy and safety automation, i.e., turning on/off the lights if the system senses a human walk-in corridor, automatic water spray if smoke sensors detect fire, etc. BAS also does not provide facility management and enhancement of interior comfort. Moreover, the majority of the commercially available BMS systems are designed to implement very specific functions

chosen by the manufacturer. If more functions are required, then the provider will charge extra or the order will be refused. These systems also suffer from inefficient automation, increased maintenance & security costs, etc. However, this work presents a comprehensive BMS system that covers all the deficiencies in the existing BAS and BMS by introducing an extremely compatible/scalable system due to fast data collection and automatic controlling.

4. BASIC FUNCTIONS OF BMS

In the comfort way of human lifestyles in the building, there are many systems has automated, with increase the almost all the function to throughout all the system with less economics introduces. The Building structure is equipped with electronic circuits, monitoring, controller, sensors, and DC motors. To provide better security. Sensor and hardware part are implemented. Light control, Power Control, gate open close, Smart Plug proposed here. Keeping in the mind internal facility has also automated, controlling light in buildings should be necessary. Keeping all the things in the mind all the system are introduces building automated here.

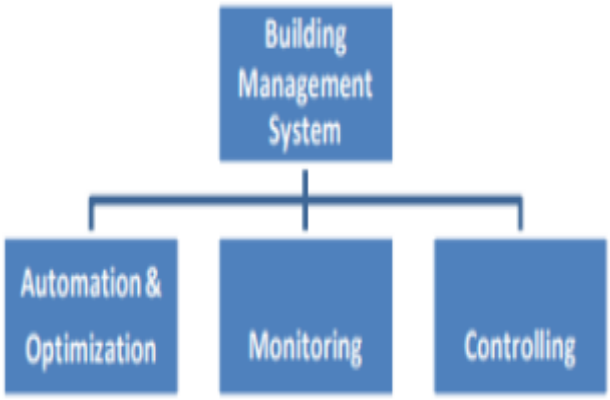

Fig.1 Basic function of BMS

5. PROPOSED SYSTEM

Most basic criteria for building automation operation for commercial buildings are to ensure comfort for users and security of the building, by controlling building technological infrastructure, while minimizing energy consumption. The comfort means providing optimal conditions of indoor Lighting systems and indoor power plug system. The security means to execute the functionality of occupancy monitoring, controlling who has access to protected areas of the building. Many building energy management (BEM) software platforms are commercially available to monitor and control energy consumption. These platforms are hosted on the physical hardware within the building, due to which the hardware specifications limit their performance. To address this limitation, cloud technology emerged which facilitates software to be deployed at a remote location that has scalable hardware resources. In this we are going to develop different applications like

1. Smart Lighting system
2. Smart Plug
3. Smart gate and
4. Smart Power Meter

1. Smart Lighting System, Smart Plug, and Smart Gate

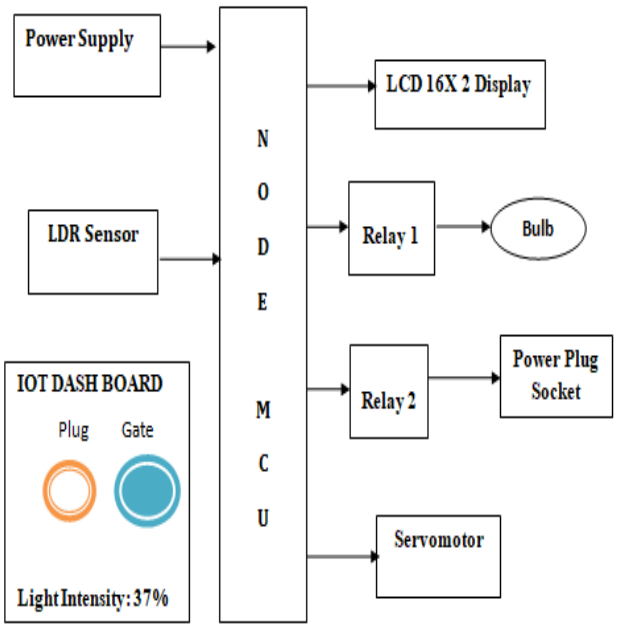

Fig 2.Proposed Architecture for Smart Lighting, Smart Plug, Smart Gate System

2. Smart Power Meter

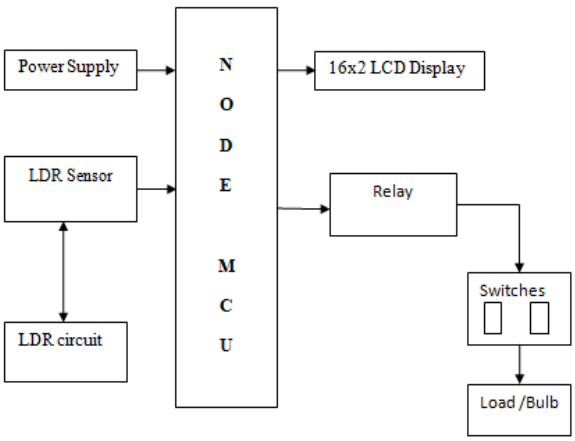

Fig 3.Proposed Architecture for Smart Power

Figure 2 and 3 shows the block diagram of the proposed system. It contains different sensors and functions.

1. WORKING OF PROPOSED SYSTEM

1. Smart Lighting System

A smart light system incorporates a cluster of House lamps that can communicate with each other. It allows facility managers to remotely control house lights while keeping track of electrical power consumption in the lamps and in the driving circuits. The proposed IoT based system provide a solution for energy saving. We use Light Intensity

sensor (LDR) and NodeMCU (ESP8266) board to design an intelligent system. We use Light Dependent sensor for detecting light intensity. Based on light intensity present in the house, we control lights. We can automatically ON/OFF lights or we can control brightness of the lights.

2. Smart Plug

In this, we propose an advanced method in solving electrical power monitoring and managing problems. A smart plug is a power receptacle that plugs into a traditional electrical outlet and integrates it into your smart home network, allowing you to control whatever you plug into it from an app on your smart phone or with your voice through a virtual assistant. A smart plug transforms even the oldest and non-advanced devices into a part of your smart home network, giving you greater control and customizable options just by plugging the device in Table lamps, the clothes iron, and even the coffee maker get an IQ upgrade with smart plugs. For the most features and best reliability, stick with smart plugs that connect to Wi-Fi either directly or using a bridge or dongle that plugs into your router.

3. Smart Gate

Automatic gate is one of the most preferable domestic intended to provide easy access to gate home. In this for cost-effective as we are automating the gate system at homes that we are using will eliminate the need of human operators this will save our precious time. In this system Gate going to operate in automatic mode. Here we can operate gate from remote location. There are two mode in automatic operation first one is controlling operation, in which with help of smart phone application. In this block diagram smart phone is connected with Node MCU and Node MCU is interface with microcontroller. So, with help of smart phone we can provide instruction to Nodemcu and as per the instruction Nodemcu provide input to microcontroller. And microcontrollers output goes to driver IC, and gate perform action as per the instruction.

4. Smart Power Meter

Since IOT is cost effective compared to SMS, monitoring of energy meters at lower cost is made possible. Daily consumption reports are generated which can be monitored through Android application. The system is more reliable and accurate reading values are collected from energy meters. Live readings of the energy meter can be viewed through Android application. Also, the readings can be viewed online. on and/or web portal.

2. HARDWARE REQUIREMENTS:

A. Node MCU

The NodeMCU (ESP8266) shown in Figure 4 is a microcontroller with an inbuilt Wi-Fi module. The total pins on this device are 30 out of which 17 are GPIO (General Purpose Input/ Output) pins which are connected to various sensors to receive data from the sensors and send output data to the connected devices. The NodeMCU has 128KB of RAM and 4MB flash memory storage to store programs and data. The code is dumped into the NodeMCU through USB and is stored in it.

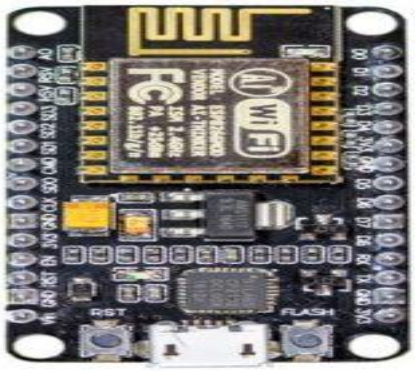

Fig.4 Node MCU (esp8266)

B. Relay

A relay is used as electrically operated switch which is shown in Figure 5. It has a set of input terminals for a single or multiple control signals and a set of operating contact terminals. The switch may contain number of contacts in multiple contact forms which make contacts or break contacts. Relay is used to turn on the water pump in order to maintain the moisture level of the crop.

Fig.5: Relay Module

C. .LCD Display

LCD stands for liquid crystal display, which is used to show the status of an application, displaying values, debugging a program, etc.A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. This LCD has two registers, namely, Command and Data. Shown in fig 6.

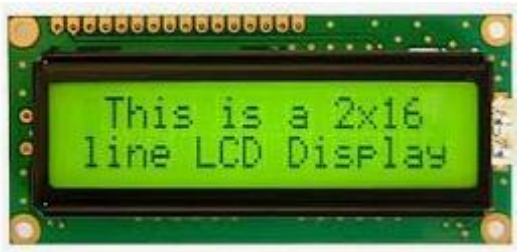

Fig.6: 16x2 LCD Display

D. Power Meter

An energy meter shown in figure 7 is an electrical device that measures the electrical power being consumed and this allows the energy consumed over time

(by a residential building, a business, or an electrically powered device) to be determined.

Fig.7: Power Meter

E. .LDR Sensor

An LDR shown in fig 8 is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. LDRs (light-dependent resistors) are used to detect light levels, eg in automatic security lights. Their resistance decreases as the light intensity increases. In the dark and at low light levels, the resistance of an LDR is high, and little current can flow through it.

Fig.8: LDR Sensor

F. .Servo Motor

Servo motors or "servos", as they are known, are electronic devices and rotary or linear actuators that rotate and push parts of a machine with precision. Servos are mainly used on angular or linear position and for specific velocity, and acceleration.

Fig.9: Servo Motor

3. SOFTWARE REQUIREMENTS:

1. *ARDUINO IDE*

Arduino IDE Arduino IDE is an open source software that makes to write the code in easy manner and helps to upload it into the Arduino board and the uploaded code contains the program that describes the working of the process. The main advantage is the software can be used in any Arduino board. The Arduino can control and interact with a wide variety of sensors like temperature, accelerometer and heart beat sensor.

2. *UBI DOTS*

The basics components of any Internet of Things application powered by Ubidots are: Devices, Variables, Synthetic Variables Engine, Dashboards, and Events. Within this article we will address each of these concepts as they relate to Ubidots IoT Development and Deployment Platform and how you can better organize your Ubidots Apps to best connect with the users.

6. EXPERIMENTAL RESULTS

The hardware setup is designed and the applications such as Lighting system, power meter, smart plug system using different sensors. The LDR sensor is used to measure the intensity. The parameters are measured and transferred to the mobile phone through IoT and the results obtained from the different sensors are discussed in this chapter. The hardware design can be designed in parts which is shown in figure 10 and figure 11.

1. Smart Lighting System, Smart Plug, and Smart Gate

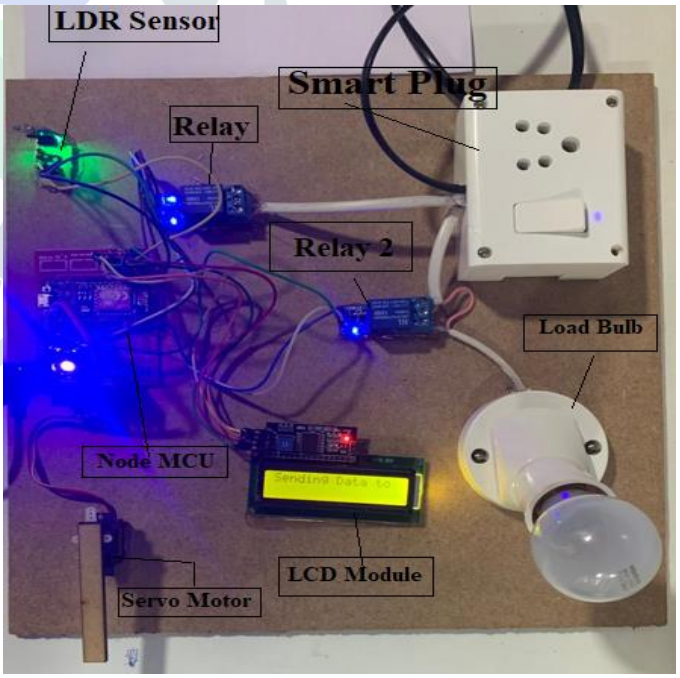

Fig.10: Designed hardware kit for Smart Lighting, Smart Plug, Smart Gate System

The above Figure 10 shows the hardware setup of IoT based Smart Lighting, Smart Plug, Smart Gate System. The reading data from inputs sensor is transmitted to the Node MCU controller. LCD Display shows the displayed output of different applications.

Fig.11: LCD Shows that the Lights ON when NO Light Exist

Figure 11 shows that when light not exist in building automatically lights will be ON. The corresponding data sent to cloud. These applications of data send to the IoT that displayed shown in figure 12.

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Fig.12: LCD Shows that data Sending to IoT

Figure 13 shows the light intensity value in cloud (ubidots) when Lights ON in the building.

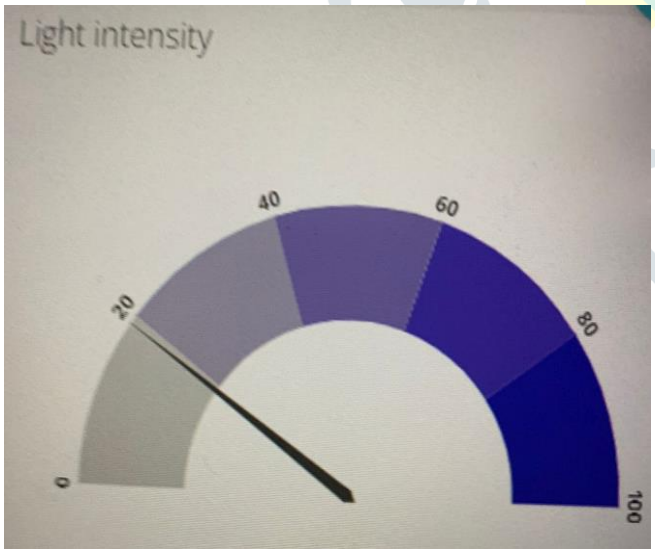

Fig.13: Shows Light Intensity value in Cloud (ubidots)

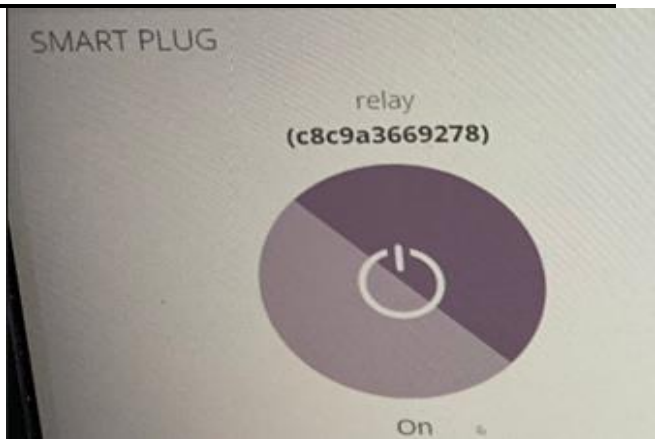

Fig.14: Smart Plug Switch in Cloud

Figure 14 show that the switch available in cloud to make ON and OFF the Smart Plug application in buiding. Smart plug application condition displayed in LCD shown in figure 15.

Fig.15: LCD Shows that the condition that when Plug ON

Figure 16 show that the switch available in cloud to make ON and OFF the Smart gate application in building. Smart gate application condition displayed in LCD shown in figure 17.

Fig.16: smart gate switch in cloud

Fig.17: LCD shows that smart Gate condition

2. Smart Power Meter

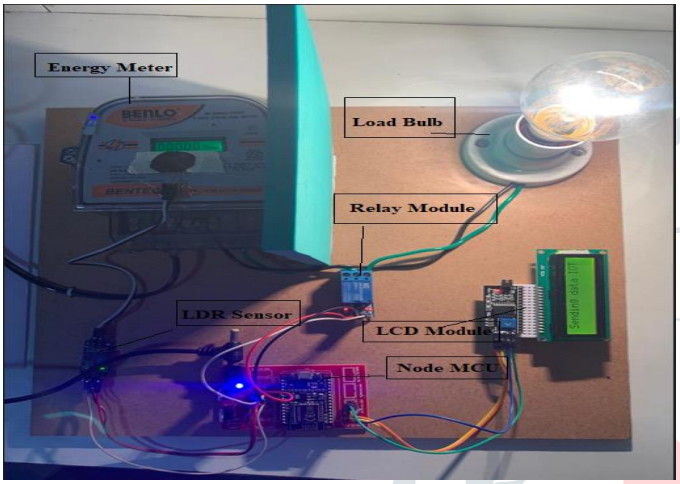

Fig.18: Designed hardware kit for Smart Power

The above Figure 18 shows the hardware setup of IoT based Smart meter. The reading data from inputs sensor is transmitted to the Node MCU controller. LCD Display shows the displayed output of different applications.

Fig.19: LCD Shows that name of the application

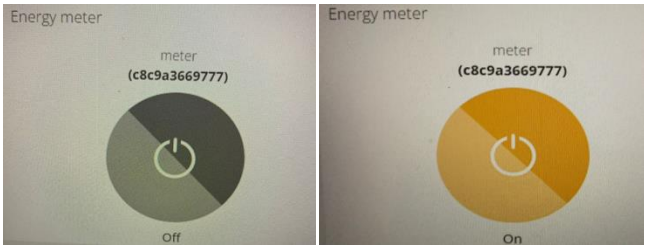

Fig.20: Shows that Energy meter switches

When hardware kit is ON, first name of the application is displayed on LCD shown in figure 19. And Figure 20 show that the switch is available in cloud to make ON and OFF the Smart mater application in building. Smart mater application condition displayed in LCD shown in figure 21.

Fig.21: LCD shows that the condition that when meter ON

Fig.22: LCD shows that unit consumptions and cost of unit

When consume the energy in building and amount to be paid for the consumption of energy shown in figure 22. That is it shows the 1 unit consumption of energy the cost will e for that is 4 rupees. These applications of data send to the IoT that displayed shown in figure 23.

Fig.23: LCD Shows that data Sending to IoT

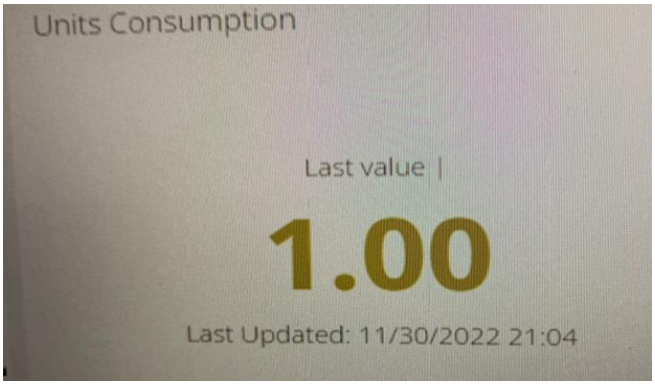

Fig.24: Shows unit consumptions in cloud

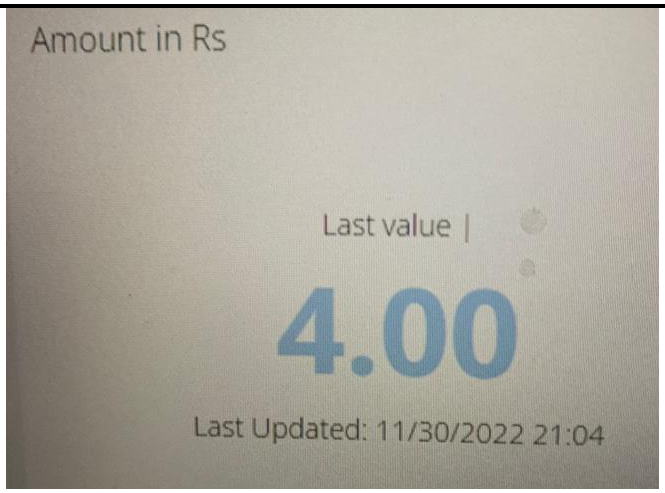

Fig.25: shows that amount of 1 unit consumption

The output of the different applications send to cloud which is Ubidots. Ubidots consist of Devices, Variables, Synthetic Variables Engine, Dashboards, and Events. Within this article we will address each of these concepts as they relate to Ubidots IoT Development and Deployment Platform and how you can better organize your Ubidots Apps to best connect with the users. Figure 24 and 25 shows that utilization of power in units and cost per unit in cloud (ubidots).

7. CONCLUSION AND FUTURESCOPE

We have designed an advanced automation system which has features like smart lighting system, smart plugging system, smart gate and smart power meter which in turn reduces most of the human interactions, by supporting this system using Internet of Things (IoT). For the most part, we can say that the intelligent building management system is a set of software and hardware for monitoring and controlling different sections of a building. In this 21st century with the advent of the several artificial intelligent technology the work places became very cozy to work with. It has changed the uncondensed working environment leading to the increased output and also lessen the running cost to a certain extent. Lighting efficiency it will cut down the electricity bills. But any how today the cost of such equipment's to make a building artificially intelligent is a costly means. With the increase in demand of such systems the cost of these will become affordable as more and more builders will be using such systems in future

Future Scope

Future researchers may hence enhance features of this developed IoT gateway by targeting custom developed hardware with private key encrypted to the hardware. The aspect of performance tests with several hundred or thousand devices in a real building can also be studied. Additionally, this paper can be extended to architect distributed IoT gateway architecture where several IoT gateways communicate with each other to cover multiple floors in a building for reliability improvement. The data collected by the gateways can also be subjected to edge analytics to make local instantaneous actions.

ACKNOWLEDGEMENT

The satisfaction that accompanies with the successful completion of the model would be put incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crown all the efforts with success.

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