

Smart Energy Management System

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Abstract - This paper describes a smart campus management system (SCEMS) that will reduce the energy consumption of all electrically powered devices in a campus environment by using a mobile application, a Bluetooth Low Energy Beacons (BLE Beacon), Microcontroller, different sensors. BLE Beacons and mobile application determines whether a user enters or exits the room. Sensors will determine the position of the user inside the room, includes whether the user is walking or not. This paper enables the automatic control of electrical appliances thus reducing electricity costs. The proposed system will cut off the power of appliances when the user is not around them. There by reducing the energy consumption and ensures a cost effective energy usage

Key Words: BLE Beacon, Microcontroller, Microprocessor, Relay, TCP/IP, MQTT, IoT...

1. INTRODUCTION

Energy Powered Systems in the world are undergoing drastic changes and also facing many challenges in the matters of production, reliability, and efficiency. The Energy consumption in most campuses are not efficient because of the user's ignorance. This results in the large wastage of resources. Since this cannot be controlled from Energy Supplier side, a more efficient manner should be implemented. There exist many methods for energy management[1]. The major advantage of our system when compared to others is that our system monitors energy consumption continuously and controls the appliances to save energy.

The development in IoT influenced many studies and developments in Energy Management Systems. Here we use several sensors, microcontrollers and a BLE Beacon for conserving energy. The thermal sensors can monitor the physical activities and biometric information of the user inside the room. The BLE Beacons will determine whether a user enters or exits the room, thus enabling the system to control the appliances without causing any interference to the user[3]. There are large number of IoT products available in market that manages energy by switching on/off the light based on human presence[4]. The main disadvantage of these systems is it requires large infrastructure. Our System provides a better solution for these problems.

2. LITERATURE SURVEY

Since our system mainly focuses on automation the need for dividing the modules and identifying the component needed was challenging. The proposed system consists of three modules.

An Indoor Positioning System (IPS) is used for monitoring the user's presence inside the room. There exist many methods for detecting the presence of user in the room. But here we are only using a couple of sensors and a beacon only. The beacon is used to detect the entrance or exit of the user by emitting a low energy Bluetooth signal[2]. We also implement a lightweight algorithm for controlling the power in an environment. Thus our paper eliminates the need for usage of a complex methods like fingerprint scanning, retinal scanning or a triangulation process. Since our system doesn't use any complex process for power controlling, it can run on any smartphone without causing severe drainage of battery.

The next module is an Energy Management System (EMS). Based on the results of survey that we conducted, we understood that we do not necessarily need a microprocessor for triggering a relay. So Arduino microcontroller are used here for triggering the relay. In the future works, to make our system completely independent we can implement microprocessors like raspberry pi for more advanced complex operations.

Then comes the Server module (SM). Traditionally a server receives the request from a smartphone via a mobile app, processes the request, and then gives a command to the microcontroller whether to or not to change the current state of electrical appliances. The communication is done based on traditional TCP/IP powered MQTT method[7].

3. CONCEPT LEVEL DESIGN

3.1 Arduino Microcontroller

It is an open-source hardware. It is coded using its own Arduino IDE. This microcontroller board is equipped by a set of digital and analogue pins that are used to interface other various expansion boards and circuits[5]. This microcontroller board has two communication interfaces, including a USB, that can be used to load program from a PC.



Fig -1: Arduino Microcontroller

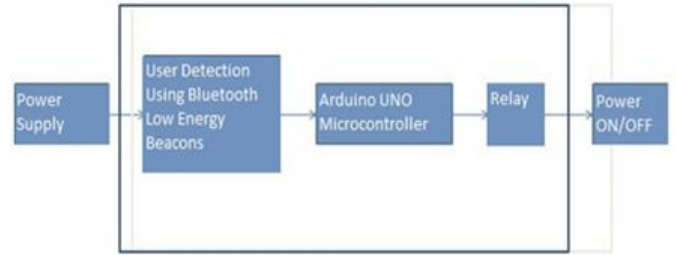


Fig -3: Block Diagram

3.2 Relay

A Relay is a special type of switch, which contains an Electromagnet. When a current flow through the coil an Electromagnetic field is set up [6]. The contacts at the ends of iron armature are pushed together for completing the circuit. Thus relay acts as a switch which is operated electrically. In the open state, when the relay is activated and circuit is closed. In the closed state, when the relay is inactive, circuit gets disconnected, allowing no current to flow. Thus relay provides a safety logic.



Fig -2: Relay Unit

3.3 Block Diagram

When Arduino Microcontroller is boots up, our proposed algorithm is executed first and starts detecting the presence of any user in the room with the help of Beacons and Sensors attached. If the presence of any user is detected, then the Server module will send a command to the microcontroller to turn the power on. After receiving the command, the microcontroller will initialize its pins to trigger the relay unit. If there is no user, then the microcontroller will command the microcontroller to switch-off the initialized pins, thus pushing the relay unit into an open state where the power is cut down.

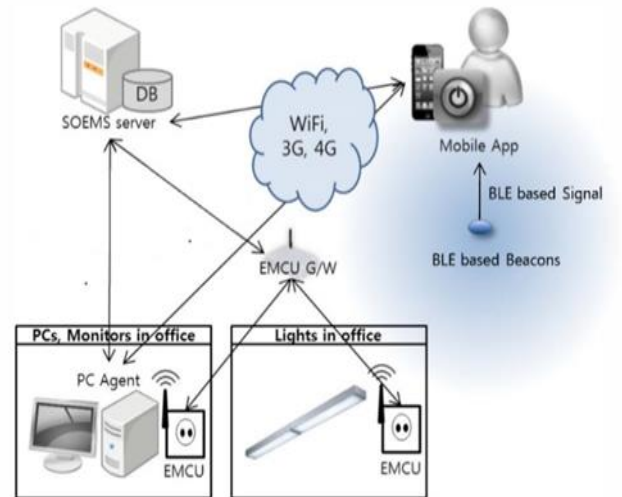


Fig -4: Structural Overview

4. STEPS & ADVANTAGES

First we started our project by setting up the Arduino microcontroller. An Ethernet Shield is mounted on microcontroller for enabling the connectivity. Then an open-source platform Android studio is installed for writing the codes. Another open-source platform Arduino IDE is also used for coding.

As discussed above, we employ BLE Beacons for sensing the user's position. Our mobile application installed in the user smartphone executes our power control algorithm. As per our algorithm power-supply in the office is turned on only when the user is inside the room. Processing is done in our server. This process is done by comparing the distance of user with the nearest beacon. It also compares previous distances to check that the user is approaching the door either from outside or from inside. The sensors will help determining the user's position inside the room.

Now based on the results obtained from our algorithm, we need to control switching of electrical appliances. The server will now give commands to the Arduino microcontroller which is interfaced to a relay unit. This relay unit will control the electrical appliances like lights, fans etc.

When Server detects the presence of a user then it sends a message to the Arduino microcontroller to turn the power on. Then the Arduino initialize its pins to trigger the relay unit and it makes the power on. If that's not the case, that is if Server didn't detect any activity, then it commands the Arduino microcontroller to turn off the power. This will switch-off any initialized pins in Arduino microcontroller thus making the relay unit into an open state where power is cut off.

We made a script and stored it into the Arduino microcontroller and had made that script self-executing whenever the system is booted up. Thus eliminating the running of code manually or by giving commands using an IDE on every booting.

Advantages of the proposed method are:

- 1) The usage of beacon increases the engagement between the application and user which also increases the retention.
- 2) Since the microcontroller and Beacons are implemented, our product is cost efficient.
- 3) Our system does not have a large infrastructure, which makes the real time implementation easier.
- 4) Even though traditional MQTT protocols are used, user detection is pretty faster.

5. CONCLUSIONS & FUTURE WORKS

The proposed method is implemented on Arduino microcontroller using Android studio and Arduino IDE. The code is written in JAVA language and different IDE libraries are also linked to ascertain the user movements and controlling the power.

The software we are using are mainly open-source. We are implementing the code on a microcontroller rather than on a microprocessor. So maintenance and installation costs are thus reduced drastically. Also usage of BLE Beacons also reduced the cost. Thus overall our system is cost effective and can be easily developed to a product.

As the future work, Since the orientation of the Beacons and Sensors are a bit harder to implement thus there exists a scope for improving our algorithm for better reliability. Also in future the implementation of human detection algorithm increases the security thus by detecting intruders.

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