# THE ORGANIZING OF A WIRELESS REMOTE LIGHT CONTROL SYSTEM USING BLUETOOTH

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## ABSTRACT

With the introduction of the Internet of Things, the research and implementation of home automation are getting more popular. Much of the research attention has been given in academia which made use of different wireless technologies such as Wi-Fi, Bluetooth, ZigBee... etc. to support remote transfer of data. In this paper we design a prototype of a home automation lighting system that can be remotely switched on/off by an android application via Bluetooth. Affordability of smart phones had made majority of people to be attached to their phones. A mobile phone has become an inseparable part of human life which is an opportunity for us to take this advantage to manage power usage at home and provide convenience to users by integrating it in smart home. A lot of countries are suffering from huge power shortages which resulted in serious inconvenience to the socio-economic growth. Consumers had opted for other alternative such as the use of solar energy, generators, biogas and firewood of which some of these means destroy the ecosystem and emit poisonous gases into the atmosphere. As nations, there is need to look for ways that manage and control available power together with load shading.

## INTRODUCTION

Affordability of smart phones had made majority of people to be attached to their phones. A mobile phone has become an inseparable part of human life which is an opportunity for us to take this advantage to manage power usage at home and provide convenience to users by integrating it in smart home. A lot of countries are suffering from huge power shortages which resulted in serious inconvenience to the socio-economic growth. Consumers had opted for other alternative such as the use of solar energy, generators, biogas and firewood of which some of these means destroy the ecosystem and emit poisonous gases into the atmosphere. As nations, there is need to look for ways that manage and control available power together with load shading.

People tend to forget to switch off their electrical gadgets while leaving their homes and there is need to empower people on the importance of managing available power hence the need for ways to control appliances from afar. With just a click on your phone you can save energy. With this type of systems in place, and embracing affordable smart phones users can save their time and have a greater experience of enjoying the benefits of internet of things.

This paper is organized as follows: the II gives an overview of Home Automation System (HAS). The next part III is about Bluetooth Classic and Bluetooth Low Energy (BLE). The IV is more about organize a lightning system using Bluetooth (its requirements, architecture and diagrams) and the last one V gives the conclusion.

## INTERNET OF THINGS

Internet of Things (IoT) was first used in 1999 by Kevin Ashton to describe a system in which objects in the physical world could be connected to the Internet by sensors. IoT also can describe as intelligently connected devices and systems which be made up of smart machines, environments, objects and infrastructures and Radio Frequency Identification (RFID) and sensor network technologies [1].

## HOME AUTOMATION OVERVIEW

Home automation principle is one of amazing concepts which was embraced some decades ago although there are no specific dates of invention and was even seen in science fiction movies of 1920s. Home automation technology was not a one day experiment. It gradually came into existence with only insignificant improvement having the previous step almost the same as the next step. It takes time for consumers to accept automation technologies as they were no standardized solution to carry out every job that they could think of. Most of the negative issues associated with on-off remote control devices can be eliminated and with full automation there is an increased level of control to nearly all the appliances in the home.

This technology of automation has found its use in security systems, environment, Medical field, Home Automation etc. The table 1 below shows comparison of different wireless home automation technologies [2].

Table 1

Wireless automation technologies

| Protocol | Bluetooth | Wi-Fi | ZigBee |
|---|---|---|---|
| Frequency | 2.4GHz | 2.4GHz, 5GHz | 868MHz, 915MHz, 2.4GHz |
| Modulation | FHSS | QPSK, COFDM, QAM | BPSK, Q-QPSK |
| Error control | CRC (16-bit) | CRC (32-bit) | CRC (16-bit) |
| Range | 10m | 100m | 10m-100m |
| Network size | 8 | 2007 | 64000 |
| Power consumption | Medium | High | Very Low |

A lot of research work on home automation has been done across the globe using different platforms mentioned above. The most important aspect in automation is to minimize human intervention by connecting devices and sensors

## BLUETOOTH CLASSIC VS. BLUETOOTH LOW ENERGY (BLE)

The Bluetooth Classic radio, also referred to as Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR), is a low power radio that streams data over 79 channels in the 2.4GHz unlicensed industrial, scientific, and medical (ISM) frequency band. Supporting point-to-point device communication, Bluetooth Classic is mainly used to enable wireless audio streaming and has become the standard radio protocol behind wireless speakers, headphones, and in-car entertainment systems. The Bluetooth Classic radio also enables data transfer applications, including mobile printing [3].

The Bluetooth Low Energy (BLE) radio is designed for very low power operation. Transmitting data over 40 channels in the 2.4GHz unlicensed ISM frequency band, the Bluetooth LE radio provides developers a tremendous amount of flexibility to build products that meet the unique connectivity requirements of their market. Bluetooth LE supports multiple communication topologies, expanding from point-to-point to broadcast and, most recently, mesh, enabling Bluetooth technology to support the creation of reliable, large-scale device networks. While initially known for its device communications capabilities, Bluetooth LE is now also widely used as a device positioning technology to address the increasing demand for high accuracy indoor location services. Initially supporting simple presence and proximity capabilities, Bluetooth LE now supports Bluetooth® Direction Finding and soon, high-accuracy distance measurement [3].

Table 2 below shows a comparison between Bluetooth classic and Bluetooth Low Energy [3].

Table 2

Comparison between Bluetooth classic and BLE

|  | BLE | Bluetooth Classic |
|---|---|---|
| Frequency Band | 2.4GHz ISM Band (2.402 – 2.480 GHz Utilized) | 2.4GHz ISM Band (2.402 – 2.480 GHz Utilized) |
| Channels | 40 channels with 2 MHz spacing | 79 channels with 1 MHz spacing |
| Channel Usage | Frequency-Hopping Spread Spectrum (FHSS) | Frequency-Hopping Spread Spectrum (FHSS) |
| Modulation | GFSK | GFSK, $\pi/4$ DQPSK, 8DPSK |
| Data Rate | [2 Mb/s - 125 Kb/s] | [3-1] Mb/s |
| Communication Topologies | Point-to-Point (including piconet) Broadcast Mesh | Point-to-Point (including piconet) |
| Positioning Features | Presence (Advertising) Proximity (RSSI) Direction (AoA/AoD) Distance (Coming) | None |

When a link is established between two Bluetooth devices a secure connection is made. To secure the link level, four entities are used; the Bluetooth devices address which is unique for each Bluetooth device, private authentication and encryption keys, both which are 8 to 128 bits in length, and finally a random number which changes frequently. These entities are used to generate a key or Personal Identification Number (PIN) which is then used between the devices to connect or transfer data. The link protection was meant for protection against eavesdropping [4].

### AN OVERVIEW OF ANDROID TECHNOLOGY

Android, by Google Inc. provides an opensource platform for the development of android mobile based applications. The Android framework is distributed under the Apache Software License (ASL/Apache2), which allows for the distribution of both open and closed source derivations of the source code. Android application developers can distribute their applications under whatever licensing scheme they prefer. Developers can write opensource freeware or traditional licensed applications for profit and everything in between. Android applications are written in the Java programming language. Android SDK tools are found on the Android website on free charge of after agreeing to SDK License terms. Tools for code creation and data packaging are offered on Android SDK and are then stored with 'apk' file extension. Android devices use the 'apk' file to install the application [5].

The incorporation of android with Bluetooth APIs allows wireless connection to any nearby Bluetooth devices. As a result, it is possible to establish connections with other Bluetooth devices, enquire information about any paired Bluetooth devices, easy data transfer to and from other devices and to manage multiple connections.

### CHALLENGES OF BLUETOOTH BASED HAS

Bluetooth technologies have their own flaws which limit its functionalities as shown below.

– Limited transmission range: Bluetooth operates in a range of 10-100m hence there is need to merge it with internet technologies so to increase the range of connectivity.

– High interference rate: Bluetooth operates in the free band which is prone to interference with other systems which operate in that same range for example microwave oven, cellular phones, Wi-Fi and ZigBee.

– Wireless technologies are prone to security threats hence there is need to look for ways to mitigate these problems.

– Resource constraints: higher power processing sensor are preferred unlike the other sensors which suffer from limited battery, low memory and limited processing power. Merging both Wi-Fi and Bluetooth technology consume more power as a result a constant power supply unit should be used.

– People may fail to embrace the system due to its initial cost and fear to have everything done automatically.

– Power constraints issues are resolved through embracing the new version of Bluetooth Low Energy (BLE) technology. BLE is used in very low power network and Internet of Things (IoT) solutions aimed for low-cost battery-operated devices that can quickly connect and form simple wireless links. Target applications include HID, remote controls, sports and fitness monitors, portable medical devices and smart phone accessories, among many others that are being added to a long list of BLE supporting solutions.

### BENEFITS OF THE PROPOSED SYSTEMS

The adoption of an automated system come along with several advantages to the users as mentioned below

• Able bodied people cannot fully appreciate the need of automation unlike the disabled who understand the difficult of turning ON/OFF a simple light switch.

• Energy cost can be minimized by controlling and monitoring power usage through automatic turning ON/OFF electrical appliance in question.

• Deployment of wireless technology is much easier and cheaper as some nodes may be placed everywhere where cabling is impossible.

• Incorporation of Bluetooth technology is an advantage since almost every smart phone has a Bluetooth application in it. Mobile devices can be easily integrated as they can allow easy accessibility so long the device is in network vicinity.

• here is improved personal safety

• Tim  and a lot of effort is saved

• There is increased independence and greater control of the environment.

### SCOPE OF THE WORK

The project will mainly work on the lighting system and allow remote control of lights via Bluetooth. This will cover a radius of 10m in which the Bluetooth strength will be felt. The system will not control multiple appliance.

There are some assumptions of the research are:
• Greater part of the population is in possession of an android smart phone.
• Every smart phone has a Bluetooth facility.
• Proper hardware components are available for the implementation of the system

The Limitation of our system is that the system will only control lighting system.

Research Questions are:
1. Does the system provide remote control to lights?
2. How secure are the systems to be developed from tempering by unauthorized users?

## THE PROPOSED SYSTEM

We will present a system interconnected with Arduino Uno board (microcontroller), electrical devices and an android based mobile application (Fig. 1-3). The mobile application provides a communication mechanism between the microcontroller and the user over Bluetooth link. The system control and connection utilities is offered on user interface of android mobile cellular phone. The system will be quite different as it will also make use of security mechanism to guard against malicious user. An authentication mechanism using biometric (finger print) will be used. We will make use of relay drivers, microcontrollers, Bluetooth module and LEDs for hardware development.
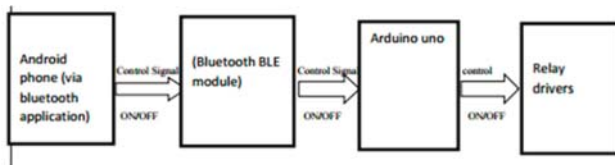


**Figure 1.** Block diagram of HAS system

The home automation system via Bluetooth is implemented using:
I. Arduino microcontroller.
II. Bluetooth enabled Android smart phone.
III. Hc-06 Bluetooth module.
IV. Rel    and LEDs.



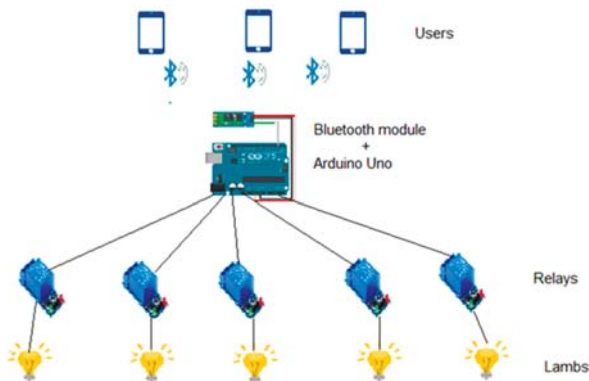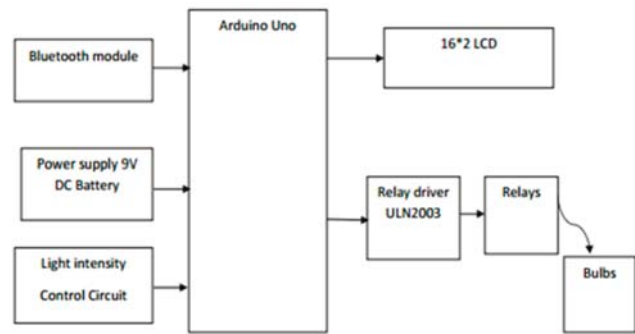**Figure 2.** System topology



**Figure 3.** System architecture

This project is aiming at designing a Bluetooth based home automation using Arduino Uno. The third-part user will be able to use his or her android phone to control all the lights in the house. The Arduino board is the brain of the project. A mobile application has the capability to control the lighting system. The android phone sends commands to the microcontroller via Bluetooth module. The microcontroller responds to send commands by comparing it to the predefined ones. When the signal is identified, the microcontroller will activate a corresponding relay attached to it by sending a 5V through. To switch off appliance, the microcontroller will send a 0V signal to the respective relay.

## SYSTEM REQUIREMENTS

### Functional requirements
These are statements of services the system should provide, how the system reacted to particular inputs and how the system should behave in particular situation. Functional requirements reveals the expected behavior of the intended system which may be expressed as task, functions and services. The statements below shows the expected results of our system.
• The system should provide users with a facility to scan and store their fingerprints to be used in the authentication process.
• System should allow authorized users to control the appliances.
• The system should allow new users to pair their mobile devices with the hardware for easy Bluetooth connectivity.
• System should ge erate energy consumption report.

### Non-functional requirements
They do not reflect specific behavior of system but rather reveals system operation. They are the constraints of the application. Below are the non-functional requirements of the application:
Confidentiality – Data in transit should be kept secure as it is prone to interception. The system must provide necessary security to its users and data must be free from errors.

Reliability – The system must be able to provide specified service to authorized users

Availability – The system must provide service whenever a valid user needs it.

Portability – the system application should be easily transferred to different android mobile device without problem.

Usability – the application interface must be user friendly such that a naïve user must feel free to operate it.

## PROJECT DIAGRAMS

*1) Use case diagrams* are there to model the functional requirements of the system. It reveals a relationship between actors and use cases. The diagram below shows the use case diagram of HAS system (Fig. 4-6).
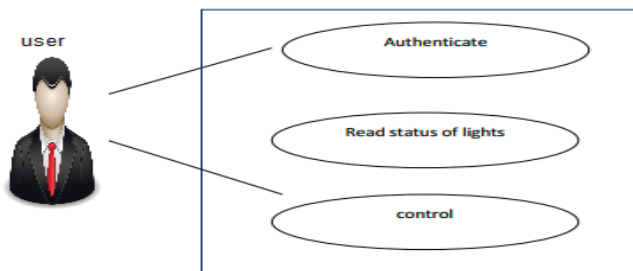


**Figure 4.** Use case diagram

User acts as a main actor who can read the status of appliances in ON/OFF state through the LCD and mobile application. A service of authentication is offered to users to identify authorized users. In addition, users control home appliances by sending request to microcontrollers which then responds to specific needs.

*2) Sequence diagram:*

A remote control system is used to operate each HAS. The operation of the remote-control is explained by the sequence diagram. A mobile device facilitates communication between the user and microcontrollers.

Authentication: Flow of events:

1. When a user connects to the remote system, user should use valid fingerprint to log in. After consecutive 5 failed login attempts, system will lock for security reasons.

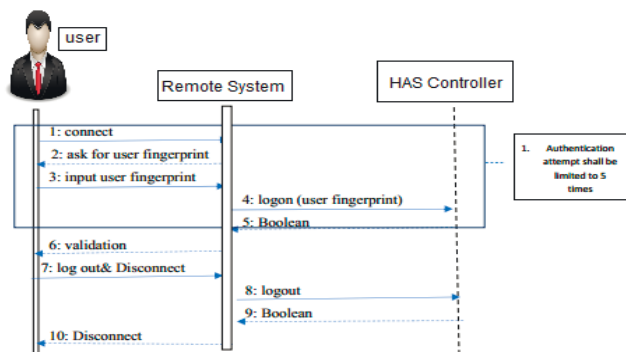2. When a user is done, user shall log out to terminate the session.



**Figure 5.** Sequence diagram for authentication

Operate lights: Flow of events:

1. When a user log in, the remote device shows a list of rooms with lights.

2. The user chooses the room and send commands to the controller to turn ON/OFF lights.

3. The lights will respond to the command and status of results is shown.
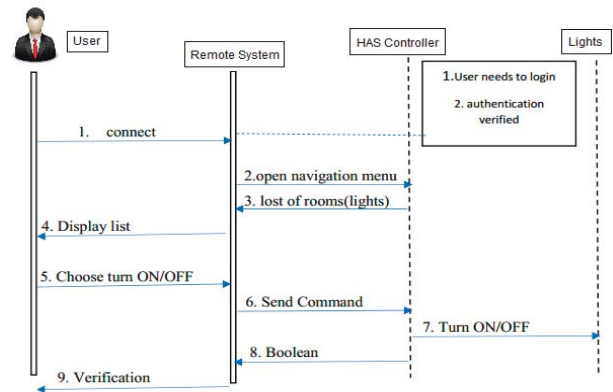


**Figure 6.** Sequence diagram for lights operation

*3) The flow chart* clarifies the logic of the code and how we implemented a real time control algorithm (Fig. 7).
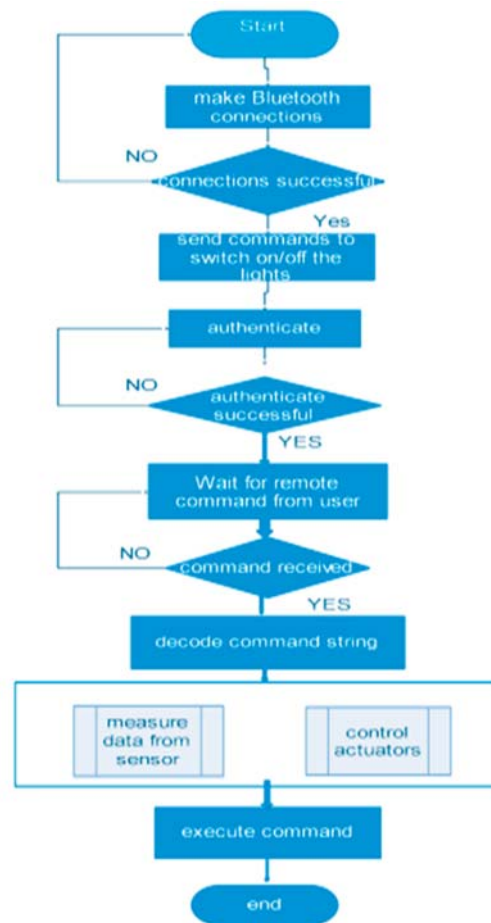


**Figure 7.** Flow chart

## CONCLUSION

Considering that a large part of the population owns an Android smartphone and every smartphone has a Bluetooth facility, the proposed system for smart home lighting using Bluetooth technology is the most effective because it is easy-to-use, stable, low cost, and has good expansibility.

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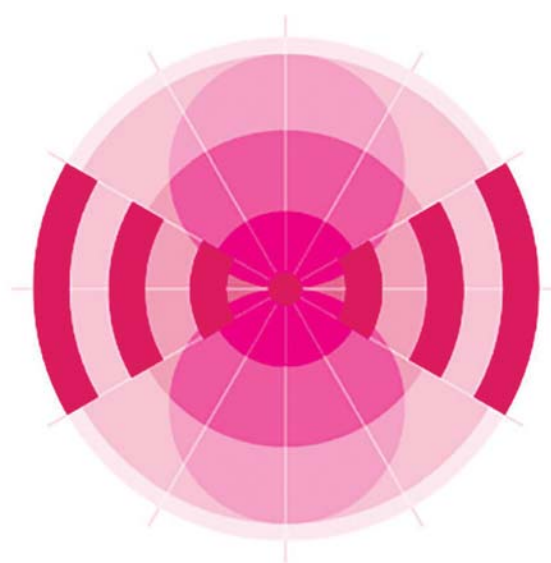
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