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# Home Automation with Indoor Location Using Bluetooth Low Energy and Arduino-ZigBee Nodes

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**Abstract -** *With the conveniences and security offered by IOT, control of devices that were created before the IOT advent by a means of devices to interface between the internet and the device Home Routers have limited capacity and are susceptible to failure under load, the Wi-Fi protocol is also power consuming and in most sub-urban and urban regions the 2.4ghz Wi-Fi bands are occupied and noisy ZigBee provides a way of communicating wirelessly and has mesh-networking built in. This allows for unparalleled range in home and commercial distributions without the need for additional infrastructure, it also allows for enhanced security as there is only one entry point for control of the devices on the Wi-Fi network*

***Key Words***: IoT, Home Automation, Bluetooth Low Energy (BLE) , RSSI, ZigBee, Indoor Location

## 1. INTRODUCTION

Home Automation system that does not stress the home Wi-Fi network Uses ZigBee and Arduino's to give a total of 18 control lines from the Arduino and 12 Digital Input Out- put (DIO) pins on the XBee module. Having a large number of pins available allows for great flexibility when it comes to controlling devices allowing almost any device to be controlled by the XBee-Arduino endpoint. The setup is configured as follows Each endpoint consists of an Arduino with an XBee mounted on a shield whose primary function is to convert 5v signals from Arduino to 3.3v signals coupled with additional hardware such as relays, dimmers, Infrared (IR) modules, fingerprint sensors or almost any other device to be controlled. Server consists of Raspberry Pi running Tomcat 9 with a Java based Backend and JavaScript frontend this is connected to XBee Coordinator device by means of Universal Serial Bus (USB)-Serial converter, the server uses restful API.

### 1.1 ZigBee Network

Digi Xbee 802.15.4 module Designed for point-to-point, mesh and star communications at over-the-air baud rates of 250 kbps. Server communicates to all end points by means of the 802.15.4 XBee network

### 1.2 Bluetooth Low Energy

We use RSSI to measure the radio signal strength. Both RSSI (Received Signal Strength Indication) are indications of the power level being received by an antenna. The difference between RX and RSSI is that RX is measured in milliWatts (mW) or decibel-milliWatts (dBm) whereas RSSI is a signal strength percentage the higher the RSSI number, the stronger the signal. RSSI is a relative measurement

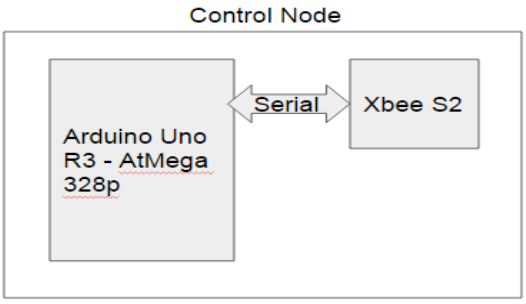
## 2. SYSTEM ARCHITECTURE

### 2.1. Server

The Raspberry Pi is coupled with a ZigBee Coordinator chip over a USB-Serial inter- face this allows the Raspberry Pi server to communicate on the ZigBee network Xbee modules have 2 modes transparent serial bridge and Application Programming Inter- face (API) Mode, API mode is used as it allows for directed sending and security features the Pi also comes with Bluetooth, Wi-Fi and Ethernet interfaces allowing for other modes of communication even if Wi-Fi network at home goes down, the web-server used is tomcat 9 and back-end is written in Java with REST API and front-end uses Java Script. Pi4j Library used for serial communication

### 2.2. Arduino Xbee Endpoints

Arduino is connected to Xbee through Serial port a Shield is used to power the Xbee module and to carry out signal level conversion between 5v to 3.3v used by the Xbee module this endpoint gives me 18 control lines with 3 ADCs to use, making it sufficient for many applications



### 2.3. Dimmer Module

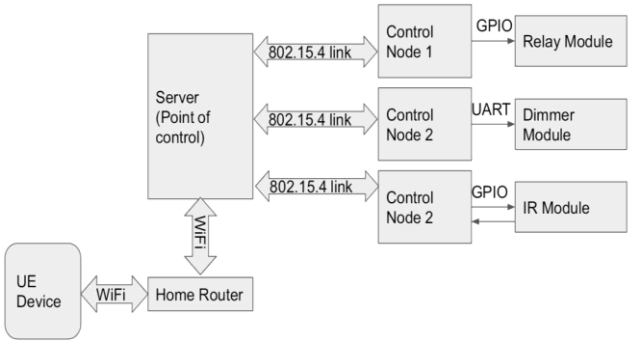
Dimmers are devices used to lower the brightness of a light. By changing the volt- age waveform applied to the light source, it is possible to lower the intensity of the light output. Although variable-voltage devices are used for various purposes, the term dimmer is generally reserved for those intended to control light output from resistive in-candescent, halogen, and (more recently) Compact Fluorescent Light (CFL) and Light Emitting Diode (LED). More specialized equipment is needed to dim fluorescent, mercury vapor, solid state and other arc lighting. Single Dimmer Module controlled via Serial Port has 4 levels of power 0%, 25%, 50% and 100% operates using a SSR and a 8bit PIC IC

### 2.4. Relay Module

A Relay is operated by a relatively small electric current that can turn on or off a much larger electric current. The relay is one of the most widely used components in industrial electronic. In combination with transistors, electron tubes and other circuit elements, this electromagnetic device performs countless tasks. In this project, 8 channel parallel opto-coupled relay module with 8 relays running on 12v supply

### 2.5. IR Module

IR module Consists of a IR Led, IR Receiver (TSOP 1376) and a push button 3 signal wires 1 input for IR LED and 2 output lines for button and IR receiver, it has the capability to learn and repeat IR commands from any remote due to memory limitations on the Arduino Uno it supports only 3 commands this can be easily overcome by using external memory or other microcontrollers with higher memory




### 2.6 Bluetooth Low Energy Beacon

BLE Beacons are Bluetooth 4.0 smart devices that broadcast a UUID and major and minor IDs that are user configurable the RSSI Values from this can be used to approximately gauge the proximity of the beacon to UE device.

## 3. SYSTEM IMPLEMENTATION

The Endpoints are placed in places convenient to the user the relay module can be placed behind a usual switchboard, the IR module placed in a device the user wishes to control with IR and the dimmer also placed behind any switchboard with a dimmer the dimmer and relay modules will run off AC power supply after a 5v SMPS supplies needed voltage to the Arduino, the Central server needs to be configured to connect to the home Wi-Fi network first and the system is ready to be used, to enable the indoor location feature BLE Beacons need to be placed at strategic positions around the house, after which the app on the BLE enabled smartphone needs an initial calibration and it will automatically turn on lights or other devise as per user's configuration depending on user's movement through the house, this can be used in tandem with PIR sensors to give higher energy efficiency to the house and reduce the overall power consumption

## 4. EVALUVATION

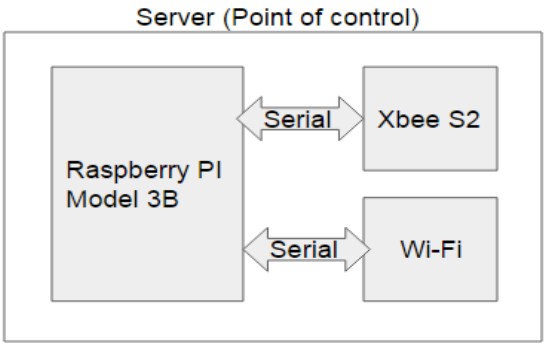
Devices were constructed using discrete components and mounted on Plexiglass they were then connected to requisite power sources, AC supply lines were fed to dimmer and relay modules, automatic opening of appropriate pages as per BLE Beacon configuration was tested and worked perfectly, app was able to control all devices connected to ZigBee network via the server, relays and dimmer worked as expected and the IR commands learnt by the IR module were repeated successfully upon issuing command to do so. The devices could be placed at opposite ends of a 2500 square foot home with thick walls, performance was not affected, range was broken only after 107 meters in open space and was easily extended using intermediary router with no setup apart from pairing to coordinator, BLE beacons were placed at centers of each room and the indoor locating system worked as expected, the right control screens were opened at the right location on user device the beacons used in this case were Gimbal Q-Fyx beacons configured for iBeacon protocol as it is easy to use

## 5. WORKING OF BLUETOTH LOW ENERGY LOCATION SYSTEM

The BLE Beacons transmit at 100ms intervals the UE device i.e the smartphone can use the RSSI readings from each beacon to approximately judge the users location in the house thus enabling it to turn on lights with movement of user through the house to the user's desired settings, some beacons come with built in proximity measurement

hardware allowing us to skip the approximation and keeping a beacon in each room, once proximity registers as "near" or "immediate" we can open the needed menu

## 3. WORKING OF THE SYSTEM




The smartphone/web client uses JSON objects and REST API implemented in the server to communicate bidirectionally with the server, the server abstracts the ZigBee interface layer, uses a simple datagram to deliver information to the respective ZigBee device after which the paired Arduino will do the respective action. Use of REST API allows any device to communicate with server thus making it flexible.

## 7. CONCLUSION

The implementation of the system was a success and is robust enough to be used on a 24x7 basis without failure with various normal domestic loads, the BLE based indoor location system is a game changer for low cost home automation systems as it allows for a new level of personalization without having to use expensive power consuming RFID based systems, the entire system has been designed with immense flexibility in mind and is suitable for medium industry level automation as well with users having Bluetooth tags and BLE receivers in each room allowing good ERP and employee tracking

## 8. FUTURE SCOPE

As with any project there is always scope for improvement, these are a few that seem essential to me

- 256 bit RSA based encryption running atop the ZigBee network for initial key exchange for coordinator pairing will overcome an essential problem in most ZigBee home automation systems
- system can be made more flexible by use of microcontrollers with more I/O ports and increase of memory allowing local and remote control seamlessly for high density switchboards,
- more modules with various other functions can be developed and used to make a great ecosystem
- the entire source code has been uploaded to an open source code sharing GIT for version control the code can be found at www.github.com/gokul96/home_automation

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