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# Embedded Open Source Smart Home Automation System

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## ABSTRACT

*The main aim of this paper is to provide open-source and open-hardware solution for home control automation systems. Final approach uses wireless communication, solar powered sensor array and simple scale-up system network and it is called Home Beacon. System consists of one central station and multiple portable units providing the sensor array. As a control part, various action units can be implemented according to desired needs to nearby located units. Home Beacon system is built to be energy efficient which is mainly represented by solar panels powering up each Beacon Unit and to be flexible where the aim is to provide the ability of simple scaling-up and adjustment of individual Beacon Units to suite them for particular operation needs.*

## INTRODUCTION

This article deals with open-source and open-hardware solution for intelligent home modules. Nowadays, various companies exists which deliver automated and intelligent systems to our homes across the world. Their products are both powerful and reliable. However the flexibility and purchase price with additional service can be quite high. New technologies and open-source community together with open source development boards made programming and system development a lot easier. Apart of this personal computers considerably improved IT skills of its users across the whole population. Even though we live in consumer society, certain people still appreciate the possibility to make such a system by their own. The conditions were never been better for such a project. With tutorials, forums and open-source projects all over the internet, small kids can program and create their own intelligent home system.

The motivation for this particular thesis was to have the possibility to monitor and control our homes via internet from all over the world. To know the exact state of our home appliances such an oven, iron or stove are, can be calming element of our everyday lives. Such a system could not only save us substantial amount of money and time but keep us from some amount of stress which is the part of everyone's life today. Ease of Use.

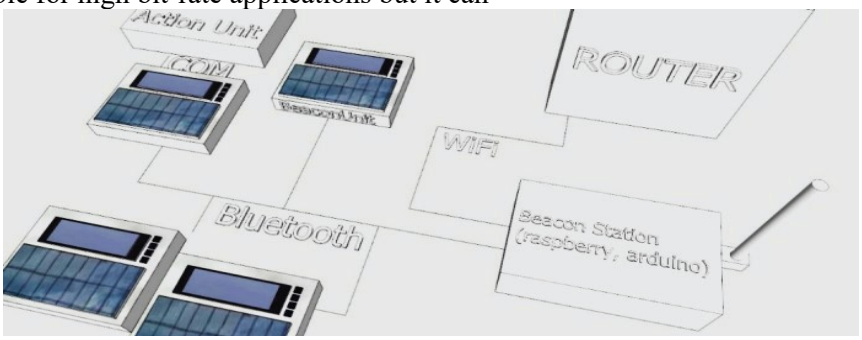
Nowadays, new era of technology arises. The Internet of Things (IoT) covers extensive monitoring, flexible sensor arrays and control possibilities which one could only dream of just few years ago. Development of three key technological areas made this idea possible. The first is tremendous progress in the field of wireless technologies, where Wi-Fi, Bluetooth, ANT or ZigBee ensures the communication among devices with various speeds, distances and low power consumption.

The second field which helped the existence of IoT is microelectromechanical systems also known as MEMS. And the last was development of general internet applications, cloud applications and connectivity to internet everywhere at anytime.MEMS technological advancement placed accelerometers, gyroscopes, pressure sensors and more others inside a tiny chip. Apart of this the development and new technologies for Internet and Embedded systems played the key role as well.The idea of IoT is to connect all device ("things") to the internet and create a huge sensor network, which

would provide enormous amount of precious data. This data can now be efficiently processed, used and stored thanks to the new technologies such a compression or data storage capacity are.Apart of few differences among the vendors and manufacturer of individual Home automation or IoT components the main differences are defined by communication protocol used. Several communication protocols exists. Among the most used ones Insteon, KNX, ZigBee and Z-Wave are.

Insteon communication protocol involves dual-mesh networking topology, where all devices are peers and they automatically transmits, receives and repeats message. The network itself is considerably stabilized by the function of every device to find errors and perform correction of signals before re-transmitting data. The used frequencies are 868MHz and 2.4GHz for Europe and 915MHz and 2.4GHz for U.S.

UPB or Universal Powerline Bus is home automation standard with broad range of applications. It uses high-power pulses to control the appliances via power line circuits. This technology can store up to two digital bits signal within one AC halfcycle. Since there are 100 AC half-cycles per second (considering Europe's 50Hz power grid) the raw speed of UPB will be around 200 bits per second. This communication speed is hardly usable for high bit-rate applications but it can




purchase price, availability and popularity. Since every component of the structure deals with different task, has different architecture and level of transmit commands or control appliances with substantial stability.

## COMMUNICATION STRUCTURE

The first practical aim for intelligent home system is to design individual modules which could sense, control and monitor the environment around them. In this project multiple sensor array modules which could control several action units are covered. There are multiple features one should consider.

Among the most crucial ones communication, placement, design, power supply, system architecture and sensor types are.The power consumption varies according to the range and data bitrate. Since the Beacon Units are expected to send and receive mostly only sensor and true or false values, the bitrate is mostly off the hook. Additionally, the range in a standard home will most probably not exceed few dozen meters. With these conclusions one can easily dismiss few wireless options available on the market.

### STRUCTURE OF THE SYSTEM

System's structure was designed with respect to the economic issue. The requirements for the components used were low

data processing the compatibility and communication was crucial to the system's design.

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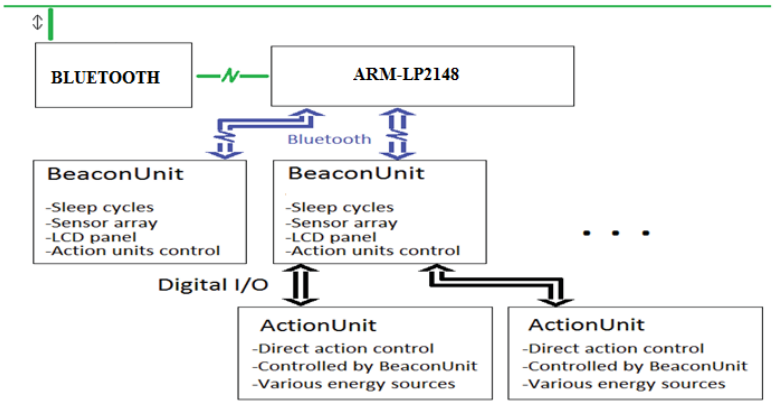



**System's block diagram and communication**

### Sensor Module (Beacon Unit)

Sensor module is designed to communicate with server via Bluetooth protocol with master/slave topology. System's server unit is built on ARM-LP2148 . The task of Sensor module is to collect desired data, process them and sent to the server. Server then updates the database with newly collected data and the visual application will display new data from the database.

### The main features of sensor module are:

ARM-LP2148
-Bluetooth BLE 4, HM-10 Module
-3D printed box for the Beacon module
-USB port as additional power
-LCD panel for simple visualization
-Temperature, Humidity, PIR presence sensors and others via I2C

## Server Module

The acquisition of sensor data is performed by general I/O pins of ARM-LP2148 . Individual components are either wired to the pin port of the ARM-LP2148 board or connected via Bluetooth module. In the first option the logical input is being scanned for all selected pins, while for the second option the data are being delivered by string bursts from individual Beacon Units. The data bursts coming in are composed of multiple sensor data, which are then being processed and written to the board's memory and synchronized with database. The programming is handled in Python language.

## System's database

The database of the system is built on Deployd software. This software consists of a simple core library, with a modular API needed for extensions of individual applications. Deployd is an open source platform running under Apache license version 2.0. It is possible to perform advanced queries over HTTP and push real time data to other clients over Web Sockets. The main advantage of Deployd is, that it takes care of backend service complexity and provides flexible way to build the front-end.

System structure is built on Node.js and MongoDB. The server-side itself is built with Java Script. All API data are stored as JSON.

JSON also known as JavaScript Object Notation is used for transmitting data objects of attributes and values as pairs. It is open standard format with human-readable text. The main usage is to transmit data between a web application and a server. It is an alternative to widely used XML. JSON is considered to be an ideal data-interchange language because it is completely language independent with familiar conventions used in the C-family of languages, including C, C++, C#,
Java, JavaScript, Perl, Python, and many others as well.

All the data information and structures are easily set via Deployd Dashboard (IDE). Multiple data formats can be set for individual elements.

- String (standard string format)
- Boolean (as true or false)
- Array
- Number (with support of floating point values)
- Object

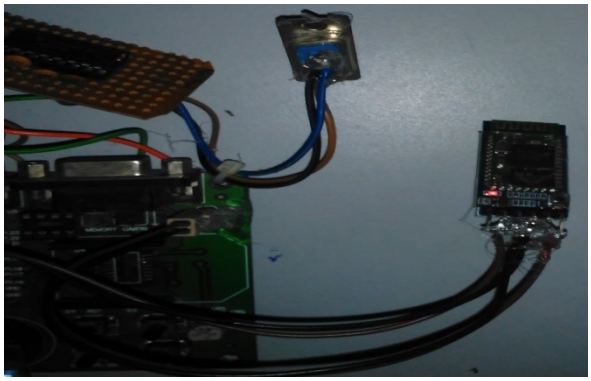
Every element is provided with automatic and original id code as shown in the first column in the figure above. Through this id, JSON interchange element's values are adjusted via requests quires.

## Application interface

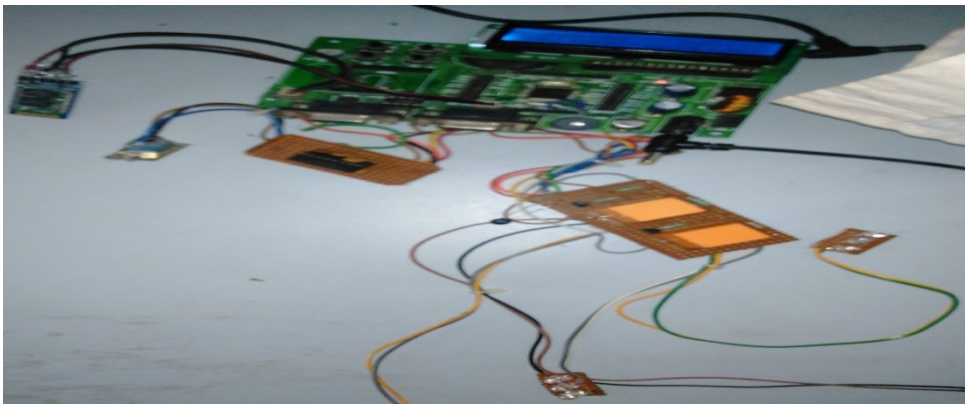
Simple, user friendly and easy-touch page was created in html. Additional component named Bootstrap was used, which ensures proper handling of individual components in terms of responsive site. This provides solution for mobile and tablets users, which are widely spread nowadays. The bootstrap file can be freely downloaded from the web.

**RESULTS& SUMMERY**

**LPC2418 MODULE**



**BLUE TOOTH MODULE**



**TOTAL CIRCUIT**

## CONCLUSION

The work on project of open-source modules for intelligent home was dedicated to search for the current technologies and provide their features as an open-source platform. Sensor array modules including PCB schematics, layout development and 3D models were designed and assembled. The most relevant, accessible and effective sensors available on the market with respect to the open-source approach were selected.

ARM-LPC2148 environment proved to be both flexible and development-friendly for such a task. System with multiple devices and different components was put together. Both simple and smart sensors were connected on brand new board with ATMEL microprocessor programmed in processing language used by ARM community This module communicates with ARM-LPC2148 programmed in python and acting as a server for data acquisition and database managing. User-friendly web interface then ensures impact and monitoring at a specific part of user's household from all over the world via internet by simple clicks.

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