

# Literature Review on Home Automation

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**Abstract** – As smartphones and tablets become increasingly prevalent, Smart Home tech is becoming easier to use and dramatically more affordable. This paper reviews the new technologies used for the Home Automation. We will be discussing about the concepts and the working of the several techniques used by the different companies for Home Automation. We will discuss the Apple Home Kit, Google's Nest Thermostat, Amazon Echo, Wemo Switch, IFTTT and the Blynk Application. As the standards, hardware architecture, software models, and protocols of most of the companies are hidden; thus, we will try to speculate the details as to how they were able to implement their respective smart home technologies. This paper presents the overall study of the new technologies used for Home Automation.

**Key Words:** Home Automation, IoT, Apple Home Kit, Amazon Echo, Google's Nest Thermostat, IFTTT, Belkin's Wemo Switch and Blynk App.

## 1. INTRODUCTION

Home, it is the place where one fancies or desires to be after a long tiring day. People come home exhausted after a long hard working day. Some are way too tired that they find it hard to move once they land on their couch, sofa or bed. So any small device/technology that would help them switch their lights on or off, or play their favorite music etc. on a go with their voice with the aid of their smart phones would make their home more comfortable. Moreover, it would be better if everything such as warming bath water and adjusting the room temperature were already done before they reach their home just by giving a voice command. So, when people would arrive home, they would find the room temperature, the bath water adjusted to their suitable preferences, and they could relax right away and feel cozier and rather, feel more homely.

Human assistants like housekeepers were a way for millionaires to keep up their homes in the past. Perhaps this is still a solution for the rich in some societies. However, not everyone is wealthy enough to be able to afford a human assistant. Hence, the need for finding an inexpensive and smart assistant for normal families keeps growing.

As today's technology develops, many automatic products and concepts have already come true and can be used at home. Moreover, many of these technologies have the same purpose, which is to reduce people's work and create a smart environment where people are able to have better, easier, and more comfortable life.

This paper reviews all the new Home Automation technologies.

## 2. PRESENT AND FUTURE OF HOME AUTOMATION

The basic automation systems have become a large part of people's lives today. Systems such as motion sensing, intelligent thermostat control, adaptable luminescence, RFID, biometrics, IR technology, RF technology, and CCTV security have become very common. Advanced automation technology such as user recognition using facial features, voice controlled commands, assisting in planning, and advising in daily life chores is already implemented. The popularity of residential automation is growing quickly. According to ABI Research [1], 1.5 million home automation systems were installed in the US in 2012, and a sharp uptake could see shipments topping over 8 million in 2017. Cisco CEO John Chambers predicts that the market will be worth \$19 trillion by 2020 [2].

In the year 2014, Google bought a company named Nest Labs for \$3.2 billion (£2bn) [3]. California-based Nest Labs makes 'smart' home appliances [2]. Nest was founded by Tony Fadell, the so-called "godfather of the iPod", after he left the position of head of music at Apple in 2008 [2]. Although Nest has many research oriented devices, Nest Labs currently has just two products in market: the smart smoke alarm and smart thermostat. Nest is planning to make home appliances smarter by giving them unique features such as washing machine that will text its status, the refrigerator that can call, etc. It remains unseen, how many features users want in their home appliances.

Today, we have a lot of cheap and costly home automation products in the market. Each has a way to communicate to the device controllers. For example, the RF based remotes can turn lights on and off, a smart plug that can be controlled via a smart phone or a tablet, which can later be used to control specific devices. Motion detection has been around, since the 1970's. Opening of the door, as soon as someone walks in front of it is a great example of automation. These are a few common examples among a vast majority of diverse, and most importantly, intelligent systems.

Most of the world's top technology companies have been working on developing their own version of home automation technology. The research has been ongoing for a couple of years now. Many of them have either come up with their version of the technology for the general public to buy, or they have their initial prototypes, ready to be launched soon.

We will try to understand the technologies of some of the most accomplished in the market. As mentioned in the abstract section, the standards, hardware architecture, software models, and protocols of most of the companies are hidden; thus, we will try to speculate the details as to how they were able to implement their respective smart home technologies. Each company has its own unique designs and implementations. None of the designs are public. The companies developing technologies also collaborate with other manufacturers so that the third party manufacturers can develop devices compatible with their platform. For example, Phillips’s Hue bulb which changes its color can now be controlled via Apple’s Home Kit, and Siri commands. To do this, Phillips had to collaborate with Apple to use Apple’s platform and communicate with its devices.

### 3. TECHNOLOGY STANDARDS

The most commonly used standards and protocols are discussed in this section. Although, most of the companies implement their own version of standards, it is difficult to analyze each and every product’s unique platform. Thus, we would look into the comparisons of open source and general defined standards.

In today’s time, there are a multitude of standards and protocols implemented by industries. Each company is trying to implement their own technology into the market. Internet of Things or IoT is the communication platform for light-weight microcontroller based devices. Each company and organization has its own unique way of implementing IoT based solutions. Some have their ZigBee based routers needed to communicate with their in-house manufactured devices, whereas some companies use Wi-Fi as its base wireless network. Bluetooth is also widely used for designing IoT based networks.

Some examples of the home automation system are Apple’s home kit, Samsung’s Smart Things platform, and AT&T’s home automation solutions. Comcast also has its own home automation system. Each has their own devices talking to each other.

Thus, standardization is very fragmented in current times, which include Wi-Fi, ZigBee, Bluetooth, Infrared or other wireless techniques to form a dedicated small network of Internet of Things.

### 4. POPULAR PLATFORMS FOR HOME AUTOMATION

To implement home automation, there need to be three essential things:

1. The device gets user input to control all the actions, such as remote control or voice recognition based hardware
2. A reliable medium to transmit messages/commands

3. End devices to perform actions such as turning on/off, brewing coffee, changing heater/AC controls, and etcetera.

**Table -1:** Comparison of Wi-Fi and ZigBee Network Technologies

	Wi-Fi	ZigBee
<b>Basic Technology</b>	Uses a router of longer range to send data.	It is designed to carry small amounts of data over a short distance, while consuming very little power.
<b>Networking Type</b>	Centralized hub type network.	It is a mesh networking standard, as each node in the network is connected to each other.
<b>Power Consumption</b>	Needs lots of power as compared to ZigBee.	Very low power consumption. The battery can last for months, even years sometimes.
<b>Speed</b>	Up to 5 Gbps.	250 Kbps.
<b>Cost</b>	Higher than ZigBee, but affordable \$50 to \$500.	Very cheap, \$10 - \$50.
<b>Type of content that can be sent</b>	Streaming music, videos, and high bandwidth data.	At max, text based data can be sent.
<b>Ease of use and implementation</b>	Lots of online documentation, and support for general public to use, and implement Wi-Fi based network.	Very technical for general users to understand and implement the technology. Require some knowledge regarding embedded systems.
<b>Availability</b>	Huge number of United States households and work places have Wi-Fi availability for Internet sharing as basic goal	Not widely implemented. It has to be implemented by manufacturers in their devices. Although, a lot of manufacturers use ZigBee for the device implementation, they are mostly hidden from common user.

## 5. STUDY OF APPLE HOME KIT

In June of 2014 at their World Wide Developers Conference (WWDC), Apple announced iOS 8 and highlighted some of the upcoming features. Among those features were two new “Kit” platforms, HealthKit and HomeKit, which are designed to integrate iOS with two rising digital-age trends: quantified self-healthcare, and smart homes. HealthKit is to your body and fitness gear, HomeKit is to your home and electronics.

HomeKit is not a single control application. It is instead a hardware certification platform, and database system that allows developers to create hardware. Moreover, it helps to integrate the hardware with iOS to provide for easy discovery, configuration, management, and communication between a wide variety of smart home products such as locks, lights, security equipment, and other home automation products.

Armed with HomeKit products and your iOS device, one can set up their home such that the lights turn on a specific time to wake one up. Furthermore, the thermostat could crank the AC up when one will be driving home on a hot day. Additionally, at the end of the day, one can snuggle into bed and talk out loud to their iOS device and tell HomeKit to shut the house down for the evening.

Home kit manufacturer certification criteria:

1. HomeKit products have to meet two criteria in order to be compatible with the HomeKit platform. First, they need to be certified through Apple’s MFi (Made For iPhone/iPad) Program, a certification process Apple has had in place for years (reaching back in some form or another all the way to the original “Made for iPod” certification circa 2005). This certification is designed to ensure that any product labeled works properly with Apple hardware, iOS, and that developers have said that hardware needs to adhere to specific rules and security practices.
2. HomeKit platform must include a custom encryption co-processor in all HomeKit certified hardware.

### 5.1 HOME KIT WORKING

HomeKit serves as the underpinning of your Apple-driven smart home experience. There is no central HomeKit control panel. For example, on your iOS device that you can just open up and control all your devices, HomeKit is always present in the background handling everything. The actual interaction comes in four forms: through the manufacturer’s application, through a third-party application created by an iOS developer, through Siri voice control, and via digital and physical triggers.

### 5.1.1 MANUFACTURER APPS

Every application for a HomeKit-certified device typically contains two HomeKit related elements. First, the application will have some ability to link your HomeKit-certified hardware to a scene, room, or a zone. For example, your smart bulb system might have a “scene” system where you can create scenes like “relaxation”, “movie time”, or “morning routine”.

It might also give you the ability to group lights together into physical rooms or zones like “bedroom” or “upstairs”. The second HomeKit related element is the ability to link the application to the iOS voice assistant Siri; you’ll find an option somewhere in the menu system of the application that reads like “Enable Siri”, “Enable Siri HomeKit Integration”, likewise.

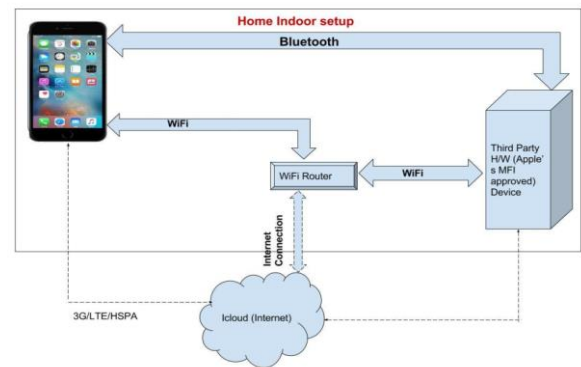


Fig -1: Speculated Architecture of Apple Home Kit

### 5.1.2 VOICE COMMANDS THROUGH SIRI

While the apps are great, (and essential to setting up and configuring the HomeKit environment) the real welcome feature of HomeKit is the integration with iOS’s digital voice assistant Siri.

Due to heavy Siri integration, HomeKit system can now be controlled with nothing more than the dedicated iOS device and user voice. There are online guides on how to add the Philips Hue system with the HomeKit.

Siri’s control is pretty flexible, and if there is a scene/room/zone and a matching task Siri can complete within the HomeKit database, she is pretty good about following natural language patterns to fulfill the commands. Commands such as “Turn off the office lights”, “Set the house to 75 degrees”, or “set morning scene” are all easily understood by Siri, if your product’s HomeKit hardware/app supports it. There are various third party manufacturers developing for HomeKit platform. Products such as coffee machines, colorful lights with brightness control, smart thermostats, video door bells, automatic garage doors, and alarm clocks are already available to common users for purchase.

## 6. GOOGLE'S NEST THERMOSTAT

The Nest Learning Thermostat goes beyond just simple temperature detection in order to make a real impact in user's HVAC energy consumption. In this section, we will see what Nest can do, how it does, what it does, who is behind it, and what challenges it faces in the HVAC industry.

### 6.1 CURRENT THERMOSTAT WORKING

To understand Nest's value, let's first look at what other thermostats do. All thermostats let you set a desired temperature, and monitor the current temperature. Many thermostats rely entirely on the user to set the temperature. Though in recent years, manufacturers have offered programmable thermostats that can help save energy. This helps the user program certain temperatures for certain times of the day. For instance, letting them automatically lower the temperature when they will be out of the house (to save energy). However, due to the complexity of these thermostats, people do not always program them correctly, which can negate most, if not all, of their energy-saving potential.

### 6.2 NEST SMART APPROACH

The Nest Learning Thermostat aims to solve this problem. Nest actually programs itself by learning its user's behavior patterns and desired temperatures for certain days and times during the week, and then builds a schedule for their HVAC. It is not the only smart thermostat in the market, but Google's purchase of Nest Labs for a reported \$3.2 billion in January 2014, has made it the most famous.

### 6.3 NEST FEATURES DESIGNED TO APPEAL TO CUSTOMERS

1. Nest uses various inputs to observe day-to-day routine of its user and uses them to maintain an HVAC schedule automatically, based on what it learns. (The company calls this Nest Sense technology.)
2. Nest creates an auto-away mode based on what it has learned. This sets a temperature for minimal HVAC activity, when the user is not in the building. The "set away" mode can also be manually set, if the user wishes.
3. While it is actively heating or cooling, Nest displays an estimated time for the system to reach the desired temperature.
4. Nest displays a green leaf any time the thermostat is running at energy-saving settings. This can help teach users to make energy-saving decisions. For example, if Nest has learned that they typically run the AC until the house is 74 degrees Fahrenheit (23.3 Celsius), they could turn up the temperature until you see the green leaf to save energy. The leaf will always appear at cooling settings of 84 degrees Fahrenheit (28.9 Celsius) or higher, and heating settings of 62 degrees Fahrenheit (16.7 Celsius) or

lower, but its threshold will change based on its user's habits.

5. Nest lets the user know what activity (between auto-away, user's own adjustments and the weather) results in the greatest energy savings throughout the day.
6. Nest uses Wi-Fi to connect to the user account at nest.com. This feature allows them to monitor and adjust the Nest remotely from the Web site.
7. Nest supports a mobile app available for Apple iOS (iPod Touch, iPhone and iPad) and Android devices. The app turns the mobile device into a remote control for your Nest.
8. Nest can be added to any number of thermostats in a multi-thermostat building. They will work alongside other thermostats, but note that each of Nest's energy-saving features only applies to the rooms in its sensor range, and to the HVAC components it controls.
9. A Nest account can manage up to 10 Nest devices, whether they are in the same building or at multiple locations.

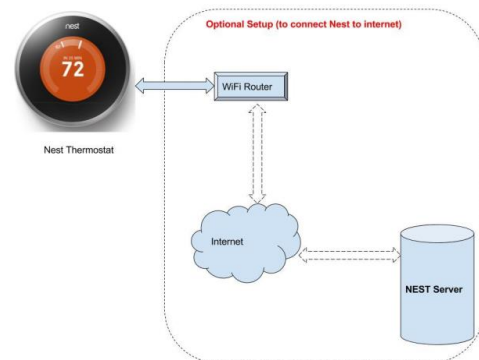


Fig -2: Speculated Nest Thermostat Network Architecture

## 7. IFTTT (IF THIS THEN THAT)

IFTTT also pronounced "lift" without 'L', is a very novel approach of controlling multiple devices by a trigger. IFTTT has a website and an application on both the Android market and the Apple store which encourages users to design their own triggers, actions and conditions to make compatible devices perform tasks. IFTTT calls these scripts with triggers Applets formerly called as Recipes.

1. For example, if a user just makes a recipe that the sensor inside his/her liquor cabinet detects that a bottle is fetched, then the system would tweet a celebratory message.
2. If one owns the Philips Hue smart lighting system, for instance, the user could use IFTTT to automatically turn on a light every time they are tagged in a Facebook photo.
3. In one more example, the user could use IFTTT to automatically email readers when they comment on

your WordPress blog. There are numerous combinations (called recipes) on IFTTT that can make life easier.

IFTTT is not a home automation platform; it is more general platform to perform a task if a trigger is met. It can simply send a notification on a Smartphone if the weather gets bad. In this example, there is no home automation used. Although, IFTTT is expanding to work with many home automation sensors and devices.

### 8. AMAZON ECHO

Amazon is another player in the market with their unique smart home device, named Amazon Echo. Amazon has been developing a comprehensive home automation product to help user order items from their website with just their voice. The device they were developing had to be intelligent enough to understand what the user needs just by natural language voice processing.

The Amazon development team had an idea that if they can connect Echo with home automation in a way that the device's natural language processing can be used for more than just order.

They came up with a minimalistic, yet intuitive design of a cylindrical speaker. The device is just a speaker with 7 noise cancelling microphones. The device can respond to any user's voice commands and their natural speech. Amazon's Echo device responds to a wake-up command. The command is 'Alexa' or 'Amazon' or 'Echo' as per the user sets the command. The Echo has multi-coloured light that indicate the user that it is listening. It lights up, when the wakes up and when command is spoken by the user.

#### 8.1 SPECULATING WORKING OF AMAZON ECHO

Let's speculate. It needs a Wi-Fi connection to connect to the home Internet, thus all the natural language processing and understanding should be done on the cloud. Echo has a female voice to talk back to the user. The sound can be heard from the speaker of the device. Echo can also play the user's favorite music. To do this, it has to have an access of the user's account along with the access of the cloud.

To setup Amazon Echo, an app is required to connect with the device's own Wi-Fi channel to provide login information, and preferences. Once the device is set, it keeps the track of the user's demands and learns about their requirements, and behavior.

#### 8.2 SPECULATED ARCHITECTURE OF AMAZON ECHO

Amazon Echo seems to have similar architecture to that of Google's Nest thermostat. However, it can do much more than just learn about the temperature preferences. Echo is a dedicated device which can be connected to the Internet using user's already setup home Wi-Fi network. The more detailed diagram can be shown in the diagram below.

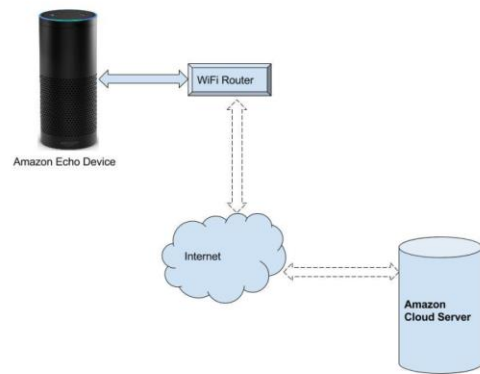


Fig -3: Amazon Echo Connecting to Cloud Server Speculated Diagram

The Amazon Cloud Server is a collection of different services such as voice processing server, searching for user requirements, login services, and many more.

### 9. BELKIN'S WEMO SWITCH

Belkin already had a name in networking devices, power, and cable accessories. Belkin came out with Wi-Fi based switch before companies like Apple, Google and Amazon came into the home automation business. The Wemo switches were launched in 2012. Back then, the Wemo switches were controlled with iPhone/iPod/iPad app. In January 2013, Belkin announced the support for Android OS. They also demoed their other home automation products line. New products such as smart motion sensors, IP cameras were displayed in Consumer Electronics Show (CES) 2013. They made huge interest regarding the capability of smartphones controlling home devices.



Fig -4: Belkin's Wemo Switch

Till then, numerous journal articles and white papers were written to control devices like lights, fan, and AC with the help of Bluetooth, ZigBee, and Wi-Fi, using a Smartphone app. The app connected with the hardware was something that the market was ready to embrace. The smartphone app concept became a fad. Belkin was able to leverage the peaking interest in 'what new can apps do?' idea.

### 9.1 WORKING OF THE BELKIN'S WEMO SWITCH

Wemo switches work with a bit different architecture as compared to Apple's HomeKit, and Amazon's Echo. As per a Gigaom.com article [23], Belkin does not think a centralized hub is necessary for developing a smart home environment. Apple's home kit and Amazon Echo both use a hub architecture to create their home automation platform.

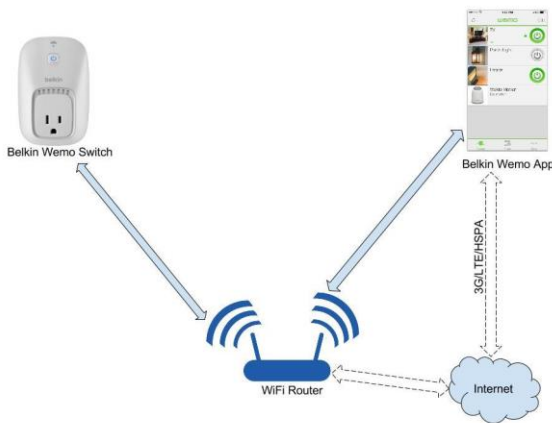


Fig -5: Belkin Wemo Speculated Connection Architecture

Wemo switch uses a dedicated IP address to connect with a Smartphone app. Each Wemo switch has an inbuilt Wi-Fi chip that can individually act as a TCP/IP server. The Wemo app is free to download through app stores. Once installed, the app asks user to connect with the Wemo's own Wi-Fi access point. The user has to manually connect to the Wi-Fi access point of Wemo switch. The app then requests user to enter the main router's login credentials. This router is the Wi-Fi router that connects to your smart device. The app then sends the credentials to the Wemo switch. The Wemo switch uses this login credentials to authenticate itself as a device on the wireless network, and receives an IP address on the network. The switch then sends it to its app, which stores it in its memory for sending and receiving messages.

### 10. BLYNK APPLICATION

Blynk is a Platform with iOS and Android apps to control Arduino, Raspberry Pi, NodeMCU and several other boards over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets.

Mobile app was built and customized by Blynk. Data is collected and stored in Blynk Cloud. Hundreds of companies around the world use Blynk for their connected home products, real estate monitoring, and home automation.

Blynk help businesses to build successful connected products. This platform enables organizations to move smoothly from prototype to production in short iterations, collecting feedback, and refining the product at every

development stage. With Blynk, a single engineer can get any electronic equipment online, connect it to the Internet, and build a mobile application in minutes to remotely monitor and control it.

### 10.1 WORKING OF THE BLYNK APP

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things.

There are three major components in the platform:

1. **Blynk App** - allows us to create amazing interfaces for our projects using various widgets they provide.
2. **Blynk Server** - responsible for all the communications between the Smartphone and hardware. We can use Blynk Cloud or run the private Blynk server locally. Its open-source could easily handle thousands of devices and can even be launched on a Raspberry Pi, Arduino or NodeMCU.
3. **Blynk Libraries** - for all the popular hardware platforms - enable communication with the server and process all the incoming and outgoing commands.

Now imagine, every time we press a button in the Blynk app, the message travels to the Blynk cloud, finds the linked hardware through the authentication key and then sends the message to the hardware. Once the message is received by the hardware, it performs accordingly or as programmed. It works the same in the opposite direction and everything happens in the blink of an eye. Figure below shows the working of the Blynk app.

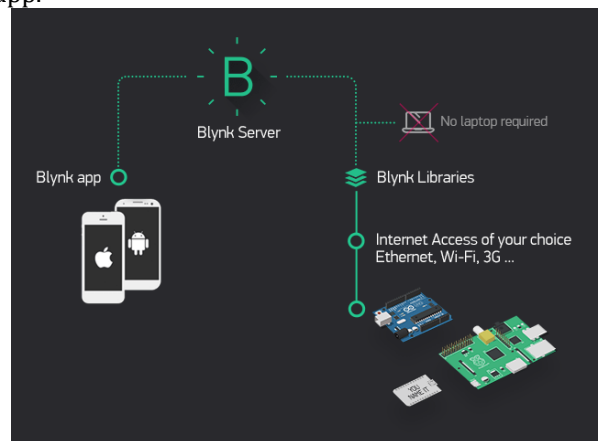


Fig -6: Working of the Blynk App

### 11. CONCLUSION

The aim of this paper was to study and review the existing Home Automation systems. Most of the popular Home Automation techniques and its working has been speculated as the standards, hardware architecture, software models,

and protocols of the companies are hidden. Home Automation techniques of various models and its working has been studied and reviewed successfully.

This study can influence us and help us design and develop our own home automation system. As the above studied home automation products are bit expensive and most of us would think twice before owning them. An effort can be made to design a cost effective, low energy Home Automation system.

## REFERENCES

- [1] ABI Research on home automation future: <https://www.abiresearch.com/press/15-million-home-automation-systems-installed-in-th>
- [2] Pew Research center: <http://www.pewInternet.org/2014/04/03/older-adults-and-technology-use/>
- [3] Nest Thermostat: <https://nest.com/thermostat/meet-nest-thermostat> R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.
- [4] Blynk working: <https://docs.blynk.cc/>
- [5] Blynk: <https://www.blynk.cc/>
- [6] IFTTT working: <https://www.pocket-lint.com> › Smart Home › Smart Home news
- [7] IFTTT: <https://ifttt.com/discover>
- [8] Google Nest news: <http://www.independent.co.uk/life-style/gadgets-and-tech/google-buys-nest-what-does-this-mean-for-home-automation-the-internet-of-things-and-apple-9058217.html>
- [9] Gigaom.com: <https://gigaom.com/2014/10/03/belkin-looks-at-the-smart-home-and-doesnt-see-a-place-for-hubs/>
- [10] ZigBee as Communication Platform for smart house applications: International Journal of Engineering - ISSN: 1584-2673
- [11] IOT Bytes pinouts: <https://iotbytes.wordpress.com/>