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Creation of a voice-driven controller for home automation

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Granada, 13 de agosto de 2018

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Creación de un controlador domótico activado por voz

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Palabras clave: domótica, asistencia por voz, sistemas distribuidos, Raspberry Pi, software libre

Resumen

El objetivo principal de este proyecto es la creación de un controlador domótico activado por voz en un sistema embebido, como la *Raspberry Pi*, centrándose en el uso de software libre, obteniendo la máxima compatibilidad y el mínimo coste.

Para conseguirlo, se ha analizado la situación actual del sector, distinguiendo entre dispositivos domóticos, asistentes de voz y sistemas orientados a la automatización del hogar. A través de la Ingeniería del Software, se han estudiado las posibles necesidades de los usuarios, intentando suplir las carencias actuales del sector. Finalmente, se presenta una implementación de un sistema domótico en un entorno real, utilizable y extensible a cualquier situación cotidiana.

Por tanto, el proyecto trata de demostrar las infinitas oportunidades que habilita el reciente campo de la domótica, y la posibilidad de crear sistemas domóticos funcionales de bajo coste.

Creation of a voice-driven controller for home automation

David Vargas Carrillo

Keywords: home automation, voice assistance, distributed systems, Raspberry Pi, open source

Abstract

The main goal of this project is the creation of a low-cost, voice-driven home automation controller in a embedded system, such as the *Raspberry Pi*, using open source technologies and trying to obtain maximum compatibility with minimum cost.

To achieve this, I have analyzed the current state of the sector, distinguishing between domotic devices, voice assistants and home automation oriented systems. Through Software Engineering, I have studied the possible necessities of the users, trying to make up for the scarcities in this sector. Finally, I show an implementation of a home automation system in a real environment, usable and extensible to any daily situation.

Therefore, this project tries to demonstrate the infinite opportunities that the recent field of domotics enables, and the possibility of creating low-cost functional home automation systems.

Yo, **David Vargas Carrillo**, alumno de la titulación GRADO EN INGENIERÍA INFORMÁTICA de la **Escuela Técnica Superior de Ingenierías Informática y de Telecomunicación de la Universidad de Granada**, con DNI 76592492P, autorizo la ubicación de la siguiente copia de mi Trabajo Fin de Grado en la biblioteca del centro para que pueda ser consultada por las personas que lo deseen.

Fdo: David Vargas Carrillo

Granada, a 13 de agosto de 2018

D. **Juan Antonio Holgado Terriza**, Profesor del **Departamento de Lenguajes y Sistemas Informáticos** de la **Universidad de Granada**.

Informa:

Que el presente trabajo, titulado ***Creation of a voice-driven controller for home automation***, ha sido realizado bajo su supervisión por **David Vargas Carrillo**, y autoriza la defensa de dicho trabajo ante el tribunal que corresponda.

Y para que conste, expide y firma el presente informe en Granada, a 13 de agosto de 2018.

El director:

Juan Antonio Holgado Terriza

Agradecimientos

A mis padres, cuyo esfuerzo y dedicación han hecho que hoy esté escribiendo estas líneas.

A todos los compañeros y amigos que han estado conmigo en este camino, por haberlo hecho mucho más agradable y ameno.

Y, por supuesto, a Juan Antonio, por haber aceptado mi idea y haber hecho posible este proyecto.

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Chapter 2

Home Automation

Home automation, also known as domotics, has been a recurrent topic in Computer Science that has become a reality in the last decades, thanks to the growth and decrease in the price of embedded systems and wireless technologies, that have permitted to create distributed systems, the heart of this technology.

In this chapter, I am going to analyze this technology and its current state, including its implementation in commercial products.

2.1 What is Home Automation?

Although science fiction has represented the idea of smart houses since the past century, including in them an intelligence able to respond to all the dweller's needs and desires, it has never felt as close to real world as today.

The basic idea of home automation is to employ sensors and control systems to monitor a dwelling, and accordingly adjust the various mechanisms that provide heat, ventilation, lighting, and other services. By more closely tuning the dwelling's mechanical systems to the dweller's needs, the automated ïntelligent ̈home can provide a safer, more comfortable, and more economical dwelling.[21] For example, the automated system can determine the intensity and direction of the sunlight, and adequate the house according to its condition (which would include closing the blinds and adjusting the air conditioner).

Unlike many may think, we don't actually need a very modern house, since advanced systems can be perfectly integrated in older, traditional buildings. This fact makes domotics a real possibility in every situation. In fact, the number of home automation systems installed in Europe is expected to reach around 29 million by 2019.[17]

Figure 2.1: Example of a smart home with security-oriented devices

Therefore, a Smart Home is expected to meet the following applications.

- Temperature control, including heating, air conditioning and air ventilation.
- Lightning control.
- Occupancy detection.
- Power control.
- Security system, including theft, or smoke or fire detection.
- Baby and pet care.
- Basic health control, like water and air monitoring.

There is not an exact point where we can set the beginning of the domotics as a real concept, but during the last century there has been some remarkable efforts, and even before. In 1898, Nikola Tesla created a wireless control for a toy boat, the first of its kind [2]. That marks the beginning of wireless technologies, one of the fundamental parts of Home Automation.

Figure 2.2: The Clapper, a sound-activated switch

In 1975, after lots of appearances of the idea of home automation in films, the first general purpose home automation technology, called X10, was developed. X10 defines a protocol for communication between electrical devices, which uses power line wiring for signaling and control, where the signals involve brief radio frequency bursts representing digital information. Therefore, it also defines a wireless radio based protocol. Surprisingly, the X10 technology is still widely used and available, with millions of units in use worldwide.

However, it was not until 1984 that the word Smart Home appeared, invented by the *American Association of House Builders*. After that, different inventions rapidly followed one another, with devices such as
The Clapper (which was operated through sound, like a clap or a bark) and interest from the biggest technological companies, like Microsoft.

Home Automation has not stopped gaining ground on our homes and now it is experiencing one of the best moments in its lifetime, with the unstoppable growth of the Internet of Things (IoT) and the simultaneous development of Artificial Intelligence for the general public, with the biggest companies, like Google and Apple, investing millions of dollars on it. Devices like Amazon Echo and Google Home, or assistants like Siri, Cortana, Google Assistant and Amazon Alexa are a good representative of this trend. I will talk in depth about them in the following chapters.

We have always imagined that Smart Homes would bring us a whole world of benefits. And that is partly true, but they have ended up offering benefits that no one could imagine some decades before, when matters such as energy savings were not as important as today. These benefits are

responsible for their increasing popularity, and they can be summarized in the following points:

- **Control anywhere:** Smart Homes can be completely controlled anywhere in the world from smart phones or other devices with Internet connection, so we can know the status of our devices at any time. That would allow us, for example, to stop worrying when staging out of home thinking if we have left the air conditioning on.
- **Safety:** there are tons of security systems ready to work on Smart Houses. They are capable of monitoring the people going in and out of home and send alerts to the owners if necessary. Like many other devices, there are also smart locks for the door and cameras that we can control from our smart device.
- **Accessibility:** Smart Homes can increase a lot the quality of life of elderly or disabled people, as they can be managed via voice commands, making the interaction much easier to people which is not experienced with computers and improving their independence.
- **Energy efficiency:** one of the main goals of Home Automation is to work with the least amount of energy needed, and a big part of the research in this field is going in this direction. There are induction cooktop stoves that can be powered on only if there is anything placed over them (and even get the perfect cooking, powering off themselves)[4] or heating systems that power on and off depending on the weather and inner conditions of the home, or even a faucet technology that can maximize shower water usage by shaping the individual droplets of water, so the experience feels almost the same but with less water usage.
- **Money saving:** the last point leads to another benefit: saving money. Smart Homes can use less energy and water, making a big difference in how much we pay at the end of the month. Reports show that the savings on the energy bill for this reason range from 10% to 30%.[4]
- **Comfort:** Smart Houses can also help save time. Today, when everyone is trying to make the most of their free time, this technology is capable of doing housework, so that people can spend their time on things they enjoy most, or simply gain time to spend with their families.

This range of benefits has made possible to see home automation systems in many homes, but also in offices. Now, almost every new house that is built is prepared for domotics, including Internet access points in every room, a

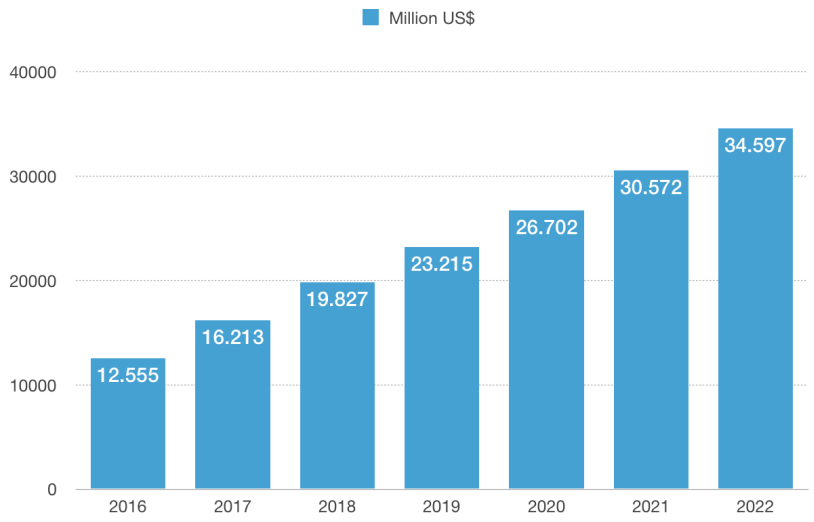

Figure 2.3: The Smart Home Market revenue from 2016 to 2022 in the US[18]

big amount of plugs, and a lot of space to extend its capabilities in a future. Indeed, the global home automation and security control market is expected to reach 12.81 billion dollars by 2020.[12] The following charts is a perfect example of how rapidly is growing the Smart Home sector and how powerful it is at this moment, showing the data for the most important Smart Home market at this moment: the United States.

Predictions are not bad either: they show that this trend will continue in the coming years, reaching 34.5 million of the US dollars, and this is just in the United States, although there will be similar situations in the rest of the world.

2.2 Home Automation System Design

After a look at the definition and history of Home Automation and its benefits, I am going to explain how these systems are usually organized. There is more than one valid way, and it will always depend on the requirements and conditions of the user, the home environment and of course the capabilities of its components.

First of all, from all the elements present in a Smart Home Environment, we can mainly distinguish the following ones:

- **Controller or controllers:** which are usually devices in charge of

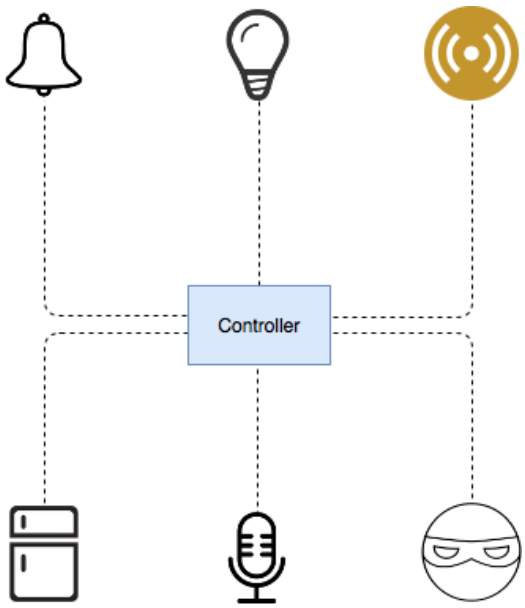

Figure 2.4: Centralized Smart Home structure

processing the data and take decisions, as well as communicate the devices between them and with other controllers, if any.

- **Sensors:** they are devices that are capable of perceiving changes in their environment by different means (audio, video, movement...). Examples of sensors are motion sensors or microphones.
- **Actuators:** these devices are the opposite of the sensors. They can inform of events, but they can also make changes in their environment. An actuator could be a light bulb or a speaker.
- **Communication mediums:** this is what devices and controllers use for communication. They can use the power grid, or by wireless protocols, like WiFi or Zigbee.

The figure 2.4 is a good example of a basic organization for Home Automation[5]. This organization has a name, indeed: centralized architecture.

2.2.1 Centralized Architecture

In a centralized Smart Home Environment architecture, the Control System, which is realized by means of a computer system, is in charge of acquiring data from sensors, providing a user interface, and executing the control

algorithms and sending instructions to actuators.[20] In the example in the figure 2.4, the sensor, in the upper right corner, could represent a smoke detector that can trigger the alarm (the actuator) to alert the householders.

The controller is often called Home Gateway, and in this case it is the central computer. It is also responsible of making accessible the system via Internet, as well as providing services to the home residents. An option to increase its performance while maintaining the same architecture is to limit the functionalities of the Home Gateway to data acquisition, software interfacing with domotic devices and basic processing, and to delegate to more powerful servers outside home the most part of the processing.

If they are placed in a powerful system, it is probably beneficial to use this architecture and get the maximum performance, which is ideal in big, complex systems.[11] However, there is only a controller and the system fully depends on it. If it failed, the whole system could be affected, which is a major issue in a Smart Home Environment.

This is the most popular architecture in home automation, partly because product manufacturers tend to centralize communications between their intelligent devices in a hub or gateway of the same brand, which users need to install to operate the rest of the devices.

2.2.2 Decentralized Architecture

In this case, there is more than one controller in the system. They are interconnected with a bus, so each one of them can interact and communicate with the rest. An example system that could use this architecture is a system with smart devices connected to hubs from different makers, and all of them interconnected thanks to a system that can work with all of them.

In the figure 2.5, we can spot three different controllers. Although the example shows a simple configuration, with this architecture it would be possible to interconnect big centralized systems, making one even bigger. Each controller is an independent system, and in this case they represent a lightning system, a voice assistant and a smart system for the garage.

2.2.3 Distributed Architecture

In a distributed Smart Home Environment architecture, the Control System software is conceptualized and implemented as a distributed computing system, that is, a series of intercommunicating devices working together to achieve an end, which in this case is running a Smart Home system. The integration and interoperability of heterogeneous domotic devices is achieved by an intermediary software layer called *middleware*.[20]

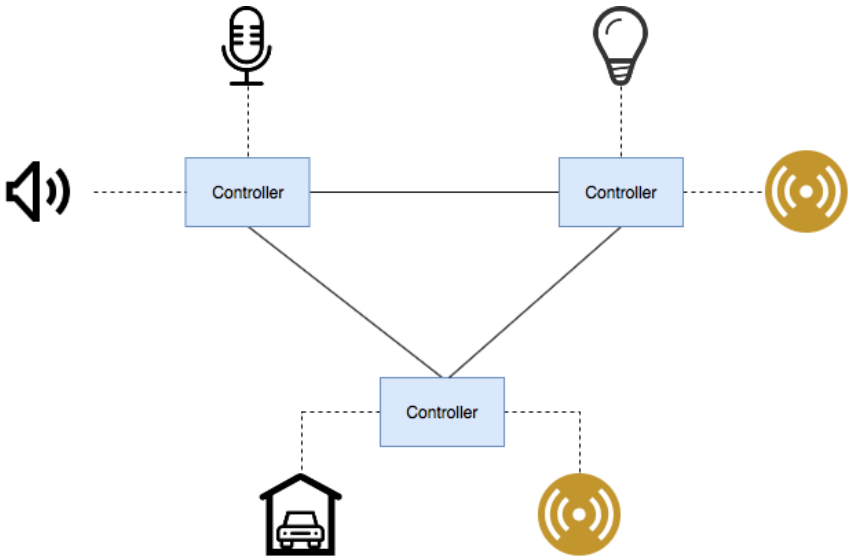

Figure 2.5: Decentralized Smart Home architecture

The distributed architecture benefits from the computational resources of smart devices to integrate software components into the nodes of the Home Automation network, which produces a big increase in autonomy and modularity[11]. However, the cost of this architecture is significantly higher compared to the centralized architecture, and therefore it is hard to achieve a fully distributed architecture. For this reason, this architecture is often applied conceptually, while still physically centralized into the Home Gateway.

In the figure 2.6 we can see an example of this architecture applied over a similar example as the one shown in 2.4. In this case, we can distinguish 4 independent but intercommunicated devices. For instance, the one at the upper right corner could contain a motion and a sound sensor, that could activate the alarm system located in the bottom right corner. The most important part about the distributed architecture is that each device acts as a controller as well, so there are not independent controllers anymore.

2.2.4 Hybrid Architecture

This architecture is a hybrid of the architectures mentioned above. In a system that follows this architecture, we may find a central controller (such as a centralized system), or a set of them (as the decentralized system), but also the end devices are controllers themselves, as it happens with distributed systems.

The main benefit of this architecture is that the devices are able to

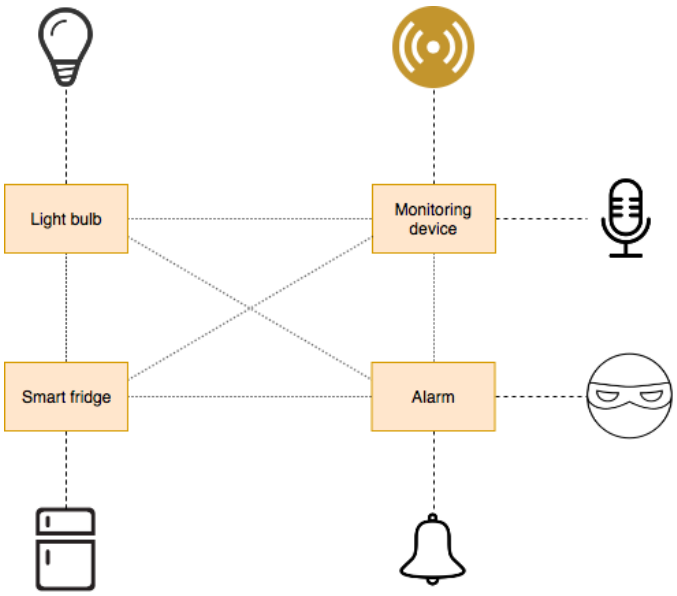

Figure 2.6: Distributed Smart Home architecture

retrieve, process and communicate the information they get directly between them, so it does not have to pass through the controller. On the downside, this architecture could create an unnecessary mess in our system.

In further chapters, I will explore more in depth Home Automation applications and technologies, showing different devices and their usages. Finally, I will use this knowledge to create a home automation controller, which will be functional in a real environment.

Chapter 3

Voice Assistance

We spend so much time using devices that have integrated voice assistants that we usually forget how incredibly fast they have evolved. Nowadays, they can recognize thousands of words and expressions really fast, and they are even capable to imitate emotions. What is more, they fit in a pocket. But the reality was totally different just a couple of decades ago. From the IBM Shoebox to Siri, in this chapter I will explore the fundamentals of voice assistance.

3.1 What is Voice Assistance?

Voice assistance is the result of another form of interaction between humans and computers.[3] The Voice User Interface (VUI), which has the voice assistants as a result, allows a user to interact with computer or mobile or other electronic devices through speech or voice commands. Thus, VUI is an interface of any speech recognition applications.

Therefore, a voice assistance, also known as virtual assistant, is an application program that understands natural language voice commands and can perform tasks or services for an individual. Its expansion has been truly remarkable in the last few years, to the point that we can see devices that exclusively work as virtual assistants, with integration with many other services. Its real usefulness in society, though, remains to be seen, as this field is commonly viewed with skepticism and mistrust, and the fact of talking to a machine as if it were another human being remains an obstacle to overcome.

As I mentioned, voice assistants are now present in plenty of platforms:

- **Smart speakers:** Google Home (Fig. 3.1), Apple HomePod, Amazon Echo, Movistar Home.

Figure 3.1: Google Home, a smart speaker integrated with the Google Assistant

- **Mobile operating systems:** Siri on iOS, Google Assistant on Android, Bixby on Samsung phones.
- **Desktop operating systems:** Siri on macOS and Cortana on Windows 10.
- **Smartwatches**: Apple Watch, Google Wear OS.
- **Cars:** Apple CarPlay, Android Auto.
- **Televisions:** Siri on Apple TV (Fig. 3.2) and the voice assistant in Samsung Smart TVs.
- **Inside mobile apps:** EVO Assistant in the mobile application of the Spanish bank EVO.

The history of voice assistance goes back to 1961, when IBM introduced the IBM Shoebox.[19] This was a very innovative product at that moment. Although it was not suitable for commercial use, it did mark the beginning of a revolution, the fruits of which we can now see.

The Shoebox was capable of recognizing 16 spoken words, including ten digits from 0 through 9. When a number and command words such as *plus*, *minus* and *total* were spoken, Shoebox instructed an adding machine to calculate and print answers to simple arithmetic problems. It classified the electrical impulses generated from a microphone according to various types of sounds and activated the attached adding machine through a relay system.[6]

Figure 3.2: Apple TV and the Siri Remote, which has a microphone to interact with the assistant

Later on, there were more attempts from the research field, as the HARPY Speech Recognition System from the Carnegie Mellon University, in 1976.[22] Is could recognize about 1000 words.

Nevertheless, it was not until 1990 that the first speech recognition for consumers appeared: the Dragon Dictate. Seven years later, the same company presented the Dragon NaturallySpeaking, which introduced continuous speech recognition as a novelty. They led the way with competent voice recognition and transcription. This field attracted the attention from big companies of that time, and Microsoft began working on their own assistant: Clippy, in the Microsoft Office suite. In spite of the fact that this was not a voice assistant exactly, it showed how natural language could be interpreted and used in order to allow the human-computer interaction. It was quite unpopular and Microsoft decided to end it on 2001, but its impact was huge for the assistants that followed it. A bit before Windows XP, Microsoft introduced the speech recognition feature in their Office XP suite.

With the launch of Siri in 2014, Apple marked the modern era of voice assistants. For the first time, people could fit a full functional voice assistant in their pocket. And most importantly, Siri reached a wide audience and began to popularize this technology. Siri was able to make searches on Internet and reproduce the results, to set reminders and events in the calendar or to call any contact by its name, between many others. In addition, it included a layer of *natural interaction* with the user, being able to respond to any other phrase as any other human would (even to sentences that were

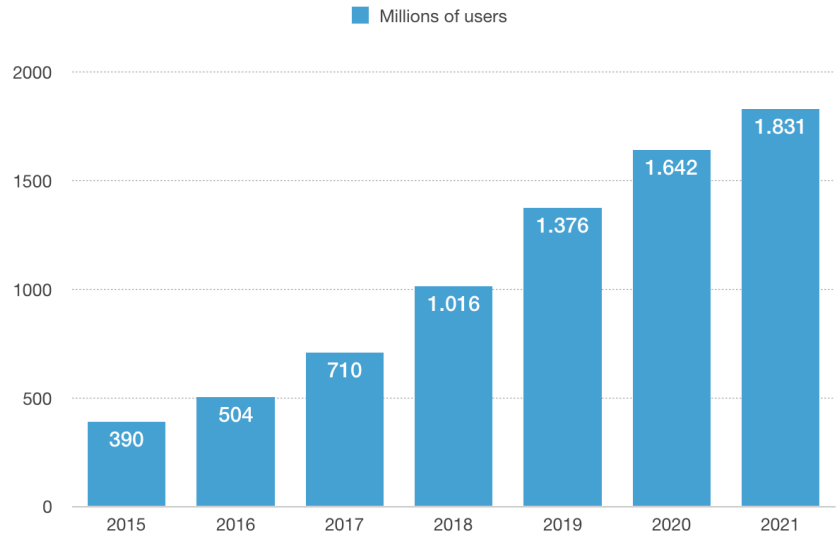

Figure 3.3: Estimated number of users of virtual assistants worldwide [16]

not commands, like *How do you feel today?* or *Tell me a joke*).

Google, with Google Now, and then Microsoft and Amazon, with Cortana and Alexa respectively, followed this trend, even improving on what Siri failed, and in the case of Microsoft, making a voice assistant available on PCs as well. Then, in 2014, Amazon introduced Echo, the first smart speaker of all time. It was just the beginning of what we now call the *Smart Speaker Revolution.*[19]

After the Echo, Apple and Google followed with the HomePod and Home, respectively. In fact, Google Home has been recently launched in Spain, and the HomePod is not available yet, as an example of how recent this technology is. Its number of users is expected to continue to grow, and even faster than it has already done.[16]

3.2 Services Voice Assistants Provide

The range of services provided by voice assistants is constantly becoming bigger, as they are a booming technology that is constantly receiving new updates. The following are shared by most of the virtual assistants currently:

- Provide information, such as weather forecast, routes to any point in a map or general knowledge.

- Manage components in a Home Automation environment.

- Interact with media content, such as music and video (which is commonly integrated with streaming services, like Netfix or Apple Music).
- Make phone calls and send instant messages.
- Manage the personal agenda.
- Provide accessibility indications.
- In call centers, they complement or replace the customer service by humans.

We are nowadays in the first stages of this new technology, that combines artificial intelligence, machine learning, voice recognition and human-computer interaction. Google is the company that apparently has done the biggest advancements and, in fact, they have recently introduced Google Duplex, a technology capable of almost perfectly simulating a human speech, which can be used for a wide range of purposes, such as ordering food or making an appointment with a hairdresser. This would be a new service to include in the previous list.

They are also providing very useful tools to developers and makers, like the Cloud Speech-To-Text API. I will come back to this technology in the following chapters, as it will be an essential part to achieve my objective, the creation of a voice-driven home automation controller, a service that can also be seen in the previous list.

Chapter 4

Product Analysis

The aim of this chapter is to provide a detailed analysis of the devices more closely related to this project, now that we have a clearer idea about its main pillars. I will go into many of the available commercial devices and software in the fields of home automation, voice assistance and smart devices.

4.1 Home Automation Systems

This section covers all the hardware and software systems related to home automation. As we will see, there are lots of solutions with very different purposes: while there is Amazon Alexa, a full hardware and software system that integrates other home automation systems, we can also find pure online solutions, like the automation platform IFTTT. Sometimes, home automation systems are built underneath a virtual assistant, as it happens with Amazon Alexa, so some devices are going to appear in this section and in the next one. However, they will analyzed from two different perspectives, as having a good virtual assistant does not mean having a good home automation system.

4.1.1 Philips Hue

Philips Hue is a personal wireless lighting system aimed at the smart home. In combines LED light bulbs, LED strips and other lightning devices, and sensors that can be configured in their mobile app, so they can modify the home lightning based on a set of rules. There is a wide range of products, including color and only white lights, so users can build a pretty customizable lightning experience.[10]

The system requires a bridge connected to the Internet (called Philips Hue Smart Hub) in order to work. This is because the Hue devices do not

Figure 4.1: A Philips Hue dimmer switch, three color light bulbs and the Hue Smart Hub

use WiFi in order to communicate with the bridge, but the system needs to have WiFi to be controllable from a mobile phone. Thus, it follows a centralized architecture. Moreover, Philips does not provide any type of assistant or external interface to manage the system apart from the mobile application by default, although Hue works with the most popular home automation systems, like Alexa or Apple HomeKit, that provide much more flexible home automation management.

4.1.2 LG SmartThinQ

LG SmartThinQ groups the range of Wi-Fi enabled home appliances made by the company LG, including refrigerators, dishwashers, vacuum cleaners or air purifiers, between others. As of September 2017, they were the most extensive range of devices of their kind.[7]

Unlike Philips Hue, SmartThinQ devices do not require a bridge to work. They can be controlled from the mobile phone and, in some cases, like in the refrigerators, they include a touchscreen to interact with the device. However, LG does not provide any extra device or virtual assistant to interact with them, though they are manageable through Amazon Alexa and Google Assistant. A standard setup with this system will follow a hybrid architecture, as some devices are also their controllers, but there can also be external controllers.

4.1.3 Samsung SmartThings

Samsung SmartThings is a home automation system composed by a series of applications for the Samsung mobile phones, Samsung TVs and Samung refrigerators. It is even possible to do small management tasks from Samsung smartwatches, called Galaxy Gear. It uses the cloud to synchronize all the applications, in order to have the most recent information in all of them. This makes it necessary for the user to have a Samsung account.[13]

Unlike the previous systems, SmartThings is not a specific system for a range of devices from the same maker, but it is more aimed to provide an effective interconnection between devices from different makers, as long as they are compatible with their system. The SmartThings Smart Home Hub is necessary in order to use Samsung SmartThings. It is a bridge that supports common home automation protocols, like Zigbee or Z-wave, essential to manage some devices that only use these protocols. It also provides comprehensive automation options.[14] The usage of the Hub makes the architecture of this system centralized.

Furthermore, SmartThings is not yet compatible with many commercial devices, and the restrictions imposed by Samsung forces the user to stick to their environment. In addition, the system is not open source, so making any modification apart from the ones that Samsung allows is impossible. Also, users are forced to purchase the Smart Home Hub, which makes it necessary to have an additional device, unlike other similar systems. The system is compatible with Bixby, the virtual assistant from Samsung.

4.1.4 Google Home

Introduced at Google I/O 2016, the annual Google developer conference, *Google Home* is the name of Google's smart speaker, which is Google's biggest insight into home automation technology. Its aim is to work with all the possible smart home devices, so it follows the same idea as the Samsung SmartThings system, being a *maker-independent* system, as long as, of course, devices are compatible with it. Also, Google Home brings all the functions of Google Assistant to the smart speaker.

The main difference with SmartThings is that this system is mainly voice-driven. The home automation layer is pushed down to just one more function of the virtual assistant, and Google does not even provide a graphical interface to manage the smart devices. Anyway, normally the makers of each device provide a mobile application from where users can manage their devices in a more user-friendly interface, but having a centralized view is a desirable feature. On the bright side, all Google devices that support Google Assistant can automatically control smart home devices.

The number of compatible devices with the Google Assistant, unlike SmartThings, is very high, and almost any new smart home device is tagged as compatible with it.

4.1.5 Apple HomeKit

HomeKit is the result of Apple's efforts to create a home automation environment adapted to its devices. It has been also made to work with a wide

range of devices, but in this case, Apple included some notable security policies, with the goal of achieving the highest security and privacy. In fact, all HomeKit devices need to be approved by Apple first.

On iPhone and Mac computers (starting with macOS Mojave), Apple includes an application called Home, which displays all of the smart home devices in a convenient way and lets people organize and manage them. In addition, it is also possible to establish automation rules, based on the user's location, time of day, actions or even occupancy of the house. Furthermore, Apple also provides integration with their personal assistant, Siri. As it happens with the Google Assistant, all Apple devices configured with the same Apple ID will have the same information automatically synchronized.[1] Usually, systems made under Apple HomeKit will follow a decentralized architecture.

Although this is a very comprehensive home automation system, the number of compatible devices is not as high as in other options. Apple has been lately working on promoting their home automation system and their assistant by introducing the HomePod, their smart speaker with Siri.

4.1.6 Somfy

Somfy is a French company founded in 1960, which since the 1980s has been devoted to the construction of home automation systems. They have implemented their solutions in important places, like the United Nations Headquarters or the Vancouver Convention Center and have created their own home automation technologies, such as *Radio Technology Somfy (RTS)* and *Somfy Digital Network (SDN)*.[15]

Their range of products goes from control devices (as hand-held remotes, mobile applications and wireless switches) and sensors (sunlight, temperature, wind) to blinds, lightning systems and other smart home utilities. Unfortunately, the control devices only work with Somfy devices. The system follows a hybrid architecture, where each device is a controller, but there can also be extra controllers, like the hand-held remotes.

In addition to the previous domotic systems, which are proprietary, there are also open source and more customizable solutions that, although they may require more time in their configuration, are much more adaptable to the needs of the user. I will explore three of the most popular: openHAB, Home-Assistant.io and Jeedom.

4.1.7 OpenHAB

OpenHAB, the acronym for Open Home Automation Bus is an open source, technology agnostic home automation platform which runs as the center of the smart home. [9] This means that its aim is to integrate different home automation systems into a single one. It allows the user to configure almost every aspect of the system, providing a common interface and a uniform approach to automation rules.

In its most recent version, openHAB 2, it has implemented new user interfaces that automate many processes, so it is almost unnecessary to write a single line of code, making the system more attractive to all types of users. OpenHAB needs to be installed in a computer that will act as a server in the local network, making the system accessible via HTTP. It also offers more connectivity options that I will explore in the following chapters. The architecture, in this case, is decentralized, as there may be multiple controllers, including openHAB itself.

OpenHAB's compatibility is somewhat limited when it comes to home automation devices, but it supports Apple HomeKit and common protocols, such as ZigBee and Z-Wave, to get rid of specific gateways from other systems.[8]

4.1.8 Home-Assistant.io

Home-Assistant.io, or simply Home Assistant, is a open source home automation platform running on Python 3. Based on a distribution called *Hass.io*, it creates a secured local server in the computer where it is installed. It is accessible via HTTP and also includes a web user interface that will automate the process of discovering and configuring devices. In terms of functionality, it is very similar to openHAB, although it might be a little simpler for some users, as it uses the YAML syntax for configuration, while openHAB has its own.

Its functionality is organized in *Components*, the name that Home Assistant gives to any add-on, which will add a compatibility layer with a device, system or service. They are fully backed by the Home Assistant community and they are similar in number and type to what openHAB provides, but with very interesting additions, including Wink and Arduino.

4.1.9 Jeedom

Jeedom is a open source, multi-protocol, autonomous and customizable home automation software. It is aimed for individuals and professionals, and provides custom support for both. They also sell what they call *Boxes*,

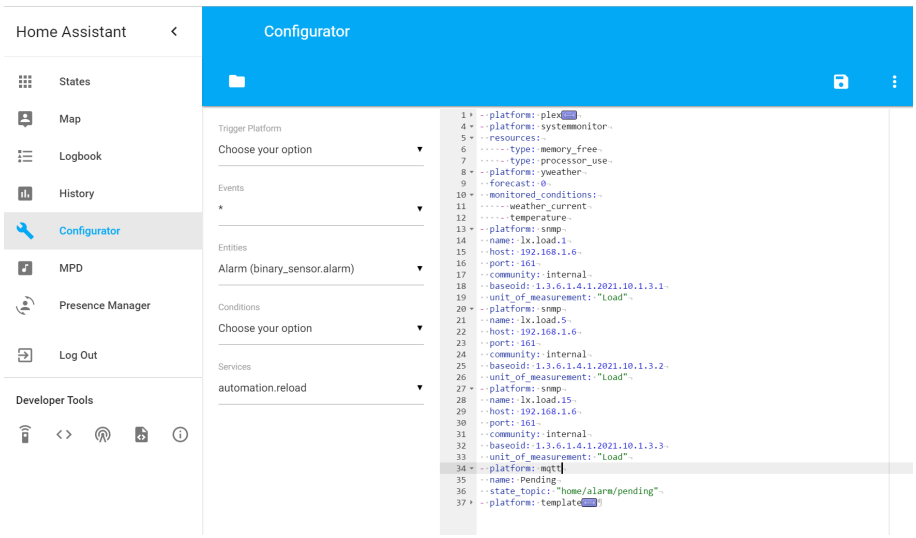

Figure 4.2: Home-Assistant.io web user interface

which are small computers with Jeedom pre-installed, although their software can be installed on any Linux system. Jeedom also provides mobile phone apps for Android and iOS, which connect to the Jeedom system by scanning a QR code. As in the previous platforms, they also provide the *Jeedom Market*, from where users can add new features to their system.

Also, there are different Jeedom versions, which are called *Service packs*. There is the free and open source version, which includes the lowest number of functionalities. Then, the other versions can be purchased, although some of them come with their Boxes, and they include dynamic DNS and HTTPS, the mobile application for free or more plugins offered, among other things.

Although the free version is fully open source, the limitations that it has and the obligation to pay in order to have the *full experience*, could annoy some users and make them lean towards other platforms.

It seems difficult to directly compare these home automation systems, but all of them share characteristics that we can contrast. The table 4.1 represents a comparison of the features that I consider most important.

4.2 Voice Assistants

System name	Developer	Free	Open source	Architecture	Requirements	Extra software	Extra hardware	Compatibility
Hue	Philips	No	No	Centralized	Hue Smart Hub	Mobile app	Hue devices	Only for Hue devices Integrable in Alexa, Google Assistant, HomeKit
SmartThinQ	LG	No	No	Hybrid	None	Mobile app	SmartThinQ devices	Only for SmartThinQ devices Integrable in Alexa and Google Assistant
SmartThings	Samsung	No	No	Centralized	Smart Home Hub	Mobile app	Samsung smart home devices	Compatible with devices from different makers Integrated in Bixby
Assistant	Google	No	No	Centralized	A device with Google Assistant	Google Home app	Google Home smart speaker	Huge compatibility with devices from different makers
HomeKit	Apple	No	No	Decentralized	An Apple device	Home app	Apple HomePod	Compatible with devices from different makers Integrated in Siri
Somfy	Somfy	No	No	Hybrid	None	Mobile app	Somfy smart home devices and controls	Only for Somfy devices
openHAB	The openHAB Community and the openHAB Foundation e.V.	Yes	Yes	Decentralized	A computer with Internet connection	myopenHAB openHABian	None	Compatible with devices and services from different makers, fully customizable
Home Assistant	The Home Assistant community	Yes	Yes	Decentralized	A computer with Internet connection	iOS app Hass.io	None	Compatible with devices and services from different makers, fully customizable
Jeedom	Jeedom SAS	Part.	Part.	Decentralized	A computer with Internet connection or a Jeedom Box	Mobile app	Jeedom Boxes	Compatible with devices and services from different makers

Table 4.1: Comparison between different home automation systems

Chapter 5

OpenHAB

openHAB

Chapter 6

Project Development

Project development

Chapter 7

Conclusions and future work

Conclusions and future work.

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