CONTROLLING LIGHT IN A DEFINED ROOM VIA A MOBILE APPLICATION

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ABSTRACT

Implementation of a specific home automation function, which consists of turning a light bulb on or off remotely in a test room that is connected to the ESP8266 chip. This action will be indicated by voice commands, compiled by the Android operating system and its Speech Recognizer class that operates through an application designed for mobile devices. The information that enables such operations will be condensed and transmitted to the non-relational Google cloud database called Firebase. Finally, the construction of said system transmits packets of 5 kilobytes per command in an average of 0.3 seconds at a reduced cost.

KEYWORD: Home Automation, Mobile Application, Remote Connection, Server, Transmission, Information & Cloud Computing

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INTRODUCTION

The home automation is a field of informatics development, which is devoted to developing embedded systems to buildings from any type that manages and automates the space and the services that could bring. (Ovules, Bolivar and Rodriguez, 2019).

In order to increase access to these services, mobile development is shown as an efficient option to bring portability and simplicity to projects that have a direct impact on the daily life of the people (Gutierrez, Acer, and Rodrigo, 2018). To support this idea, the voice commands boost more this possibility, leaving out the use of mobile devices with traditional methods when we use them on modified spaces with this technology (Ceils et al, 2018).

Besides, preserving the computer integrity information transmitted is vital to ensure good operational capacity (Swati and Prasad Gupta, 2018). It is essential to employ cloud computing in other to quickly send and retrieve data buses, no matter under which protocol belonging to TCP/IP architecture are we working (Li, 2017).

RELATED PAPERS

(Ceils et al., 2018): What did they do? They created a mobile application to develop an automatic home system, supported on an artificial intelligence put on a Raspberry Pi B + embedded system, operable by voice command, which recognizes acoustic models from the North Santander's population.

How did they do it? They designed an application using the "Command and Control" method in the Android Studio editor. This lets the transmission and reception of commands and the monitoring of real-time

connected devices to the database. The connected devices could control the lighting in the house; measure the temperature, humidity, and presence of individuals, applying bidirectional reference with the Raspberry Pi. The evaluation of the system consisted of a point-to-point comparison with a licensed system considering the characteristics required by the user and obtaining a cost reduction of 57% including labor, with a commercial gain of 50%.

Ideas to retake: Mobile development together with an embedded Raspberry Pi system, voice commands are also an interesting plus.

(Gutierrez, Acer, and Rodrigo, 2018): What did they do? They made a home automation control system based on a mobile device that allows the curtains to be controlled by the protocol Sigsbee.

How did they do it? They made a home automation system with open-source software and low-cost hardware, interacting via mobile, based on the IEEE802.15.4 protocol (known under the name of Sigsbee), which provides secure connections with a low shipping rate of data and maximizes the life of your batteries. Ideas to retake: the interaction using the Sigsbee protocol.

(Andò et al., 2019): What did they do? They created a network of intelligent sensors that provides assistance to the elderly, all under a project between organizations, companies, and universities on the border between Italy and Malta called NATIF Life.

How did they do it? They created a remote platform in the cloud that manages the operations of the entire system, stores data, performs data mining, returns information to end-users, and alerts their caregivers. The sensors that collect the information could be smart watches, fall detectors, or a cardiac monitor. Through a mobile application that works as an intermediary, it connects with the sensors and displays the information processed on the associated server. Ideas to retake: a medical projection of great breadth of applicability to no conventional users of the Internet of Things (IoT).

(Li, 2017): What did they do? They developed a cloud server for the smart home system designed in this article.

How did they do it? They provided a cloud server-based on smart home architecture, meeting the defined functional requirements. Messages used the MQTT protocol, while their encryption and decryption used on the HTTPS and AES protocols. For its part, the server managed services to clients for the database and socket server for real-time communication, HTTPS and MQTT. Ideas to retake: Security and transmission media supported by the HTTPS, AES and MQTT protocols. Also, the uses of cloud computing.

(Swati and Prasad Gupta, 2018): What did they do? They ensure, for an effective cost, an automated home system through a biometric system. How did they do it? The proposed system operates the functions of the home thanks to the Bluetooth connection controlled by an app in android. The biometric system based on the fingerprint employs the security provided by the house: door insurance and electrical system. Home automation implements the 8051 microcontrollers and the HC05 Bluetooth module. The biometric system uses an Adriano Uno and the R305 fingerprint sensor.

Ideas to retake: security supported by a biometric system and knowledge of the terminals that enabled the development.

(Chacón-Troya, Ortiz Gonzalez and Campoverde Campoverde, 2019) What did they do? They explain the design of a smart home for the control and monitoring of residential electric charges.

How did they do it? They created a hybrid application. This application measures the voltage, energy consumed, power and time from the measurement; An attached activity is to verify the cost of these activities. Through the application, you can control the lighting, outlets, and circuits. In addition, the application created a report where the associated consumption is shown. The project used a Raspberry Pi 2 Model B, a touch screen and an Arduino Nano. The Raspberry Pi 2 is responsible for controlling the circuits and the Arduino Nano performs voltage and current measurement and consumption calculation.

Ideas to retake: Another more electric option as a field of action, also a different combination of terminals used.

(Fronting et al., 2019): What did they do? They developed a framework that allows the rapid development of new complex hardware and software systems, integrating new classes of existing devices and controlling and centralizing data.

How did they do it? They defined and managed the different types of devices: interface, simple, mesh and mixed. An XML file condenses this information. The service is capable of supporting the TCP / IP protocol and every 15 minutes updates the information in the database. Through the web page designed, you can see the status of the connection and communication of each device.

Ideas to retake: implementation of a framework for communication between network devices.

(Navarro-Touch et al., 2019): What did they do? They created a system that uses home automation to influence and react by the emotional state of the users, seeking to modify the scenario appropriately.

How did they do it? An industrial production simulator tested the system in which the hue of the lighting adapts according to their impact on the emotions of the users. The biometric platform emotions analyzed the emotional impact through the FACET module. After a data collection and the experiences of researchers led to check over other variables such as humidity and temperature. The KNX standard supports the communication between the CO2ES2178 sensors, the biometric measurements of the emotions and a Mat Lab interface.

Ideas to retake: They allow me to appreciate new possibilities of home automation as a tool for a deeper purpose than mere automation, also knowledge of the KNX standard.

(Ovules, Bolivar and Rodriguez, 2019): What did they do? They implemented an embedded home automation system with Wi-Fi in a conventional space such as classrooms, which can be more comfortable for the end user.

How did they do it? They used the ADDIE model (analysis, design, implementation, and evaluation).

They analyzed energy expenditure in conventional spaces and designed a prototype device with a database that compiles the system control. They implemented the embedded system, evaluating the device through tests.

Ideas to retake: other spaces in which home automation can modify the emotional state of a person. }

(Saba et al., 2019): What did they do? They contributed concerning agent-based modeling and simulation for a residence powered by a hybrid system with renewable energy.

How did they do it? They used a multi-agent system (MAS), which allows adding or removing new functionalities in their execution.

Ideas to retake: knowledge compared to the multi-agent system model.

The related papers to compare are (Ceils et al., 2018), (Li, 2017), (Swat and Prasad Gupta, 2018), (Chacón-Troya, Ortiz Gonzalez and Campoverde Campoverde, 2019) y (Navarro-Touch et al., 2019). Between them, the closest paper to our purpose is the first one; the implementation of an embedded system on a Raspberry Pi that operates with voice commands performs the prospects that this project has. The second uses cloud computing, another technology that we want to implement in this project.

The third, through low cost, offers interaction through biometric means, offering other alternatives for communication with the client. For its part, the fourth referenced article seeks to control residential electricity service, promoting the optimization of resources and the environmental impact of our activities at home. Finally, the fifth article has a very important psychological approach, emphasizing the importance of the relationship between human beings and their surroundings. It is vital to contrast these articles to state the different perspectives involved in the field of home automation, which should be deepened and coupled for the proper development in a daily space.

METHODOLOGY

The system has 4 stages: system component selection, mobile application building and voice command recognition, the communication between terminals, and system implementation in the defined environment.

System Component Selection

In this iteration, we selected the components for integration between home lighting and devices for the Internet of Things (IoT). For this, we will use the ESP8266 chip that allows the internet connection.

Mobile application building and voice recognition

We will design the mobile application on the Java programming language, the Android Studio IDE to develop this application. The library Speech Recognizer from Google will help us with voice recognition.

The Communication between Terminals

To ensure effective and light communication in resources between connected terminals, we will operate using cloud computing. The most effective and scalable method is to use a database in the cloud. In this case, the service provided by Firebase under the name of Real-time Database is an attractive option, fulfilling the aforementioned requirements.

System Implementation in the Defined Environment

The environment defined for this application will be in a family home in the city of Bogotá, Colombia. Here we will connect the chip to the local network available at home. The system will respond to the commands indicated by the user, updating the status of the selected bulb.

In the following scheme, we can appreciate the architecture that the system has and each component that operates within it.

Figure 1: Application Architecture Developed.
Source: Authors

To install the system in the defined space, we must give the ESP8266 chip with a connection to the electrical network, then connect the light bulb to the corresponding GPIO and connect the chip with the local internet network. The previously configured chip will connect to the Firebase Real-time Database service. On the mobile, we will install the developed application for the interaction between the user and the system; the user uses the voice recognition function already integrated into the application.

IMPLEMENTATION

The methodology described leads us through the implementation. Therefore, we configure the ESP8266 using the Arduino development environment. This environment allows programming microprocessors from different companies; this time the reference Node MCU ESP8266-E was the selected one. Once configured, the board was programmed by adding a library that allows communication with Firebase.

```

Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
Firebase.reconnectWiFi(true);

if (!Firebase.beginStream(firebaseData, path))
{
  Serial.println("-----");
  Serial.println("Can't begin stream connection...");
  Serial.println("REASON: " + firebaseData.errorReason());
  Serial.println("-----");
  Serial.println();
}

//Set database read timeout to 1 minute (max 15 minutes)
Firebase.setReadTimeout(firebaseData, 1000 * 60);
Firebase.setWriteSizeLimit(firebaseData, "tiny");

```

Figure 2: Fragment of the Code used to Establish a Connection with Firebase.
Source: Authors

The development of the application must support the interaction with the user through voice commands. To meet that goal, we use the Speech Recognizer class already integrated into the project. This will take the voice commands and transform them into strings for later use.

Figure 3: Image of the Application Developed.
Source: Authors

The use of the Speech Recognizer library is especially important. For example, in the following fragment, we seek to recognize the language of the mobile device to recognize the language of the commands.

```
Intent intent = new Intent(RecognizerIntent.ACTION_RECOGNIZE_SPEECH);
intent.putExtra(RecognizerIntent.EXTRA_LANGUAGE_MODEL, RecognizerIntent.LANGUAGE_MODEL_FREE_FORM);
intent.putExtra(RecognizerIntent.EXTRA_LANGUAGE, locale.getDefault());
```

Figure 4: Code Fragment where we Recognize the Configured Language.
Source: Authors

After obtaining the command, we proceed to group the recognized commands into a list. Inside that list, all the possible recognized results reside. Later they are saved within an instantiated object to proceeding to update the database by sending a single package.

```
ArrayList<String> result = data.getStringArrayListExtra(RecognizerIntent.EXTRA_RESULTS);
speechToText.setText(result.get(0));
blynk.setCommand(result.get(0));
```

Figure 5: Code Fragment where the Commands Reside
Source: Authors

With the command saved, the non-relational database is updated in the Firebase Real-time Database, where the data resides in a JSON format.

```
reff.child("Int").setValue(blynk.getInt());
```

Figure 6: Code Fragment that sends the Package to Firebase
Source: Authors

These new values are constantly provided by the ESP8266 chip, updating the operations carried out; no matter in which network we have connected the devices.

Figure 7: Code Fragment used to Establish the Connection to Firebase.
Source: Authors

Now to complete the operation, we only have to update the state of the bulb in the ESP8266 chip. This through the channel already opened between Firebase and the chip.

```
if (Firebase.getInt(firebaseData, path)) {
  Serial.println("firebase data has a int");
  value = firebaseData.getIntData();
  if (value == 0) {
    Serial.println("-----");
    Serial.println("int is zero");
    digitalWrite(D2, LOW);
  } else if (value == 1) {
    Serial.println("-----");
    Serial.println("int is one");
    digitalWrite(D2, HIGH);
  }
}
```

Figure 8: Code Fragment that Updates the Bulb State
Source: Authors

DISCUSSION OF RESULTS

The projects selected to contrast our project are (Ceils et al., 2018) and (Li, 2017). The objectives of these projects are the closest to ours.

Against the first project, we found several comparable points: size and consumption of application data, implementation cost, complexity, and implemented model.

In the weight, we have that the application of this project uses 2 megabytes of memory, and its data usage is 2 kilobytes per command. Our application use 6.51 megabytes of storage and the data usage is 3 kilobytes per command.

In the cost of implementation, their project has a cost of COP 745,500, which includes the purchase of several devices. The proposed project has a cost COP 25,000 that only includes the purchase of the ESP8266 chip (the cost for the Firebase service is subject to data traffic in the database).

The complexity that manages the project in comparison is greater, thanks to the various functions that the project has to cover; however, the proposed project could be scalable for various home automation functions required in the future.

Finally, the database model implemented in the selected project is relational and is not hosted in the cloud. The project presented here uses a non-relational cloud database, which allows agile management and simplifies the system architecture.

The second project selected and the project proposed here have a great similarity: the use of cloud computing. However, they are different because this project focuses more on building a cloud service that allows the design of a smart home. Although this provides a certain degree of customization through the protocols, it does not include the user's interface, the functions operated in the smart home or quantitative data to be comparable.

CONCLUSIONS

The implementation carried out successfully the services provided by Google through Firebase, as well as the Speech Recognizer library.

The application met the defined requirements, having a simple, clear and intuitive interface for the end-user; the memory space used is 6.51 megabytes and the data consumption per command is 5 kilobytes.

The voice commands were recognized successfully and the information in Firebase was updated, allowing the module, which was connected to the local Wi-Fi network, to change the state of the bulb.

The efficiency in the transmission of data between terminals is such that the update time of the bulb status after the command has been given is equal to or less than 0.3 seconds. The non-relationship database in the cloud simplifies the connection path.

The cost of implementing this system includes only the value of the chip and the payment of a plan on the Firebase platform depending on the traffic in the database. The systems just costs COP 25,000 and bring good performance.

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