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Diseñar una arquitectura para la implementación de una plataforma IoT en viviendas con integración de WhatsApp mediante un modelo conceptual

Design an architecture for the implementation of an IoT platform in homes with WhatsApp integration using a conceptual model

Conceber uma arquitetura para implementação de uma plataforma IoT em residências com integração no WhatsApp utilizando um modelo conceptual

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Resumen

El 78% de los ecuatorianos utiliza la red social WhatsApp, por lo que se diseñó una arquitectura que permita la interconexión y comunicación entre los componentes de la plataforma IoT, incluyendo la integración con WhatsApp para un hogar inteligente. Para ello, se definió el uso de un enfoque teórico y cualitativo basado en la revisión bibliográfica de fuentes especializadas, que permitió identificar los diferentes dispositivos y tecnologías que pueden integrarse a la plataforma, considerando los objetivos del usuario, definiendo la interoperabilidad transparente y accesible entre ellos. De esta forma se obtienen buenas prestaciones que pueden ser mejoradas mediante la implementación de diferentes tecnologías. La arquitectura propuesta busca mejorar y facilitar las actividades diarias que un usuario puede realizar, aprovechando la popularidad y facilidad de uso de WhatsApp como canal de comunicación. A través de una simulación, se analizó la eficacia y eficiencia de la arquitectura, lo que garantizó su estabilidad, por lo que se espera que contribuya a nuevos avances en tecnología y domótica, mejorando la comunicación y el confort y siendo más amigable y eficiente para el usuario.

Palabras clave: Internet of Things (IoT); WhatsApp; Chatbot; Smart Home; architecture.

Abstract

78% of Ecuadorians use the WhatsApp social network, so an architecture was designed to allow interconnection and communication between the components of the IoT platform, including integration with WhatsApp for a smart home. To do this, the use of a theoretical and qualitative approach based on the bibliographic review of specialized sources was defined, which allowed to identify the different devices and technologies that can be integrated into the platform, considering the user's objectives, defining transparent and accessible interoperability between them. In this way, good performance is obtained that can be improved through the implementation of different technologies. The proposed architecture seeks to improve and facilitate the daily activities that a user can perform, taking advantage of the popularity and ease of use of WhatsApp as a communication channel. Through a simulation, the effectiveness and efficiency of the architecture was analyzed, which guaranteed its stability, so it is expected to contribute to new advances in technology and home automation, improving communication and comfort and being more user-friendly and efficient.

Keywords: Internet of Things (IoT); WhatsApp; Chatbot; Smart Home; architecture.

Resumo

78% dos equatorianos utilizam a rede social WhatsApp, pelo que foi desenhada uma arquitetura que permite a interligação e comunicação entre os componentes da plataforma IoT, incluindo a integração com o WhatsApp para uma casa inteligente. Para tal, definiu-se a utilização de uma abordagem teórica e qualitativa com base na revisão bibliográfica de fontes especializadas, que permitiu identificar os diferentes dispositivos e tecnologias que podem ser integrados na plataforma, considerando os objetivos do utilizador, definindo soluções transparentes e acessíveis. interoperabilidade entre eles. Desta forma, obtém-se um bom desempenho que pode ser melhorado através da implementação de diferentes tecnologias. A arquitetura proposta procura melhorar e facilitar as atividades diárias que um utilizador pode realizar, aproveitando a popularidade e facilidade de utilização do WhatsApp como canal de comunicação. A través de una simulación, se analizó la eficacia y eficiencia de la arquitectura, lo que garantizó su estabilidad, por lo que se espera que contribuya a nuevos avances en tecnología y domótica, mejorando la comunicación y el confort y siendo más amigable y eficiente para o utilizador.

Palavras-chave: Internet das Coisas (IoT); Whatsapp; Bate-papo; Lar inteligente; arquitetura.

Introduction

Since 2020, we have seen ourselves interacting with some Chatbot or conversational Bot, the same that can be found on a web page or in some application on our smartphone. This is because companies, to have greater reach with users, both frequent and future, implement this tool as a virtual assistant, where the user can communicate through text messages and thus interact automatically. (Sanket Salvi et al., 2019) With this, you can communicate in real time and resolve concerns and / or questions that arise, without the need for any person in the middle. A Chatbot, being an AI development, processes natural language, and can communicate adequately with users. (Kadali et al., 2020).

The versatility of this tool, WhatsApp, is that it can be integrated with various messaging systems, such as: social networks, internal messaging of a web application, etc. Given this and the constant advances in AI, this tool, WhatsApp, can be implemented for many cases, in which the desired information can be obtained just by writing a message. An example in which it can be optimized

and be effective, efficient and effective is to link it with the Internet of Things (IoT). (Matic et al., 2021).

This article will focus on the design of an architecture that allows the interconnection and communication of the different components of the IoT platform, including the integration with WhatsApp, defining the interoperability between the IoT platform and WhatsApp.

Literature review

A systematic literature review was conducted to select which devices and technologies can be used for the design of an IoT platform architecture with integration to WhatsApp. In about 50 references where the use of Chatbot has been involved in different sectors and needs, because it uses Artificial Intelligence, it can simulate a conversation as if it were a human, and being used for different functions, it can be found in websites, mobile applications and embedded in digital assistants. (Matic et al., 2021) Therefore, in order to integrate it to an IoT platform, an easy and user-friendly communication tool, such as WhatsApp, was selected.

IoT in Homes

The use of IoT for automation systems has gained much popularity due to the technological advances it has had, which in recent years appliances and various electronic devices have joined the automations, giving the opportunity to connect through the internet. This leads to the concept of home automation or also known as home automation. (Patil & Torvi, 2020) By implementing and using smart appliances by connecting them to wireless bases such as Wi-Fi, Bluetooth, this led to download or develop different programs, because the appliances have different functionalities and learning each one hindered their usefulness and took up too much space on the phones and was not productive for users. (Tseng et al., 2019) Therefore, to integrate the use of home appliances and their ease of interaction, it has begun to integrate into IoT architectures, social networks, which, through its Chatbot, as the basis of control and greater ease of use, users can control their appliances without downloading other software.

Consequently, different architectures have been investigated and implemented on home automation or Smart Home, where we can see the number of devices to perform automation, sensors, in which are in the home devices, a microcontroller such as Raspberry Pi, which will be connected to the

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Internet, and communicate via the MQTT protocol, which can control with a Web-based application. (Patil & Torvi, 2020) They can also be controlled through other communication applications, such as WhatsApp, Telegram, Line, which also have an API that allows you to use a Bot, the purpose of using these applications is to be able to control the home devices through a text message. (Muslih et al., 2019).

Social Networks with IoT

Automation systems and the Internet of things have taken over the whole world, that just by having access to the internet you can control, through programs, homes, work areas and more, and the worldwide boom that social networks have, has begun to be implemented among them. Each social network has its messaging and therefore you can set up a Chatbot in them, that makes them the main platforms to interact with the home. (Kaed et al., n.d.) For reasons of shortening the development time and making it more accessible to users, since they know and have experience in its use. (Institute of Electrical and Electronics Engineers, n.d.).

From the Chatbot of a social network, whether Facebook Messenger, Line, Telegram, among others, they can connect and control the home, regardless of where the user is. They will not only be able to send messages, but they will also be able to send messages by voice, link, or depending on the configuration or services the Chatbot has. (Tseng et al., 2019).

WhatsApp and IoT

One of the most popular messaging platforms is WhatsApp, with 15.8% worldwide, this is because it is widely used every day, whether it is for work, studies, business, etc. Because it can not only be used from a cell phone, but can also be accessed from the web, giving greater breadth of its services. That is why when using IoT and wanting to have a more accessible control and communication with the user, they are integrated with this platform that is WhatsApp. By implementing IoT in homes can facilitate everyday tasks, gaining more time to focus on other tasks and saving energy not only in the home, but also body energy. This integration involves the reduction of independent programs for each electronic device or to develop a program that may take too much time, therefore, by using the Chatbot of the WhatsApp platform we can reduce development time and have all the control and communication of our space in a single program

without the need to learn to use it from 0 but, knowing how to handle it, you just have to send messages and get the expected result. (Muslih et al., 2019) .

Methodology

We defined the use of a theoretical and qualitative approach based on a literature review of specialized sources. It will allow us to gather relevant information from previous research regarding various technologies and devices related to the implementation of an architecture for an IoT platform.

Selection of technologies and devices

By having appliances or any device connected to a wireless network we can automatically control our functions or activities that we carry in our lives. Therefore, to provide control of an intelligent home or Smart Home will integrate an IoT platform, with this we can have access to the status and control of any smart device you have in your home, and this can be done through a Chatbot. (Tseng et al., 2019) (Institute of Electrical and Electronics Engineers, n.d.) (Lee et al., 2020) Given this, exhaustive research has been carried out that has taken into account the following technologies and devices for the integration of an IoT platform with WhatsApp:

Raspberry Pi: This device will be our microcontroller, having several functions such as web, IoTOne, OpenHab and a network controller. By functioning as a computer, it consists of various types of I/O, HDMI, USB, etc. It also has a network communication module such as Bluetooth, Ethernet, wireless, suitable for use in smart homes. (Bandung & Arvandy, n.d.)

MQTT Protocol: OASIS standard communication protocol for the Internet of Things (IoT). It was developed to be a highly efficient means of transporting publish-and-subscribe messages, especially suitable for connecting remote devices with limited memory resources and low network bandwidth. (VEDANTJ.BAVISKAR et al., 2022)

Sensors: Smart home systems are composed of numerous sensors and triggering devices that are connected to a central gateway. This main gateway serves as the main control system that users can access through their digital devices, such as smartphones or personal computers. (Choi et al., 2021).

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Databases in the cloud: MySQL, where data and user activities will be recorded, and the terms that will be used to send from the Chatbot will be compared.

Chatbot: WhatsApp messaging social network, being a highly popular and friendly application, making it the control command of our home through text messages.

Twilio API: Facilitates two-way communication with the vast number of users on WhatsApp. (VEDANTJ.BAVISKAR et al., 2022).

Connecting technologies and devices

The focus for the design of the smart home automation architecture is simplicity and ease of use. Regular users will be able to send and follow messages, instructions or commands seamlessly and ultimately get the expected results by interacting with a familiar and uncomplicated user interface. (Institute of Electrical and Electronics Engineers, n.d.)

For the process involved, from the WhatsApp Chatbot, you can control any smart device in the home. It should be noted that all devices must be connected to the same wireless network. (Ario et al., 2022).

The sequence of connection between devices and technologies would be as follows:

The user sends messages to the WhatsApp chatbot, either to inquire about the status of a particular device.

It goes through the Twilio API, which detects which message or command is being sent.

Then it gives way to the Validation and Message Mapper component, which will validate from where the message was received or sent to obtain all the defined rules.

This user activity and its message is stored in the MySQL database in the cloud.

The message is validated and transformed to PLN (Natural Language Processing), since the system has already been trained.

Then move on to the next component, Dialogue Management, which will maintain the flow of the conversation you have with the user. (Tamrakar et al., 2021)

Therefore, the action will be carried out using the MQTT protocol, which was just designed for IoT communication.

Sends the information to the microcontroller (Raspberry Pi), because it has a PLN unit, processes the text sent and through the sensor executes the action or gets the information from the device specified by the user. (Sakib Ahmed et al., 2020) .

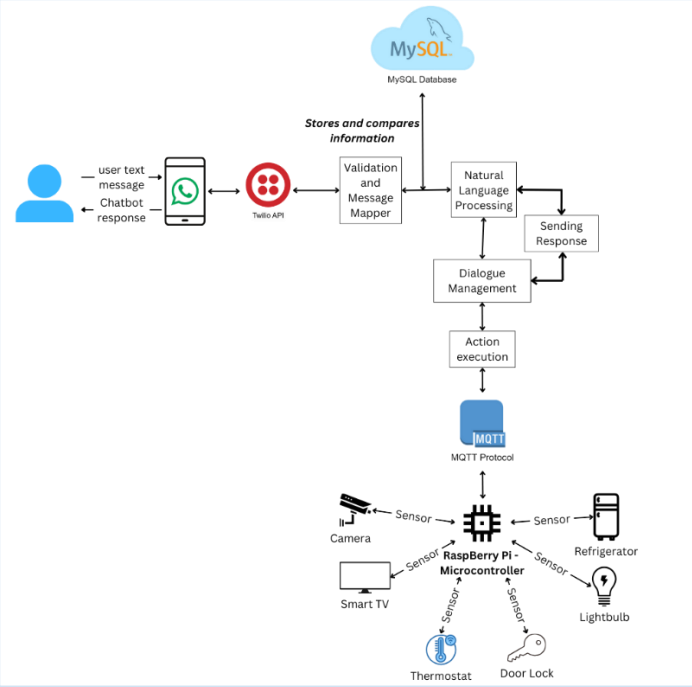
To send the response, the information goes through the same components and displays the message of the result of the user's request, it should be noted that this response will also be stored in the database.

Results

Figure 1 depicts a conceptual model for a smart home automation architecture with WhatsApp integration. This architecture emphasizes the importance of simplicity and ease of use for users to interact with the system and the interoperability of the different devices. It is anticipated that regular users will be able to send and follow messages or commands using the WhatsApp Chatbot and expected results are expected when interacting with a familiar interface.

In addition, it describes the process of how messages sent by the user through WhatsApp are detected and processed by Twilio, going through the theoretical components Validation and Message Mapper and Dialogue Management are designed to validate and maintain the flow of the user's conversation, transforming the message into PLN and executing the action on smart devices through the MQTT protocol. Therefore, for this process, at the actual implementation stage, it will require additional training and adjustments to achieve accurate results.

Fig. 1: *Architecture of an IoT platform with WhatsApp integration*



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Evaluation of the technical and financial feasibility of the proposed architecture

Within the environment of designing an architecture for the implementation of an IoT platform in homes with integration to WhatsApp, it is important to consider the technical and financial feasibility of the proposed architecture. Since the preliminary analysis will serve as a reference point for decision making. The success of any project depends mostly on its sustainable and effective implementation.

Technical Viability

The technical viability of our architecture must be evaluated at a conceptual level before we start implementing it. This involved investigating the feasibility of incorporating tools such as Twilio for WhatsApp communication, PLN system for message interpretation and the MQTT protocol for communication with smart devices. We also identified potential technical challenges and considered how all these components will work together to achieve a smooth and efficient user experience.

Identification of technological components

- Components identified for our architecture include Smartv, refrigerators, lighting control actuators, motion sensors or surveillance cameras, and mobile application.

Evaluation of technical requirements

- Technical prerequisites were established for the components, taking into consideration factors such as interoperability, reliability, power consumption, ease of use and scalability.

Research of existing technologies

Initial research has been carried out on technologies available in the market, which may be important in our architecture. This allows us to have promising options for future implementation.
Integration analysis

- Component integration has not yet been implemented, it has been defined how they could communicate and collaborate with each other in the architecture.

Identification of potential technical challenges

– It is recognized that technical challenges may arise as the implementation unfolds. These could include selecting appropriate technologies, resolving potential communication issues and ensuring data security.

Technical feasibility study

– Despite the technical challenges that may arise, it can be addressed, even though no real-life tests have been conducted, it can be assured that there are viable solutions for it.

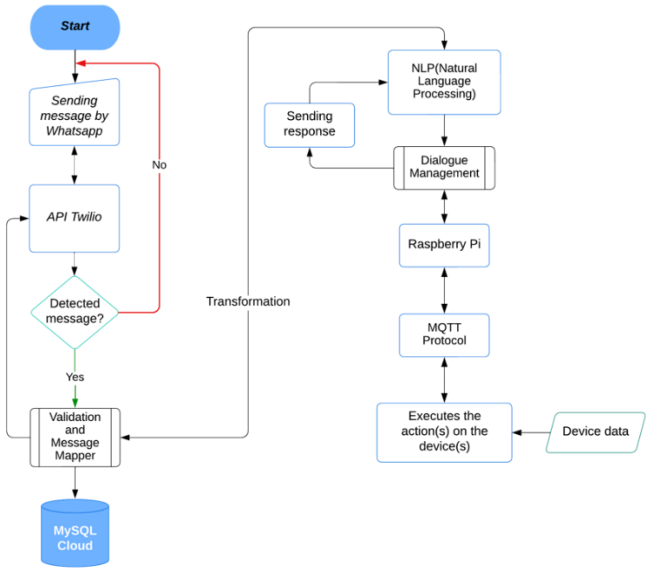
Tentative selection of technologies and platforms

– So far, technologies that can fit into our architecture have been investigated. However, there may still be changes with respect to which technologies can be adopted with each other.

Conceptual design and diagrams

– A diagram has been designed to represent the interaction of the devices and how the flow would be when using the proposed architecture, as shown in Figure 2. This will serve as a basis for future developments.

Fig. 2: *Flow Diagram*



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Financial Viability

A preliminary financial analysis was performed to evaluate the economic feasibility of our proposed architecture, although it has not been implemented in real life.

Identification of initial costs

We have estimated preliminary costs associated with the purchase of the first components that could be implemented. Our budget is based on market research and price estimates.

- Smartv = $650
- Lighting (Dimmer) = $18,72
- Raspberry pi = $96

Evaluation of operating costs

Preliminary operating costs have been calculated, which include energy consumption, maintenance and upgrades. These costs are an estimate based on typical usage and current rates.

- Power consumption = $40 monthly - $480 annual
- Development=$4000 in 4 months
- Maintenance= $50 - 2 times a year
- Upgrades= $200 (if applicable)

Identification of financial benefits

The identified financial benefits of our architecture include energy savings and a considerable increase in property value due to new home automation features.

Estimated energy savings

By automating the home and controlling lighting, energy savings of 15% are estimated. This estimate is based on the savings potential offered by automation technologies.

- Energy saving = 15%
- Estimated value = $40x0.15=$34 per month - $408 per annum
- This is without taking into account the increase in electricity rates and assuming constant consumption.

Calculation of estimated return on investment (ROI)

Having the initial costs, operating costs and preliminary financial benefits, a preliminary ROI is calculated. Being an approximate at this conceptual stage, we will evaluate the payback time of the initial investment through savings and benefits.

Assuming the following values to be considered:

Item	Value
Smart TV	$ 650
Lighting	$ 18,72
Raspberry Pi	$ 96
Development	$ 5000
Power Consumption	$ 420
Total costs per year	$ 6184,72
Energy savings	$ 60
Total profit per year	$ 60

$$ROI = \frac{60 - 6184,75}{6184,75} = -0.99$$

A negative ROI represents that in the annual period considered, the costs exceed the benefits. However, consider that the result shown is only an initial interpretation, therefore, there may be different causes that influence, so it should not be considered as a definitive result. These results could change as more accurate data is obtained, the consideration of external factors, which could lead to positive results with more comprehensive analysis, so it is important to continue researching and analyzing the proposed feasibility over time.

Architecture efficiency analysis

One of the relevant aspects considered was the yield, therefore, a formula was used to determine its average yield.

Fig. 3: *Average performance formula*

$$P = 100 - \frac{1}{\frac{\left(\frac{Vt}{bps}\right)}{100000}}{\sqrt{(St - Sn) \cdot At \cdot Su}}$$

Where:

- P = architectural performance.
- St = number of sensors to collect information.
- Sn = number of invalid sensors.
- At = number of sensor locations.
- Su = number of user sessions.
- Vt = 1GBps (Average transmission speed)
- Bps = 100 bytes/s

For the calculation of the average performance of the architecture, 3 initial sensors were taken into account, in 3 different locations, where the user would have 15 sessions per day, resulting in a performance of 99.88. This guarantees the stability of the architecture; however, the performance may vary based on the following evaluation criteria: the number of sensors, locations and sessions the user has.

Discussion

The architecture offers a theoretical approach that allows users to send messages and commands via WhatsApp, representing an important step in home automation and communication through popular platforms such as WhatsApp. As this is not a functional implementation, potential technical and infrastructure challenges are recognized and should be addressed in future stages of development and implementation. By focusing on ease of use, it presents a more user-friendly experience and improves the interaction between users and the home automation system.

Likewise, this article contributes to future research work on a smart Home or smart home. Therefore, it is recommended to carry out tests in real situations to check its feasibility and safety.

Conclusion

In this research work we have selected technologies and devices that can be integrated into an IoT platform with components that guarantee the functionality and usefulness of the platform, as well as integrating it with WhatsApp, which facilitates and improves communication between the user and the system. Given this, the next step is to design the architecture that meets the user's needs.

An architecture for home automation was presented, which allows interconnection and communication, allowing the user to interact with the system and control the devices in their home, allowing them to perform daily activities easily and quickly, and to monitor elderly or dependent people who can also interact with the system.

Interoperability between devices has been prioritized, allowing it to adapt to future incorporations and improvements in the future. Although a simulation on efficiency analysis was performed, it is expected that in future research and development more tests will be performed and the architecture will be validated, giving impetus to new perspectives and advances involving automation.

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