Intelligent building automation system using ESP32, Azure and internet of things technologies

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ABSTRACT

The adoption of home automation systems in buildings faces limitations due to their cost, integration complexity, and protocol heterogeneity, which hinders the development of accessible solutions based on embedded devices to improve interaction in environments within buildings or homes. The literature review indicates that the selection of hardware and communication protocols in home automation systems considers factors such as cost, available infrastructure, and application context. In addition, approaches are identified that prioritize security, wired or wireless connectivity, and affordability. This paper presents the development of an affordable home automation system for building automation in Lima, using the ESP32 microcontroller and internet of things (IoT) technologies. The objectives focus on hardware design, implementation of control algorithms, remote monitoring interface, and validation in a simulated environment. The solution includes Wi-Fi connectivity, a cloud-based MySQL database, and a web interface. Key findings include the home automation system, integrated with Flask technology and web services, enabling monitoring and control via a responsive web interface, demonstrating its operability and ensuring lossless data transmission.

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1. INTRODUCTION

Currently, the implementation of home automation systems in buildings faces significant challenges due to their high equipment cost and integration complexity, which limits the adoption of automation solutions [1], [2]. This situation limits access to technologies that can improve security and comfort in various environments [3], [4]. On the other hand, the diversity in communication protocols and existing infrastructure generates barriers to the integration of these solutions [5], [6]. That is why it is crucial to provide access to automation technologies in buildings, as it facilitates access to affordable home automation solutions to transform the way people interact with their environments [7], [8].

The scientific literature review analyzes the current state of the technologies and approaches used, the types of devices and sensors used, the communication and connectivity protocols, and the applications of home automation systems. A review of the types of devices and sensors used allows for the identification of a variety of hardware components, communication protocols, and connectivity, evaluating the advantages of technologies such as wired and wireless. In addition, the applications of home automation systems are analyzed to identify trends and opportunities in this area.

The selected research articles describe how hardware devices are critical to defining the smart home's operability. In this context, programmable logic controllers (PLCs) can be used in home air quality control systems, [9] enabling continuous monitoring of pollutant levels and adjusting ventilation systems. However, the implementation of PLC can be expensive so devices such as Arduino, light sensors, motion sensors and security cameras can be integrated [10] using low-cost components [11], [12]. In addition, the use of microcontrollers (MCU), temperature, humidity and motion sensors is considered to contribute to precise control of the home environment [13].

In the case of communication protocols, their choice depends on the application context. For example, Ethernet/industrial protocol (IP) technology allows taking advantage of the existing network infrastructure, reducing costs [12], [14]. However, its dependence on the wired structure is a problem in environments where access is limited and device mobility is necessary [10], [15] which is why Wi-Fi and Bluetooth technologies emerge [16], [17]. Furthermore, a cloud management layer can also be integrated to improve remote monitoring and control, although it introduces latency and security concerns [18], [19]. Comparing these approaches, the choice of protocol depends on the specific system needs and the available infrastructure [20].

The literature review allowed to find a variety of applications and functionalities of home automation systems with different approaches adopted by researchers such as the use of PLCs [21], [22] applying to their use for air quality control [9]. Some home automation system functionalities are based on the integration with an internet of things (IoT)-based system that prioritizes security [23], connectivity and remote control [24], [25]. Another application approach focuses on a low-cost smart home system [26], focused on accessibility and economy, for users with budget constraints [27], [28].

Based on the above, the research question is posed as follows: How is it possible to integrate a home automation solution for building automation in the city of Lima? To answer this question, the main objective is to develop a home automation system using the ESP32 system-on-chip (SoC) microcontroller and IoT technology for building automation.

On the other hand, the motivation of the research is related to the contribution it makes to the field of automation and smart building management. Previous works have focused on PLC-based [9], [21] or on implementations with limited scalability [26]. In contrast, this proposal addresses both scalability by integrating a SoC device and Microsoft Azure services. The novelty lies in demonstrating how an open-source platform can be combined with an enterprise-grade cloud infrastructure to ensure real-time monitoring.

2. PROPOSED SYSTEM

The main building blocks of the system are determined to be the sensors for data collection, the ESP32 control device, and the cloud services. In the cloud, the data is processed by an application programming interface (API) (Backend) and stored in a MySQL database, allowing it to be displayed on a web-based dashboard. The system allows for real-time monitoring and management of the devices, with the ability to send commands from the web interface to the actuators, as illustrated in Figure 1.

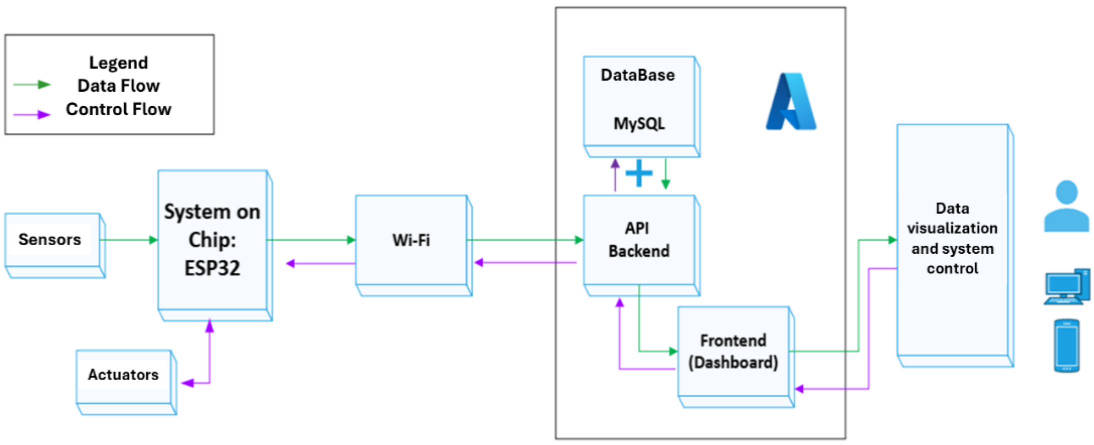

Figure 1. System architecture diagram

2.1. Home automation system hardware design

The hardware stage is based on the ESP32-WROOM32 microcontroller, which centralizes the connection between the sensors and the remote application. The entire system is powered by a 9 V rechargeable lithium-ion battery (nominal capacity of 2,000 mAh), which supplies energy to the microcontroller and peripherals, ensuring its autonomous operation, as illustrated Figure 2. The battery has an average discharge current of 500 mA, providing an estimated autonomy of 4 to 5 hours with continuous operation of the sensors and Wi-Fi communication.

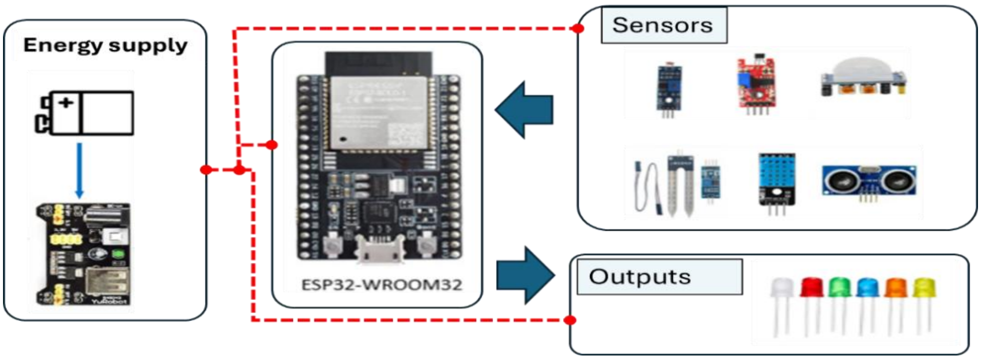

Figure 2. Hardware layout diagram

The ESP32 microcontroller was selected over alternatives such as Arduino and Raspberry Pi due to its affordable price, computational power, and the need for a ubiquitous, low-power Wi-Fi solution for real-time building automation [16]. Previous studies confirm that these features make the ESP32 a scalable option for IoT-based home automation systems in resource-constrained environments [24].

The selected sensors (light dependent resistor (LDR), passive infrared sensor (PIR), digital humidity and temperature sensor 11 (DHT11), proximity, and humidity modules) were chosen for their proven integration with ESP32 and their wide use in low-cost IoT applications [10], [27]. Each sensor comes calibrated according to the manufacturer's specifications considering the datasheet indications on the deviation values from the factory readings.

2.2. Design of the management algorithm

The management algorithm architecture is implemented using an Azure-hosted API, which acts as an intermediary between the IoT system and the user interface. The API receives data from the sensors connected to the ESP32, and this data is processed locally and then stored in the Microsoft Azure cloud. In addition, the API allows the remote interface to query and update data in real time, providing users with up-to-date information on the status of sensors, as illustrated Figure 3. The decision to use JSON for data exchange and a Flask-based representational state transfer (REST) API was based on its simple structure and wide adoption in IoT projects [24]. While protocols such as message queuing telemetry transport (MQTT) or constrained application protocol (CoAP) are efficient for IoT networks, REST was prioritized over HTTP due to its compatibility with cloud services such as Azure and the lower complexity in communication between devices and the web interface [19].

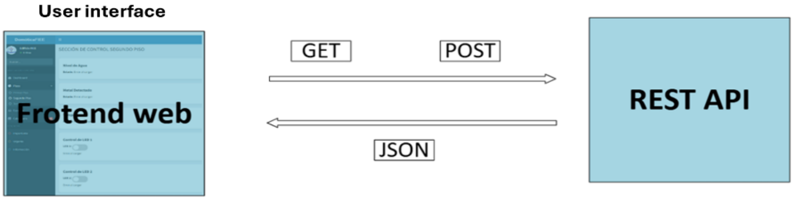

Figure 3. API diagram

The Python programming language was used to develop communication algorithms due to its compatibility with web communication libraries for IoT, where the REST API was implemented using Flask technology libraries. The code was organized into modules for each core functionality: lighting control, security, and HVAC. The development of the algorithm included the implementation of specific routes for the interaction between the ESP32 and the REST API, using the HTTP POST and GET methods, which facilitates the sending and receiving of data to and from the sensors and actuators connected to the system, as presented in Table 1.

Table 1. Summary of REST API routes

Route	HTTP method	Parameters	Description
/api/insertdata	POST	esp_id, pir_status, ldr_status	Send sensor data to the server from the ESP32.
/api/getlateststatus	GET	hespid	Get the current state of a device based on its esp_id.
/api/updateled	POST	led_status, esp_id	Control LEDs from an app or web interface.
/api/getledstatus	GET	esp_id	Check the status of the LEDs controlled by the ESP32.

2.3. Design of the remote interface for monitoring

A user-monitored interface was developed using HTML, CSS, and JavaScript, with the web browser defining the page structure, CSS styling the visual elements, and JavaScript implementing the interactive logic. JavaScript communicates with the Azure API to query sensor data and send commands to the actuators. The web interface allows users to control the system by connecting to the Flask API, enabling communication with devices controlled by the ESP32. Figure 4 shows the mockup of the interface, where we can see the different sensors, each with added functionality. The stages were; wireframes: creation of a basic visual layout and functional prototype: development with HTML, CSS, and JavaScript.

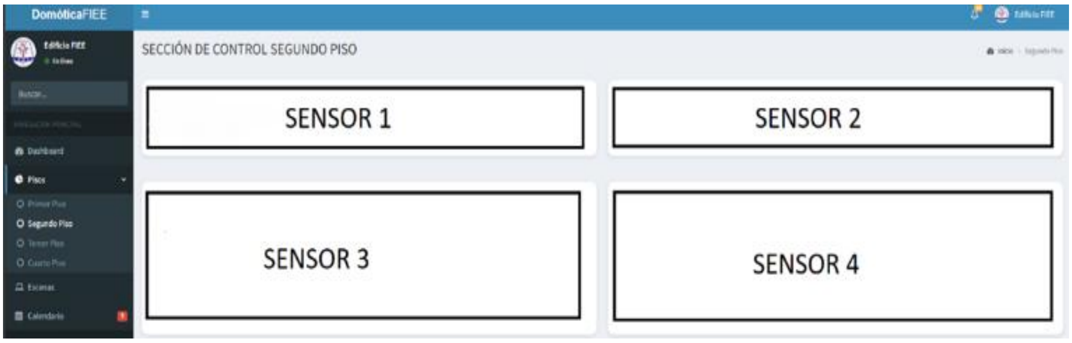

Figure 4. Visual prototype of the web interface

2.4. Cloud integration for real-time data management

Figure 5 shows the architecture of an IoT system where data captured by the ESP32-WROOM32 and its sensors are sent to an Azure cloud API for processing. The API receives the data and stores it in an Azure database for logging and analysis. Finally, a web interface hosted in Azure queries the database through the API, allowing data visualization and actuator control. Integration with GitHub was configured directly with Azure App service using a continuous integration/continuous deployment (CI/CD) pipeline, with GitHub serving as a cloud repository, as illustrated Figure 6.

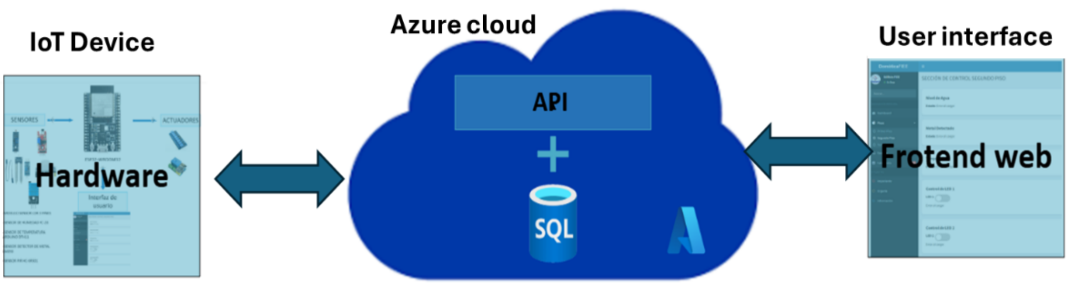

Figure 5. Cloud deployment diagram

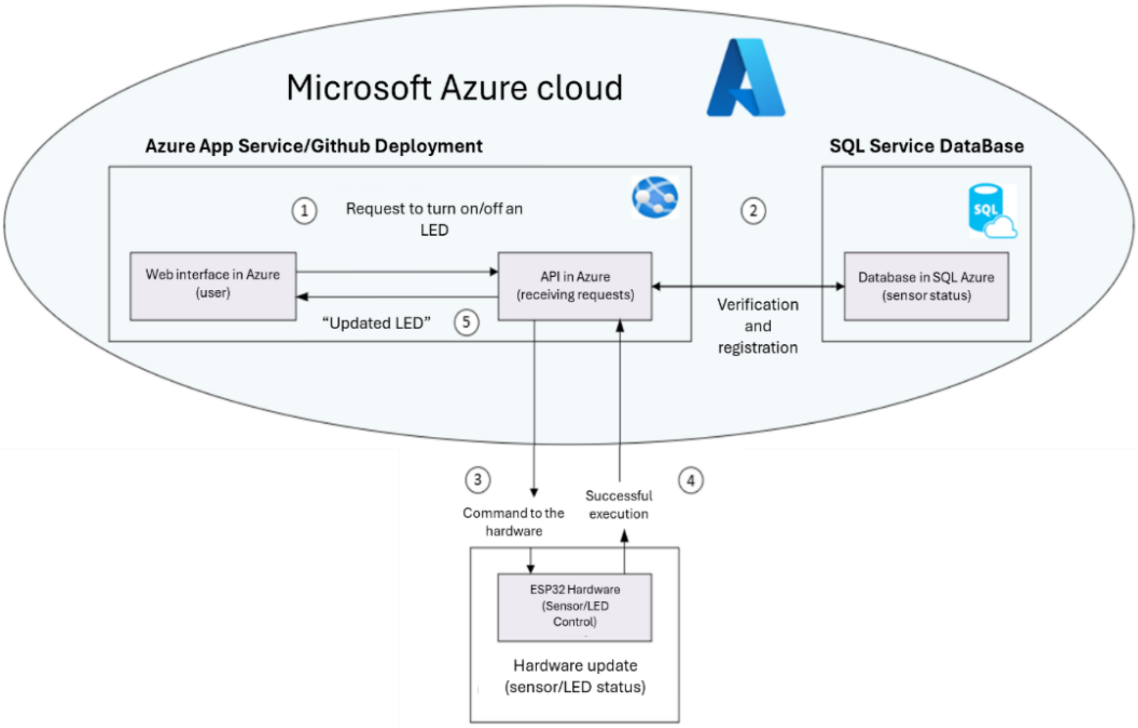

Figure 6. Cloud-hardware integration architecture diagram

3. RESULTS AND DISCUSSION

3.1. Remote monitoring interface

The development of a responsive website, called "DomóticaFIEE," provided accessibility from mobile devices and computers, as illustrated Figure 7. This interface offers a summary of the building's overall status, including the number of illuminated LEDs, motion detection on different floors, the status of the main door, and the condition of the garden.

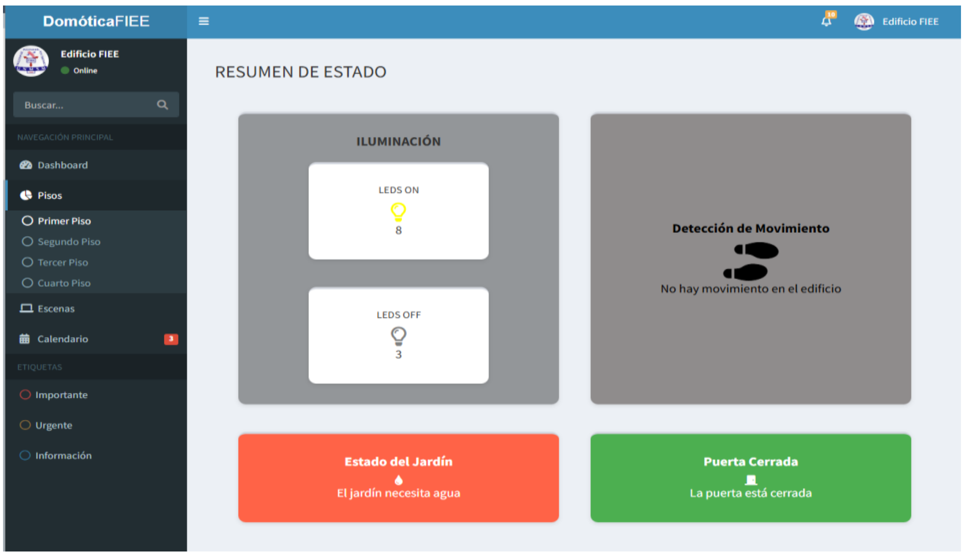

Figure 7. Main page of the "DomóticaFIEE" home automation system

Figures 8 show the specific interfaces for levels 1 and 2, respectively. These pages allow users to manage various aspects of the home automation system, such as turning LEDs on and off using virtual switches. They also provide real-time data from integrated sensors, such as PIR (motion detection), LDR (brightness measurement), temperature, and proximity.

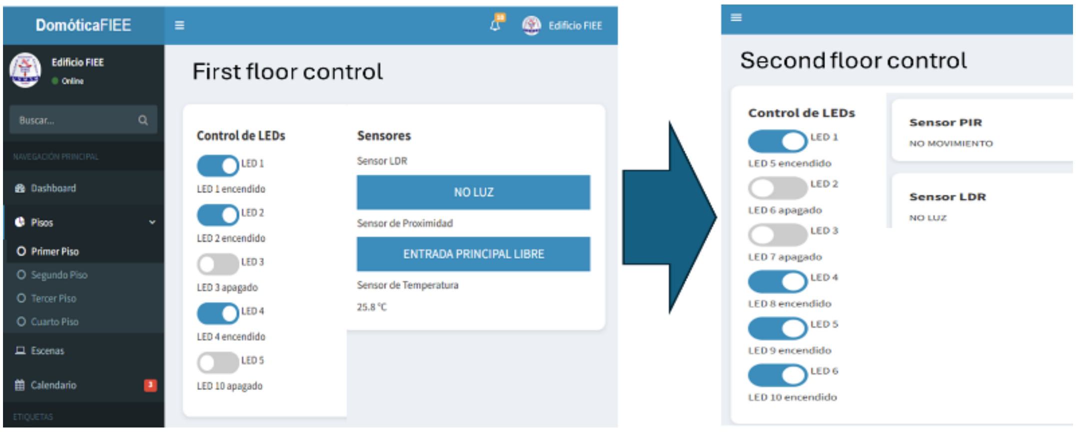

Figure 8. Home automation system interface for the two floors

The choice of Microsoft Azure over other platforms such as AWS IoT Core and Google Firebase was based on its easy integration with REST APIs, its support for relational databases, its accessibility through free credits, and its compatibility with GitHub, reducing the complexity of integration with other systems compared to AWS [18]. These comparisons are shown in Table 2.

Table 2. Comparison of cloud platforms for IoT-based automation

Platform	Microsoft Azure	AWS IoT core	Google firebase
API integration	Native REST API support, easy with Flask	Strong MQTT/REST, more configuration	REST/WebSockets, limited for IoT
Database options	SQL and NoSQL (flexible)	DynamoDB (NoSQL), RDS (SQL, paid tier)	Firestore (NoSQL) only
CI/CD	Built-in with GitHub integration	Requires setup with CodePipeline	Basic with Firebase Hosting
Educational access	Free student/academic credits widely used	Limited academic credits	Free tier but limited in scaling
Best suited for	Prototypes needing data+IoT	Large-scale enterprise IoT deployments	Lightweight real-time apps

3.2. Integration with the Azure cloud

Integration with Azure App Service verified proper communication between the home automation system and cloud services by generating communication logs that confirm connection execution, including messages such as "connection successful," the receipt and sending of data in JSON format, and values associated with the states of LEDs and sensors. Figure 9 shows this sequence of logs, demonstrating the continuous flow of information between the local system and the cloud.

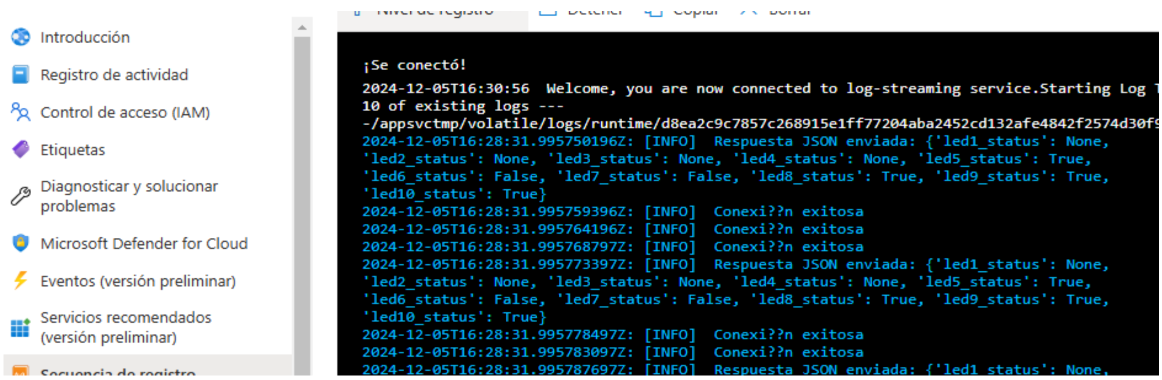

Figure 9. Log stream in Azure App service

3.3. Validation of the developed system in a test environment

The system was evaluated in an environment simulating real-world building-scale conditions. This prototype included two floors to validate the system's design and implementation, with the possibility of scaling to additional floors in the future. Each level is equipped with sensors and LEDs, simulating a home automation system. On the first floor, a proximity sensor is integrated to detect the presence of people near the building's main entrance, as illustrated Figure 10. During validation testing, the average latency between sensor activation and display on the web interface was 320 ms, with a 98% data transmission success rate over Wi-Fi. The DHT11 sensor presented an error margin of approximately ±2 °C in temperature and ±5%, consistent with those reported in previous IoT-based implementations [10], [27].

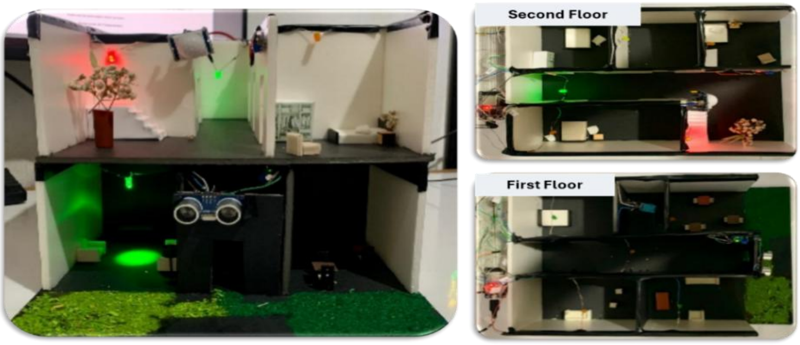

Figura 10. General view of the home automation prototype

3.4. Response to simulated situations

The home automation system was evaluated under various simulated situations to verify the proper functioning of the sensors and LEDs integrated into the prototype, as well as the transmission of data to the cloud for visualization. Test scenarios included:

a. PIR and LDR sensor test scenario. The PIR sensor located on the second level and marked red was activated. This action automatically triggered the LED corresponding to the central hallway to turn on, simulating automatic lighting upon detection of motion in that area. Additionally, an LDR sensor marked blue was used to evaluate low external lighting conditions, as illustrated Figure 11.
b. Proximity sensor test scenario. Located near the main entrance of the building, it lit an LED upon detecting a person's presence, representing the illumination of a door opening.

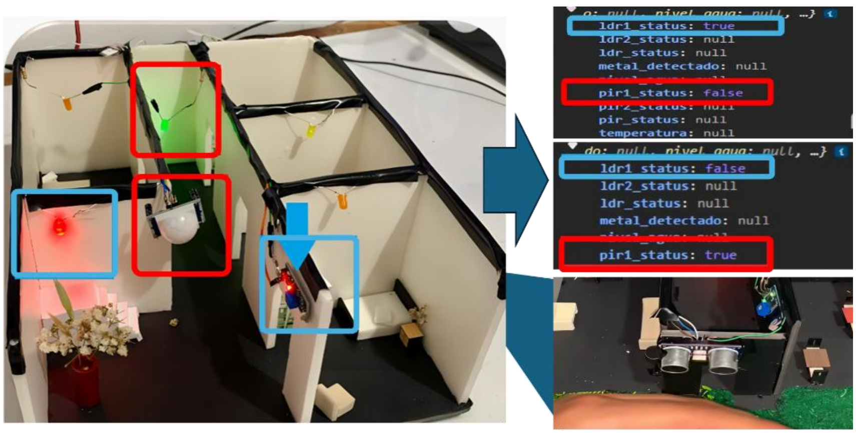

Figure 11. PIR and LDR sensor test scenario

Compared to previous Arduino-based IoT home automation systems [10], the proposed integration offered greater scalability through Azure SQL databases, which allow structured data queries. Unlike PLC-based approaches [21], this research demonstrated a reduction in the cost of the ideal hardware for small-scale building automation. The novelty of this work lies in demonstrating that an open-source microcontroller can be combined with enterprise-grade cloud services. A comparison with other solutions is shown in Table 3.

Table 3. Comparison of cloud platforms for IoT-based automation

Study	Hardware platform	Cloud/platform	Strengths	Contribution of this paper
Ajagbe *et al.* [10] (2024)	Arduino+sensors	Firebase	Low cost and simple prototyping	Adds scalability and cloud SQL support
Mittal *et al.* [21] (2023)	PLC-based system	Local/industrial	Robust and reliable for industrial use	Reduces cost by >60% with ESP32
Netinant *et al.* [17] (2024)	IoT devices+voice cmd	Custom cloud	Usability via voice commands	Achieves lower latency (~320 ms)
This work (2025)	ESP32+sensors	Azure (REST API)	Scalable and real-time	Combines low-cost SoC with enterprise cloud

3.5. Control and monitoring from the web interface

The system's ability to be controlled and monitored from a web interface was validated through practical testing, as illustrated Figure 12. The LEDs on both levels of the prototype were remotely switched on and off via the web page. Additionally, sensor readings, such as temperature, motion, and luminosity, were displayed in real time on the web interface. To confirm synchronization between the page and the prototype, the browser console was used, where messages such as "LED X updated" were logged.

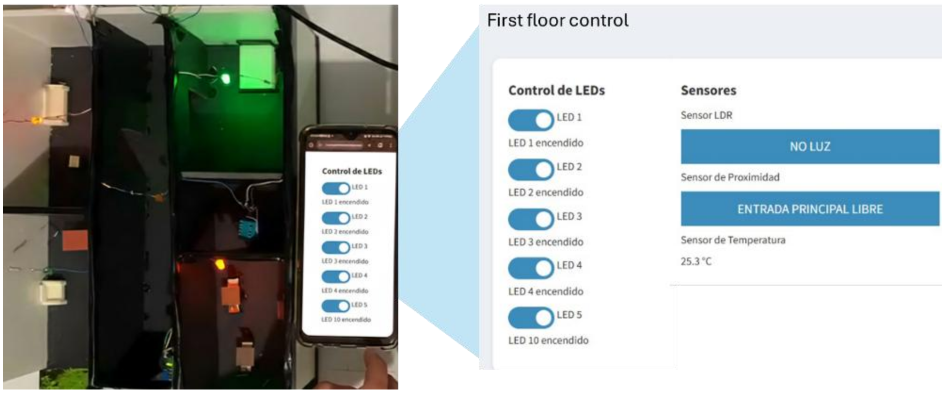

Figure 12. Light control from the interface

Although the system demonstrated stable performance, some limitations were identified such as the dependence on Wi-Fi which adds latency and network congestion issues [15]. Secondly, the use of DHT11 and LDR sensors, although cost-effective, limits accuracy and might not be suitable for industrial applications [27]. Finally, although Azure facilitated the integration, the dependence on an external cloud presents security vulnerabilities and scalability limitations, so edge computing techniques could be integrated.

4. CONCLUSION

The development of a low-cost home automation system based on ESP32 microcontrollers and IoT technology demonstrates that building automation is accessible and efficient even in resource-limited settings. Furthermore, the integration of hardware and software through a responsive interface allows users to monitor and control different devices in real time. The ESP32 microcontroller was an excellent choice for the home automation system's hardware design, as it had the hardware capabilities to manage multiple sensors and actuators. Furthermore, the temperature, humidity, light, and motion sensors provided comprehensive control over environmental aspects, ensuring the modular design was scalable.

In the case of the algorithm, it successfully acquired data from the sensors and sent signals to the actuators connected to the ESP32. It was also complemented by the implementation of an API that facilitated real-time communication between the hardware and the remote interface. The use of specific routes in the communication API optimized interaction and allowed for the integration of new modules without compromising system performance. Additionally, the remote user interface provided a dynamic user experience, allowing easy control of the home automation system from any internet-connected device.

Despite the above, it is necessary to recognize limitations related to Wi-Fi connectivity, such as latency and reliability with network traffic. Furthermore, the use of basic sensors such as DHT11 limits measurement accuracy. Future work can explore these aspects through the use of architectures that combine edge computing with cloud services, the adoption of industrial-grade sensors, and the implementation of enhanced privacy mechanisms.

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Cristy Samamé	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, Ricardo Yauri, upon reasonable request.

REFERENCES

[1] D. Yadav and S. Gangwar, "Generic Home Automation System Using IoT Gateway Based on Wi-Fi and ant+ Sensor Network," *Int. J. Recent Innov. Trends Comput. Commun.*, vol. 11, no. 3, pp. 153–165, Mar. 2023, doi: 10.17762/ijritcc.v11i3.6332.

[2] A. Singh and B. K. Panigrahi, "A HEN-PPO strategy for home energy management system with reduce EV anxieties," *e-Prime - Adv. Electr. Eng. Electron. Energy*, vol. 10, pp. 1-14, Dec. 2024, doi: 10.1016/j.prime.2024.100871.

[3] B. A. Kumar and I. Bala, "Design and Development of IoT-Enabled Power Management System for Smart Home with Enhanced Security Feature," *Iraqi J. Comput. Sci. Math.*, vol. 5, no. 3, pp. 650–659, Jan. 2024, doi: 10.52866/ijcsm.2024.05.03.039.

[4] F. F. Alruwaili, "Blockchain-Powered Deep Learning for Internet of Things With Cloud-Assisted Secure Smart Home Networks," *IEEE Access*, vol. 12, no. 1, pp. 119927–119936, Jan. 2024, doi: 10.1109/ACCESS.2024.3450796.

[5] Ó. Blanco-Novoa, T. M. Fernández-Caramés, P. Fraga-Lamas, and L. Castedo, "An electricity price-aware open-source smart socket for the internet of energy," *Sensors (Switzerland)*, vol. 17, no. 3, pp. 1-34, Mar. 2017, doi: 10.3390/s17030643.

[6] S. B. A. Khattak, M. M. Nasralla, H. Farman, and N. Choudhury, "Performance Evaluation of an IEEE 802.15.4-Based Thread Network for Efficient Internet of Things Communications in Smart Cities," *Appl. Sci.*, vol. 13, no. 13, p. 7745, Jul. 2023, doi: 10.3390/app13137745.

[7] S. W. Tay, N. Zhang, and S. AlJanah, "A Problem Analysis of Smart Home Automation: Toward Secure and Usable Communication-Based Authorization," *IEEE Access*, vol. 12, no. 1, pp. 18103–18121, Jan. 2024, doi: 10.1109/ACCESS.2024.3359442.

[8] D. Singh and A. Singh, "Role of Building Automation Technology in Creating a Smart and Sustainable Built Environment," *Evergreen*, vol. 10, no. 1, pp. 412–420, Mar. 2023, doi: 10.5109/6781101.

[9] C. I. Rizescu and D. Rizescu, "smart home air quality control system controlled with a PLC," *Int. J. Mechatronics Appl. Mech.*, vol. I, no. 12, pp. 99-103, Nov. 2022, doi: 10.17683/ijomam/issue12.15.

[10] S. A. Ajagbe, O. A. Adeaga, O. O. Alabi, A. B. Ikotun, M. A. Akintunde, and M. O. Adigun, "Design and development of arduino-based automation home system using the internet of things," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 33, no. 2, pp. 767–776, Feb. 2024, doi: 10.11591/ijeecs.v33.i2.pp767-776.

[11] P. Anuradha, K. Vasanth, G. Renuka, and A. R. Rao, "IoT based enabling home automation system for individuals with diverse disabilities," *e-Prime - Adv. Electr. Eng. Electron. Energy*, vol. 6, no. 1, pp. 1-5, Dec. 2023, doi: 10.1016/j.prime.2023.100366.
[12] T. Feng, B. Zhang, C. Liu, and L. Zheng, "Security assessment and improvement of building ethernet KNXnet/IP protocol," *Discov. Appl. Sci.*, vol. 6, no. 4, pp. 1-17, Apr. 2024, doi: 10.1007/s42452-024-05707-6.
[13] C. Huang, "Application Research of Internet of Things Smart-home System Based on MCU Micro Control," *J. Phys. Conf. Ser.*, vol. 2078, no. 1, pp. 1-8, Nov. 2021, doi: 10.1088/1742-6596/2078/1/012076.
[14] S. S. Khairullah and A. N. Sharkawy, "Design and Implementation of a Reliable and Secure Controller for Smart Home Applications Based on PLC," *J. Robot. Control*, vol. 3, no. 5, pp. 614–621, Sep. 2022, doi: 10.18196/jrc.v3i5.15972.
[15] T. Azad, M. A. H. Newton, J. Trevathan, and A. Sattar, "IoT edge network interoperability," *Comput. Commun.*, vol. 236, no. 1, pp. 1-12, Apr. 2025, doi: 10.1016/j.comcom.2025.108125.
[16] A. Adhikary *et al.*, "Design and Implementation of an IOT-based Smart Home Automation System in Real World Scenario," *EAI Endorsed Trans. Internet Things*, vol. 10, no. 1, pp. 1–10, Jun. 2024, doi: 10.4108/eetiot.6201.
[17] P. Netinant, T. Utsanok, M. Rukhiran, and S. Klongdee, "Development and Assessment of Internet of Things-Driven Smart Home Security and Automation with Voice Commands," *IoT*, vol. 5, no. 1, pp. 79–99, Mar. 2024, doi: 10.3390/iot5010005.
[18] H. H. Prezotto, N. B. F. da Silva, L. D. H. Sampaio, and R. S. Pozza, "Shower–IoT: An Internet of Things System for Monitoring Electric Showers," *IoT*, vol. 6, no. 1, 1-22, Mar. 2025, doi: 10.3390/iot6010011.
[19] A. Biheng, C. Tu, P. A. Owolawi, D. Du Plessis, and S. Du, "Network Architecture of a Fog–Cloud-Based Smart Farming System," *IoT*, vol. 6, no. 1, pp. 1-16, Mar. 2025, doi: 10.3390/iot6010017.
[20] S. M. Hashim and I. B. Al-Mashhadani, "Adaptation of powerline communications-based smart metering deployments with IoT cloud platform," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 29, no. 2, pp. 825–837, Feb. 2023, doi: 10.11591/ijeecs.v29.i2.pp825-837.
[21] U. Mittal, A. Gupta, G. Kaushal, Lokesh, and Abhishek, "PLC-based home automation system for maintaining efficient task scheduling and security," *J. Phys. Conf. Ser.*, vol. 2570, no. 1, pp. 1-9, Jan. 2023, doi: 10.1088/1742-6596/2570/1/012034.
[22] J. Chen, "Design and Analysis of Home Control Complex System Based on PLC Technology," *Mob. Inf. Syst.*, vol. 2022, no. 1, pp. 1–9, Aug. 2022, doi: 10.1155/2022/6830120.
[23] H. B. Ahmad, R. R. Asaad, S. M. Abdulrahma, A. A. Hani, A. B. Sallow, and S. R. M. Zeebaree, "Smart home energy saving with big data and machine learning," *J. Ilm. Ilmu Terap. Univ. Jambi*, vol. 8, no. 1, pp. 11–20, Jun. 2024, doi: 10.22437/jiituj.v8i1.32598.
[24] Z. Sharif, L. T. Jung, M. Ayaz, M. Yahya, and D. Khan, "Smart Home Automation by Internet-of-Things Edge Computing Platform," *Int. J. Adv. Comput. Sci. Appl.*, vol. 13, no. 4, pp. 474–484, Jan. 2022, doi: 10.14569/IJACSA.2022.0130455.
[25] A. S. M. Mussa *et al.*, "Deploying an IoT-enabled Integrated Comprehensive Home Automation System using WSN for Enhanced Continuous Optimization and Fault Identification System," *Stat. Optim. Inf. Comput.*, vol. 14, no. 1, pp. 282–310, May 2025, doi: 10.19139/soic-2310-5070-2340.
[26] M. H. Elkholy, T. Senjyu, M. E. Lotfy, A. Elgarhy, N. S. Ali, and T. S. Gaafar, "Design and Implementation of a Real-Time Smart Home Management System Considering Energy Saving," *Sustain.*, vol. 14, no. 21, pp. 1-22, Nov. 2022, doi: 10.3390/su142113840.
[27] H. Omidvarborna, P. Kumar, J. Hayward, M. Gupta, and E. G. S. Nascimento, "Low-cost air quality sensing towards smart homes," *Atmosphere (Basel).*, vol. 12, no. 4, pp. 1-33, Apr. 2021, doi: 10.3390/atmos12040453.
[28] A. A. Sahrab and H. M. Marhoon, "Design and Fabrication of a Low-Cost System for Smart Home Applications," *J. Robot. Control*, vol. 3, no. 4, pp. 409–414, Jul. 2022, doi: 10.18196/jrc.v3i4.15413.

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