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Temperature Control System for brewing beer using IoT

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Abstract. The problem addressed is the temperature monitoring of a craft beer brewing equipment and the corresponding use of cooling or heating systems, adding support for querying the temperature of the system through voice commands with the help of the intelligent assistant Alexa, developed by Amazon. This work allows you to remotely monitor the temperature, because its control is essential to obtain quality results. Which reduces human errors and errors due to equipment malfunction. The incorporation of voice command through the Alexa smart assistant allows the person in charge to monitor the temperature, be doing another task or even be able to hire people with a physical disability.
Keywords: Internet of things, Bluetooth, applications, NodeMCU, connectivity.

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1 Introduction

The term "Internet of Things" (IoT) was coined by the British Kevin Ashton in 1999 to describe a system in which objects in the physical world could be connected to the Internet via sensors [1,2].

Over time the term has become popular, becoming an emerging topic of technical, social and economic importance, defined as scenarios in which network connectivity and computational capacity are extended to objects, sensors and everyday items, allowing these devices to generate, exchange and consume data with minimal human intervention.

Projections of the impact of the Internet of Things and the economy are impressive: some anticipate that by 2025 there will be up to 100 billion devices connected to the IoT and that the economic impact will be exorbitant [2,3].

The Internet of Things can be implemented in multiple environments, such as the human body, the home, offices, factories, construction sites, vehicles, cities, etc. [4, 5, 6, 7], or as in this case, in applications that allow making a task much easier and controlled, even as specific as in this case, the temperature measurement of a beer fermenter.

However, to implement IoT applications, simple sensors and actuators are required, as well as a processing unit to operate them, query them, control them and communicate with other computing devices to collect and visualize the data. This is where development boards come in such as Arduino, Raspberry Pi, or NodeMCU, which are usually boards that easily interconnect and operate sensors and actuators while running such applications. For the case of this project, a NodeMCU board is used.

NodeMCU is a development board especially oriented to the Internet of Things (IoT). It is based on the highly integrated ESP8266 chip, designed for the needs of a connected world. It integrates a powerful processor with 32-bit architecture (more powerful than the Due development board) and Wi-Fi connectivity [8,9].

For the development of applications, you can choose between different languages. It has a voltage regulator on the board that allows it to be powered directly from the USB port. The input/output pins work at 3.3V.

The board used (see figure 1) in the project has the ESP32 chip, which also has WiFi + Bluetooth connectivity, among other features that improve its memory and interface capabilities, as it is an improved version of the ESP8266. Like its predecessors, it is a development board with dimensions of just a few centimeters in length and width [10].

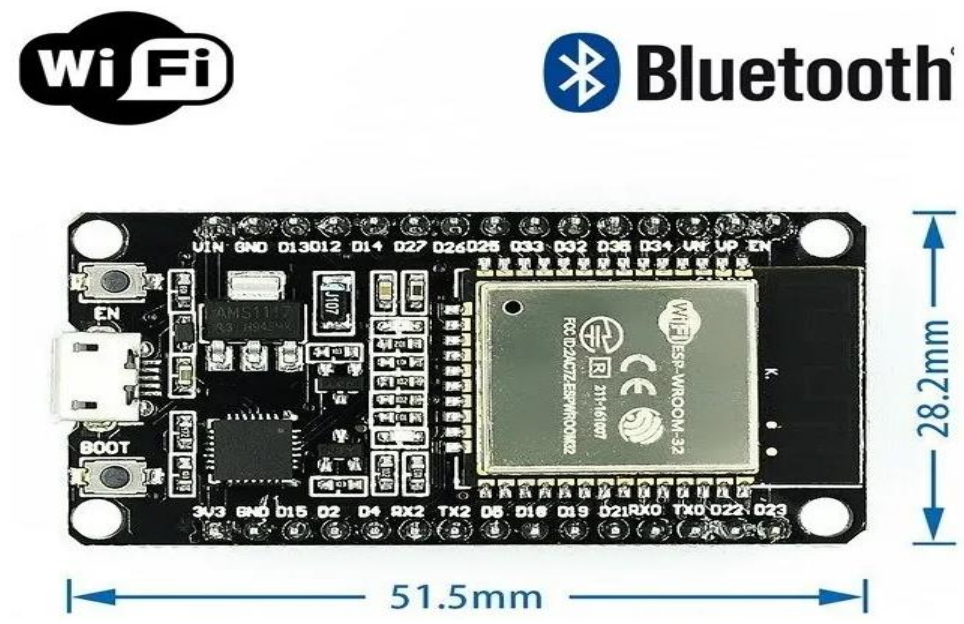

Figure 1 - ESP32 NodeMCU board, with its dimensions and communication technologies

This project includes:
1. IoT implementation to a real-life problem.
2. The use of a NodeMCU development board.
3. Functionalities of a distributed type computing system, implementing the use of technologies such as intelligent voice assistants.

2 Problem Description

During the process of craft beer brewing, one of the procedures that requires proper control of the temperature at which it takes place is fermentation. During fermentation, the yeast in the beer breaks down the sugars in the beer to generate mainly alcohol and CO2 [11].

However, in order to obtain better results during this process, it is necessary to control the temperature at which the beer is fermenting, since this factor influences the health of the yeast and, therefore, the generation of adequate alcohol. In addition, a final consideration to take into account is that the optimum fermentation temperature varies according to the type of beer in the fermenter.

Having a temperature measurement system that also applies the necessary corrections for fermentation can be of great help during the craft brewing process.

3 Solution Proposal

It is proposed to create a system that implements the use of a thermometer, a heating and cooling method, a set of relays and a NodeMCU development board to control the system, as well as an Amazon Echo Dot voice-controlled smart device to interact with the system using Alexa, the artificial intelligence entity that the Echo Dot runs on.

The implementation of the proposed solution behaves as follows:

1) By using the nodeMCU board, the C++ language and the Arduino development platform, a programm is created that by means of the input signal from a thermometer, sends two output signals of activation or deactivation to what will be the cooling or heating systems.

2) The electronic components that make up the solution are integrated with the help of wiring, resistors, experimental board (Protoboard), and other basic elements:
   a. A DS18B20 temperature sensor (preferably in its waterproof version).
   b. A set of relays
   c. Heating equipment. In a first implementation, consisting of a mesh heater with USB power supply.
   d. Cooling equipment. In a first implementation, consisting of a 5V DC mini fan.
3) An account is created and a temperature sensor device is configured on Amazon's Alexa-enabled IoT device development platform called Sinric Pro (https://sinric.pro/). This requires configuring everything from the voice commands that Alexa will recognize, to the language in which to interact with her.
4) The codes include the necessary directives to establish the network communication between the nodeMCU board and the device previously configured in the Sinric Pro platform
5) From a mobile device and through the Alexa app, the Echo dot is configured to consult the temperature status of the thermometer connected to the nodeMCU board. The Sinric Pro skill (Skill) must be added to Alexa and connected to the account previously created on the platform [12]. Alexa will immediately recognize the devices configured in Sinric, and with that, our temperature sensor will be consulted.

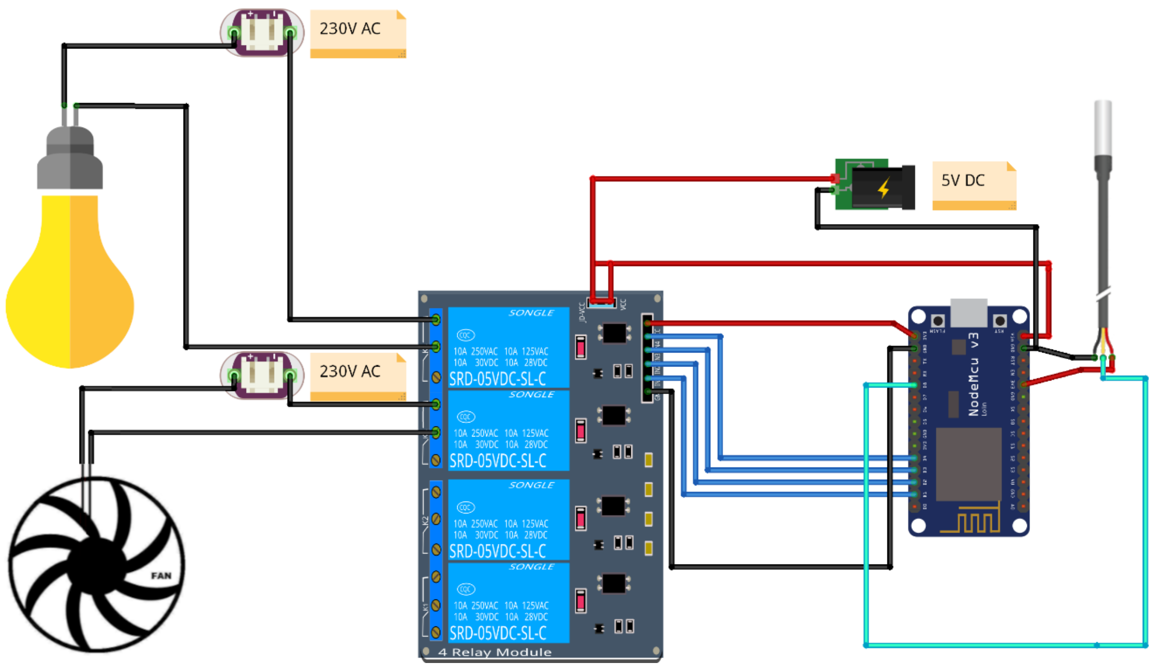

Figure 2 – Diagram of system components. From left to right you can see the heating and cooling systems, their power connections, the relays that activate them, the NodeMCU board and its voltage source, and the temperature sensor.

6) Once the system is energized, the sensor and the heating and cooling systems can be placed in the fermenter for use.
Figure 2 shows the general connection diagram of the system.

4 Generated Code

The source code on the board was developed in C language for Arduino, and is described below:
Main board configuration (SD_Project_Final.ino)
Main Arduino program. It includes in the project the necessary libraries to create a Sinric Temperature Sensor, the management of the WiFi chip, and for the management of the relays from the temperature captured by the sensor.
Because the Sinric Pro platform is operated through a graphical interface, configuring the new device does not present the task of making a source code, but rather that of including the credentials generated on the platform in the source code of the NodeMCU card so that it can communicate, in turn, between the sensor and the Alexa intelligent assistant.

5 Evidence y Results

The correct operation of the system is shown in action in Figures 3 to 12. Which even show a real fermenter in use, which contains mead, a beverage that is the predecessor of beer, and whose optimum fermentation temperatures range from 18°C to 28°C, values at which the system was configured to turn on or off the corresponding heating or cooling systems.

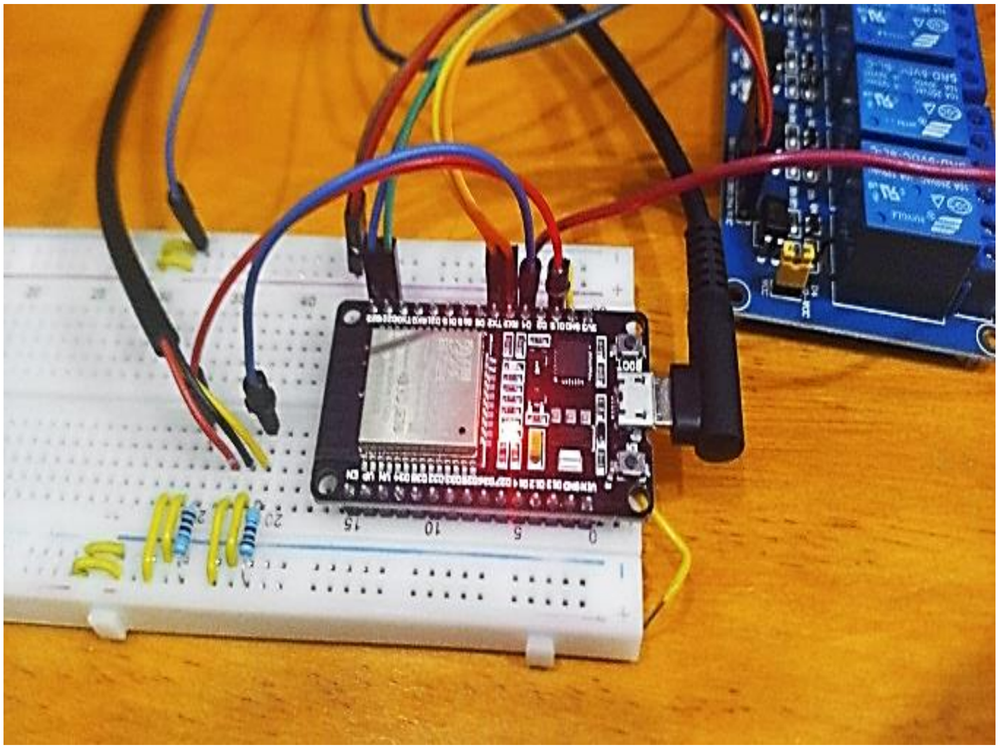

Figure 3 - NodeMCU development board programmed and wired.

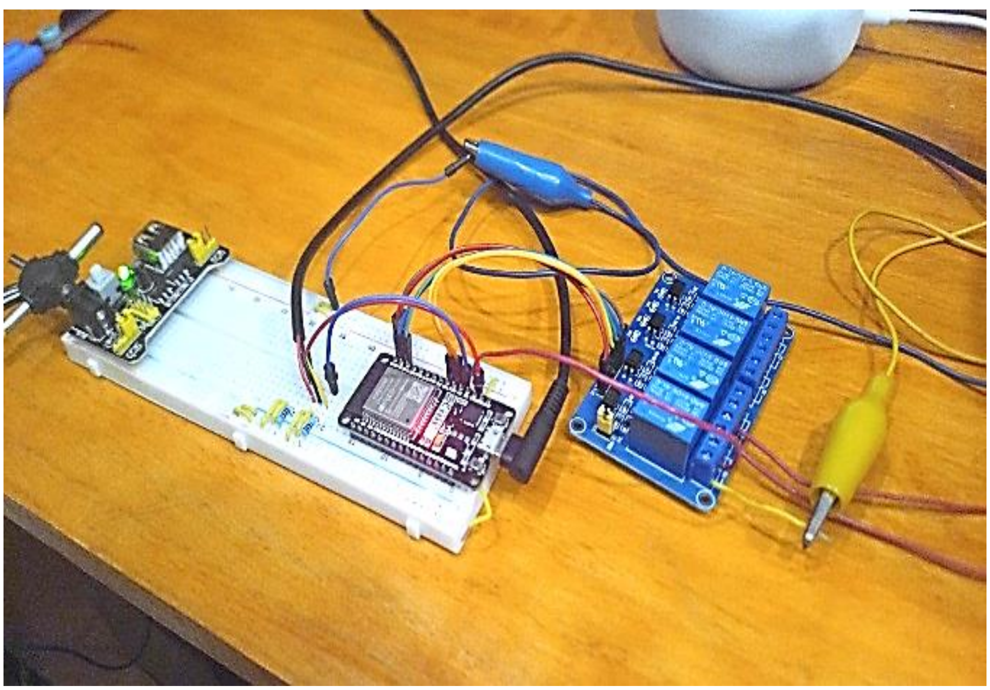

Figure 4 - Protoboard and relays that make up the system. In addition, a 5V power supply is added to operate the relays without failures.

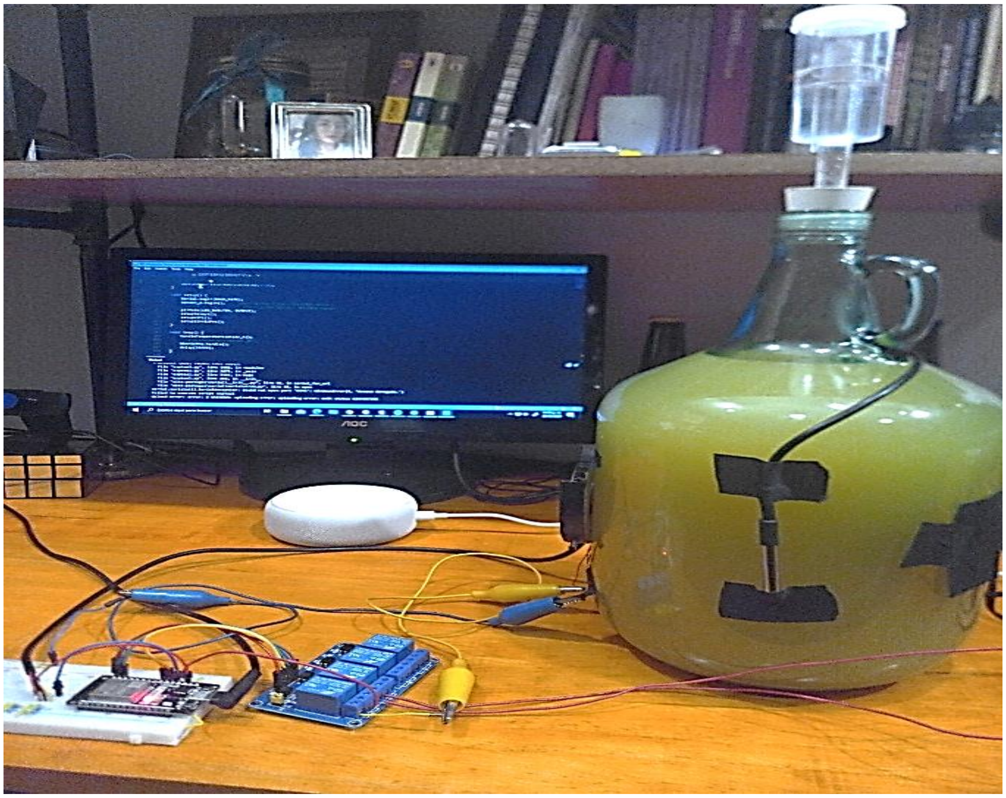

Figure 5 - Complete system. Electronics, Amazon Echo Dot, and beer fermenter shown in use.

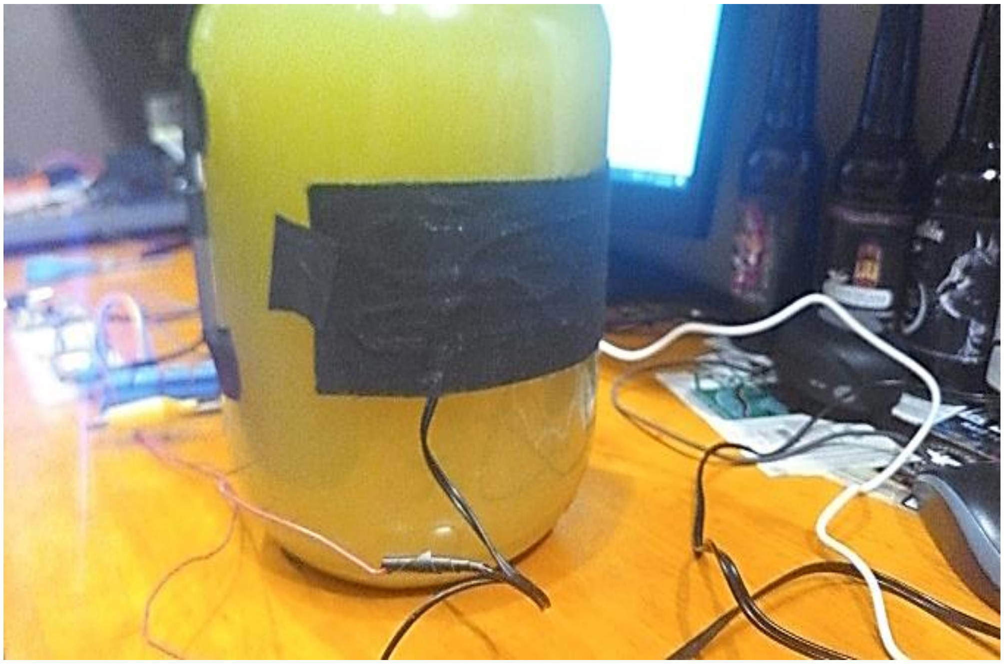

Figure 6 - Heating system consisting of a modified mesh, which is connected to a USB power supply and one of the relays.

Figure 7 - Temperature sensor attached to the fermenter. Although the most appropriate way to measure the temperature is by inserting the sensor into the beer.

Figure 8 - Cooling system. The fan used shows that the system, even in cooling operation, is working properly

Figure 9 - Skill needed to activate the connection between Alexa and the temperature sensor.

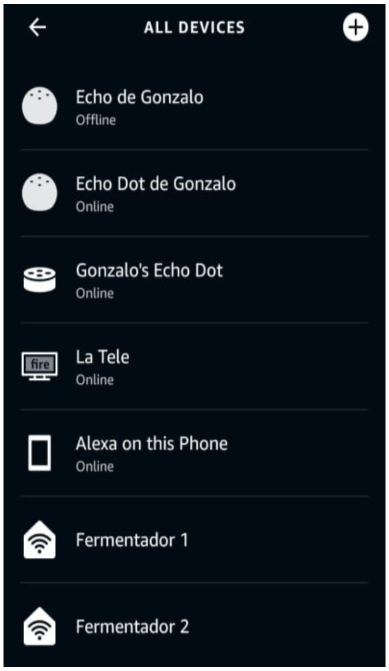

Figure 10 - It is possible to see fermenter 1 in the list of Alexa devices.

Figure 11 - Detail of the device configured from SinricPro

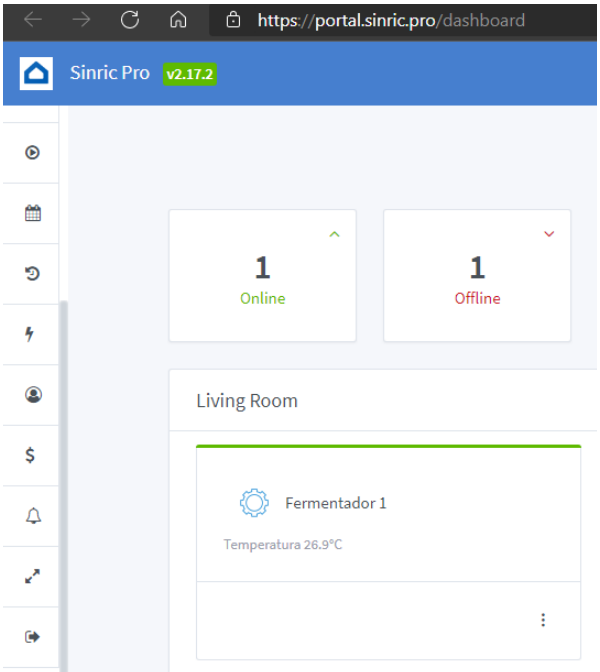

Figure 2 - Screenshot from the Sinric Pro platform, showing temperature sensor activity.

6 Conclusions

This paper presents the implementation of a true computational solution to an everyday life problem. It uses the integration of multiple skills, such as the development of electronic prototypes, the programming of specific-purpose devices, the configuration of devices from dedicated platforms, and, above all, the implementation of knowledge corresponding to distributed computing systems as well as the development of IoT solutions to real problems.

These types of technologies have countless applications, integrating solutions, but not only that, they also open the possibility of using technologies that are already in our homes and our lives, and through which it would facilitate the monitoring and operation of the systems created, such as cell phone devices or intelligent voice assistants such as Amazon's Alexa, or Google Home.

References

1. Eldridge, S., & Chapin, L. (2015). The Internet of Things: An Overview. *The Internet Society (ISOC)*. https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC-IoT-Overview-20151221-en.pdf.

2. Amri, Y., & Setiawan, M. A. (2018). Improving Smart Home Concept with the Internet of Things Concept Using RaspberryPi and NodeMCU. *IOP Conference Series: Materials Science and Engineering*, *325*, 012021. https://doi.org/10.1088/1757-899x/325/1/012021.

3. Global Connectivity Index. *Huawei Technologies Co., Ltd.*, 2015. Web. 6 Sept. 2015. http://www.huawei.com/minisite/gci/en/index.html.

4. Abdullah, A. H., Sudin, S., Mat Ajit, M. I., Ahmad Saad, F. S., Kamaruddin, K., Ghazali, F., Ahmad, Z. A., & Abu Bakar, M. A. (2018). Development of ESP32-based Wi-Fi Electronic Nose System for Monitoring LPG Leakage at Gas Cylinder Refurbish Plant. *2018 International Conference on Computational Approach in Smart Systems Design and Applications (ICASSDA)*. https://doi.org/10.1109/icassda.2018.8477594.

5. Skraba, A., Kolozvari, A., Kofjac, D., Stojanovic, R., Semenkin, E., & Stanovov, V. (2019). Prototype of Group Heart Rate Monitoring with ESP32. *2019 8th Mediterranean Conference on Embedded Computing (MECO)*. https://doi.org/10.1109/meco.2019.8760150.

6. Pujaria, U., Patil, P., Bahadure, N., & Asnodkar, M. (2020). Internet of Things based Integrated Smart Home Automation System. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3645458.

7. Kumar, P., Dwarkani, V., Vishal, S., & Ramados, V. (2020). Traffic Light System for Smart Ambulance Using IOT. *Journal of Xidian University*, *14*(6). https://doi.org/10.37896/jxu14.6/233.

8. Veloso, A. F., Sousa, B. A., Braz, A. R., Rabelo, R. A., Brito, E. M., & Lima, E. M. (2017). Prototipação com nodeMCU para Internet das Coisas em Smart Cities: Uma pesquisa. III Escola Regional de Informática do Piauí. *Livro Anais-Artigos e Minicursos*, *1*(1), 105-110.

9. Kurniawan, A. (2019). *Internet of things projects with ESP32: build exciting and powerful IoT projects using the all-new Espressif ESP32*. Packt Publishing.

10. Espressif Systems Co. *ESP32*. ESP32 Wi-Fi & Bluetooth MCU | Espressif Systems. https://www.espressif.com/en/products/socs/esp32.

11. Palmer, J. J. (2006). *How to Brew: Everything you need to know to brew beer right the first time*. Brewers Publications.

12. Sinric. (n.d.). *SinricPro (ESP8266 / ESP32 SDK)*. GitHub. https://github.com/sinricpro/esp8266-esp32-sdk/.