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A prototype for automated management of air conditioning in the hospital environment

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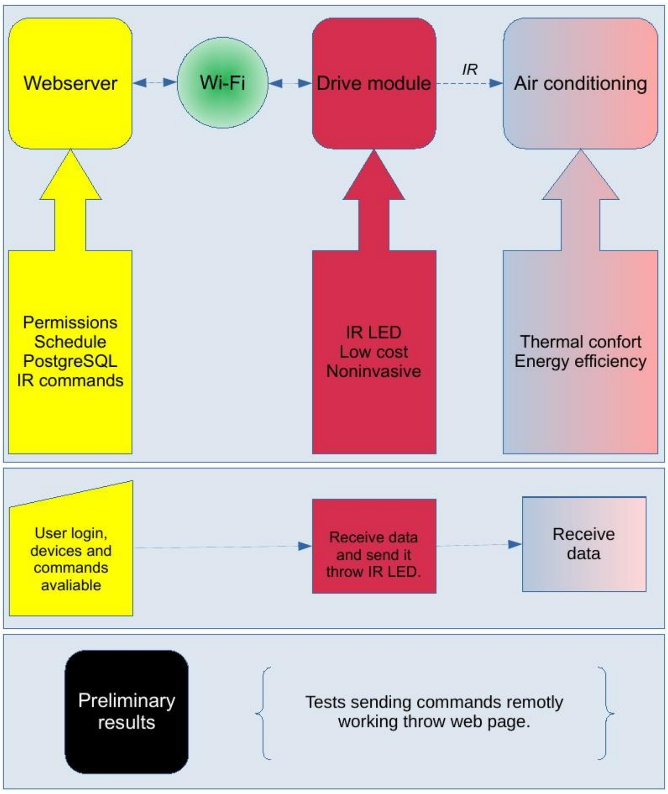
Graphical Abstract



Abstract

A large part of electricity consumption in hospitals is spent on air conditioning equipment. This is due to the fact most equipment is old and has low energy efficiency. In addition, in some places there are no rules of use the air conditioning and it can be used at temperatures that do not generate thermal comfort for patients, also causing greater energy consumption. The present work develops a non-invasive system for control and automation of conciliated air, seeking energy efficiency and low cost of implementation, combined with sustainability and thermal comfort. Using the same infrared communication principle as conventional remote controls, a drive module with a Wi-Fi connection was developed, connected to a database that contains the equipment information. The activation and control can be done remotely. The drive module is composed of a power supply, an IR LED and a microcontroller with Wi-Fi connection. The database used is PostgreSQL and to perform the communication between these two systems, a web page was created with login and password, where the user can start the equipment and also configure operating hours so that they work autonomously. Until now, tests have been carried out on air conditioning units in the split model, commanding them remotely, showing that the system is capable of accomplishing its purpose. Future studies will evaluate if this systems will reduce the energy costs.

Introduction

Electricity plays a fundamental role in today's life and can be characterized as a basic requirement for citizenship. However, the universal and efficient supply of electricity is indispensable for sustainable development. The conscious use of electricity in public agencies becomes even more necessary, since public money must be spent sparingly and invested to improve the life of society. About 48% of the electricity consumption in public buildings is related to air conditioning equipment [1].

Since these devices do not have usage control, they are often not used correctly. In addition, there is a large number of low energy efficiency equipment. For example, it was found at least 78% of the air conditioners in classes C and D in the São Borja campus of IFFar-SB, according to the INMETRO seal [2].

The development of new technologies in the area of telecommunications has provided a favorable scenario for the development of applications that assist in the daily life of human beings. Thus, the Internet of Things (IoT) was defined, which can be characterized basically by the connection of physical devices to a network [3]. The main feature of IoT is the high impact it will have on the various aspects of daily life and the behavior of possible users. IoT has been more applied in home and work environments, for example, in the area of health, safety, communication and energy. In this way, we can use the IoT in the development of systems that help the human being in the use of energy in an efficient and sustainable way, controlling and automating certain activities.

Some works are being developed with this same purpose. Correa et. al. (2018) develops a system to prevent unrestricted access to equipment and activation at break times, also monitoring the energy consumption of each device [2]. Similarly, the present work seeks the development of a non-invasive system for the control and automation of air conditioners, seeking energy efficiency and low cost of implementation, combined with sustainability and thermal comfort.

Materials and Methods

(a) Decryption

The air conditioning equipment in general has the functionality of operating by remote control, using infrared light to perform the communication and allow the activation of its functions. The signal is modulated in a carrier frequency, between 30kHz and 56kHz, to be sent to the receiver, which demodulates and interprets the received signal. There are several protocols used for this process. To decode this signal, an infrared decoder is required at the same frequency as the carrier. Since the tested air conditioning equipment operated with a 38kHz carrier, then for the tests we used the TSOP4838 component, which demodulates the signal in pulses, so that the output can be connected directly to a microcontroller.

The differentiation between high and low logical signal is made through the distance between pulses. Each pulse is followed by a space, so that if this space has the same duration as the pulse, it is of low logical level. If the space has three times the duration of the pulse is interpreted as high level. The beginning of the signal is identified by a long pulse of approximately 9ms and a space with half that time. Thus, to interpret the signals in the microcontroller, we used an algorithm that identified the duration of pulses and spaces by storing each sequence in vectors. This way, we were also able to send the signal back to the air conditioner and confirm that the command interpreted by the algorithm was in accordance with the transmitter signal.

Generally, the message transmitted by the remote control of the air conditioner contains 8 bits of device address, followed by 8 bits of its logical inverse, 8 bits of command, also followed by its logical inverse of 8 bits, besides the pulses of beginning and end of the message, as shown in Figure 1. However, for the various devices tested it was not possible to identify this protocol. Some messages contained 50 bits, others reached 192 bits. Thus, to identify each part of the message as address, command and confirmation, would bring an unwanted complexity to the project, being possible to solve this issue in other ways. First, the use of software for decoding, such as LIRC, was attempted, but it was not able to interpret the messages of various air conditioning models.

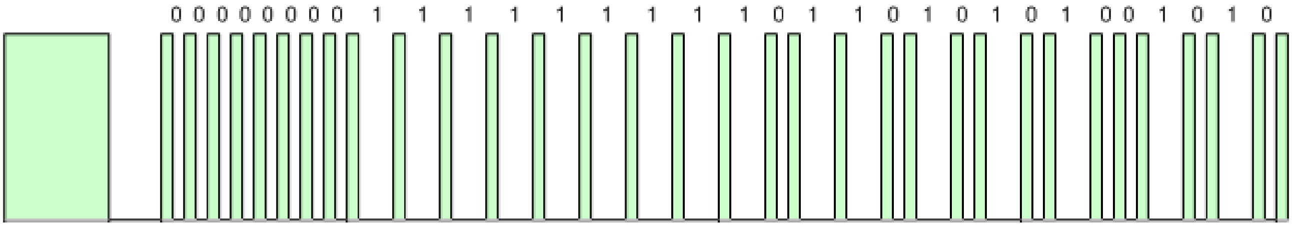


Figure 1 – Message transmitted by the remote control of the air conditioner (Source: (https://techdocs.altium.com/display/FPGA/NEC+Infrared+Transmission+Protocol)

For this reason, a database was chosen, which stores the messages of the commands of each air conditioner. Thus, the microcontroller is responsible only for receiving the message via *http* protocol (hypertext transfer protocol) and sends it via infrared, simplifying complexity and reducing cost, and allowing easy scalability of the project.

b) Drive modules

Since infrared communication requires emitter and receiver to be visibly exposed, a drive module, consisting of a microcontroller connected to the network infrastructure and an IR LED, must be installed close to each air conveyed.

In order to use a hardware suitable for the function, we chose to use the ESP8266 module, which contains *WiFi* connection and sufficient outputs for implementation, being also a compact and low cost component (Figure 2).

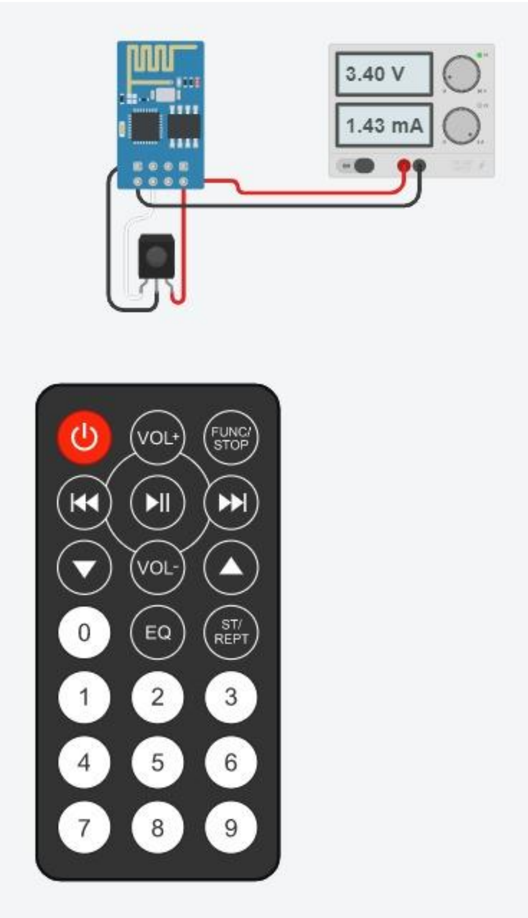
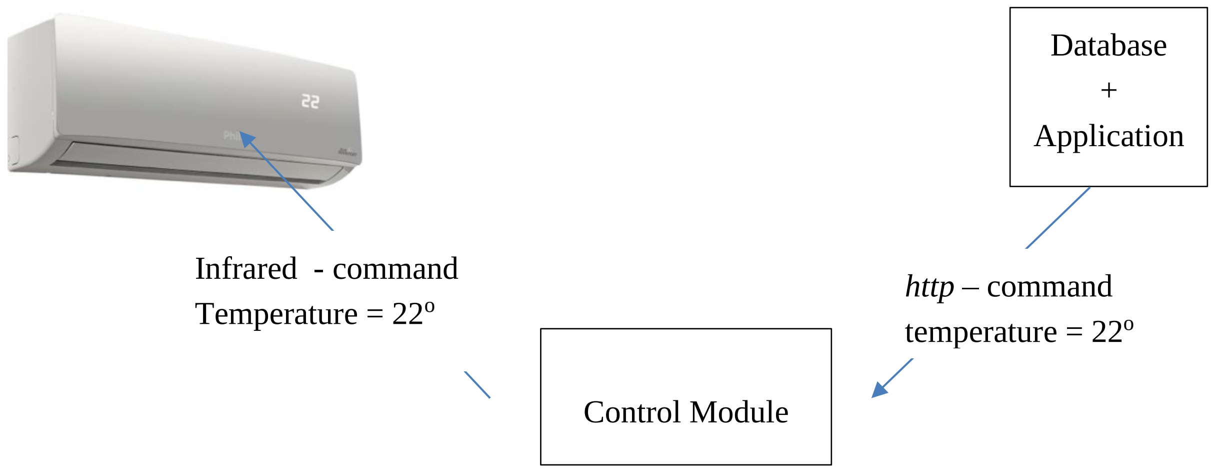


Figure 2 – System components

c) Database

Among the many existing relational databases, PostgreSQL was chosen as one of the most advanced open source systems today. The system was configured in a Raspberry Pi, where the database was modeled so that it has for each air conditioning model, a coding system, and identifying the messages is function, temperature and speed of ventilation.



The database also stores the status of the drive modules to know in real time the situation of each device, when a controller module of the air conditioning is turned on, it announces itself to the system, recording date and time of activation.

d) Web page

As an interface for users, we developed a graphical interface, using HTML and PHP, to search for information in the database, and expose them to the user, with the functionality of sending the command to the air conditioning issue. The system has a login screen so that it is possible to manage according to the compliance of each user.

Results and Discussion

We performed some tests using residential air conditioners, commanding them remotely by the system. We achieved success in all control attempts using the proposed system. It was possible to note the system has the potential for scalability and it can be implemented in places with a greater number of air conditioners, such as hospitals, schools and public buildings. Besides the proposed system is not invasive, the system is low cost and can work independently using only the local WiFi connection.

In addition, the system can incorporate other functions as automatic activation by schedules. Besides, the system also prevents users from starting the air conditioners at inappropriate times or temperatures, which would generate thermal discomfort and higher energy consumption.

The present work differs from Correa et. al. (2018) in a main aspect. In our work the air conditioning is not connected to our system. This decreases complexity of implementation and installation cost. Furthermore, it does not prevent the air conditioning from being activated in the event of system failures.

Conclusions

Preliminary results indicate proposed system is feasible to be carried out on a large scale. The system can control air conditioners systems remotely, in a pre-configured and automatic way. In future work, a web system will be developed to manage the air conditioners via the web, allowing the user to configure, through this system, the time to start and stop each air conditioner, over the Internet.

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