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Article

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Definition and Development of a Control Concept Applied in Elements Distributed for Manage Them Using IoT

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Abstract: In recent years, the Internet has gradually developed into a mature tool, which can integrate technologies involved in different application scenarios. The Internet allows the integration of solutions to different problems, which benefits both users and companies. The Internet of Things is a further development of the Internet, which can further realize the interconnection of people, machines, and things. The work of this paper mainly focuses on the use of Internet of Things technology to achieve efficient management. A wireless device is designed in the paper, which can be integrated in a helmet. This helmet can be used in some specific scenarios. Managers can use the Internet of Things technology to call the data generated by the hearing equipment and lighting equipment in the helmet to identify users. These helmets can be managed through a network platform. On the network platform, in addition to the helmet, some other components can be allowed to access, making the platform more universal and convenient. This paper elaborates on the design and development of the project and shows how to use it for effective time management in the skating rink.

Keywords: Helmet; skating rink; telemetry; users management; web application

1 Introduction

Since the Internet has been called a part of human life, it has been used as a tool to promote communication between people in different locations. Nowadays, with the development of a number of emerging technologies, the development of the Internet has made many solutions possible. New ideas that emerge every day can bring many benefits to mankind, such as making life easier with the advantages of the Internet [1].

The biggest advantage of the Internet of Things is that it can remotely control multiple objects, because these objects are connected to the Internet. Therefore, by effectively controlling multiple objects, efficiency, productivity, and creativity can be improved. In turn, it can further spawn new useful ideas and business areas. This forces that each day the Internet must be faster, and have better connectivity to it, to have the ability to support the elements necessary to implement a distributed system supported about it. In addition to owning and controlling these elements through the Internet, we can also use examples to obtain information that is difficult for humans to perceive. The information obtained can help us make a decision, so that the system can make more accurate decisions to implement improvement strategies that are beneficial to users [1–5].

Nowadays, the world is faced with a very complex situation when it comes to make to management the time in a system of mass use of users. The company requires precise monitoring of everyone's time, because this will undoubtedly increase utilization and optimize the productivity of the company. Meanwhile for a user is important know as its situation in front to the resource they are requesting, which is the time. This will satisfy all parties who use the above-mentioned system. In addition, this improvement is for waiting time. When the service providing this kind of control is at the maximum occupancy point, disqualification or complaints will be avoided [5]. This problematic is currently presented in the management of spaces, which is defined as a good that can be managed, as is the case of a skating rink, which it stands out for being an interesting entertainment environment to share with friends and family, which can be exploited commercially [6]. However, this type of business idea does not have an adequate system to manage the times in which a user makes use of the leisure environment, what has caused difficulty in the administrative tasks of its managers of this, generating discomfort in the clients who wait patiently their turn to enjoy the service that they have requested.

The collaborators of the skating rink have implemented a system that controls moderately the matter by means of helmets of different colors, which are assigned to a set number of clients [7–8], who enter at a certain hour, with the purpose to identify to each group and the times in which they access the service are taken manually with a notebook and a clock; as a result of this, the customers who wait for a turn will be seen with disagreement by not being able to access the service purchased properly, this occurs to poor times management [8], because there may be people who try to stay skating more than the required time, doing who are in the aforementioned queue, they have to wait a little longer since the managed space has a limit of people who can enter to enjoy the paid service.

For this reason, it was built a system to improve the users time management process to give a better feeling to the customer, so that they can more efficiently enjoy what they acquire [5]. In this way, for this project a web platform is implemented, which connects to the devices controlled in the space, since through this the shifts of the clients who use the space or skating rink are managed [6]. The devices arranged for the users establish a wireless communication with the management system, and the interfacing mechanism that is incorporated in the protection helmets, which guarantees better handling of the situation, in such a circumstance, there is a hearing device and visual, to inform the user that the time paid it's already finished; In addition, a lighting device is attached, which allows managers to better visualize users on the skating rink when they have run out the time [9–13].

The purpose of this project is to provide a solution by applying the IoT concept, in this case in a specific business model, but not limiting its implementation to solve other problems [5–6], which in the scenario's potential treats the management of users for a service within a space that is open or closed, as this could open many possibilities and improve multiple business ideas, so that they can adapt to the new challenges that today's actual society [10–12].

2 Methodology

For the development of the device, it was necessary to carry out a quantitative research, because it is necessary to consider the factors that affect the process of the space to be managed, which in this case are the users, the track, and the schedule. The next step was to carry out a descriptive and evaluative investigation, since they were analyzed different variables that affect the problematic of the space in mention, so it was necessary to make multiple observations to establish the best solution for the development of the appropriate device to operate said environment [7].

Once the analysis phase is completed, the design phase of the project begins. The development of the telemetry system can be used as a reference for this design, and its foundation is the establishment of a communication model. With the communication mechanism, remote elements (helmets) can be managed [6]. In the case of hardware, it was chosen work with devices based on the Arduino system, this due to its low cost and high practical implementation, which allows multiple adaptations to the needs of today's world [10].

For the logical part, it was chosen to work through by an online platform recognized as UBIDOTS, in order to communicate and manage the times of the helmets, because it allows adapting different Widgets, allowing controlled the device and modules to be that are connected to this [5–6], facilitating management that will allow good usability by the operator. The methodological development scheme can be seen in Fig. 1 [11].

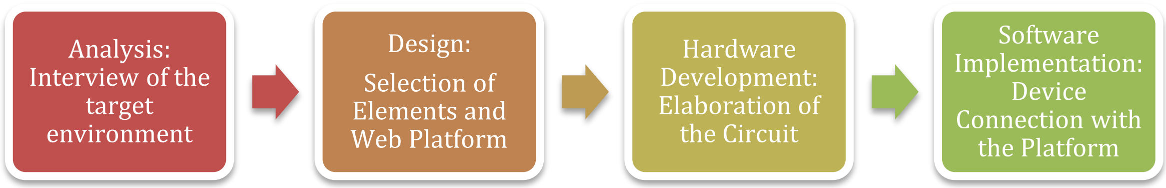

Figure 1: Methodological development scheme

The telemetry involved consists of the measurement of physical variables through a data acquisition mechanism, which it will be sent later for manipulation or interpretation from a control center. This is normally done wirelessly, but it is also possible through different wired means. Telemetry systems can receive the necessary instructions and data from a defined control center on a suitable platform through the Internet [11].

Features of telemetry:

- Measure: In this process, it is captured the necessary information from the source, a process or machine, which is done by means of sensors and/or hardware.
- Communication: This consists of the transmission of previously acquired data through a suitable means to the control center.
- Visualization: The acquired data are stored in a storage structure, and this are presented by means of a viewing platform.
- Analytic: Through the platform, it is made the use and manipulation of the information to facilitate its decision-making of the same.

3 Project Development

The development of the project required 4 phases, which were made rigorously, to make a device that can meet the needs of the company and users. The phases for this were: Analysis, Design, Hardware Development and Software Implementation [12].

3.1 Analysis Phase

Different visits were made to the application environment (skating rink), in which the pertinent information could be collected, with which were known important details as to the different processes carried out within of this, of the operation of the company to observe the viability of the development of the project and that this provides a correct solution to the employees in charge of supervising the users who enter said environment, is allowed the entrance of an approximate between 60 and 70 users. The track can only offer a 40-minute plan due to this problematic.

To avoid confusion in the moment to supervising the users, the supervisors allow the entry of this a certain time, with a span of difference to 10 min per group, giving them to each group a different helmet color and writing down the entry time of each of these, in order to differentiate and avoid confusion. The track has 11 groups of different helmets, standing out the yellow helmet that is the one used when an enter a large group, approximately more than 10 users at the same time. The helmets on average on a day of high user flow are worn 2–3 times each one [13–15].

3.2 Prototype Design

The first objective is the development of a circuit that allows through a Wi-Fi network to establish a connection with distributed and dispersed objects, and the purpose is to monitor the users to whom the service is provided, since, by normativity, they must wear the helmet during the time they remain on the track. This device establishes connection to the network in the moment of this is activated through a wireless access point, which, in turn is connected to the master computer from where the status of the helmet connection and the duration time of the client within the track are observed [1]. The helmet works as a slave device that provides the connection status periodically [3,7]. The conceptual scheme can be seen in Fig. 2.

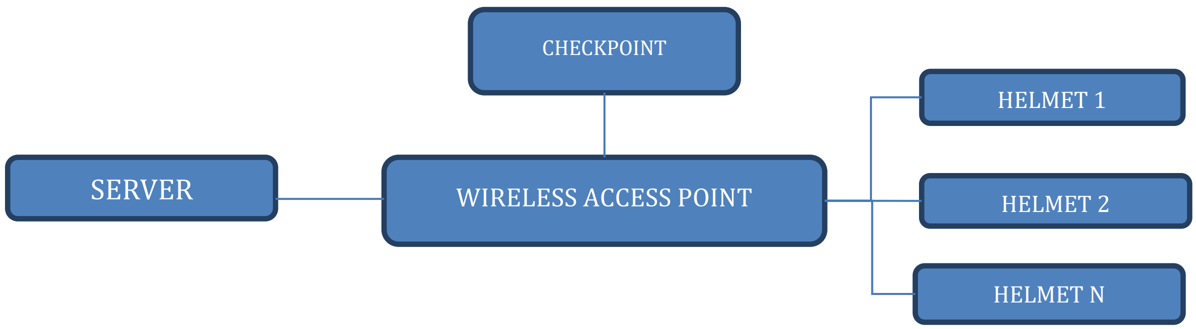

Figure 2: Conceptual system diagram

From the master computer, the track supervisor is in charge of monitoring that the helmets that are inside the track are connected through the application, who will also show you for each helmet the duration time that the user has canceled before entering the track, the time of entry, and the time that carries inside of this [14,16]. Once the service usage time has expired, the system will take care of send a message, which activates the luminous warning, which, are the strips of LED lights that are attached to the front of the helmet, in order that the supervisor can identify without problems the users who have finished the time, the strip will turn off once the user has withdrawn from the track, which must be validated by the administrator. This can be seen in Fig. 3.

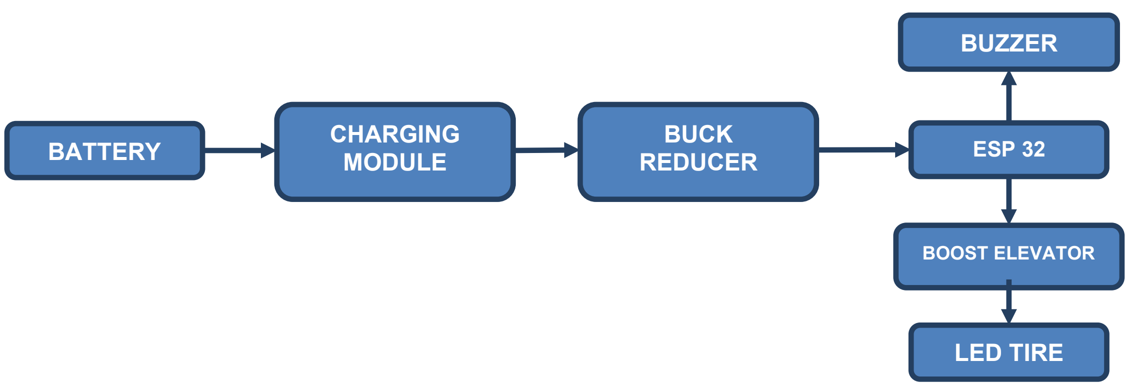

Figure 3: Conceptual circuit diagram

Therefore, at the same moment when the light strip is turned on, the buzzer located inside the helmet will be activated. The buzzer can realize the sound warning function and remind the user that the requested time has passed. This means that users must leave the track in the shortest possible time. The buzzer is activated three times with a duration of 3 s, with a time lapse of 10 s between each activation.

The sound is regulated at a frequency of 200 Hz, which does not affect the health of the user, nor does it cause this to react by unexpected way [17–18].

3.3 Hardware Development

For the development of the device hardware to be installed in the helmets, 2 stages were considered: The communication stage is the part that is established the association with the master server, in addition to activating the light module and the hearing module when required, this can be seen in Fig. 4. The detailed modules are described as follows:

- **ESP32 Development Module:** For this purpose, this device is important, because it has a low consumption development board which includes within its design the relevant protocols of the standards of Wi-Fi (IEEE 802.11) and Bluetooth (IEEE 802.15), this element is essential within the circuit since it is the one in charge of communicating the device with the platform, in order to be able to activate the modules when has activated the control timer that has assigned.

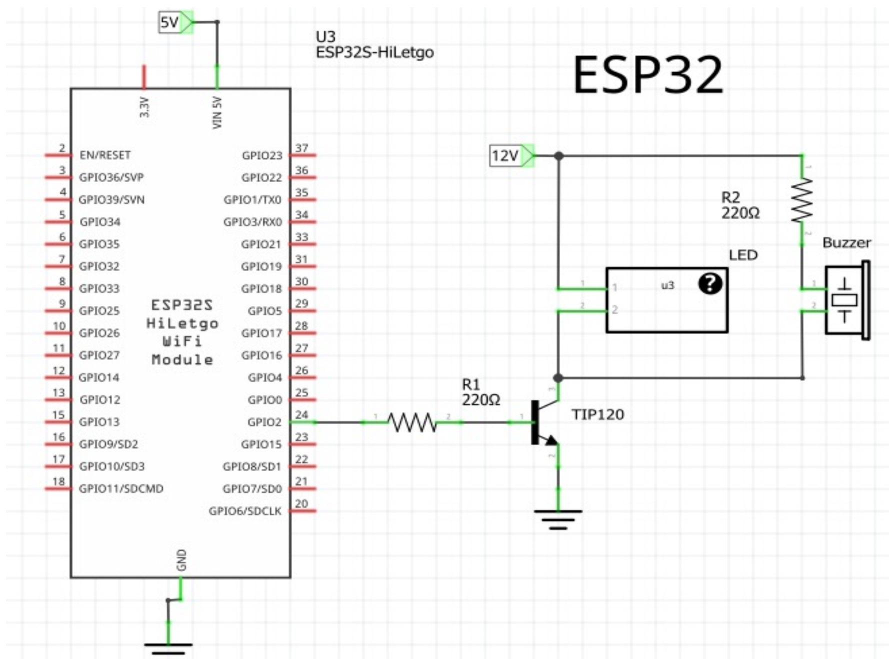

Figure 4: Communication circuit schematic

The energy stage is the which one is guaranteed which the correct supply of the circuit, because this one, although it does not consume much energy, it is necessary to have a robust system since it must support autonomy during the time of use, in addition to avoiding an overload that affects the circuit, of which can be highlighted the following components:

- **XL6009 DC-DC Elevator Converter Booster type:** This module allows to raise the input voltage of a circuit guaranteeing its current intensity of the same, which is implemented for hardware that requires more supply, avoiding altering the initial input voltage of the main chip or the use of a second load source, this module was implemented in order to power the LED tapes, since they require a 12 V supply.
- **Mp23070n DC-DC Buck Converter Mp23070n:** This module allows to reduce the input voltage of a circuit guaranteeing its current intensity, which it is done in order to guarantee the supply of a circuit element that requires a lower voltage than the supply. This chip was implemented to guarantee the supply voltage of the ESP32 and guarantee its correct operation.
- **USB Lithium battery charger module with BMS protection:** As you can see in the Fig. 5,

this module in addition to allowing the charging of the lithium battery through a micro USB input, protect the same cases of overload cases, avoiding he affectation of the product.

- **3.7 V LIPO Rechargeable battery 1000 mAh:** This battery is responsible for providing power to the entire circuit, since it has the characteristic of working at 3.7 V, ideal voltage to work with the ESP 32 Module, it is a rechargeable type battery and that provides a great autonomy of work, which is ideal since will be working much of the day.

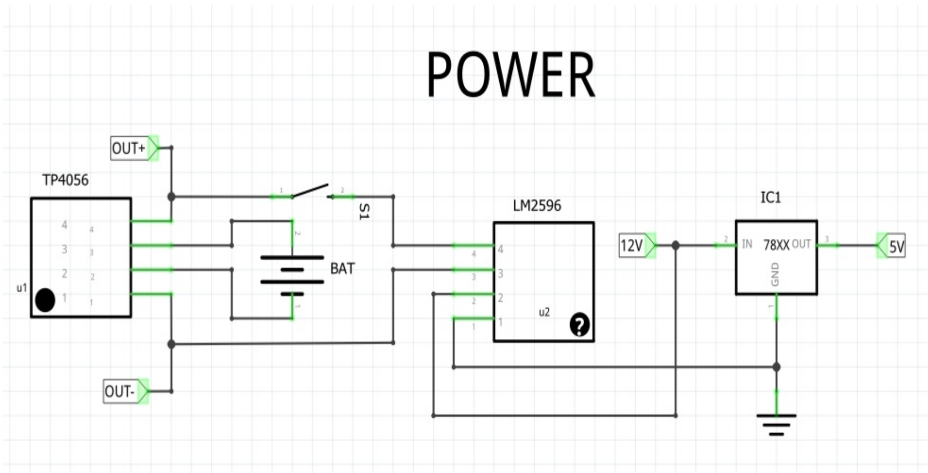

Figure 5: Energy circuit schematic

To complete the circuit, was added a Darlington type transistor [3], to regulate the current of the LED tape that was placed on the outer part of the helmet [6], which it works as a luminous warning, to notify the space supervisor about the users that it has expired the time of use within the same [10], also was connected a buzzer as an audible warning, which it will allow to notify to the user by means of a soft tone that has been finished the service time [17–18], we can see this in the Fig. 6.

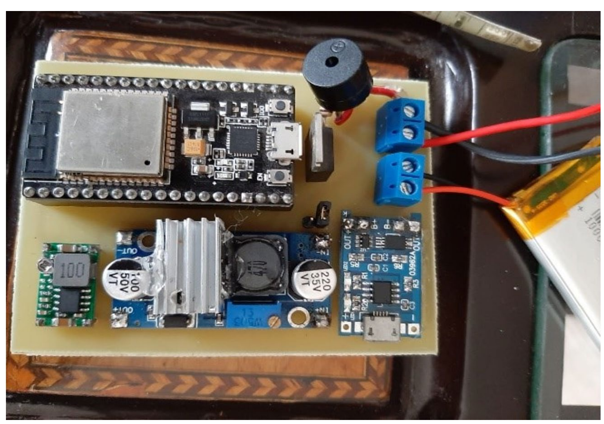

Figure 6: Finished circuit view

3.4 Layout and Association of the Software

One of the crucial elements was the moment to determine the web environment with which the system is implemented, since this is decisive for the correct functioning of this, because you must ensure the management of connected devices, in addition to allowing the necessary functions to be carried out for the development of the project. For this was used UBIDOTS, which is a solution-oriented Web platform through IoT, because it allows adding multiple devices for later control. This solution has the characteristic of being cross-platform, that is to say, can be used in a computer, cellphone or Tablet, what allowed a remote control of the devices and this lends itself to perform a monitoring constantly the operation and performance of activated devices [19].

This platform allows to add them to the de devices a series of widgets, what it allowing to develop multiple functions that you want to implement in the different connected objects, in addition, allows to develop remote actions that you want to control through these, and it has a development environment and very intuitive use, this allows it to be very easy to use for the user.

When the hardware design process is completed, the corresponding programming should be carried out next to ensure that the hardware circuit can work normally. The first is the programming of the ESP32 module. ESP32 is responsible for communicating with the main device and finally activating the light-emitting device and the hearing device.

To develop the code, it was implemented the C language, which is compatible with the latest versions of Arduino, in addition to having the advantage that can be added the PubSubClient libraries, which is based on MQTT architecture (Message Queue Telemetry Transport), which is a protocol created by IBM, whose function is to facilitate Machine-to-Machine communication (M2M). This focuses on the sending data in applications where very little bandwidth is required, which is an IoT reference. In addition, its characteristics allow it to dispose of a low consumption, as well as specifying to very few resources for its operation.

The characteristics that make a MQTT architecture the most suitable for the implementation of the device is the ease of use it has with devices that have little bandwidth for connection, since, by managing several devices simultaneously, allows you to manage several at the same time, it allows to manage several at the same time, which it makes a very ideal technique for managing solutions based on IoT. In addition, as it requires little bandwidth for its implementation, this is reflected in the energy consumption, which is a potential characteristic for solutions where a low consumption of this is required.

These features have done that quickly is become a standard protocol for sensor communication and WSN networks (Wireless Sensor Networks) [10], which are elements of the Internet of Things [14]. The library is essential to establish communication between the platform and the devices, since it is necessary to add the credentials so that they establish the connection with the platform, for their later use, this can be seen in the Fig. 7.

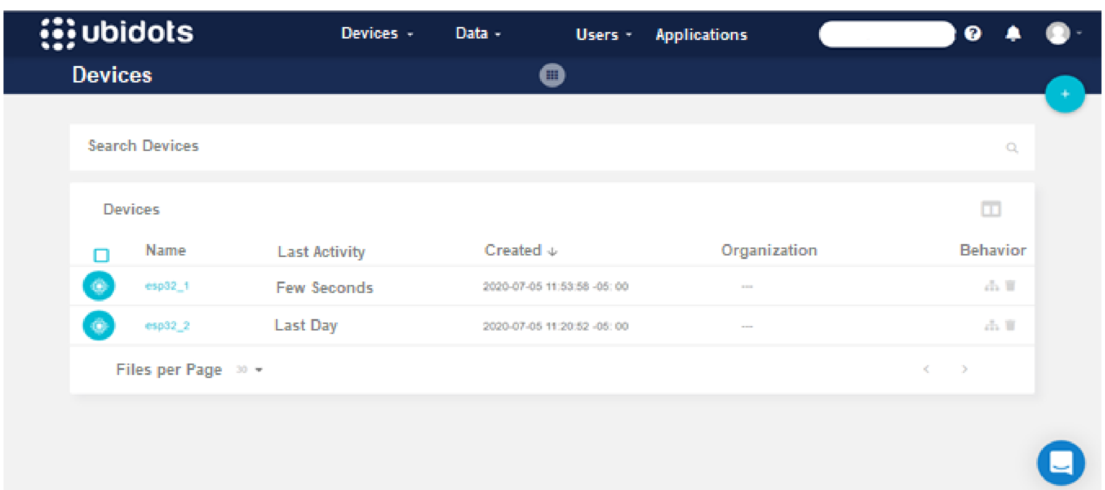

Figure 7: Ubidots platform with connected devices

Once connected the devices to the web platform, we proceeded to add an on/off widget, which is in charge of establishing the connection with the helmets, these must be turned on and must be correctly activated the Wi-Fi credentials, to communicate correctly [13]. In order to synchronize the management time, a timer needs to be established. Use this counter to set the time and assign it to the helmet [20–21]. This time can be set in minutes. Once the set time is exceeded, it means that the buzzer will be activated and complete the audible alarm. When the alarm is no longer needed, the on/off widget needs to be manually pressed to deactivate the sound so that the system can be restarted. This process can be shown in the Fig. 8.

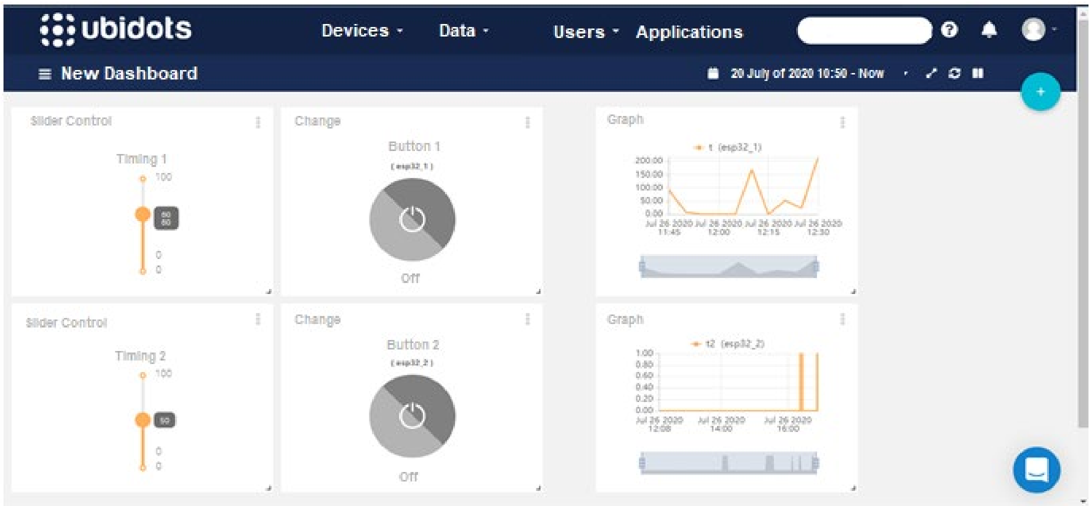

Figure 8: Ubidots view with configured widgets

4 Device Tests

As a method to demonstrate the functioning of the built system, it was chosen for modeling the Cisco Packet Tracer program, which is a program that allows simulations of networks and systems based on IoT, for this it was necessary to create the appropriate object, which is configured to show the appearance of the helmet states when they are in operation, later, was implemented the code within this to establish activation through the network. The system simulates from the moment you enter from a control device to the page, to later show the states of the same, and thus manipulate them in the correct way [20,22]. This can be seen in the Fig. 9.

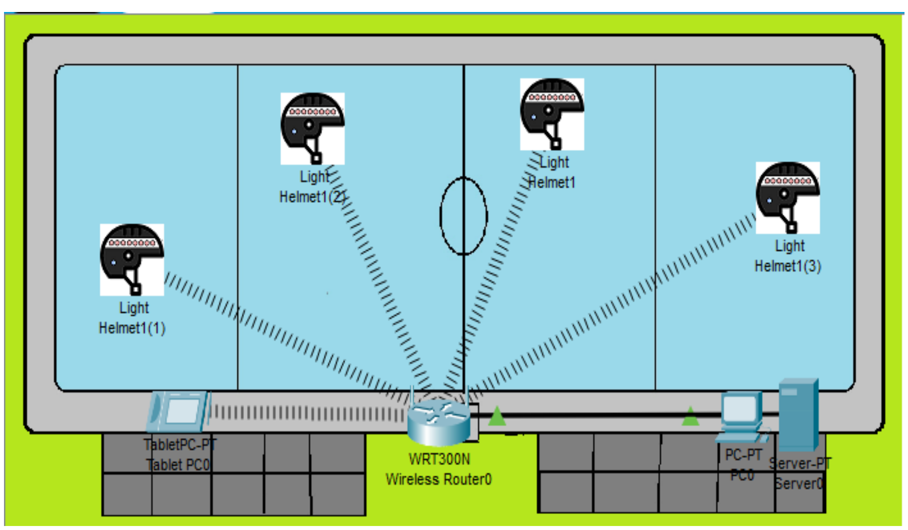

Figure 9: System modeling view in Cisco Packet Tracer

5 Results

In the development process, it was built a device of a distributed system [3], which it connects and associates through a wireless network scheme [6], that having been configured, and in relation with the UBIDOTS software [14], this is allows a user to enter said platform, and thus being able to establish the appropriate parameters that allow temporize and make control to the system, so that thus start the countdown of the times, and that in turn the luminous and audible actuators are activated when it finish the service administered by each user [21], which cab been seen in the Fig. 10.

Figure 10: Final project model

The system is implemented on a platform that fully considers the elements of the Internet of Things. It allows multiple devices to be operated simultaneously in this way, with efficient management and data analysis capabilities [3,6]. The system is supported in IEEE 802.11 connections (Wi-Fi), with which you can associate the devices and thus manage them from a command post that controls the operation of these [14–15]. A device is embedded in the helmet. The module in the device can enable the helmet to connect to the above network solution and activate the actuator when the management conditions are met, thereby facilitating the distributed control of the system administrator and the user's audible alarm [22]. The detailed process is shown in Fig. 11.

Figure 11: Project activated

6 Conclusion

Currently, most telemetry applications are designed for large enterprises. Large enterprises involve many users. In this case, they face the problem of continuous monitoring of multiple users. The research in this article can provide a good solution to this problem at a very low cost. At the same time, the solutions we propose will also inspire new design ideas. For example, it is possible to provide feasible ideas for user monitoring through a positioning system. In addition to positioning users in a specific space, users can also be located in the track, which is convenient for determining the user's tariff. This project has great potential, due to its multi-user adaptation, since with creativity and implementing correctly the widgets, it is very easy to use in other scenarios, can be implemented in spaces mainly where the users use reservation and scheduling mechanisms to acquire the services., this in order to correctly manage the times thereof, and that including this in the current panorama, this is taken advantage thinking about controlling the amount of users that can access to this type of system at the same time, and where the model of many businesses can already be migrating.

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