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Analysis and control of soil moisture through a system supported by sensors in the botanical garden "Jorge Quintero Arenas".

Análisis y control de humedad del suelo a través de un sistema soportado por sensores en el jardín botánico "Jorge Quintero Arenas"

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ABSTRACT

Various solutions for continuous improvement are generated from new integrated technologies, without affecting the environment, generating various changes in the teaching/learning process. In the end, the impact will be in a sustainable botanical garden. This paper describes the development of a prototype sensor system created for soil moisture analysis and control. This prototype is made up of a network of sensors that will support the administration of the botanical garden. It was obtained the evaluation of the obtained variables and likewise, the approach of strategies with respect to the reduction of the waste of the hydric resource, all this focused on the use of the Internet of the Things (IoT). This is that by having a detailed knowledge of each of the variables that influence under the conditions established for this project, it was possible to achieve with greater ease and security the appropriate approach of strategies that allow water saving and avoid more effectively the waste of this resource so precious and necessary for consumption and also for saving money and better environmental quality.

Keywords:

Internet of Things,
Botanical garden,
Technology,
Smart University,
WSN.

RESUMEN

Diversas soluciones para el mejoramiento continuo se generan desde las nuevas tecnologías integradas, sin afectar, el medio ambiente generando diversos cambios en el proceso enseñanza/aprendizaje. Al final, el impacto se dará en un jardín botánico sostenible. En este trabajo se describe el desarrollo de un sistema sensor prototipo creado para el análisis y el control de humedad del suelo. Este prototipo está conformado con una red de sensores que dará soporte a la administración del jardín botánico. Se obtuvo la evaluación de las variables obtenidas y así mismo, el planteamiento de estrategias con respecto a la disminución del desperdicio del recurso hídrico, todo esto enfocado al uso del Internet de las Cosas (IoT). Esto es que al tener un conocimiento detallado de cada una de las variables que influyen bajo las condiciones establecidas para este proyecto, se pudo lograr con mayor facilidad y seguridad el planteamiento adecuado de estrategias que permitan el ahorro del agua y evitar de manera más efectiva el desperdicio de este recurso tan preciado y necesario para el consumo y también para el ahorro de dinero y mejor calidad ambiental.

Palabras clave:

Internet de las Cosas,
Jardín botánico,
Tecnología,
Universidad inteligente,
WSN.

Introduction

For the development of agriculture it is an essential resource. Water being expensive and scarce in various parts of the world, so its optimal management is essential and mandatory. It is necessary to carry out the instrumentation of the variables that affect the growth process of the crop (soil, water and plant) and the use of the techniques associated with this instrumentation to take actions to optimize production. At the Francisco de Paula Santander Ocaña University, the Jorge Enrique Quintero Arenas University Botanical Garden was created with the mission of conserving the dry forest ecosystem and the types of vegetation and flora present in northeastern Colombia.

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Due to the effect of climatic phenomena, the water decreases and this affects the population in general terms. In crop irrigation, the use of water is not controlled, so its use is wasted. A controlled crop irrigation system could solve this problem that arises and thus avoid the loss of this precious liquid, since monitoring studies in controlled crops show the need to measure climatic variables under real-time conditions, which would allow manage resource use appropriately [1] - [5]

In this context, it is important to relate the above with the mission and vision of the Botanical Garden of the Technological University of Pereira, since in its mission “it contributes to the conservation of the biological diversity of the Andean forest, through research and management of its area of conservation, germplasm bank and related ecosystems, to generate and disseminate knowledge and offer spaces for enjoyment and recreation. Likewise, it proposes as a vision that it is recognized at the regional, national and international levels, for the excellence and social and environmental impact of its research and extension activities for the conservation of the biological diversity of the Andean forest ”[6], [7] .

This work describes the development of a prototype sensor system created for the analysis and control of soil moisture. This prototype is made up of a network of sensors that will support the administration of the botanical garden. The HC-05 bluetooth module, fc-28 soil moisture sensors were used and the hardware used to support the proposed architecture was developed under Arduino Uno R3 with the ATmega328 microcontroller,together with ESP8266 integrated chip with WiFi connection and compatible with the TCP / IP protocol, which will allow us to give access to any microcontroller to a network, taking the system to the Internet of Things level with the aim of storing information in the cloud and thus achieve to carry out BigData that allows us to discover information of interest for decision-making in the botanical garden. Additionally, for the activation of the sprinklers that allow generating irrigation based on soil moisture, they used 12V surface pressure pumps. The article is divided into: introduction, background, methodology, contextualization and results.

Materials and methods

The methodology that will be used as a development tool for the research will be the experimental quantitative one since it requires the execution of prototypes and the study of measurement variables that will be captured through sensory technology. Due to the lack of humidity in the earth, it is necessary to measure this variable in order to carry out their respective analyzes and studies by means of a monitoring prototype. The methodology begins with a state-of-the-art phase that allows knowing the main findings about the analysis and control of soil moisture. An analysis of the results found is carried out in which it is possible to obtain the literary material, price and suitable for the investigation.

Said literary material also focused on what is related to Industry 4.0 and especially the Internet of Things, a technology that allows the connection of various devices to the Internet, generating volumes of data which, when processed, achieve communication between devices of a more correctly, bringing with it the opportunity to interact with the environment to which it is exposed, through sensors and network modules that capture variables from the outside and all this autonomously without the need for human intervention.

Methodology

The fourth industrial revolution and the internet of things [8], the possibility of interconnecting devices in order to be more efficient in the processes that are developed in the different fields of industry such as agriculture, deportation, medicine, commerce and other sectors of the economy of the countries. In the garden, the use of elements that would allow us that the infrastructure to be used will achieve an interconnection of the devices with the internet was proposed, which led us to take into account devices such as the ESP8266 and the ESP8285 that are microcontrollers which can be worked with them loose or buy them integrated into a PCB (Printed Circuit Board or Printed Circuit), the feature of this device Supports IPv4 and TCP / UDP / HTTP / FTP protocols [9].

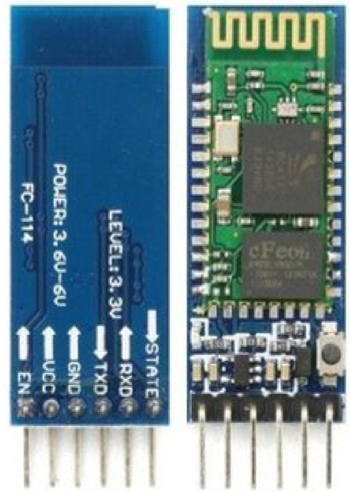


Figure 1. Bluetooth module HC-05
Source: [12].

In M2M communication, where two machines communicate with each other without human presence, the reference protocol used to achieve the devices made by the Arduinos was the Message Queue Telemetry Transport (MQTT) [10], said protocol Open source used in low-throughput devices that need to send and receive data using low bandwidth, improving latency and reliability. This protocol allows devices to be faster and independent of data, delivering quality of service.

For the development of the sensor network that will support the administration of the botanical garden, the HC-05 bluetooth module was used, see figure 1, which is a Master-Slave module, being a main characteristic the ability to receive connections from devices such as PC or Tablet and generate connections to Bluetooth devices, allowing data to be transmitted between two microcontrollers or devices [11].

Additionally, the activation of the sprinklers that allow generating irrigation based on the humidity of the soil used 12V pressure pumps surface, see figure 2, ideal for installations where it is necessary to transport a certain flow of water, ideal to solve our problems.

Figure 2. Pressure pumps

Source: [12]

Soil moisture sensors fc-28, see figure 3, This element is frequently used to control the humidity of the soil or soil of the plants under study in the botanical garden, the sensor works using the voltage proportional to the measured humidity level, which will allow us to know if the soil is dry, humid or has too much water [13].

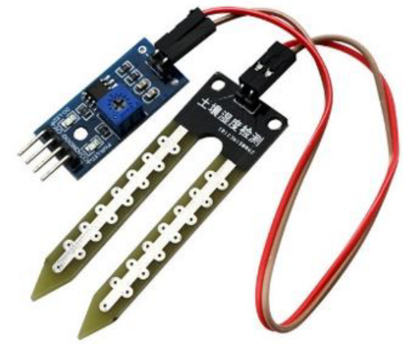


Figure 3. fc-28 soil moisture sensors

Source: [13]

The Hardware used to support the proposed architecture was developed under Arduino Uno R3, see figure 4, uses the ATmega328 microcontroller. Which is quite powerful and met the characteristics that would allow us to manage the sensor network of the botanical garden[12].

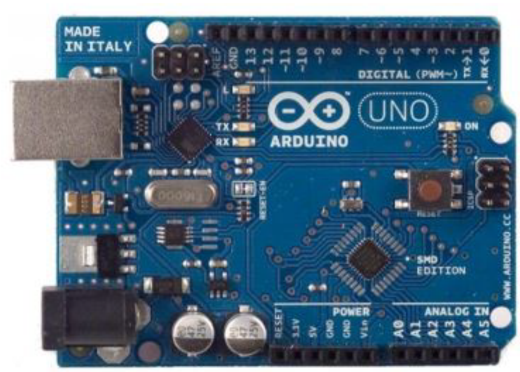


Figure 4. Schematic of Arduino Uno R3.
Source: [12]

A WSN (Wireless Sensor Network) system has evolved from the idea that small wireless sensors can be used to collect information from the physical environment in a large number of situations ranging from monitoring wildfires and observing animals to agricultural management and industrial surveillance. Each sensor wirelessly transmits the information to a base station. The sensors help each other to transmit the information to the base station, as seen in Figure 5.

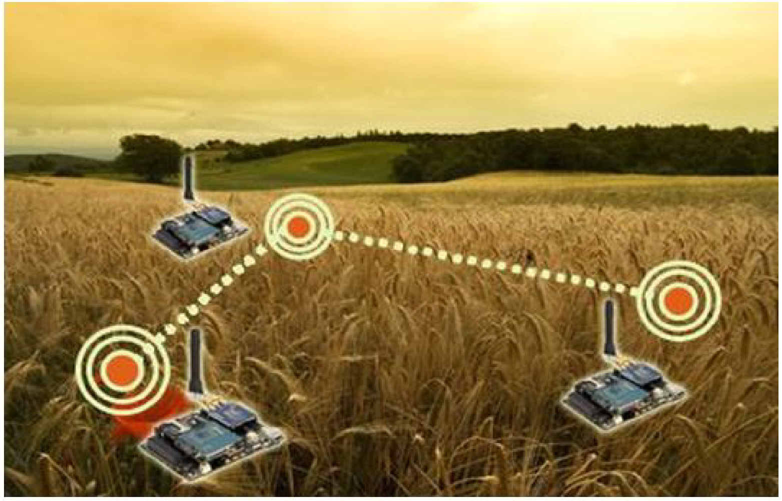


Figura 5. Integration of Sensory Systems.
Source: [14]

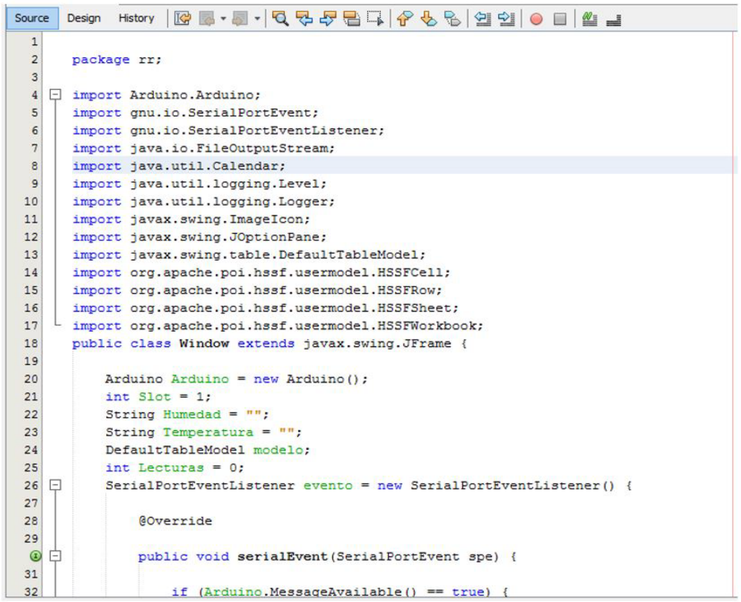
Results and Discussion

Technology and architectures in botanical gardens

Botanical gardens are considered today as the lungs and most important public green spaces in the main cities of the world. They support various investigations in different fields of science such as plant ecology, gardening and botany [1]. Its purpose and design are varied, but the vast majority its main objective is the conservation of the environment and its great contribution to education [6].

Thanks to the strategic deployment of an infrastructure and the services that technology offers, a community can become smart and ecological, achieving the objectives of the sustainability policy [15]. The practice of accessing the plants when they enter the collection and then keeping records of this material throughout their life stands out, then as one of the main attributes that distinguishes a botanical garden from a purely exhibition garden is [7] , [16].

To support this transformation, the implementation of a sensor infrastructure for the garden whose function is to collect and analyze data on changes in climate and soil moisture conditions. Sending everything to devices, including mobiles, generating alerts depending on the configuration on the behavior and changes of the monitored variables. For example, a good system will be able to automatically control the existing irrigation system based on the data collected by the garden sensor [1], [17].

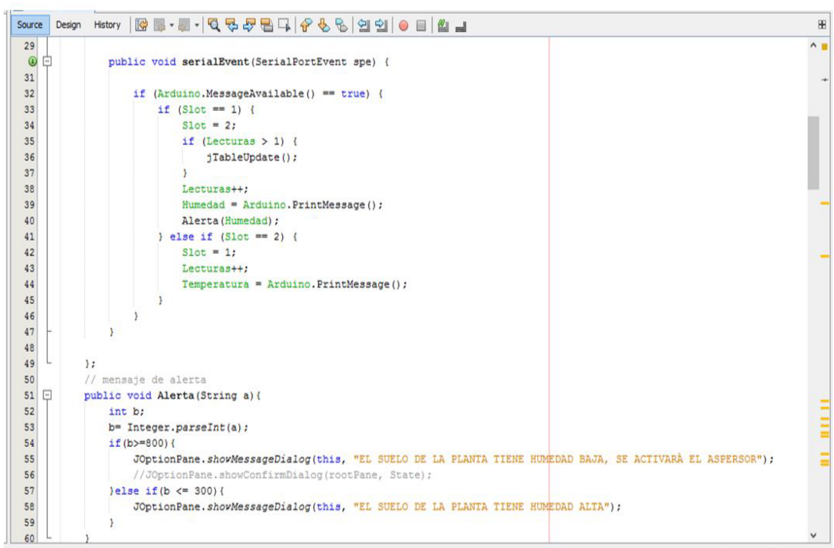


```java
package rr;

import Arduino.Arduino;
import gnu.io.SerialPortEvent;
import gnu.io.SerialPortEventListener;
import java.io.FileOutputStream;
import java.util.Calendar;
import java.util.logging.Level;
import java.util.logging.Logger;
import javax.swing.ImageIcon;
import javax.swing.JOptionPane;
import javax.swing.table.DefaultTableModel;
import org.apache.poi.hssf.usermodel.HSSFCell;
import org.apache.poi.hssf.usermodel.HSSFRow;
import org.apache.poi.hssf.usermodel.HSSFSheet;
import org.apache.poi.hssf.usermodel.HSSFWorkbook;
public class Window extends javax.swing.JFrame {

    Arduino Arduino = new Arduino();
    int Slot = 1;
    String Humedad = "";
    String Temperatura = "";
    DefaultTableModel modelo;
    int Lecturas = 0;
    SerialPortEventListener evento = new SerialPortEventListener() {

        @Override

        public void serialEvent(SerialPortEvent spe) {

            if (Arduino.MessageAvailable() == true) {
```

Figure 6. Netbeans libraries (java language).
Source: Own elaboration.

Prototype development

In figures 6 and 7, you can see the different libraries used in the development of the prototype, it is important to bear in mind that said software was developed under the Model View Controller design pattern which will allow us to be scalable over time migrating to different operating environments, such as the web, mobile devices, Tablet, etc.



```java
        public void serialEvent(SerialPortEvent spe) {

            if (Arduino.MessageAvailable() == true) {
                if (Slot == 1) {
                    Slot = 2;
                    if (Lecturas > 1) {
                        jTableUpdate();
                    }
                    Lecturas++;
                    Humedad = Arduino.PrintMessage();
                    Alerta(Humedad);
                } else if (Slot == 2) {
                    Slot = 1;
                    Lecturas++;
                    Temperatura = Arduino.PrintMessage();
                }
            }
        }

    };
    // mensaje de alerta
    public void Alerta(String a){
        int b;
        b= Integer.parseInt(a);
        if(b>=800){
            JOptionPane.showMessageDialog(this, "EL SUELO DE LA PLANTA TIENE HUMEDAD BAJA, SE ACTIVARÀ EL ASPERSOR");
            //JOptionPane.showConfirmDialog(rootPane, State);
        }else if(b <= 300){
            JOptionPane.showMessageDialog(this, "EL SUELO DE LA PLANTA TIENE HUMEDAD ALTA");
        }
    }
```

Figure 7. Code in netbeans (java language).
Source: Own elaboration.

In Figures 8 and 9, the programming of the Arduino began, through software construction standards that allow us the most efficient operation between the different modules that interact with each other such as sensors, valves, bluetooth modules, WIFI network interface. In the coding process, it was possible to implement a library for the communication of the devices called Arduino Client for MQTT, to achieve the sending of messages in a very light way following the publication-subscription model (“pub / sub”).

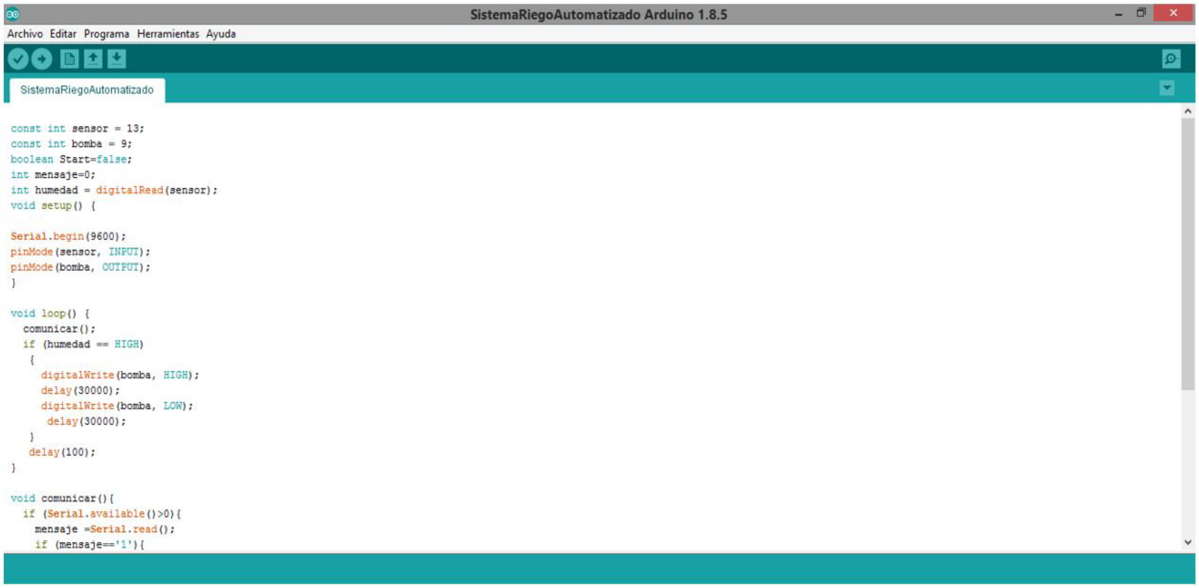


Figure 8. Arduino code library.
Source: Own elaboration.

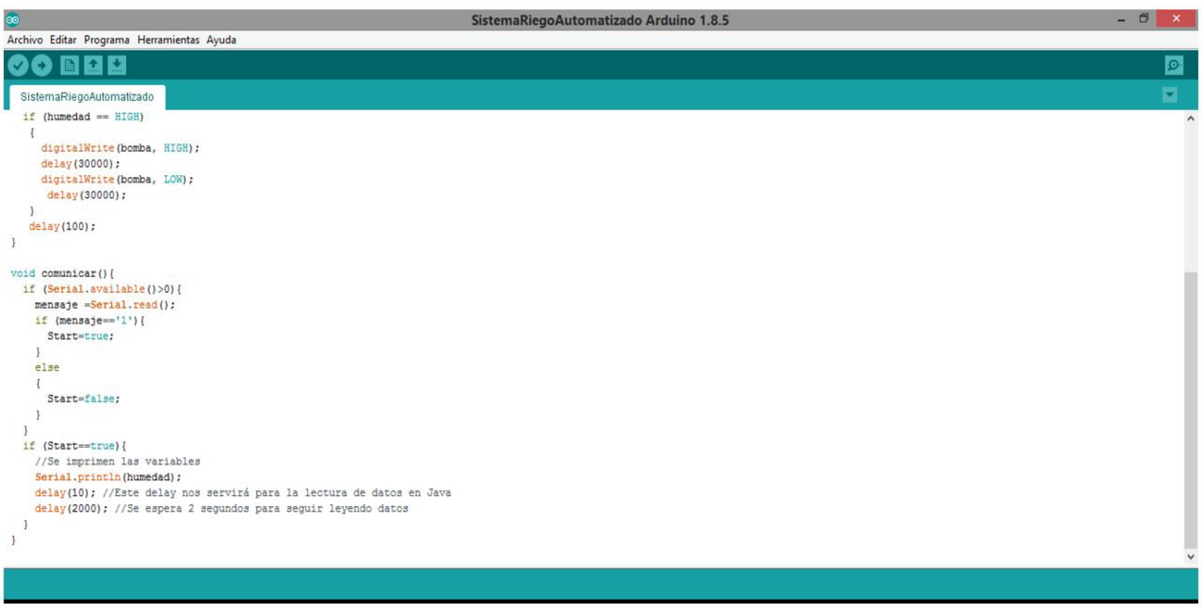


Figure 9. Arduino code.
Source: Own elaboration

In figure 10, the application is observed in one of its modules working taking data in real time, from the Arduino who is the one that is making the communication as said in the previous text, once the information is collected it is stored for its subsequent analysis.

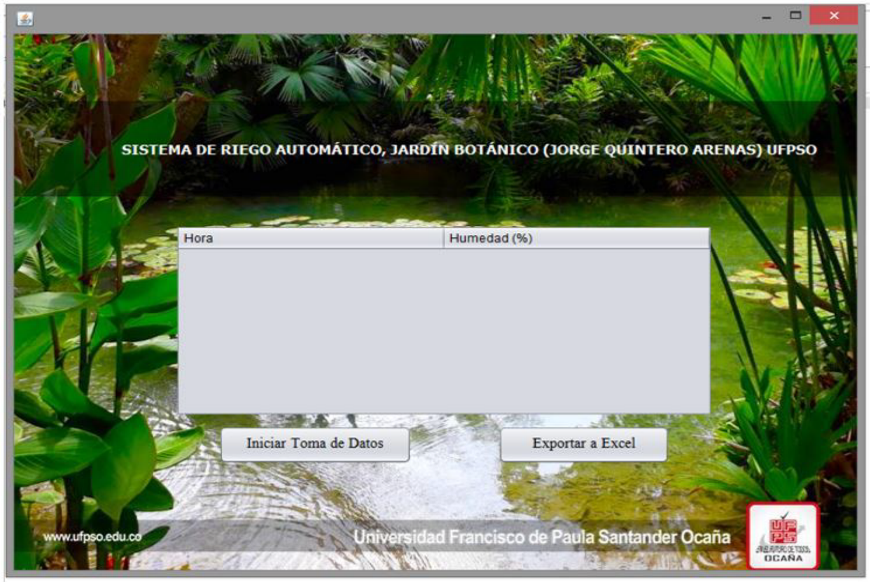


Figure 10. Software in execution.
Source: Own elaboration.

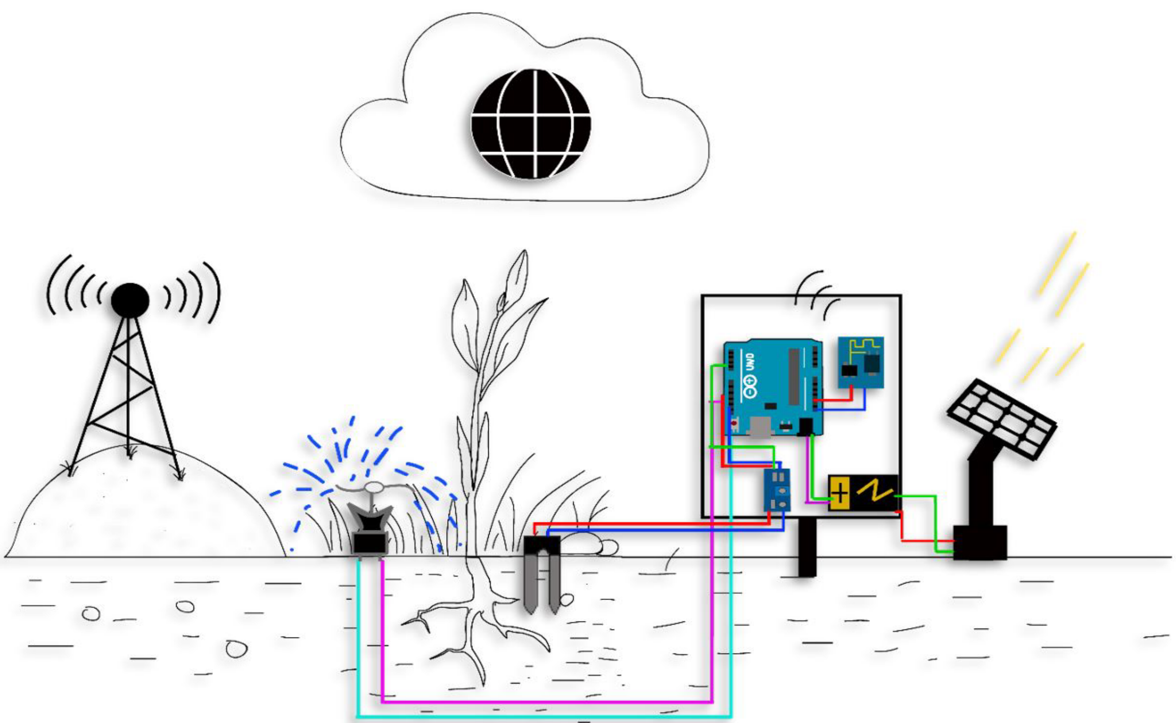


Figura 11. Schematic of project prototype model.
Source: Own elaboration

The transformation from the traditional university to an intelligent university, taken not as a goal, but as a way of life, a continuous process of improvement, promises a change in paradigm or model. A concept of a more open and user-centered university is consolidated, and as a consequence adapting its management model to the new times where all the actors and their infrastructures must coordinate for a common purpose: sustainability and quality of life [18] - [25]. As a specific result, the evaluation of the variables obtained was obtained and, likewise, the approach to strategies with respect to reducing the waste of water resources, all of this focused on the use of the Internet of

Things (IoT) [26] - [30] .

Conclusions

With the following research, it was possible to contextualize the different elements used in the construction of a sensor network for the botanical garden of the Francisco de Paula Santander Ocaña University "Jorge Enrique Quintero Arenas", with an Internet of Things IoT approach, detailing the Operating scheme.

Additionally, an operation architecture can be established where it is described how the sensors take information from the ground which allows sprinklers to activate according to certain configuration parameters, then the data is sent to the Arduinos devices who through internet access modules They manage to send the information to the cloud, allowing administrators to monitor in real time relevant aspects of the processes carried out in the garden, seeking to improve decision-making.

Another aspect to highlight from this research is the incursion into BigData which, thanks to the volumes of data sent by the sensors, it will be possible in the future to perform data analysis to better understand relevant aspects of the irrigation districts, seeking that these are increasingly more efficient in their operation, so that through these processes we can contribute to the "Fourth Industrial Revolution in the area of agriculture", improving the rational use of water, efficient use of energy, analysis of soil behavior and other variables involved in the care of plants or crops.

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