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Review Article

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Internet of Things (IoT) System to Monitor Environmental Variables in a Coffee Crop

William Ruiz Martinez[1] * and Roberto Ferro Escobar

[1]Candidate for Magister in the strategic direction of Software Engineering, Funiber- Specialist in Project Management, Systems Engineer, Armenia, Colombia

[2]PhD in Computer Engineering Universidad Pontificia de Salamanca Madrid Spain, Associate Professor and Associate Researcher at Colciencias, Bogotá, Colombia

***Corresponding author**
William Ruiz Martinez, Candidate for Magister in the strategic direction of Software Engineering, Funiber- Specialist in Project Management, Systems Engineer, Teaching in the Systems Engineering Program, Member of the Axon Research Group, Armenia, Colombia, E-mail: william_ruizmar@cun.edu.co

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Abstract
One of the challenges of the modern farming its based in satisfy the demand of a growing market, the same time that is increased the need to introduce technological alternatives of sowing and production that lead to a greater economic and environmental sustainability. The Coffee is one of the flagship products of our economy worldwide, for nobody is a secret that our grain is listed as one of the softest in the world due to the climatic conditions in which it is carried out its cultivation. This reason has allowed Colombian coffee to have great acceptance in international markets due to its high quality and flavor. But like all crops, coffee is exposed to a set of environmental variables such as temperature, humidity, soil type, rainfall index and wind, also of pests like the drill, and the rust, which finish for influence in the quality and grain production. Manually establishing the behavior of these variables becomes complex and not very functional, which is why the concept of the precision farming it allows us to introduce technology as an ally for coffee farmers, allowing them to reduce costs and significantly increasing grain quality.

Keywords: Agriculture, Precision, IOT, Sensors

Introduction
The Policies to support the agricultural sector in our country has not been the most ideal over the years, hence the government support specifically for coffee farmers through the accredited bodies does not cover all the expectations initially proposed and almost always they remain in good intentions, unfulfilled pacts and agreements or poorly managed and directed policies that in many cases are a reflection of the regional interests of the politicians of the day.

Due to this series of administrative problems mentioned above and others of a technical nature, the coffee sector is faced with a series of problems when it comes to optimizing harvesting and production processes, since for many years this sector, as we said previously, has not received the necessary attention from the state. Colombia has a huge agricultural potential that is not properly exploited due to poor planning and worse execution, government support is very few or nonexistent, and input prices are too high. Interests with which money is lent to coffee farmers end up discouraging investment in this important sector, often forcing them to diversify or, in extreme cases, abandon coffee cultivation. We cannot ignore the important role that technology plays in many sectors and agriculture is not alien to them, since with its introduction processes such as planting and production of coffee can be improved and automated improving the profitability of them.

That is why a sector such as coffee and the introduction of technology in certain processes has the potential to bring new horizons to the country's productivity, in addition to generating innumerable benefits oriented towards the sowing and production processes of certain crops [1].

Precision agriculture covers multiple practices related to the management of crops and crops, trees, flowers, plants, etc. Among the most interesting applications is the control of pests and diseases. By means of strategically placed sensors, parameters such as temperature and relative humidity of the soil, temperature and humidity of the leaves, solar radiation can be monitored in order to quickly detect adverse situations and establish the appropriate treatments. The great advantage of the use of this technology is the timely detection and optimal application of pesticides, only in those areas where it is really necessary [2].

One of the major problems that currently arise are the effects on agriculture, since there is no constant monitoring and control of environmental variables that affect the development of the same, from the sowing process to obtaining the final product. In this way, precision agriculture makes its appearance allowing it to be implemented in any type of crop and labor, as long as there is spatial variability (usable spaces), regardless of the area where it is wanted to be carried out.

“In a very general way, it is possible to carry out the adaptation of specific aspects depending on each productive system, variables such as: climate, temperature, humidity, soil type, genetic material and management system” [3].

Colombia is known for producing the best soft coffee in the world. Its production, according to reports issued by the National Federation of Coffee Growers, which is the entity that represents producers internationally, has grown by 26% compared to 2011. What makes it the third largest producer of coffee beans world-wide level, the federation has promoted in the company of the coffee growers’ aspects like: The renovation of crops, sowing of special and organic coffees, among other strategies to encourage the cultivation of the grain [4].

For this reason, we propose the design, development and subsequent implementation of a precision farming under the concept of the IOT (Internet of Things) to establish a set of measurements, alerts and controls to improve production and quality in a crop of coffee.

Through the design and development of this sensor system, the traditional farmer is offered an invaluable agricultural technification tool, which allows him to increase his economic benefits, the reduction of the environmental impact and therefore the improvement of his quality of life, from another point from sight precision agriculture tends to obtain a higher quality product with the well-known optimization of resources and works as a predictive element to avoid possible crop losses due to lack of management, supervision and timely action.

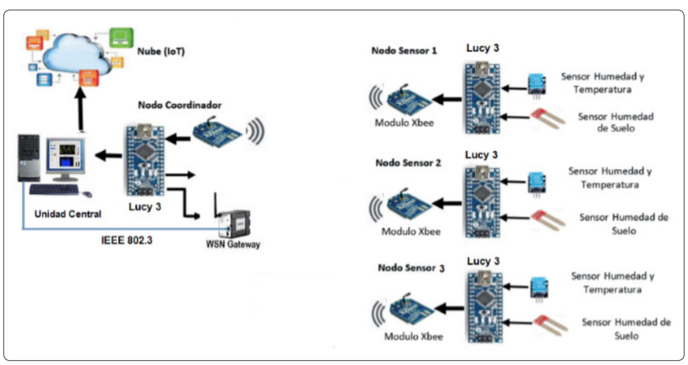

Figure 1: Architecture for the sensor network

Figure 1 shows the proposed architecture for the sensor network that allows the control of a coffee crop. It has been established that the land taken as a reference factor is a batch of coffee with an area of less than half a hectare and that is located in a coffee farm in the region.

The sensor nodes are responsible for monitoring environmental variables such as: soil temperature and humidity, ambient temperature and rainfall incidence through the use of a rainfall meter.

We also see in the figure a gateway, whose role is to send the information collected by the sensor nodes to the coordinator node that is responsible for establishing communication with the central unit integrated by a computer with Internet connection that will be responsible for uploading the information received to a cloud site for processing and further analysis.

Components of the Sensor Network

The objective, is the development of an architecture of sensor nodes, which allows to control coffee crops of an average extension of 4 hectares, and that can be separated from each other and from the house where the information will be received (Base Station) up to about 10km.

Sensor Nodes

Whose objective is basically to be a data acquisition unit. It is responsible for collecting data on environmental variables such as environmental temperature, relative humidity, soil moisture and atmospheric pressure, the measurements of the variables are transmitted to the coordinator through Xbee devices that work with the Zigbee wireless telecommunication protocol. One of the nodes is located in a range of 100 meters between one and the other. Each sensor node is integrated by a Lucy 3 programmable card [1].

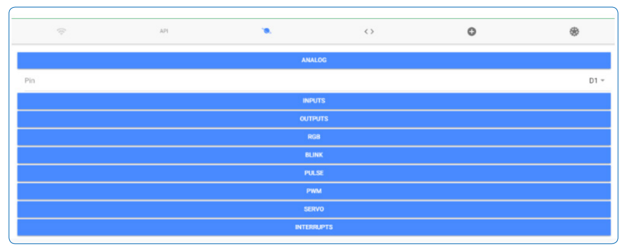

Figure 2: Functions of the Lucy3 programmable card (Source: Colmakers)

Gateway

Coordinating node or Gateway, which will be responsible for collecting the data from each sensor node to process them and send them to a computer via USB cable. In turn, among other functions are responsible for controlling the network and the paths that devices must follow to connect with each other [5].

Modules Xbee- Pro S2c

It is a low-cost module that allows wireless connections between electronic devices. It works with a frequency of 2.4 GHz and will allow you to create point-to-point, point-to-multipoint, broadcast and mesh connection networks. In this new generation of XBee-Pro S2C Series, SPI (Serial Interface Interface) communication is incorporated to provide an exchange data with a high speed between devices, optimizing the connection with microcontrollers [6].

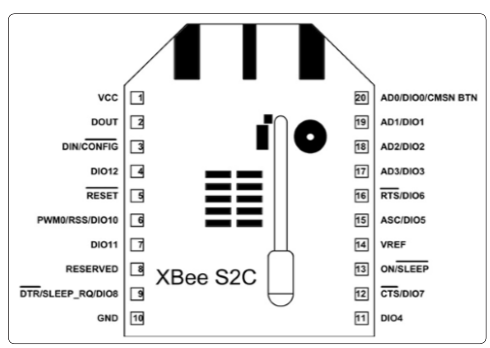

Figure 3: Xbee Module S2C Connections (Source Components 101)

Soil Moisture Sensor Tegr-101

This sensor is designed for moisture measurement of loose soil, clay, silt, etc. Ideal for applications such as, irrigation systems, moisture measurement in crops, and automatic control [7].

Functioning

The sensor sends an analog signal proportional to the percentage of moisture present in the soil where the measurement is made, this analog signal has a range between 0V and 2.4V, determining 0V shows that the soil is dry or with a percentage of humidity from 0% to 5%, and 2.4V represents a percentage of humidity of 70% to 100%.

Table 1: Moisture or dryness ranges monitored by the sensor

Soil Condition	% Humidity	Output voltage
Dry	10%	40mV
	20%	400mV
	30%	1,08V
Half Damp	40%	1,80V
	50%	2V
	60%	2,32V
Damp	70%	2,40V
	80%	-
	90%	-
	100%	-

Temperature and Humidity Sensor Tehu-120

This sensor is designed for the measurement of relative humidity and relative air temperature (Relative humidity -> Range of 20% to 90%, Relative temperature -> Range from 0 ° C to 50 ° C), ideal for applications such as weather stations, humidity measurement and automatic control temperature, etc.

Functioning

The sensor performs the measurement according to a series of trains of pulse that sends the sensor. When the sensor is turned on, it will be high status for subsequent synchronization automatically between the sensor and the Lucy card (lucy3, lucy4). Once it is done this synchronization, the sensor sends 40 data which are distributed in 5 bits, the first 2 bits will show the value of the relative humidity, the third bit and the fourth bit will show the value of relative humidity, and the fifth bit is called: the parity bit, the which is responsible for performing the calculation for humidity and relative temperature based on the 4 bits previously described.

The transmission of the data is done by serial communication, this allows the use of a single connection pin providing immunity to electromagnetic interference.

Base Station

1 base station integrated by a laptop PC with Core I5 processor and 4 gigs of RAM for information processing. Storage and processing of data in the cloud: The storage and monitoring of the data thrown by the variables will be carried out through Ubidots, this consists of a cloud service that allows you to store sensor data and visualize them in real time through of a web page. Ubidots provides an API key to each user that is used as an authentication identifier when transmitting the sensor data to the cloud [8]. This allows registering up to 30,000 data for free per month, if you need to register more data per month, you can choose to pay a service plan that offers this platform as necessary [9].

Figure 4: Measurement of environmental variables in a coffee crop on the Ubidots platform

Expected Results

It was determined that the Lucy 3 programmable cards that each of the sensor nodes have are programmed to receive the values sent by each of the sensors, process said data and send them to the monitoring center, where the measured values will be analyzed and analyzed. It will determine if they are within the programmed ranges, in order to be able to trigger the alert system in case they exceed the allowed ranges for each one of them.

Distance tests were developed to determine the maximum range of the Xbee -Pro S2C wireless modules so as to ensure reliable data transmission without loss and attenuation of the signal, finding that the maximum range is within the established limit of 100 meters in open field.

It was established that the management of coffee cultivation is quite complex taking into account the variability of species, terrains and specific conditions of the environmental variables that ultimately affect the production process and final grain quality.

It was determined that the development and implementation of wireless sensor networks is now more feasible due to the low costs with which sensors, programmable cards and communication modules are obtained, which make it profitable for coffee growers considering that with Open Source hardware and software for which there is no need to pay for licenses.

On the other hand, the incidence of environmental variables in the cultivation and production of the grain was determined by establishing how they affect the final quality of production.

It was established that through the Unibots platform, information is uploaded to the cloud, allowing users to access this information from any device that has an Internet connection and can graphically visualize the behavior of variables and signals alert in case of finding parameters outside the normal.

It was determined that the application of the precision agriculture is an excellent tool for monitoring and controlling environmental variables in coffee cultivation, allowing the entry of technology to agriculture and more specifically to the cultivation of coffee.

References

1. Pinto Rios JD (2015) Monitoreo de cultivos con redes de sensores Xbee, arduino y dispositivos de medicion de suelos (Tesis de pregrado). Pereira: Universidad Tecnologica de

Pereira.
2. Martinez Fernandez R, Ordieres MJ, Martinez de Pison AF, Gonzalez J (2009) Redes inalambricas de sensores: Teorıa y aplicacion practica. La Rioja: Universidad de La Rioja, Servicio de Publicaciones.
3. Siavosh Sadegian K (2008) Fertilidad del suelo y nutricion del cafe en Colombia. Chinchina: Cenicafe Publicaciones.
4. Urbano MF (2013) Redes de Sensores Inalambricos Aplicadas a Optimizacion de cultivos de cafe. Journal de ciencia e ingenieria, 46-52.
5. Xbee cl (2018) Retrieved from https://xbee.cl/xbee-gateway-zigbee/
6. Components 101 (2019) Retrieved from https://components101.com/wireless/xbee-s2c-module-pinout-datasheet
7. Colmakers (2018) Retrieved from https://www.colmakers.com/
8. ubidots (2018) Retrieved from https://ubidots.com/docs/sw/
9. Solar radiation monitoring using electronic embedded system Raspberry Pi database connection. (2015). CHILECON 2015 473-479.