

Surveillance of SigFox technology integrated with environmental monitoring

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Abstract— Internet of Things (IoT) became an accessible solution to the users for controlling and managing different processes and systems. Those systems can include features such as easily monitoring plants growing process, a thing that is widely needed now because of the population number exponential growth, expecting to reach 9.7 billion until the year 2050. This thing is going to increase the need for food exponentially and at the same time, it is going to reduce the area of usable soil for agriculture while the available natural resources are going to decrease. The traditional methods of environment data collecting are still in use, such as using human labor periodically to determine the different conditions such as weather, water levels, and possible pests present in the fields. In this article, we are proposing a monitoring system capable of collecting information about the environment (such as, humidity, temperature, and luminosity) that could allow the optimal growth of plants by integrating a network of sensors capable of transmitting the collected data by using the SigFox technology. This system intends to increase productivity and profits, reduce human labor, and eventually, integrate other technologies to make the agricultural process simpler and more efficient.

Keywords— Internet of Things, SigFox, LoRa, LPWAN, environment monitoring, agriculture

I. INTRODUCTION

Even though agriculture is one of the most important industries in the European Union [1], the maximum production capability was not been reached yet. The situation is even worse in the former communist countries of the continent, which have joined the European Union recently because they cannot even cover their internal needs for prime matter, which brings the need to import it from other countries. The evolution of agriculture strictly related to climate conditions and changes that have taken place recently. Considering the alerting rise of global warming, the European Union has increased the list of forbidden substances (such as pesticides and artificial fertilizers), therefore bringing the need for new technologies in agriculture. A new modern method, which can potentially lead to revolutionary progress in this field, is the global SigFox network, dedicated especially for IoT. The IoT concept refers to the billions of devices that are connected together through the internet, collecting and exchanging data between themselves without needing a direct human to human or human to computer connections because the information is generated by sensors that are attached to different devices [2].

The SigFox technology, alongside LoRa, is a part of the LPWAN (low-power wide-area network) technology family. The LPWA networks represent a new concept of communications meant to complete the disadvantages of traditional wireless communication systems such as Zig-Bee, Bluetooth, Z-Wave, WiFi, GSM, and LTE. About a quarter of the 30 billion IoT devices that are connected to the Internet use LPWA networks [3]. The main sectors in which the LPWA networks are used are agriculture, applications for smart cities, monitoring the wildlife, logistics, monitoring of infrastructure, IoT personal applications, etc.

SigFox is a French company, founded in 2010 by Ludovic Le Moan and Christophe Fourtet. The two founders started from the idea to connect every device in the physical world with the digital world. SigFox ensures coverage of 70 countries and regions; it connects 15.4 million registered devices and it transmits approximately 15.4 million messages on a daily basis. Therefore, SigFox ensures an IoT network that connects approximately 1.1 billion people [4]. This technology uses the UNB (Ultra-Narrow Band) modulation with Differential Binary Phase-Shift Keying, working at 100bps. The device initiates data transmission by sending three uplink packages sequentially, using three randomly chosen carrying frequencies. The base station receives the packages successfully even if two of the packages will get lost due to interference with another device or communications on the same frequency band. The duty-cycle restriction of the sub-band used in the 868 MHz frequency band is only 1%. A SigFox device is only capable of transmitting data for only 36 seconds within an hour. Therefore, only six messages are going to be sent in an hour with a payload of 4, 8 or 12 bytes [5].

The SigFox is used mainly for developing IoT networks when the amount of data is low (from the order of bytes to a few hundred KBs); the operating area is large (a few kilometers) and the power usage is low (mA). SigFox uses D-BPSK (Differential Binary Phase-Shift Keying) modulation, requires messages with a fixed bandwidth width of 100 Hz, which is transmit, with a speed of 100 bps. SigFox uses the frequency spectrum without ISM license: 868 MHz in Europe and 915 MHz in the American continent [6].

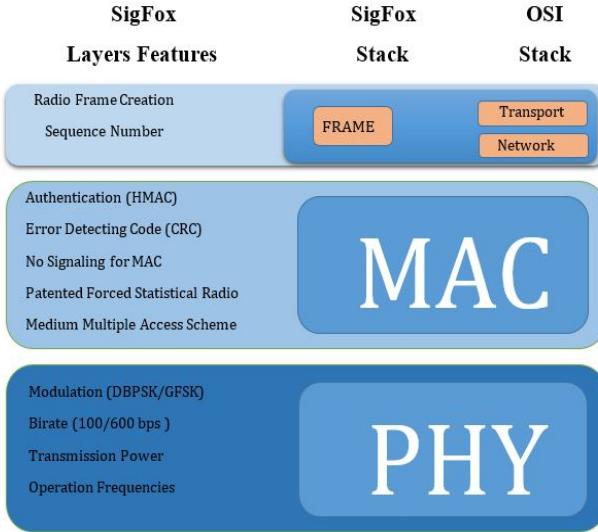


Figure 1. Stack layers for SigFox

In the present paper, we will present a solution about the possible integration of SigFox technology in agriculture and environmental monitoring.

II. RELATED WORKS

The usage of the IoT in agriculture is not a new concept. The American website Business Insider states that the global dimension of the smart agriculture industry is going to grow three times in 2020, reaching a record 15.3 billion dollars, compared to 2016 that was been rated at 5 billion dollars [7]. The IoT used in agriculture also represented the study object of multiple researchers, and the results lead to a growing in performances and production.

In [8], the authors combine the actual IoT technologies with varieties of sensors that collect data from a greenhouse using the STM32 ARM processors series as the controller, LoRa technology, and the integrated Modbus network. This system collects in real-time and with precision the environmental parameters from the greenhouse, according to the needs and it modifies the environmental parameters of the greenhouse in order to obtain optimal growth and development of the plants inside the greenhouse. The proposed system is made of three main parts: the control system of the data acquisitions from the sensors, the wireless LoRa network system and the host computer for monitoring the system.

SensorData [9] is a data-transmitting device powered by batteries, which includes a wide variety of sensors, global positioning service based localization, inputs, and outputs. SensorData uses the SigFox protocol for data transmission. This device is used, especially in agriculture alongside temperature and humidity sensors for soil. The main advantages of SensorData are the very robust case resistant to dust and water-rated IP67, the possibility of operating between an extensive very large temperature range (from -30 to +65 degrees Celsius) considering that the batteries can support it and the possibility of using a single set of batteries for an entire

season. The main disadvantage of this product is the reduced availability on the market.

In other research paper [10], the authors proposed a prototype base on wireless sensors that collect the requested information as electric signals. When the system is working, the temperature sensor converts the value of the temperature into a digital signal, which was received by the MCU (Micro Control Unit). The signals coming from both humidity sensors (soil level and air) are analogic and cannot be read directly by the MCU. Therefore, an analog to digital conversion takes place and the ADC (Analog to Digital Converter) does it. A terminal receives the signals that are sent wirelessly, which is actually a GSM modem that supports GPRS (General Packet Radio Service) technology. The received data are stored into a database, from where can be used for further processing (such as putting them into graphics or tables). Users can also set alarms for either low or high levels and receive them in the form of SMS on their mobile phones. This implementation is helpful but demands high resource usage.

Table I Low Power Wide Area Radio Technologies

	GPRS	NB-IoT	SigFox
Spectrum [MHz]	700-900	700-900	868
Band	Cellular, licensed	Cellular, licensed	ISM, unlicensed
Transmit power [dBm]	33/37	23/35	14/27
Bandwidth [kHz]	200	180	0.1/06
MCL [dB]	144	164	160

Libelium Smart Agriculture IoT Vertical Kit [11] is a kit, which allows the monitoring of environmental parameters in agriculture, vineyards, greenhouses or golf fields. The humidity and temperature of soil, the humidity of leaves and the sensors of atmospheric pressure enable the control of the sugar quantity of grapes in order to increase the quality of the wine. The gateway, using the Ethernet and 4G transmits the data to the internet.

III. SYSTEM DESCRIPTION

It is known since the past about the importance and the influence of the environmental parameters over growing plants; therefore, the people have been trying to adjust the environment's growing conditions to make growing plants more efficient. The researchers have studied the evolution of growing plants considering their environment and they have concluded that the most important factors for optimal growth are the temperature, the humidity, and the light's intensity [12]. The temperature influences the plants since their early stages of growth, more specifically, it dictates the germination's stages but it also modifies photosynthesis' stages. Therefore, depending on the plants' species, they germinate between temperatures of 5 and 18 degrees Celsius, and the photosynthesis reaches its maximum at 25 degrees Celsius. The

optimal humidity varies between 50 to 60 percent at a temperature of 25 degrees Celsius [13] [14].

In this paper, the system's foundation, that we plan to study, consists of a PYCOMM LOPY 4 development board alongside Pysense [15][16]. According to the official website (Pycomm), this is the perfect platform for many IoT applications integrating the LoRa, SigFox, WiFi, and Bluetooth technologies. It uses the latest Espressif ESP32 chip. Therefore, it offers a perfect combination of power and flexibility. The LoPy4 can be programmed using MicroPython and the Pymakr plugins.

The Pysense is a sensor shield that contains a multitude of sensors, including, a lightning sensor, a barometric pressure sensor, a humidity sensor, a temperature sensor, and a three axes accelerometer. This allows the development of fast projects and any of the multi-network Pycomm modules can be used.



Figure 2. Pycom LoPy and Pycom Pysense boards

A. Sensors used

In this paper, we are going to use the lightning sensor, the temperature sensor, the humidity sensor, and optionally the pressure sensor. These elements represent the base environment parameters that need to be monitored in order to obtain an efficient process of growing plants.

SI7006-A20 [17] is an I2C sensor that measures both humidity and temperature. It is a monolithic CMOS sensor, which integrates elements for both humidity and temperature measurements, an analog to digital converter, signal processing capability, calibration parameters, and an I2C interface. The temperature and humidity sensors have been calibrated from the factory, and the calibration parameters are stored in the chip's non-volatile memory. This characteristic ensures total interchanging of both sensors without requiring recalibration or software modifications. SI7006 ensure great precision, low power consumption, and is an ideal digital solution calibrated from factory for measuring humidity, dew point and temperature measuring in applications, varying from HVAV/R and tracking assets to industrial and consumer platforms.

MPL3115A2 [18] is a compact pressure sensor, piezo resistive that includes a digital I2C interface. This sensor has a large scale of measurement, ranging from 20 to 110 k, large enough to cover all the possible measurements on earth. The temperature measurement does with the help of a sensor mounted on the chip. The data regarding the pressure and

temperature is transmitted to a high-resolution analog to digital converter, resulting in completely digitized outputs in Pa for pressure and Celsius degrees for temperature. The pressure been then converted into altitude using the following formula:

$$h=44330.77\{1-(p^{0.1902632}/p_0)\}+OFF_H \text{ (Register value)} \quad (1)$$

, where h represents the altitude measured in meters and p is the measured pressure and p_0 is sea level pressure (101,326 Pa).The application specific integrated circuit (ASIC) has many programmable user modes such as power saving, interrupt modes and autonomous data acquisition, including programmed acquisitions and synchronized acquisitions. The amperage necessary in order for a measurement to take place is 40 μ A.

LTR 329ALS-01 [19] is an I2C digital sensor, working at a low voltage that converts the light's intensity into a digital signal output, capable of been transmitted through the I2C interface. It ensures a linear response for a range of 0.01 to 64k lux and it fits especially in applications where the ambient lightning is under the optimal operation levels of another sensor from the same class.

Table II LTR 329ALS-01 specifications

LTR 329ALS-01 SPECIFICATIONS	VALUES
Supply Voltage	2.4÷3.6 V
Digital Voltage Range	-0.5÷3.8 V
Digital Output Current	-1÷20 mA
Operating Temperature	-30÷70 °C
Measurement range for light intensity	0.01÷64k Lux

B. System functionality

In order to test and measure the parameters we want, we programmed the development board in Python using Atom, a desktop application, for each sensor, we wrote the source code, which is free on Pycomm website.



Figure 3. LoPy4 board and monitoring of radish plants

After loading and running the code we can see the parameters obtained in the main console of the program, they

can be stored in an excel file or an in a database for further processing, such as graphs and analyzes.

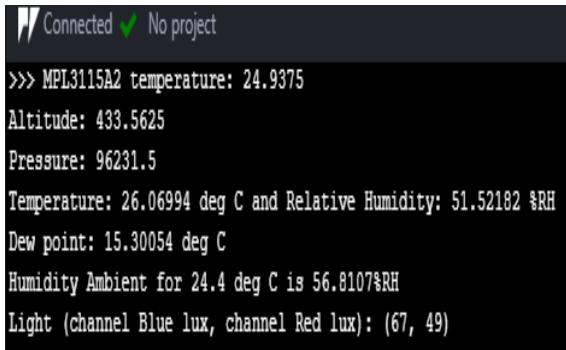


Figure 4. Results taken by the sensors in the growing environment of the radish plants

The advantage of this monitoring method over traditional methods is mainly in reducing the resources used. The entire device has a consumption of up to 15mA being powered from voltages of 3.3V and 5.5V. In addition, an important point is the operability of the application in hard to reach places and where there is no internet coverage, such as agricultural land at high altitudes and the human factor does not interact periodically. This device can be connected later in more sophisticated applications to an irrigation system by performing automated water flow control system based on the data received from the development board.

IV. CONCLUSIONS

We chose to do this study and propose an optimal and efficient solution because currently in Romania about 25% of the active population works in agriculture and this is because almost half of the population lives in rural areas.

In this paper, we presented the SigFox technology, the way this kind of communication would be integrated in agriculture, but there were also presented things that are already implemented in this domain using different kind of technologies. The SigFox and the LPWAN technologies represent the future of IoT. No matter the domain it's used into, the IoT finds its applicability, therefore the researchers and developers need to find and implement new solutions in order to increase the performances, the productivity, to reduce the used resources and also, to be accessible to the market. In agriculture, once with the introduction of the IoT concept, different solutions to the problems of resources management were implemented, but with the solution to this issue other factors that need to be monitored popped up, such as the content of chemical substances of the plants or the report of nutrients inside the fruits and vegetables. Even though the solutions offered by SigFox are favorable, there are still a lot of issues that need to be addressed in order to make them available for the small and medium farmers, and these are related to the security [20] of the systems and their prices.

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