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# Wireless Sensor Network for Monitoring Applied Physical Variables

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***Abstract*****—**This article reports an array of wireless sensors connected to a network to monitor physical variables; environment temperature, soil humidity and environment humidity applied to the internet of things. The use of the Wireless Sensor Network (WSN) has a promising future due to current technical advances and its almost unlimited applications. In this paper WSN topologies, measurement methodology, sensor distribution and visualization of recorded data are proposed based on the monitoring area, the communication protocol established by Wi-Fi and the readings of the environmental temperature (ET), environmental humidity (EH) and ground humidity (GH) are recorded and displayed on the web. In this experimental monitoring of environmental physical conditions, a record is made every hour during a period of 24 hours. Some of the potential applications for this remote measurement technique are the green technologies, industrial processes, internet of things, among others.

***Keywords****-Green technology, IoT, wireless sensors,wireless network.*

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## I. Introduction

The technological advance in the last years has allowed integrating technology in the daily activities of the human being, one of these is caring for the environment [1].

The application of sensors to monitor physical variables of interest and the use of actuators allow the interaction with the surroundings, giving the control of the environment [2].

Monitor in real-time the physical variables and apply the called internet of things present an interesting technological challenge. In the near future an exponential growth and a direct impact in the daily live [3] is expected.

The proposed that is presented in this article, is a modular system that perform the monitor of the environmental humidity, environmental temperature and ground humidity using modules. These modules are distributed in strategically points to take measurements [4].

It is proposed the development of modules or cells made for a delimited area, with a set of sensors and the connection to Wi-Fi through the Wireless protocol 802.11 b/g/n [5].

By being modular, the system can be adapted to the needs required by the application in particular.

## II. Problem Statement

The controlled environment, favors the adequate growth of the plants. As first phase of the system, physical variables are monitored: the ground humidity, the environmental humidity and temperature. These parameters directly affect growth and development of the plant. Samples are taken from environmental physical signals at each module, which provide average information of the set of specimens (plants) distributed in a larger area.

The sensors readings of the physical environmental parameters, are register and visualized and their interpretation is solved with a newfangled approach to new technologies, in this case making use of the internet of the things set to green technologies [6].

The implementation of the proposed design is using modules in specific areas, each module consists of ground humidity (GH), environmental humidity (EH) and environmental temperature (ET) sensors respectively [7]. The periodicity to register these signals is a function of the kind of specimen (plant) of interest and the environmental conditions in which it grows.

The Wireless Sensor Network (WSN) proposed monitors the physical environmental signals in each module, at intervals of one hour that guarantees a continuous registry during a period of complete insolation.

The registered information from the sensors is sent via Wi-Fi through an access point [8]. Later it is visualized in any access point with a password.

According to the registered, data is modified and controlled by applying humidity to the ground, or modifying the humidity and temperature of the ground and environment.

## III. EXPERIMENTAL ARRANGEMENT

The experimental arrangement proposed for monitoring the environmental physical variables consists of modules; each module is composed of any specimen (plant), ground humidity, environmental humidity and environmental temperature. The figure 1 shows a diagram of the arrangement and organization of an individual module.

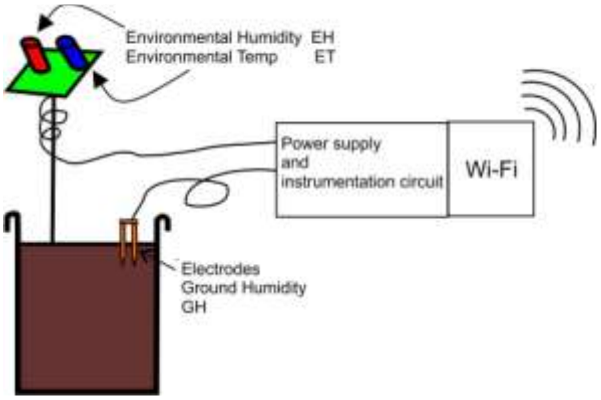


Figure 1. Individual module for the registry of the environmental physical

The ground sensor of humidity is placed at 20 cm below the surface, this due to the root of the plant. For the recording or the ambient temperature the sensor fixed a 30 cm at the surface of the floor, the humidity sensor is placed at the same height [9].

The number of sensors depends on the type of specimens to be monitored and the area under observation. Figure 2 illustrates the proposal for the distribution of a set of modules on an area surface $A_1$.

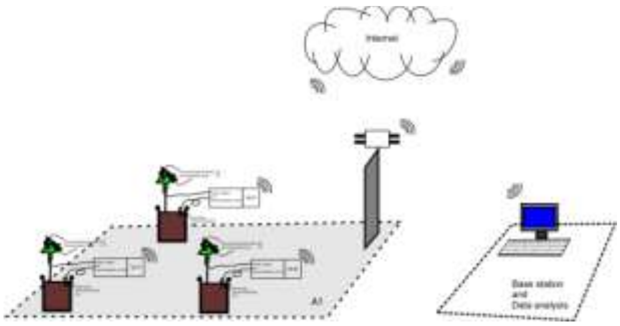

Figure 2. (Network star topology architecture) Distribution of the modules for a surface $A_1$.

The count of the environmental physical variables performed by the sensors in each module is obtained at the same time span [10]. When verifying the reading recorded by the set of sensors in each module, a chain with all the concatenated values is generated [11]. The data has been saved in PHP with command GET, via a Wireless module and a web page, where they are stored.

### *A. Ground Humidity Transducer*

The ground humidity transducer is a component of two conductive plates separated *d* centimeters. If there is moisture in the ground, conductivity is generated between the plates, the conductivity increases as a function of the percentage of moisture between the plates. Figure 3 shows the transducer used in the experimental arrangement.

Figure 3. Conductive plate transducer

The change in conductivity is proportional to an analogical electrical signal generated at the end of the circuit.

### *B. Temperature Sensor and Environmental Moisure*

The temperature and humidity sensor used is the DHT11, a low cost, modular sensor that is easy to implement and reliable in measurements.

### *C. System Implementation*

Figure 4 shows an implemented module of the Wireless Sensor Network (WSN) set. The module consists of the specimen (plant), the ground humidity sensor, environmental temperature sensor and environmental humidity sensor [12]. The sensors are connected to the control system where the signals are conditioned and sent to the web through an access.

Figure 4. Image of experimental arrangement

Data processing and remote delivery to a server is done by using the 802.11 b / g / n network protocol. The registered data are sent using jquery commands using PHP using GET method to a web page where they are stored [13].

## IV. EXPERIMENTAL RESULT

In the proposed WSN topology, each module consists of a set of sensors and each sensor registers a parameter [14]. The designed control system multiplexes the read control signal in a single module at the time to read the data recorded by each

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sensor. The control generates a reading signal at one-hour intervals to collect the measurements recorded in each module [15]. Measurements are channeled through a wireless device to an access point.

The data registered in each module are recorded and displayed on a web page at a remote point and are accessed through a password. The behavior of the remaining modules is similar.

### *A. Comparation and System calibration*

As a validation of the measurements recorded by the DHT11 sensor, a comparative table of the ambient temperature measurements recorded by three different sensors, DHT11, DS18B20 and LM335, is shown. The following table shows a sample of readings recorded over a period of time.

TABLE I. TEMPERATURE RECORDING

| TIME Hours. | DHT11 $^{o}C$ | DS18B20 $^{o}C$ | LM335 $^{o}C$ |
|---|---|---|---|
| 11:30 | 22.00 | 22.71 | 23.15 |
| 12:25 | 22.00 | 22.72 | 22.90 |
| 13:15 | 22.00 | 22.70 | 23.10 |
| 14:20 | 23.00 | 23.80 | 24.00 |
| 15:15 | 23.00 | 23.20 | 23.80 |
| 16:00 | 22.00 | 22.50 | 22.78 |
| 16:45 | 23.00 | 23.75 | 23.95 |
| 17:50 | 23.00 | 23.60 | 23.80 |
| 18:30 | 22.00 | 22.90 | 23.00 |

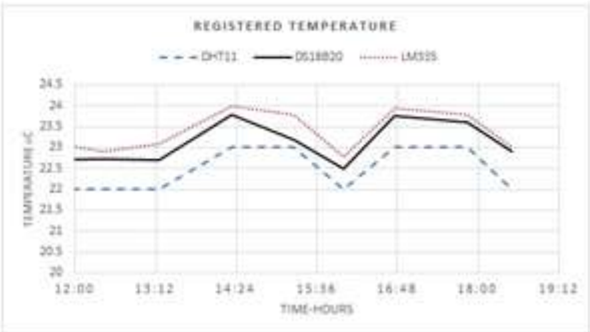


Figure 5. Temperature graph recorded by the different sensors. X axis presents the temperature and the Y axis the time range in hours

For the application being reported, the data recorded are within tolerant limits [16]. This validates the measurements recorded by the proposed Wireless Sensor Network (WSN). The temperature reported by Weatheronline is shown in figure 6.

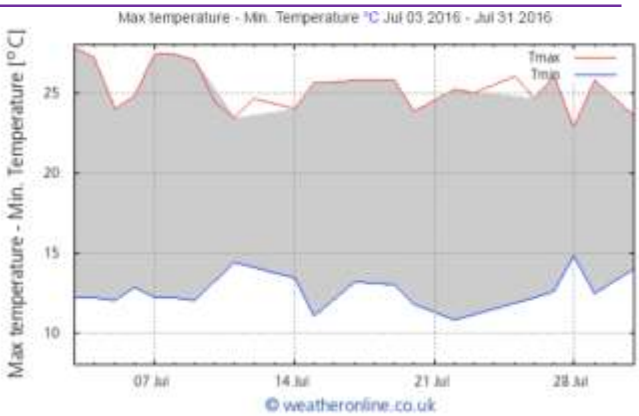


Figure 6. Graphic reporting the rank of temperature reported by Weatheronline

### *B. Algorithm of Proposed Model*

For the application reported, it is not required continuous monitoring of environmental physical signals, samples within frequencies of one hour and a period of 24 hours are enough [[8]. The proposed algorithm for this Wireless Sensor Network (WSN) system is:

```
digitalWrite( _ledpin, HIGH );
char buf[2];
char buf2[2];
String HH, TT,H2,T2;
buf[0] = 0x30 + dhtbuf[1] / 10;
buf[1] = 0x30 + dhtbuf[1] % 10;
TT = (String(buf)).substring( 0, 2 );
buf[0] = 0x30 + dhtbuf[0] / 10;
buf[1] = 0x30 + dhtbuf[0] % 10;
HH = (String(buf)).substring( 0, 2 );
buf2[0] = 0x30 + dhtbuf2[1] / 10;
buf2[1] = 0x30 + dhtbuf2[1] % 10;
T2 = (String(buf2)).substring( 0, 2 );
buf2[0] = 0x30 + dhtbuf2[0] / 10;
buf2[1] = 0x30 + dhtbuf2[0] % 10;
H2 = (String(buf2)).substring( 0, 2 );

updateDHT11( TT, HH, T2, H2, Hs1, Hs2);
```

Relative Humidity

Relative humidity RH [%], is proportion to the actual water vapor in the air compared to the amount of water vapor required for saturation at the corresponding temperature. It indicates how close the air is to saturation. Figure 7 shows the image of the relative humidity chart by weatheronline. It is measured in percentage between 0 and 100, where 0% means completely dry air and 100% saturated air.

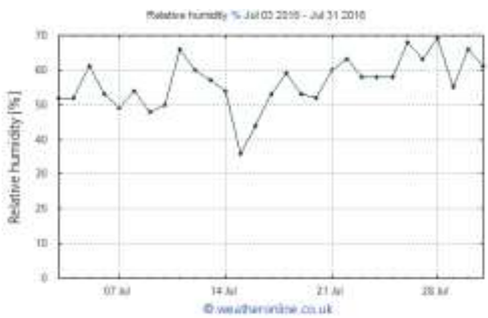

Figure 7. Image of the graph report by: weatheronline for relative humidity

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*C. Registered Data for the Wireless Sensor Network (WSN) Proposed*

Table II lists the data of the measurements recorded by the first module (MO1). Physical variables are monitored over a 24-hour period, taking data at one-hour intervals [19]. The physical variables monitored are: ambient temperature (Temp), environmental humidity (HR) and ground humidity.

TABLE II. REGISTERED DATA (MO1)

| Hour | Temp MO1 | HR [%] MO1 | Ground_Humidity [%] MO1 |
|---|---|---|---|
| 11:34:14 | 22 | 46 | 53.91 |
| 12:28:23 | 22 | 48 | 52.44 |
| 13:22:30 | 22 | 48 | 42.09 |
| 14:16:36 | 23 | 46 | 42.68 |
| 15:10:43 | 23 | 45 | 43.36 |
| 16:04:51 | 25 | 44 | 43.55 |
| 16:58:58 | 23 | 47 | 43.75 |
| 17:53:05 | 23 | 47 | 44.14 |
| 18:47:11 | 22 | 57 | 44.63 |
| 19:41:18 | 23 | 49 | 44.63 |
| 20:35:25 | 23 | 50 | 44.73 |
| 21:29:32 | 23 | 49 | 44.82 |
| 22:23:41 | 22 | 51 | 44.92 |
| 23:17:48 | 22 | 51 | 43.75 |
| 00:11:05 | 22 | 54 | 45.12 |
| 01:06:02 | 22 | 56 | 45.41 |
| 02:00:10 | 22 | 49 | 45.61 |
| 02:54:16 | 22 | 47 | 45.70 |
| 03:48:23 | 22 | 47 | 45.80 |
| 04:42:31 | 22 | 47 | 45.90 |
| 05:36:38 | 22 | 47 | 46.00 |
| 06:30:44 | 22 | 47 | 46.00 |
| 07:24:51 | 22 | 47 | 44.82 |
| 08:18:58 | 22 | 47 | 45.21 |
| 10:07:14 | 23 | 46 | 46.09 |
| 11:01:21 | 23 | 47 | 46.00 |

Table III lists the measured values of the second module (MO2). Similarly the physical variables monitored are ambient temperature, humidity and ground humidity.

TABLE III. REGISTERED DATA (MO2)

| Hora | Temp MO2 | HR [%] MO2 | Ground_Humidity [%] MO2 |
|---|---|---|---|
| 11:34:14 | 23 | 39 | 48.14 |
| 12:28:23 | 23 | 40 | 43.26 |
| 13:22:30 | 23 | 41 | 42.58 |
| 14:16:36 | 23 | 42 | 42.58 |
| 15:10:43 | 23 | 41 | 42.38 |
| 16:04:51 | 23 | 45 | 42.19 |
| 16:58:58 | 23 | 41 | 42.38 |
| 17:53:05 | 23 | 43 | 42.77 |
| 18:47:11 | 23 | 45 | 42.77 |
| 19:41:18 | 23 | 46 | 42.77 |
| 20:35:25 | 22 | 47 | 42.77 |
| 21:29:32 | 22 | 47 | 43.07 |
| 22:23:41 | 22 | 47 | 43.16 |
| 23:17:48 | 22 | 46 | 42.48 |
| 00:11:05 | 22 | 46 | 43.55 |
| 01:06:02 | 22 | 45 | 43.95 |
| 02:00:10 | 22 | 45 | 44.14 |
| 02:54:16 | 22 | 48 | 44.34 |
| 03:48:23 | 22 | 44 | 44.43 |
| 04:42:31 | 22 | 44 | 44.53 |
| 05:36:38 | 22 | 45 | 44.63 |
| 06:30:44 | 22 | 44 | 44.73 |
| 07:24:51 | 22 | 44 | 43.55 |
| 08:18:58 | 22 | 42 | 43.95 |
| 10:07:14 | 22 | 47 | 44.92 |
| 11:01:21 | 22 | 48 | 44.82 |

*D. Graphic Presentations of Recorded Measurements*

This section presents graphically the measurements recorded in one modules of the proposed Wireless Sensor Network (WSN) [20]. The rest of the modules behave in a similar way.

The measurements recorded in module one (MOD1) are shown in figure 8 for the ambient temperature (AT).

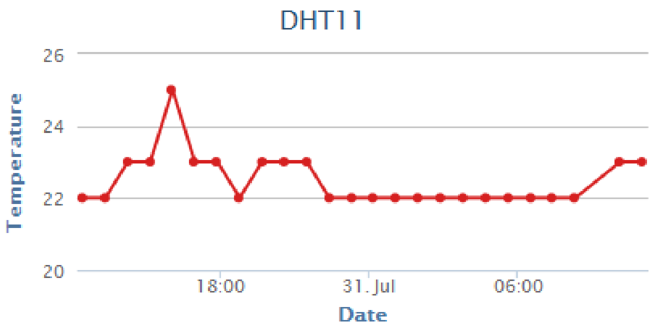


Figure 8. Environment temperature (ET) registration in module one (MOD1)

The environmental humidity recorded by module one (MOD1) is reported in figure 9.

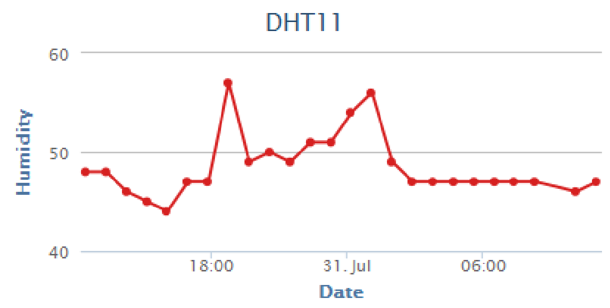


Figure 9. Environmental humidity register in the module one (MOD1).

The third measurement recorded corresponds to the ground humidity in module one (MOD1). Figure 10 shows the graph.

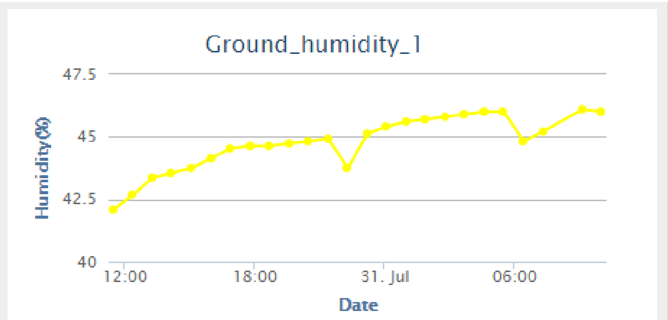


Figure 10. Ground humidity register in the module one (MOD1)

The remaining modules are similar in relation to the number of sensors and the physical variables monitored. Due to their configuration and topology, they are located at strategic points in the monitored area [21].

## V. CONCLUSION

This article reports the architecture, topology and communication protocol for a network of wireless sensors to monitor environmental physical variables in modules distributed in an area of interest. Due to the proposed topology, the wireless sensor network is scalable and modular. By means of the 802.11 b / g / n communication protocol, an adequate response is obtained for the remote monitoring in real time of the physical environmental variables. The reading recorded by the sensor set and in each module is performed at one-hour intervals and in a 24-hour period. As a first result, the information is sent and displayed on a web page for its elaboration and functionality can be said to be a classic internet system of things. Due to its application it gives rise to new experiments in the use of the green technologies and the continuity of the development of new strategies of support to the environment. The results obtained in the wireless sensor network propose research areas in future works related to data encryption, transmission power, processing speed, efficiency, type of modulation, computational cost among others.

The proposed arrangement presents a flexible, economical, modular and easy-to-implement architecture. These features are achieved due to wireless communication and the set of sensors used.

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