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Research Article

Monitoring of an Electromechanical Prototype Material for Environmental Parameters Using IoT

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The Internet of Things (IoT) is a phenomenon where everything is connected to everything, where the development of sensors and microprocessors helped in the rise of embedded technologies, such as Wi-Fi and Bluetooth, and the evolution of bandwidth available on the Internet. This phenomenon will continue unabated due to sensor technology, programmable chips, and embedded technologies. In recent years, the Internet of Things (IoT) has become one of the most prominent technology niches. IoT is the network of interconnected devices or "things" that exchange information or send data with each other over the Internet. The article describes a computer prototype for monitoring and controlling the environmental parameters of a communication equipment room. A technological tool, such as the one obtained, can be implemented in many applications, such as weather stations, food chains, smart home systems, measuring the heart rate of humans, and fruit dehydrators. The article's research was focused on an IoT electronic device and a web platform. A major feature of this electronic device is that its Internet connectivity is achieved using the TCP/IP protocol, an integrated feature of the Shield Ethernet board stacked on top of the Arduino mega board.

1. Introduction

Technological advances have marked the twenty-first century from its earliest years: personal computers are becoming ever smaller, smartphones and tablets are all increasing in popularity, and cloud computing may be one of the most important changes in the information society that we are living in today [1]. A study conducted by the Mexican Internet Association (AMIPCI) in 2015 on Internet usage habits in Mexico reveals that 53.9 million Mexicans use the Internet via their smartphone and spend an average of 6 hours and 11 minutes online each day. The study predicts that this number will continue to rise in the years to come [2]. In total, more than 53 million people connect to the Internet via various devices on average for six hours and eleven minutes every day, generating an outsized amount of data on a daily basis. The development of systems that operate in various ways under various approaches such as Data Warehouses (Data Warehouses) and large data sets (Big Data) has been one of the fruits of the development of branches of information technology that deal with the arduous task of processing this data [3]. Due to their constant miniaturization and mass production, Internet of Things devices is becoming more and more important due to their decreased cost and ability for increasing numbers of people to access and use them. As a result of this, there has been an emergence of a concept known as M2M, which entails those two devices communicating with each other to perform a task [4]. Due to this limited interaction, M2M could only be utilized by specific sectors, including the construction of

smart buildings. The Internet created a paradigm shift in the field of devices with the introduction of the Internet, which became known as the Internet of Things. The physical ojects and their characteristics are used in measuring [5]. There are devices that will allow us to exert an influence on these objects in different ways: census, which refers to taking measurements; control, which directs or indirectly affects their behavior; and act, which allows these objects to make their own decisions based on external conditions and events [6]. However, there have been a number of alternative interconnection mechanisms implemented recently that have not yet been affected by the Internet, the main means of sending and receiving data between objects. This article describes the design and development of an IoT system for the Central American Corporation of Air Navigation Services, COCESNA [7]. An electronic device connected to a LAN and the Internet is used to measure the physical properties of an environment through sensors. This web portal includes, as the main element, a Dashboard or an interactive graphic that displays the information sent by the IoT device; it also describes a mobile application on the Android operating system that allows real-time monitoring of physical magnitudes, such as temperature and humidity [8]. A web portal describes the connectivity of the information, which can be scaled and added to the country at the Central American level.

2. Methodology

It is a project management technique widely used in the IT industry and by large companies. It is the main advantage of this kind of approach that it allows for flexibility and capacity to modify the product during the project since it is used as it is being developed. An objective was determined to develop an IoT system that monitors data through a wirelessly attached electronic device connected to a web portal to display the data dynamically in real-time using a web portal connected to the Internet. An IoT system, developed in sprints, consists of an electronic device with sensors to measure preselected physical parameters of the environment such as temperature, humidity, and movement. It is LAN and Internet connection and conforms to COCESNA specifications. An IoT device dashboard or interactive graphics can be displayed on the web portal as part of its main pictorial element. The web portal has the option to scale and add new control rooms per country in Central America. The application interacts with an Android operating system to monitor physical quantities, such as temperature and humidity.

2.1. IoT System Elements. The research was conducted in the previous study to examine alternative IoT systems that can be constructive. It was determined what type of electronic device should be developed via the weighted criteria method. The system to be implemented has been determined to be one with Internet connectivity via Ethernet since Wi-Fi is out of the question due to the fact that a frequency inhibitor or signal blocker is already installed in the Women's Prison nearby the COCESNA facilities. A web portal controls objects based on a parameterized threshold based on temperature or humidity. Additionally, e-mail and SMS notifications of "all/nothing" actions can be incorporated into the web portal. As a result, the information is agile and timely enough for immediate decision-making and to prevent equipment damage. The electronic device, as shown in Figure 1, consists mainly of a controller board for the complex electronics (Arduino/brain), an Ethernet shield, sensors and actuators (indicators), a relay interface for high-voltage loads (DC/AC), switches to start and stop the device, and an LCD monitor for displaying sensor data. There is also a cooling system consisting of two side coolers. In an open-source development environment based on the Processing programming language, it is based on an open-source hardware and software platform with analog and digital sensors.

2.2. Arduino. An open-source, hardware and software platform that employs an analog and digital board with computer inputs and outputs, as well as the processing programming language. A prototyping platform using open-source hardware and software. The log-in page is shown in Figure 2.

2.2.1. Ethernet Shield. A shield designed for Arduino allows connecting to an Ethernet network. A TCP/IP protocol stack is implemented on a physical level by the protocol stack. The protocol stack utilizes the Wiznet W5100 Ethernet chip. It supports both TCP and UDP over an IP network stack. A connection-oriented protocol is TCP, and a connectionless protocol is UDP. TCP is comparatively slower than UDP, which makes it a key difference between the two protocols. In general, UDP is faster, simpler, and more efficient than TCP, but TCP is a connection-oriented protocol, while UDP is a connectionless protocol. Four socket connections can be made simultaneously. Reading and writing data streams over the Ethernet port are handled using the Ethernet library. This shield enables sketches to connect to the Internet. It is powered by a 32 bit Xtensa Dual-Core LX6 processor running at 160 or 240 MHz. The ESP8266 architecture relies on two cores, one of them dedicated to IP and WIFI communication, the other to the rest of the tasks, which solves one of the most significant difficulties. The ESP8266 architecture has one of the biggest challenges. There is 520 kB of RAM memory available to both processors, and it can use an additional 8 MB of external RAM memory.

2.3. Electronic Interface. The control interface is designed using transistors and relays. As the Arduino microcontroller's output pins are limited to between 10 and 30 mA, the higher required current can damage the pin programmed as an output. In order to handle higher currents, transistors are used, while a relay is used to handle currents that are significantly higher than those that can be handled by a BJT transistor, as well as providing isolation to handle the alternating current. The bipolar junction

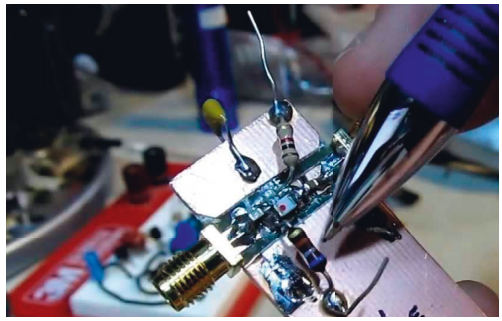

Figure 1: Prototype construction.

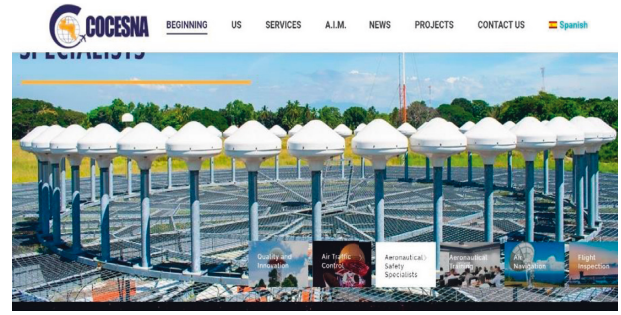

Figure 2: Log-in page.

transistor (BJT) is used as an amplifier, filter, rectifier, oscillator, or even as a switch, as we illustrate in the first section. Transistors biased into the linear region will act as amplifiers or other linear circuits. There is also a Darlington transistor shown in the diagram, which allows the relay coil to be energized by connecting the optocoupler (the device transmits electrical signals between two isolated circuits by using an LED that emits infrared light and a photosensitive device that detects the light) to the NPN transistor. Various semiconductor materials can be used to make NPN transistors, including silicon and germanium. NPN transistors are formed when two n-type semiconductor materials are fused with p-type semiconductor materials. An NPN transistor is made of semiconductor materials such as silicon or germanium. A transistor is connected to the microcontroller through an optocoupler, which isolates the currents flowing through the transistor from the microcontroller output so that an LED is powered by the optocoupler, which feeds the transistor's base in its simplest form. The device functions as a switch that is controlled by an electronic circuit consisting of resistors limiting the current, an optocoupler controlling the transistor, and a rectifier diode protecting the transistor. In the transistor, the output of the relay is controlled and the internal electromagnet is actuated, enabling the contacts to open or close and being capable of controlling an output circuit of larger power than the input circuit, in a general sense, like electrical amplifiers.

2.3.1. Sensor. Instrumentation variables are physical variables that are converted into electrical variables by a device called an instrumentation variable. An active sensor injects light, microwaves, or sound into an environment and determines if the environment has changed. The detection of infrared waves is used by many alarms and passive sensors. This type of sensor is known as a passive infrared sensor (PIR). An infrared passive sensor measures the infrared light emitted by objects within its field of view. The most common application of these sensors is in motion detectors based on PIR technology. A PIR sensor is commonly used in security alarm systems and automatic lighting systems. A sensitivity adjustment must be made to one of these sensors in order to detect human body heat. In order to implement an IoT system via Wi-Fi electronic cards, the following can be used: based on the popular chip (ESP8266) that revolutionized embedded systems with Wi-Fi, the node MCU development board is equipped with a board. The device (ESP32) is much more capable, not only because it is faster but also because it is designed to function as a microcontroller in IoT applications.

2.3.2. Actuator. A pneumatic or electric hydraulic actuator is capable of transforming energy into mechanical power and triggering a process or device in order to increase efficiency. An order is received from the regulator or controller, and the control element is activated in response, such as an air conditioner, fan, or valve. Depending on what instructions the control unit sends, these elements directly affect the output signal of the automation.

2.4. Experimental Development. A communication test between the parts of the developed IoT system was performed to verify its correct operation. These are shown in Figures 3–6.

2.5. The Brain of the System. Data exchange between the Arduino Mega and Ethernet shield is carried out by the Arduino Mega and Shield attached. Sensor data is collected by the Arduino Mega and processed by the shield. Arduino boards use a mega 2560 microcontroller to provide open-source. This board's growth environment is used to execute the processing or wiring language. This information is also sent to the Ethernet shield, which, thanks to its characteristics, and allows the data to be uploaded to local servers with the TCP/IP protocol. A sensor is an element that gathers and analyzes information from the environment, which is then sent to the controller card or brain of the system for processing, while at the same time being sent to the network through the Ethernet shield. A high-voltage 120VAC load can be controlled with these devices, which consist of an electronic interface and relay modules. The Arduino Mega board controls the relay modules using TTL signals. These electronic interfaces allow you to control objects such as air conditioning and fans.

2.6. Web Server. HTTP (Hypertext Transfer Protocol) is an application that serves web pages to users, in response to requests forwarded by HTTP clients of its equipment, based on the HTTP (Hypertext Transfer Protocol) protocol.

Figure 3: Humidity visualisation graph.

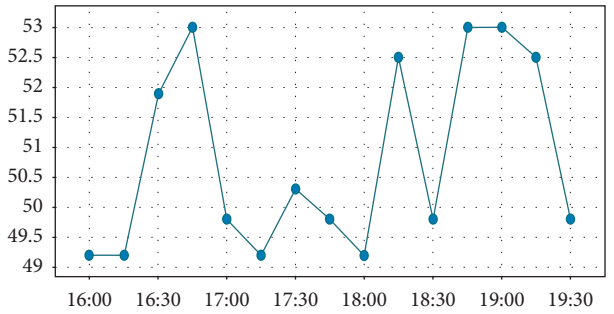

Figure 4: Temperature visualisation graph.

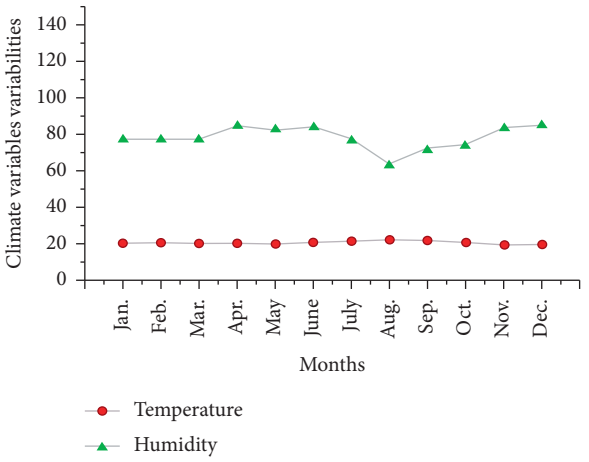

Figure 5: Statistical graph of monthly temperature and humidity.

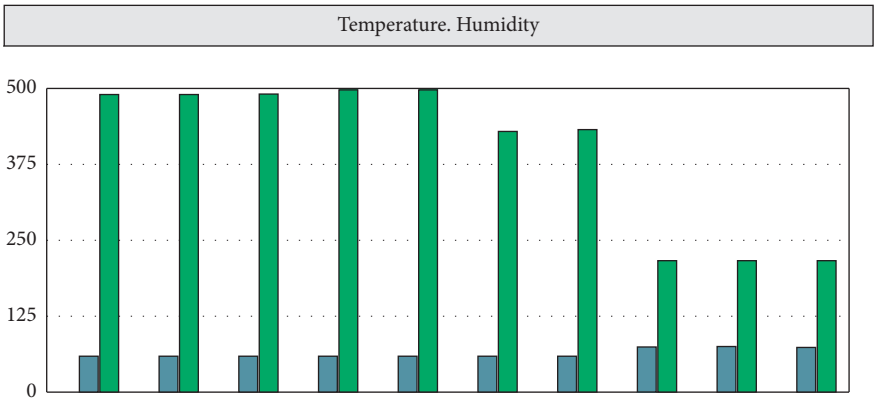

Figure 6: Bar graph views of temperature and humidity.

2.7. Router. An interconnector is a piece of hardware that allows computers in a network to communicate. In addition to environmental parameter information, the IoT device is built to send other data to the server as well. As a prerequisite to sending the information to the remote server, the router's administration website must be accessed in order to make basic configurations such as enabling the port on which it listens and responds to incoming and outgoing requests and reserving the IP address for the IoT device using its MAC address. The MAC address is a unique identifier that is assigned to a network interface controller so that it can be used as a network address during communications within a network segment. This technique is consistent with how the DHCP server of a router or network operating system determines whether the device obtains the same network identifier (IP address) over time.

2.8. Dashboard. As part of this article, you will be presented with graphical representations or user interfaces that allow you to view information handled by a system, for example, temperature, humidity, movement, communication testing signal, and SW on/off graphs. A dashboard is a control panel, which contains the instruments and controls and faces the driver of a vehicle or pilot of an aircraft.

2.9. Web Portal. There are websites and Internet portals that offer easy and integrated access to a range of resources and services related to the same subject. This portal presents a series of graphical elements to display information gathered by the IoT device in this case study. A prototype for cloud computing was tested locally as a first step to determine if it could be developed and scaled for the cloud. The results are shown in Figure 6. Computing services can be offered over a network, typically the Internet, under a cloud computing system. Cloud services are also known as cloud computing or cloud computing services.

3. Conclusions

In this article, we have discussed the concept of the Internet of Things (IoT) developed in the project, including its characteristics. An IoT electronic device connected to the cloud has been proposed as a solution for interconnecting objects with Internet access; this device then functions as a hub or HUB for connecting objects to the system via IO (input/output) ports, digital and analogue channels. As many elements as there are IO channels on the mainboard, the IoT device can control objects and monitor them with electronic instrumentation. This device was built with an Arduino Mega, which has 54 digital inputs/outputs, of which 14 can be used as PWM outputs, 16 analog inputs, and four hardware serial ports. There is a 16 MHz crystal oscillator on the board that can be programmed using a computer via USB. We developed an IoT system using low-cost hardware and software that included the ability to communicate with other applications so that business processes could be enhanced. We used devices such as sensors and actuators to generate solutions tailored to the needs of the productive sector. The purpose of this project was to explore the application of the Internet of Things in different sectors of the El Salvadorian economy. A monitoring opportunity of the equipment rooms of COCESNA was identified in coordination with the association. It has enabled these rooms to maintain environmental parameters within the tolerances defined by COCESNA or by the manufacturer, such as temperature and humidity, through continuous monitoring and recording. It also provides timely alerts or notifications through e-mails. In the event of possible overheating that may impair the availability of the equipment's service, the risk to its operational stability has been reduced, and actions can be taken accordingly.

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they do not have any conflicts of interest regarding the publication of this paper.

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