A Real-Time System for Georeferenced Monitoring of Dangerous Goods Transportation

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***Abstract*—This work presents the conception of a real-time system based on IoT concepts for georeferenced monitoring of dangerous goods transportation. In this initial proposal, the system will be able to collect information of temperature, humidity, presence of smoke, carbon dioxide, nitric oxide, ammonia, alcohol and benzene. It will send all that information and the global position of the vehicle remotely via GSM system. The collected data can be viewed by the users through a web platform. Results of an experiment are shown to validate the functionalities of the proposed system.**

***Index Terms*—real-time systems, georeferenced systems, dangerous goods monitoring**

I. Introduction

With the growing of connected world and internet of things concepts, remote sensing is becoming very common and gaining a great attention in a lot of research fields due to their unlimited applications and relevance for example in forest and agriculture monitoring [1]–[4].

Sensor nodes are autonomous devices that have processing, sensing and communication capabilities, used to monitor physical or environmental conditions such as temperature, humidity, gases, vibration and others. Sensor nodes are wireless interface devices that can be integrated allowing mobility and practicality in the desired application.

The concept of the internet of things is based on the integration of microprocessors with the internet, this concept goes beyond the idea of the Internet as a global and interconnected data network, to refer to a structure of devices interconnected through a network, such as computers and devices used on a daily basis [5]–[7].

The Internet of Things symbolizes a common basis for several recent areas of research and development, such as Pervasive Computing [8] and Ubiquitous Computing [9]. The central point of this concept is the idea that devices (things) can process information and pass information to other devices or to the environment and make decisions independently.

Real-time monitoring systems are systems that aims to manage information such as environment in which it is or its geolocation, using a number of recent technologies, including wireless sensors WSNs and RFID [13-15], in order to help solve security or logistics in the transport of dangerous goods, to the supervision and reliability of information.

II. Background

The difficulty to access remote and dangerous areas makes human monitoring complex and costly. There are several environments and situations, such as forest areas, mountains, hazardous goods transportation and others, where it is possible to apply platforms that allow collecting and sending information to distant centers. Therefore, this work proposes the development of a supervisory platform using sensor nodes with GSM data transmission to a database hosted on a server, thus reducing the time, risk and cost of a physical monitoring.

A. Global Positioning System

The global positioning system (GPS) is a satellite positioning mechanism that provides a receiving device with its position. Created for military use in 1973, and from the 1980s it was released for civilians, but with some restrictions. A GPS receiver device must be in the field of view of at least three satellites for the calculation of a 2D position (latitude and longitude). With four or more satellites the 3D position is determined, obtaining the altitude beyond latitude and longitude. With the position of the vehicle determined, it is possible with the GPS unit to calculate other information, such as speed, route, distance of travel among others.

B. GSM/GPRS Technology

GSM is a globally accepted standard for digital cellular communication. GSM is a name of a standardization group which was established in 1982 to create a common European standard for mobile telephony that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz [10]. The service was commercialized at the beginning of 1991, and in 1993 there were around 36 GSM networks in 22 countries. Although it has standardization in Europe, the technology is not of European exclusivity.

With the investment of many countries, GSM has become a very complete system, so it was not just a technology for mobile communication, various devices have been created, from smartphones to small communication modules.

C. Sensors

Sensor is a device that responds to stimuli that can be chemical or physical in a specific way, these devices can transform chemical or physical quantities into electrical quantities.

The technological evolution makes the sensors into essential instruments for several sectors, mainly in the manufacturing processes, where they are very important tools and indispensable in the branches that refer to the automation. The sensors can be divided into analogs, which are those that even limited between two voltage values can assume infinite intermediate values, and the digital ones that are based on well defined voltage levels, that is, these sensors use a binary logic.

D. Microcontrollers

A microcontroller is an electronic component, developed to perform certain tasks. Used in the control of logical processes, it has a programmable intelligence, internally provided with a data memory, program memory, input ports, parallel output, timers, counters, serial communication, PWM, digital-to-digital converters among other things [11].

E. WEB Apps

The WEB platform uses the internet network infrastructure, being centralized, that is, hosted on the web server allowing information access and enabling a cloud processing of the data. The architecture that uses this service is called client / server, where the server provides access to several devices, and contains codes for the management of information to be displayed to the client.

For [12], WEB applications are based mostly on hypertext, making it possible to include other texts on its surface and access them through hyperlinks known as links, having the function of referencing a hypertext, which facilitates publication, information search and update.

III. Materials and Methods

In order to implement the platform development, the following implementations were defined for the consolidation of the system shown in Fig. 1. The sensor node information is sent through the GSM module integrated with the ATmega328P microcontroller, which collects the data sent by the DHT11 (temperature and humidity of the air) and MQ-135 (detection of volatile organic compounds - VOCs). The coordinates of the sensor node are obtained by the GPS module, which sends the information to a web server where the collected information is managed and presented on a web page.

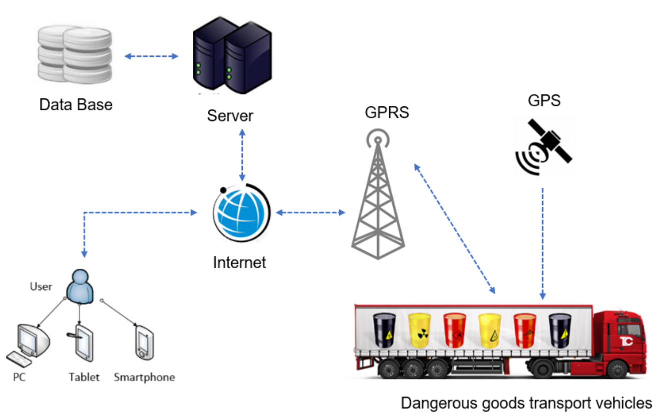

Fig. 1. System components illustration.

A Block Diagram of Components of the System is presented in Fig. 2.

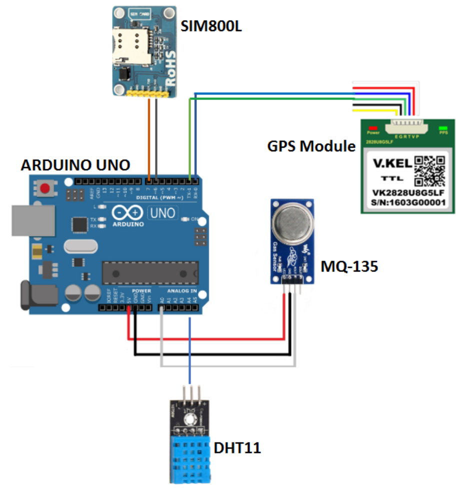

Fig. 2. Block Diagram of Components of the System

Fig. 3 shows the real components of the system.

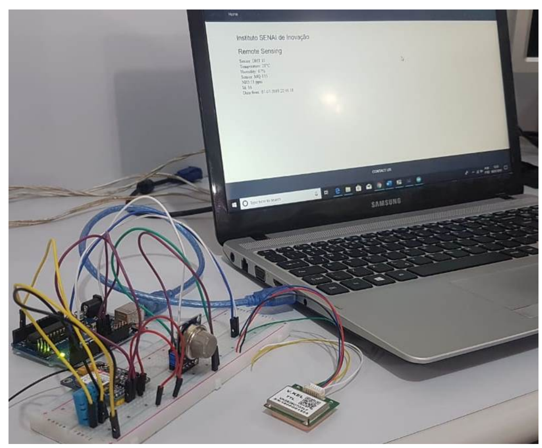

Fig. 3. Real Components of the System

A. WEB Platform

For the creation of the platform was used the jquerry library and the Bootstrap framework for the development of the interface. A web domain was used to make the proper database implementations and creation of a web page. Thus allowing to create a database in MySQL to store the data obtained by the sensor node together with phpMyAdmim to manage MySQL.

temperature	humidity	time	Id	lat	lng	gas
27	65	2019-06-06 14:21:59	1	-3.134548	-59.985729	19
27	65	2019-06-06 14:21:59	2	-3.134548	-59.985729	19
24	65	2019-06-07 11:54:09	3	-3.134548	-59.985729	16
24	65	2019-06-07 11:54:09	4	-3.134548	-59.985729	16

Fig. 4. Data Base Illustration

A script in PHP performs the request of the data that will be sent by the sensor node through the method GET, thus allowing to write the data in the database through the insert command. In the creation of temperature and humidity graphs the Highcharts library written in javaScript was used. This library has several options of graphing and customization models, besides allowing its integration with the database using a script in PHP to extract the data of a MySQL table.

B. DHT11 Sensor

The DHT11, sensor performs the measurement of temperature and humidity through a resistor temperature detector and a piezoelectric crystal, being widely applied in embedded systems, its range of measurement is 0 to 50 degrees Celsius and humidity between 20 and 90 per cent, the supply voltage of this sensor is 3 to 5V.

In this project to acquire the sensor data in the microcontroller was used a library which was installed directly in the integrated development environment of arduino. To use this library you must have the Adafruit Unified Sensor library. To interpret the analog signal in temperature and humidity quantities, the *dht.readHumidity()* and *dht.readTemperature()* commands were used.

C. MQ-135 Sensor

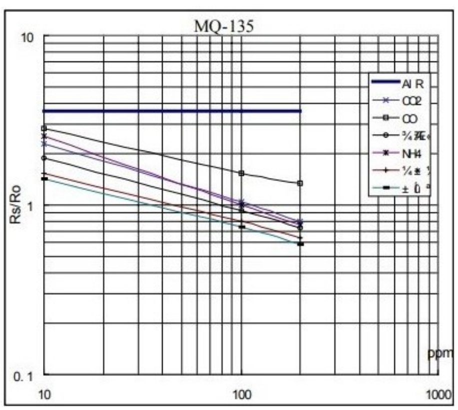

Fig. 5. MQ-135 Gas Curve

The MQ-135 sensor is a safety device used for the development of various electronic designs for gas monitoring. It is an analogue sensor whose function is the detection of flammable gases such as Ammonia, Nitric Oxide, Alcohol, Benzene, Carbon and Smoke being used with several microcontrollers.

In the validation of the prototype, a gas chamber was constructed for ammonia gas concentration analysis in which the following steps were defined. Initially the sensor was exposed to clean air for control definition, when calibrating the sensor is discovered the value of the resistance of the environment clean (Ro). After the value of Ro is founded, the sensor is placed in the area affected by gases. So, it is necessary to perform the calculation of gas concentration detected in PPM for two points from the curve of the gas sensor datasheet.

Based on Figure 5, using two points on the NH4 gas curve, P1 = (log 10, log 2.65) and P2 = (log 200, log 0.77), the points are in logarithmic scale. This calculates the approximate slope of the line. With this data it is possible to obtain the concentration of the gas in relation to the slope of the line NH4 and to display on the page its concentration in ppm.

D. Georeferencing

For the implementation of the GPS module VK2828U7G5LF the TinyGPS ++ library was used to obtain the location of the sensing. This module has a low power consumption and reduced size, ideal for application on compact platforms. The communication with the microcontroller is done by the serial interface (Rx and Tx), since the signal level of the module is 3.3V as described in the datasheet, a logic level converter was used to convert signal from 3.3V to 5V or vice-versa.

In order to obtain the latitude and longitude values the gps.location.lat () and gps.location.lng () were implemented, respectively and to view the location on the map the OpenStreetMap API was used, it is an open source software capable to rendering and easy to implement. A PHP script was used to integrate with the database and with the API to show in the web platform browser the last location inserted in the database.

E. The GSM Module

For configuration of the SIM800L GSM module, the RX and TX pins for the UART communication between the GSM module and the Arduino were used, operating through the SoftwareSerial library.

In the part of the implementation of the communication of the GSM module with the server to send the data collected from the sensor node, the AT commands were used, which are simple characters sent via serial that are interpreted by the receiver.

To send the data obtained by the sensor node to the database it is necessary to send a URL using an AT command sequence. Each command sent must wait for a response from the GSM module in order to send the next one, thus allowing access to the HTTP service of the internet. This URL contains the sensor data as the coordinates obtained by the GPS module, thus a GET request is made.

IV. RESULTS

To validate the results, an application was developed where the database of the server receives the values of the sensors used and the coordinates of the GPS through the method GET displaying the data obtained from the sensor node in a web page as well as its location on the map. The average time of sending the data to the server was on average 1 min, this is due to the GSM module response time for each AT command.

The variation of the ammonia gas in ppm was successful undergoing some variations in its measurements depending on the temperature and humidity of the environment, in addition, with this type of sensor it is not possible to calibrate it without a reference ammonia detector. This application was hosted on a server to view and validate the project simulating a real situation.

Fig. 6. Real-Time Data Dashboard

The Figure below shows the integration of the latitude and longitude database using the Open Street Map (OSM) API. In this application the last coordinate inserted in the database is always displayed.

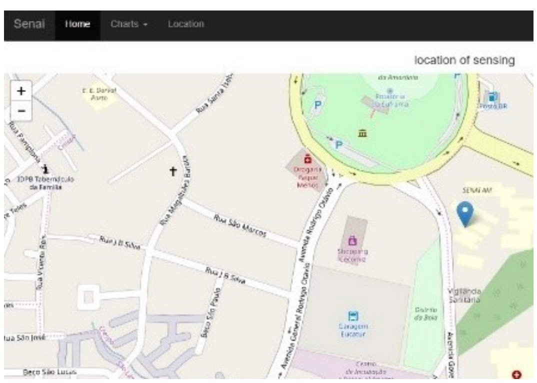

Fig. 7. Real-Time Sensor Localization

Through the described procedure, it was possible to acquire data from the DHT 11 sensor to test the operation of the graph using the Highcharts graphics library. Figure below shows the data obtained by the database plotted from a time interval entered by the user.

Fig. 8. Temperature and Humidity Data

V. Conclusion

The project monitors temperature, humidity and volatile organic compounds (VOCs) through sensor nodes with real-time data transmission. This prototype allows the inclusion of more sensors, increasing its capacity of detection parameters. With the global reach of acquired data, users can anywhere in the world observe the conditions of the environment where the sensor node is installed. The GPRS system also allows geo-localization of the sensor node and can be coupled to the vehicles for monitoring remote areas or transporting dangerous cargoes. The main advantages of the system are its reduced size, low cost and the ability to operate without the need for WIFI networks.

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