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Georeferenced Environmental Platform for Kindergarten Monitoring Basedon Internet of Things and Websockets

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Abstract

This project involves creating a real-time geo-referenced measurement platform for kindergartens, utilizing IoT technology and the WebSockets protocol to enhance environmental information in socially significant areas. The platform displays air quality data on a map and provides Twitter alerts for local pollution events. Tests in two kindergartens demonstrated effective data capture and transmission to a central server, achieving a 92% success rate at distances exceeding 800 meters. The platform also distinguished environmental differences between the kindergartens based on location, proving its utility in supporting parents and guardians in selecting kindergartens for their children.

Keywords: Internet of Things, Environmental Monitoring, Sensors.

1. Introduction

Air pollution refers to the existence of harmful elements that have detrimental consequences for human health, general well-being and the ecosystem, even affecting the cognitive performance of children [8][13][15]. The measurement of environmental variables in socially significant settings, such as schools and kindergartens, is increasingly important for safeguarding the health and well-being of children and young people. It is a concern that society as a whole should address to protect our children from the adverse effects of air pollution. According to Gauderman [1], there is evidence linking carbon monoxide air pollution to respiratory illnesses and poisoning events, particularly in children under the

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age of 5. Children residing in highly polluted areas are more likely to require medical attention for respiratory symptoms and asthma attacks, as noted by Rosales [3]. Additionally, there is evidence that air pollution, particularly carbon monoxide pollution, can reduce lung function, exacerbate asthma attacks, and increase asthma hospitalization rates, as reported by Eder [2].

The studies usually determine as an indicator of exposure the daily average of respirable carbon monoxide material, according to the WHO (World Health Organization) constitutes the short-term guideline, and the annual averages correspond to the long-term guidelines. The WHO then establishes air quality guidelines for carbon monoxide (CO) upto 15 ppm (particles per million) 8-hour average. These air quality guidelines are based on evidence from epidemiological studies which show that above these values the health effects increase significantly.

Wang [14] proposes an interactive system based on urban bird conservation. [17] presents another alternative, which consists of the use of green areas to improve cognitive performance in children, while in slovakia the implementation of a directive was carried out through an equity lens [12]. On the other hand, there are long-range wireless networks, commonly referred to as LoRa, which operate independently. This makes it possible to create a system for real-time detection and monitoring of threats associated with air pollution [16][18].

In Chile, the Ministry of Environment and the Ministry of Health are in charge of collecting information and periodically alerting about environmental conditions in the city and the evolution of medical attention due to unfavourable conditions. Currently, informative maps of environmental conditions in the Metropolitan Region are available. The map is based on information obtained from eleven stations distributed throughout the city that continuously capture particulate matter indices and other variables of interest. These stations monitor environmental conditions and issue reports that allow determining alert events, pre-emergencies and environmental emergencies to the community [9].

The information is of a general nature for the municipalities, but it does not allow us to disaggregate the environmental conditions in focused areas such as kindergartens. In reality, we do not know what is happening outside the education centers. According to this situation, a low-cost monitoring platform is proposed that uses remote telemetry and a deployment platform to issue real-time alarms about health risk situations and also to increase certainty when selecting kindergartens in specific areas of the city.

The paper is divided into 3 parts in which, first, the methodology used for this project, which consists of 4 phases, is detailed: Design of platform architecture; Design and implementation of measurement nodes; Design and implementation of measurement software; Measurements in gardens. Then the results obtained by analyzing 2 kindergartens are presented, where it can be seen that the measured concentrations correspond to 10 or 20 times higher than those obtained by the Thermo 48i sensor, which allows to check the sensitivity level of each sensor and the ranges in which each of them works, and finally the conclusions and future work, where it is shown that the platform based on Arduino, ZigBee and WebSocket allows real-time monitoring through sensors, storage and transmission to users, and that the proposed architecture behaves adequately to the requirements.

2. Methodology

The methodology for the development of the platform considers 4 stages: Design of platform architecture; Design and implementation of measurement nodes; Design and implementation of measurement software; Measurements in gardens.

The design stage of the platform architecture is based on a reference model for the Internet of Things specifically the World Forum model (Figure 1). This model incorporates seven layers from the hardware to the collaborative application [4][6].

The architecture adapted to the project (Figure 2) incorporates level 1 of the reference model, associated with hardware elements(measurement nodes), as well as the second level oriented to field communications (ZigBee network). A third level focused on data persistence, for historical data. Then a fourth level whose objective is the interaction with the users through a web site with real time update. And finally, the fifth level oriented to the collaboration with social platforms,in particular the Twitter network.

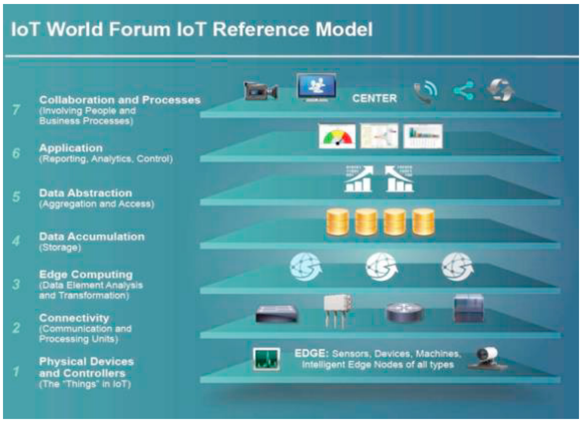

Figure 1: IoT World Forum reference model

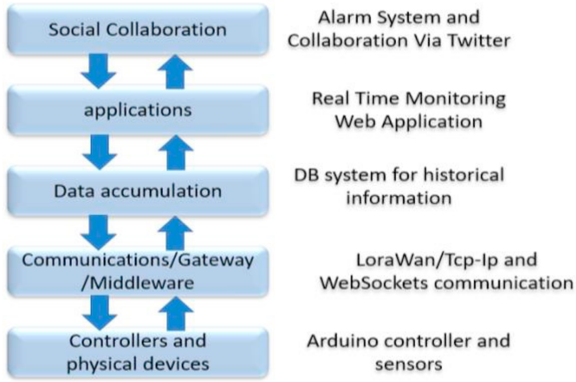

Figure 2: Model adapted to the 5-level platform

The design and implementation stage of measurement nodes considers a network of measurement nodes composed of two units that collect measurement data, to be subsequently conditioned for transmission, as shown in Figure 3. Each node has three sensors (audio, CO2 and GPS position sensor), which are connected to an Arduino-type control unit, along with their respective wireless communication interface based on ZigBee technology. The measurement nodes are coordinated by the application station, which has a device that receives the signals and also provides the identification for each emitter [7][110], the complete diagram can be seen in Figure 4.

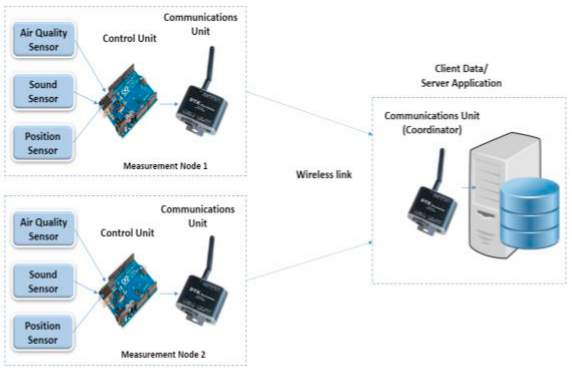

Figure 3: Measurement network diagram

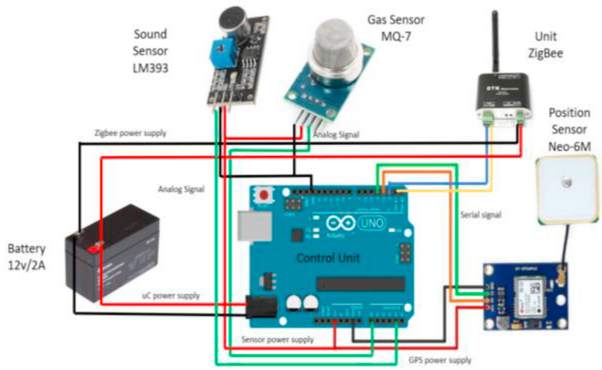

Figure 4: Measurement node diagram

Each node was built entirely from the aforementioned electronic components, which were encapsulated in a measurement device, as shown in figure 5.

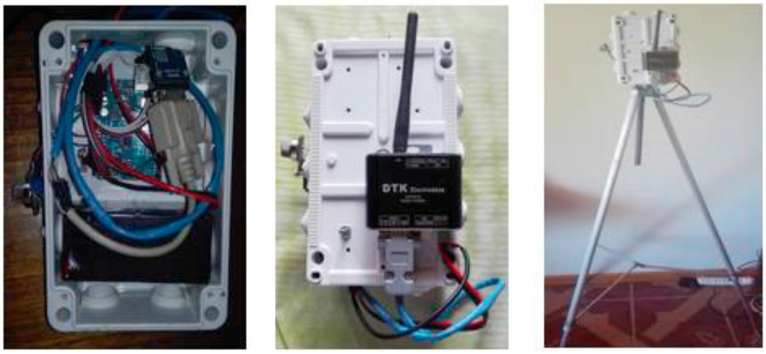

Figure 5: Schematic diagram Construction of measurement node

Regarding the design and implementation of the measurement software, the programming environment for the Arduino microcontroller (C++ language) was used. The reception of the data delivered by the measurement nodes was done through a central node (personal computer), which served as gateway and application server. This server was developed using node.js (javascript for servers), special environment to implement websocket and connection with Twitter api [5][11].

Figures 6 and 7 show the two Spanish interfaces that make up the surveillance platform.

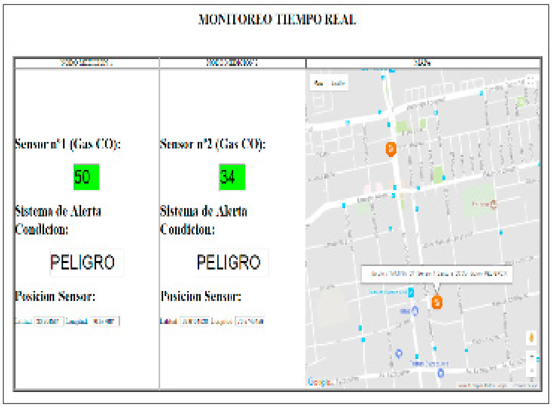

Figure 6: Web Client Interface

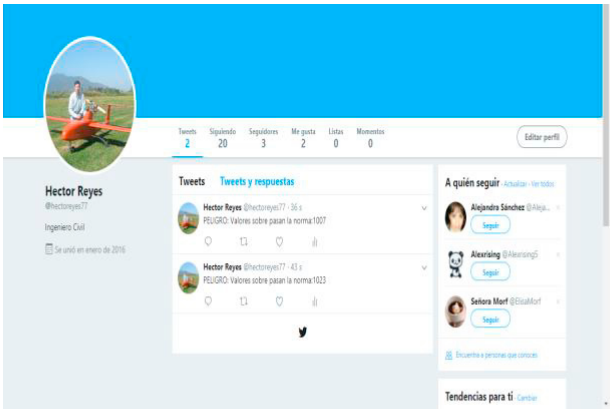

Figure 7: Twitter Client Interface

Users of the platform (directors, teachers, parents and guardians of the gardens) can access real-time information through the web interface, where they are alerted on the map by green or red color the variation in local environmental conditions, if they exceed certain levels. In addition, the platform will send a notification via Twitter to each subscriber.

3. Results

The selected experimental area corresponds to a central urban area of the commune of Puente Alto where two kindergartens belonging to the Vitamina network are located. These places were selected because they are located in avenues with high vehicular flow and they are also at a distance between them of 823 meters measured linearly, whichcorresponds to a distance less than the range described by the manufacturer of the antennas (1.6 kilometers), in figure 8, you can see a node located in one of the kindergartens.

In an equidistant position, the server node was located, which received the data from each kindergarten, as shown in Figure 9.

Figure 8: Photograph of measurement node in kindergarten

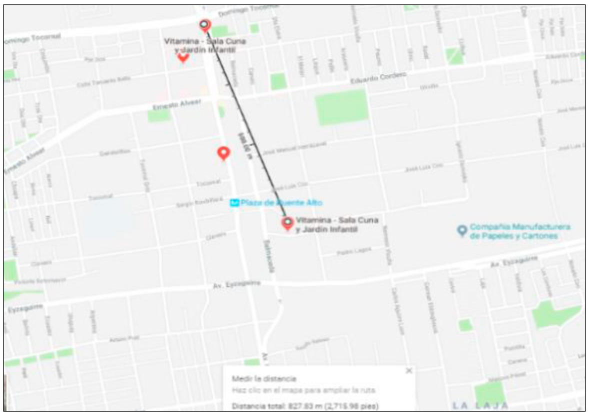

Figure 9: Map location of measurement nodes and server

The data was collected every second, but the historical record was made with the averages obtained every hour of measurement at the respective node.

The identification of the measurement nodes corresponds to Jardín Vitamina nº1 (V1) located in Concha y Toro street and Vitamina nº2 (V2) located in Manuel Rodríguez street respectively. Figures 10 and 11 below show the results of the MQ sensor for the first day of measurements, first week and comparison with the average data of the SINCA stations associated with the commune.

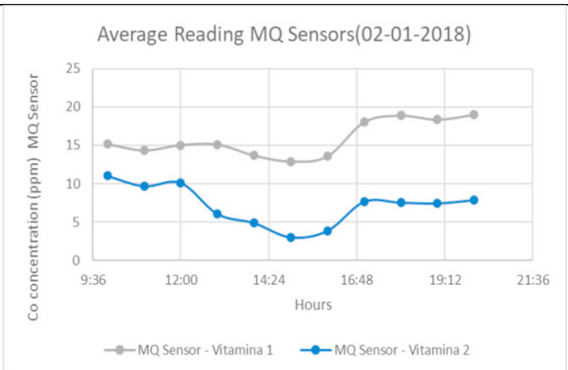

Figure 10: Average first day measurements

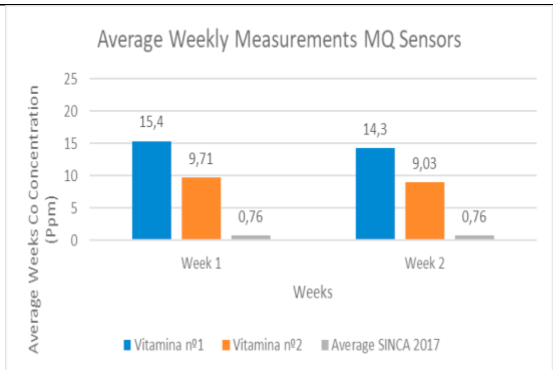

Figure 11: Averages of first week and second week measurements and comparison with SINCA values

It is observed that the measurements obtained by the MQ-7 sensor located at the Vitamin No. 1 station are slightly higher than Vitamin No. 2 during the whole period of the experiment. To validate the data, an exchange of sensors between the nodes was performed and the same trend was obtained. This situation may be due to the fact that the Vitamin Garden nº1 is located in a main avenue of Puente Alto with more vehicular flow than the Vitamin Garden nº2.

In the results of the daily measurements, it is possible to visualize different behaviors in the averages obtained in the morning and afternoons versus the midday averages (12:00 to 16:00). An initial interpretation of this behavior may be the dependence of the measurement on the vehicular flow at different times, i.e., increasing in the mornings and afternoons and decreasing at midday.

It is evident that the range of concentrations measured by the MQ-7 sensor is between 5 and 20 ppm. This range has been maintained during the entire measurement period. These values should be compared with measurements in the months of higher work activity (March and April). As a reference, primitive comparisons can be made of the measurement ranges obtained by the MQ-7 sensors versus the data available for the same date in the SINCA. Accordingly, it is observed that the measured concentrations correspond to 10 or 20 times higher than those obtained by the Thermo 48i sensor, which allows verifying the sensitivity level of each sensor and the ranges in which each of them work.

4. Conclusions

According to the results obtained, it can be concluded that the platform based on Arduino, ZeeBee and websocket allows real-time monitoring through sensors, storage, and transmission to users. The architecture of the platform based on layers behaves adequately to the scaling and flexibility requirements since it organizes the functions of each component of the system delimiting roles and responsibilities.

Regarding the field tests, it is verified that systems can be monitored at a distance of 1 kilometer in diameter, with the measurement and transmission hardware based on the ZeeBee protocol. This provides a base platform for local real-time measurements.

As future work, we seek to implement a national policy to regulate noise pollution near kindergartens, in order to work properly within them, on the other hand, as the project grows, it will be necessary to find effective methods to keep the information collected securely, using methods such as those proposed in [19][20].

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