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Presentation of the content

In the first article we present, *Android application for tracking the garbage collection vehicle in Huauchinango Puebla*, by BARRON-CASTILLO, Jorge Alfredo, HERNÁNDEZ-LUNA, Aldo, TORRES-JIMÉNEZ, Jacinto and LUNA-CARRASCO, Claudia Yadira, with adscription in the, Instituto Tecnológico Superior de Huauchinango, in the next article we present, *Secure MQTT emergency messaging system for C-V2X networks based on IoT*, by PALOS-ANGULO, Francisco Antonio & RUIZ-IBARRA, Erica Cecilia, with adscription in the, Instituto Tecnológico de Sonora, in the next article we present, *Automated notification management: Case study Advertising Agency CC2México*, by ALTAMIRANO-CABRERA, Marisol, JIMENEZ-HALLA, Johann Francisco, DIAZ-LARA, Carlos Alberto and ZARAGOZA-FARRERA, Luis Angel, with adscription in the, Instituto Tecnológico de Oaxaca, in the next article we present, *Development of a Web Application for the management of Georeferential Information regarding Biological Traps against the Fall Armyworm of the Center for Innovation and Technological Development of the Mezquital Valley*, by HERNÁNDEZ-GARCÍA, Héctor Daniel, AGUILAR-OJEDA, Cristy Elizabeth and PAREDES-REYES, Eliud, with adscription in the, Instituto Tecnológico Superior del Occidente del Estado de Hidalgo.

Content

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Android application for tracking the garbage collection vehicle in Huauchinango Puebla

Aplicación Android para el rastreo del vehículo recolector de basura en Huauchinango Puebla

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Abstract

The present investigation deals with the development of an application for Android devices to monitor in real time the garbage collection vehicle in the municipality of Huauchinango Puebla, the objective of this is to propose a solution for the collection problems in the city of Huauchinango Puebla, and thus be able to avoid sources of infection, bad appearance and accumulation of animals that can be dangerous for the general public. The application will be developed in Android Studio, using the extreme programming methodology for its development. The satellite tracking will be through an Android application which will constantly send the geolocation of the vehicle to a server that in turn will be accessed by a second application to indicate the location of the vehicle, as well as this will show the warnings when the collection vehicle does not Make your route, go late, when you are close and at what time you will be arriving at the collection area in order to remove the waste in a timely manner.

Android, Geolocation, Collection. Application

Resumen

La presente investigación aborda el desarrollo de una aplicación para dispositivos Android para dar seguimiento en tiempo real al vehículo recolector de basura en el municipio de Huauchinango Puebla, el objetivo de esto es proponer una solución para los problemas de recolección en la ciudad de Huauchinango Puebla, y así poder evitar focos de infección, mal aspecto y acumulación de animales que pueden ser peligrosos para la ciudadanía en general. La aplicación será desarrollada en Android Studio, utilizando la metodología de programación extrema para su desarrollo. El rastreo satelital será a través de una aplicación Android la cual mandara constantemente la geolocalización del vehículo a un servidor que a su vez será accedido por una segunda aplicación para indicar la ubicación del vehículo, así como también esta mostrara los avisos cuando el vehículo recolector no realice su recorrido, vaya retrasado, cuando este cerca y a qué hora estará llegando a la zona de recolección para así sacar los residuos en tiempo y forma.

Android, Geolocalización, Recolección, Aplicación

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Introduction

In the municipality of Huauchinango Puebla there is the problem that people are not sure of the moment in which the garbage collection car will pass, that is why, not knowing the correct moment to take their garbage out to the street, they take it out from the tomorrow either because you have to work, or leave your home for any reason.

Given this situation, people leave their garbage in the middle of the public road waiting for the garbage truck to pass, this generates points of infection, accumulation of animals such as dogs, rats, etc., which are also carriers of diseases, in addition to giving a bad appearance to the city and obstruct pedestrian crossings.

Given the above, an application is proposed that notifies citizens on their cell phones, the real time in which the garbage collection vehicle will be passing to their neighborhoods, as well as for some fortuitous reason, such as the breakdown of the vehicle, the absence of the driver etc., do not take the tour. The user will be able to have a better overview of the itinerary of the collection vehicle, and thus only take out their garbage at the right time or even not take it out if the vehicle does not pass.

This document will explain the analysis for the development, the design, the initial programming and the results of the first phase of the mobile application in order to treat the problem posed.

This first phase consists of the development of an application that shows the current coordinates at the moment of pressing a button. Subsequently, it will be verified that the values are correct directly in Google Maps, using the coordinates shown by the application.

Analysis

An initial analysis was made, in which the types of technologies to be used to carry out the project were compared, comparing costs, device size, and characteristics. Table 1 show the technologies that were compared.

	Android Device	GPS	Arduino
Tracking	X	X	X/Add on
GSM Network	X	X	X/Add on
Power source	Battery	Battery	USB/ Battery
Using time	Depending of device	4 a 6 days	---
Price	Depending of device	$400	$250

Table 1 Technologies comparison
Own Elaboration

At the end of the first analysis of technologies, it was decided to use a GPS tracker, since the cost was the lowest, adding that being a dedicated device, it should have the best response.

The selected device was the “GF7 mini magnetic tracker” due to its size and price, however, after doing the communication and response time tests, the results were not as expected. Since if response time ranged between 5 and 7 seconds, and its accuracy was not correct. For these reasons, the use of GPS trackers was ruled out, since several devices would have to be tested to find out which one best meets the expectations of the project.

Knowing this, the option that was chosen was the development of a mobile application. Taking advantage of the fact that cell phones already have their own GPS tracker and are programmable. Making this more adaptable to the project.

For the development of the mobile application, it has been selected that the first version should be for Android devices. Since in the city of Huauchinango approximately 80% of people use this platform.

Its development will be in Android Studio since this IDE is the native one for developing Android applications, using JAVA language, with Google maps API to be able to have a more exact geolocation of the device.

First configurations

In order to use the Google API, a key is required, which is configured from Google Cloud Platform, for this we must go to the drop-down menu and select API and services as shown in figure 1.

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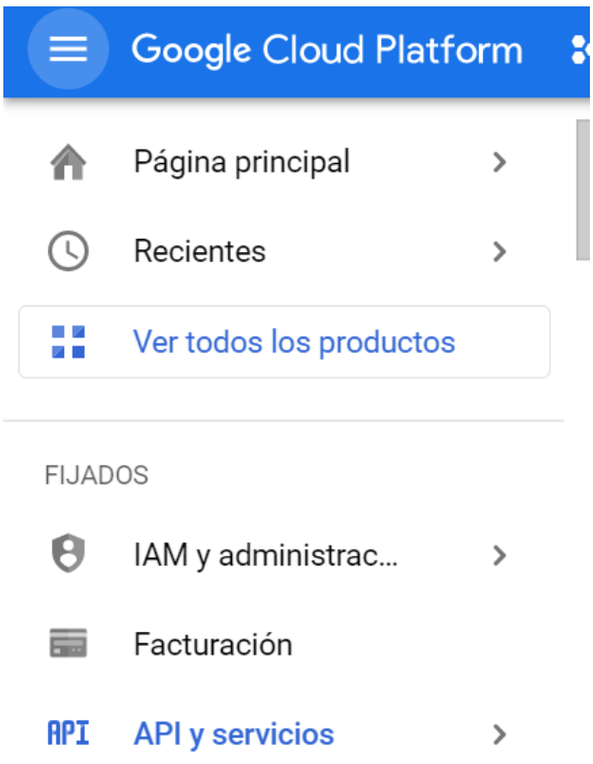

Figure 1 Services and API selection
Google Cloud platform

Once the API and services section has been selected, the library option must be selected and then the MAPS SDK, PLACES API and MAPS Java Script API services must be enabled, as shown in figure 2.

Figure 2 Google services
Google Cloud platform

After having enabled google services, an API key must be created, which is necessary to be able to use google services, for this you must select the credentials section and then select create credentials as shown in figure 3.

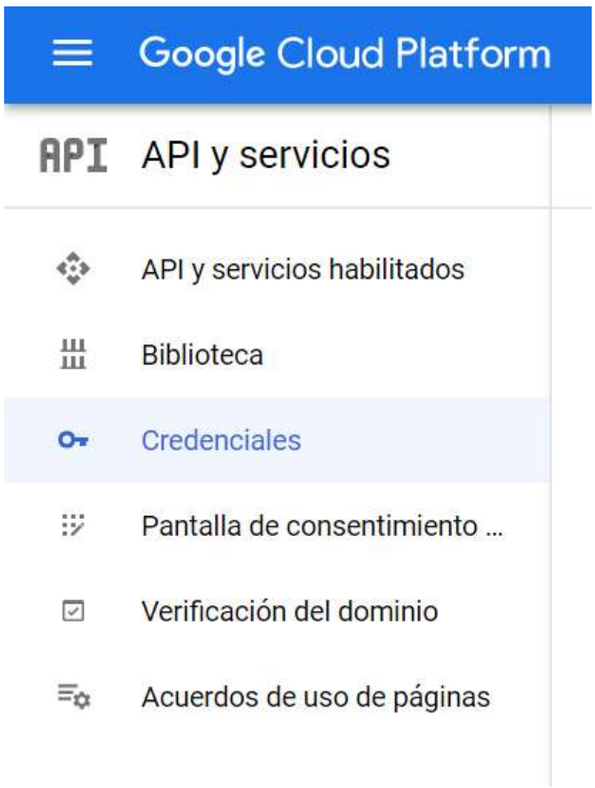

Figure 3 API credentials.
Google Cloud platform

At the end, a key will be obtained which must be included in the Android application manifest.

Programming

To be able to use google maps. The key that will obtain after the configuration of the APIs must be used, this key must be used in the Google manifest, as well as the necessary permissions so that the application can use the geolocation of the device and the internet, as shown in the following figure 4.

Figure 4 Android manifest, Key API uses
Android studio

Once the manifest is finished, the screen is developed, in this case the application must show the real location of the device when pressing a button, which we call coordinates, then the design of the first version of this application is shown.

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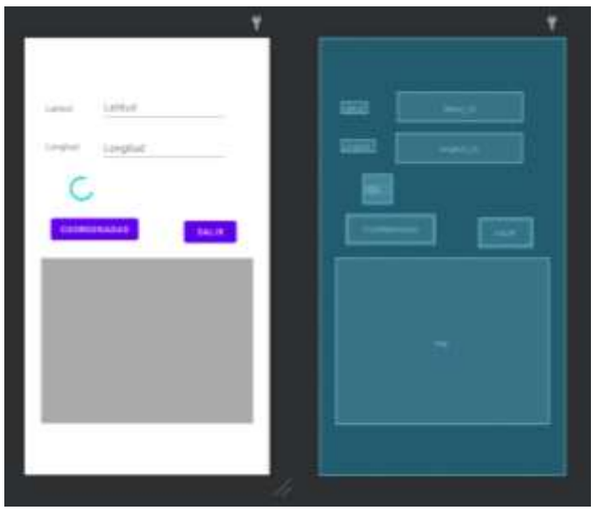

Figure 5 Application initial design
Android studio

After having designed the application, we proceed to develop the java code to make the application work.

Variables of type object found in the design screen must be created, this to make a connection between the code of our application and its design, as well as the global variables necessary for the development of our program as shown in figure 6.

Figure 6 Global variables creation
Android studio

In the *OnCreate* method, the connection of the objects with the design of the application will be made, followed by the *GetCoordenadasActual* method, in which it is checked if the application already has the necessary permissions for the execution of the program. In case of not having permissions, the application ask to the user if he grants permissions for internet use and geolocation, see figure 7.

Figure 7 Permissions and variables initialization
Android studio

Finally, the main method is created, which is going to be the one used by the button of our application to obtain the current coordinates of the device. This also checks that you have the necessary permissions to be able to use the *locationRequest* classes that allow us to use the geolocation of our device. And show the current coordinates on the screen of our application. As show in the following figure 8.

Figure 8 Main method
Android studio

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Results

The application was tested to know the accuracy of the current location, once the *coordenadas* button is pressed, it gives us the current location of our device, as shown in figures 9 and 10.

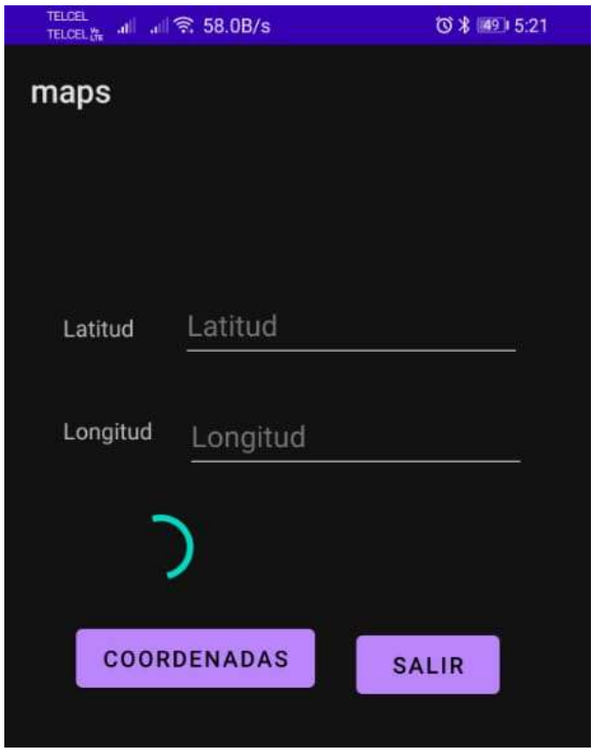

Figure 9 Main Screen
Android OS

c

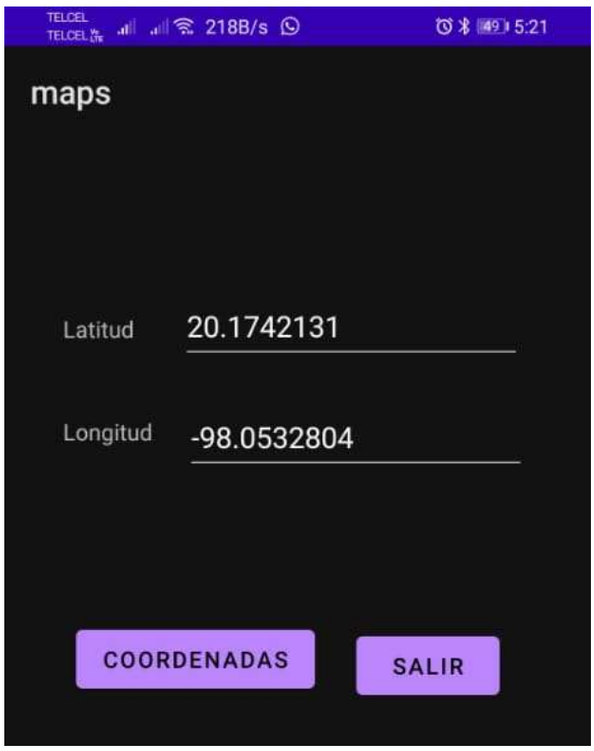

Figure 10 Program running.
Android OS

The location are checked from Google maps, figure 11, to verify that they are correct and precise.

Figure 11 Real time geolocation
Google maps

The results of the application are as expected, since it shows us the location quickly and quite accurately, with a difference margin of approximately 5 meters, this does not affect the result of the purpose of the application, which indicates that it is the most viable technology, for the execution of the project using an application that must be carried by the Android device of the driver of the garbage collection vehicle.

For the next phase, this application will cyclically send its current location to a server, so that it can then store it and thus be able to have a log, to which there will also be a client application, which will be the one that shows the map obtaining the last stored location. on the server constantly to monitor the collection vehicle in real time. As well as showing the necessary notices so that the user takes out the garbage at the right time or, if necessary, not to take out their garbage. As shown in the following figure 12.

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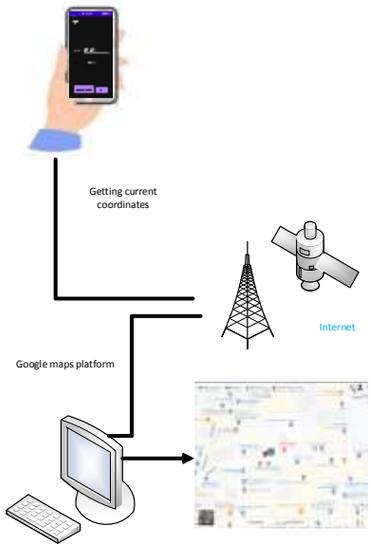

Figure 12 General diagram
Own elaboration

Gratitude

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As well as CONACYT for its support with the postgraduate scholarship for the Master's Degree in Information Technology of the student Jorge Alfredo Barrón Castillo CVU. 1162160.

Conclusions

This article introduces the real-time satellite tracking of an Android device.

This gives us certainty that the most appropriate technology for the garbage vehicle tracking project will be to use the Android device that the vehicle carries. Since its response time and accuracy are adequate, adding that the device being programmable, better functions can be added in future versions which are useful depending on the needs of the users.

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Secure MQTT emergency messaging system for C-V2X networks based on IoT

Sistema seguro de mensajería de emergencia MQTT para redes C-V2X basado en IoT

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Abstract

Currently in Mexico in some road sections, there are still areas of non-coverage where the infrastructure does not supply communication alerts or dangerous situations to the population through telecommunication technologies, this is one of the problems faced by emergency services by the authorities. Given this scenario, the present project develops a system based on IoT that provides a secure means of real-time communication of messages under the AES 128 algorithm, obtained through hardware implementation, through the MQTT protocol under a C-V2X system, which is oriented for experimental scenarios where the intensity of the signal can generate communication losses. The proposed system has been designed to achieve greater coverage on road sections and meet emergency demands by citizens with the least possible delay, without compromising the security of messages of this nature under conditions of low signal intensity and avoiding possible attacks.

VANET, AES128, MQTT, ESP32, C-V2X, IoT

Resumen

En la actualidad en México en algunos tramos carreteros siguen existiendo zonas de no cobertura donde la infraestructura no abastece para comunicar a la población de alertas o situaciones de peligro a través de tecnologías de telecomunicación, éste es uno de los principales problemas que enfrentan los servicios de emergencia por parte de las autoridades. Ante este escenario el presente proyecto desarrolla un sistema basado en IoT que brinda un medio seguro de comunicación en tiempo real de mensajes cifrados bajo el algoritmo AES 128, obtenido por medio de implementación de hardware, a través del protocolo MQTT bajo un sistema C-V2X, la cual está orientada para escenarios experimentales donde la intensidad de señal puede generar pérdidas de comunicación. El sistema propuesto ha sido pensado para lograr mayor cobertura en tramos carreteros y satisfacer las demandas de emergencia por parte de los ciudadanos con el menor retardo posible, sin comprometer la seguridad de los mensajes de esta índole bajo condiciones de baja intensidad de señal y evitar potenciales ataques.

VANET, AES128, MQTT, ESP32, C-V2X, IoT

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† Researcher contributing as first author.

I. Introduction

During the last two decades, the automotive industry has been the hotbed of technological innovation as a result of significant advances in computing, communication and storage technologies. Vehicle Ad-Hoc Network (VANET) is one of the most attracted applications of internet of things that is growing rapidly since its security offering improved. VANET is an emerging type of network that facilitates communication between vehicles on the road. This application is one of the most important elements in intelligent transportation systems (ITSs) (Eze et al., 2016).

The fully connected car will be composed of an ecosystem of connected technologies that will enable it to transfer and process large amounts of data while traveling at high speed. In the coming years, most vehicles will be equipped with an On-Board Units (OBU), Global Positioning System (GPS), Event Data Recorder (EDR), and sensors (radar) (Eze et al., 2016). These devices are used to detect congestion and traffic status. Then they will automatically take appropriate actions on the vehicle and transmit this information through Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2I) within the vehicular network.

VANET aims to ensure safe driving by improving traffic flow and thereby significantly reducing car accidents. The latter is solved by providing the appropriate information to the driver or vehicle. Moreover, any alteration of this information in real time may cause a system failure affecting the safety of people on the road. To ensure the proper functioning of the system, it is imperative to secure this information, which makes it one of the top priorities for research.

The wireless network that has the greatest coverage to establish bidirectional communication is the cellular technology network, however, at least in Mexico the report figures show that on a national scale, Telcel provides 82.2% of guaranteed coverage in 2G, 86% in 3G and 77.7% in 4G, followed by AT&T Mexico, with 68.8% in 3G and 71.8% in 4G, while Telefónica Movistar has 53.3% in 3G and 45.8% in 4G. 82% of the Mexican territory has 2G service through Telcel. (CIAPEM - Comité de Informática de La Administración Pública Estatal y Municipal A.C., n.d).

2021 When observing the official maps of the cellular telecommunications service providers, it can be seen that there is a greater concentration in urban areas with multiple nodes, while the areas of non-coverage are comprised of isolated areas and road stretches, where there is a potential problem if accidents or emergency events occur.

According to the National Public Safety System (INSP) *(Instituto Nacional de Salud Pública, 2022*), up to 24 thousand deaths are registered annually due to automobile accidents, being the fifth cause of death in the general population and the first among young people (Luto Carretero: Los Accidentes Viales Más Trágicos Del 2021 - Infobae, n.d. 2021). Not only automobile accidents can occur in isolated areas, but also forest fires, road alterations such as frozen or slippery roads, collapse of a bridge, collapse of a hill, etc. An endless number of emergency or warning events can occur, of which it is convenient to know their occurrence and location in a timely manner.

VANET still has challenges ahead, a lot of work has been done to solve them and even more on security issues. The security messages are transmitted through an open wireless connection, which makes it easier to interfere and intervene than a wired network, it is vulnerable to various types of security attacks such as spoofing, modification, identity disclosure, *Sybil* attacks and so on. In VANET, although it is necessary to propagate emergency messages due to the occurrence of events in isolated areas, it is also dangerous to expose this information to malicious entities, or people who can abuse this essential information for drivers and users, as well as for official entities such as: police department, fire department, emergency medical services, civil protection, etc. Vehicles move fast (US: 70mph or 112 kph).

As a result, a VANET system needs to handle an environment where nodes within the network move at high speeds potentially entering and exiting the network very quickly (Shrestha *et al.*, 2018). Given this scenario the following questions arise.

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How to provide confidentiality to messages, what security method is suitable for VANET requirements during the exchange of information between vehicles, what level of encryption is suitable when transmitting information between the vehicle to any entity of interest under a messaging protocol without having a delay affecting in unstable cellular signal areas?

In this sense, the contribution of our proposal is the development of an IoT system as a secure means of real-time communication of encrypted messages in VANET, in emergency scenarios, using the AES 128 algorithm and the MQTT protocol under a C-V2X architecture. The system is implemented in hardware, using ESP32 modules, and validated in low RSSI scenarios.

This paper is organized as follows: it consists of four sections, introduction, state of the art, method, results and conclusions.

II. State of the art

The messaging of information is what is going to determine the action by the authorities depending on the content of the message, therefore, how to be executed this action is fundamental. There are different related works regarding this problematic, (Nadezda, 2017) focuses on driving assistance applications and makes an exhaustive analysis based on simulations in his proposal. With the objective of evaluating MQTT and CoAP under different scenarios, (R. Tomar et al., 2020) builds an IoT architecture which is implemented in an ESP32 using MQTT messaging, in which different metrics of interest are obtained as results, among them the information sent and the time it takes, (Hussein & Shujaa, 2020), likewise uses the same messaging protocol to send encrypted messages in response of medical ambulance services. On the other hand, (R. and P. M. and S. H. G. Tomar, 2017) proposes an architecture that takes advantage of MQTT features such as quality of service, points out the null need for VANET infrastructure. In summary, what these papers have in common is how to employ MQTT as *multi-cast* messaging for the purpose of dispelling messages of an emergency or alert nature.

Security

MQTT has several security options in terms of authentication, authorization and data confidentiality. For authentication, it provides a simple authentication scheme through username and password fields in the login packet that a client can use to connect the intermediary, although authentication credentials are sent in plain text and some form of encryption must be used (Katsikeas *et al*., 2017).

Authorization in MQTT can be achieved using an access control list (ACL) on the *broker* side. The ACL contains permissions for users or system processes to grant access to objects, as well as allowed operations on particular objects. MQTT ACL contains all username and password pairs and topics that a client has publish and/or subscribe access to. Enhanced authorization features can be implemented in the broker in the form of add-ons or in the form of an additional web service. More sophisticated access control schemes can also be integrated into MQTT (Fysarakis et al., 2014), (Fysarakis *et al*., 2018). As for the confidentiality of MQTT messages, this can be achieved at the application layer by using payload encryption. For this encryption, any of the available encryption algorithms or authenticated encryption can be used, provided that there is support for the target devices.

IoT development hardware is viable for VANET applications, however, the implementation of encryption algorithms is one of the tasks that compromise the resources of the embedded hardware on the card itself, along with the task of establishing physical connection to the medium to be transmitted. Due to the work performed by these tasks it is important to consider the resources, for this we have different works where encryption algorithms are implemented in different development cards, (Singh *et al*., 2015) works with a SMQTT concept employing a key/text-encryption based encryption based on KP/AP-ABE attributes, using lightweight elliptic curve encryption, the implementation was done in *Raspberry pi*. In (Katsikeas *et al*., 2017) the authors conclude that authenticated payload cipher with AES-OCB is the most suitable for industrial applications, it was implemented on Zolertia Z1.

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Meanwhile, in (De Santis *et al*., 2017) the authors propose an optimized implementation of ChaCha20 for ARM Cortex-M4 processors, performance evaluation shows that ChaCha20-Poly1305 ciphers are promising candidates for securing emerging IoT applications with low speed and space constraints. In (Sadio et al., 2019) similarly handles the ChaCha20-Poly1305 algorithm implemented on an Arduino one.

III. Methodology

Next, Figure 1 presents the methodological route followed for the development of the project, which is described in detail.

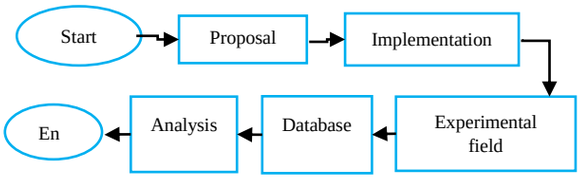

Figure 1 General diagram of the methodology used
Source: Own Elaboration

First, through an exhaustive bibliographic research on surveys of the main challenges in VANETS and a review of the state of the art, the project proposal was proposed, thus identifying the main VANET architectures and emerging technologies capable of supporting encryption algorithms.

The technologies to be used in the implementation are based on the proposal. Subsequently, the proposed system was implemented in hardware using ESP32 and GPS and GSM modules.

The system tests were performed by first evaluating the operation of the embedded system locally, then the complete IoT system was validated, implementing different services on the server to establish communication between client and server.

Finally, tests were performed in a real scenario, measuring the performance of the system in the road section from Cd. Obregón to Mochis, in order to evaluate the system with different RSSI. Finally, the results obtained during the tests are analyzed and the project is documented.

IV. Development

A. Proposed architecture

In this work, an IoT system is proposed to establish a secure and real-time communication of encrypted messages for VANET in emergency scenarios, which integrates three technologies as shown in Figure 2.

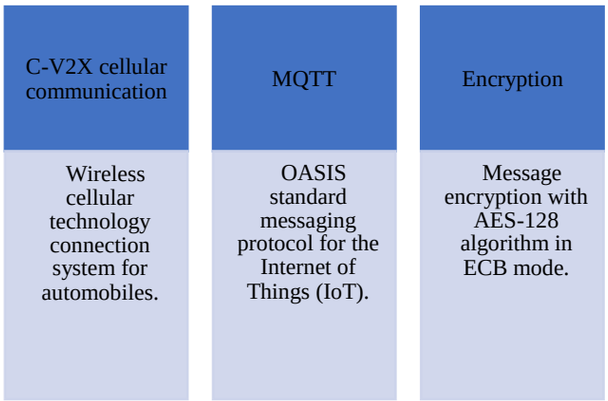

Figure 2 Main stages of the proposed architecture
Source: Own Elaboration

– CV2X is used to transmit emergency messages to the corresponding entity (such as police, ambulance, fire department, etc.) and then propagate the message to potentially affected vehicles, in order to cover areas with low signal strength (low RSSI). The vehicles are considered to be covered by the 2G GSM cellular network as it has the longest range. In addition, it is important to mention that the message requirements will depend on the type of emergency. That is to say, within the message payload, the alert message varies, where it can symbolize any type of emergency alert, from an object on the road to an accident requiring immediate intervention.

– MQTT is used as an IoT-oriented messaging protocol, which is designed as an extremely lightweight publish/subscribe messaging transport, ideal for connecting remote devices with a small code footprint and minimal network bandwidth. Such a protocol is intended to efficiently send messages to monitor vehicle location and possible emergency alert, while securing the message with payload encryption.

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- Finally, an encryption method is used to give confidentiality to the messages emitted by MQTT, with the purpose of hiding sensitive information such as the global positioning coordinates of the vehicle. Some features of AES (Al-Mashhadani & Shujaa, 2022):
- It is used in messaging applications such as *Signal* and *Whatsapp*, computing platforms such as VeraCrypt, and other commonly used technologies.
- The AES algorithm is trusted as a standard by the U.S. government as well as many institutions.
- AES is the most widely used and popular today.
- In terms of cyber security, AES is the most widely accepted encryption standard in the world.
- Figure 3 describes the proposed system architecture, which integrates the technologies described above in addition to the server. A detailed description of each of its component elements follows.

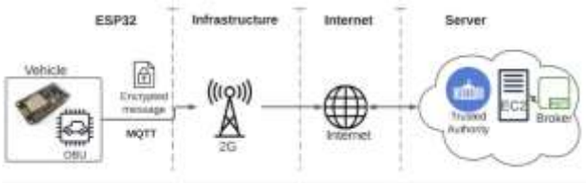

Figure 3 General architecture
Source: Own Elaboration

- ESP32: The first block refers to the identity of the car, which is equipped by the OBU unit with the characteristics of Table 1. This is the point where the information starts by obtaining the RSSI and GPS information from their respective modules, to be processed and published by the MQTT protocol once encrypted.
- Infrastructure: the second block is made up of the structure that refers to the RSU in a VANET environment, it depends on the existing infrastructure provided in this project by TELCEL, which achieves the connection to the Internet.
- Internet: the third block is the integration of the internet network in both points of the system (Device - Server) establishing the TCP-IP protocol with which MQTT works.
- Server: established by IaaS service with the characteristics of Table 2, subscribed to the corresponding topics of MQTT, when the information arrives at this point, thanks to the cloud computing features, the possibilities regarding the management of the received information increase conveniently, whether you want to do broadcasting message or send to specific points depending on the issued alert and its needs.

OBU	
ESP32 (CP210x)	ESP32 Wi-Fi/Bluetooth module, Two cores. *http://esp32.net/)*
Sim800L GSM Module V2	SIM800L v2.0 module is a GSM and GPRS 4-band device for sending and receiving SMS messages and calls, or having mobile data network and internet via GPRS.
Neo6mv2 GPS module	This GPS module has an integrated antenna and EEPROM, is highly accurate and very simple to use.

Table 1 OBU Resources
Source: Own Elaboration

EC2 AWS (Iaas) Server		
Hardware	Processor	Intel Xeon ES-2676 2.4GHz
		64Gb
	RAM	2 Gb
Software	Operating system	Ubuntu Server 18.04 LTS

Table 2 Server resources
Source: Own Elaboration

B. System Implementation

The following is a description of how the system was implemented in the ESP32 module and the MQTT server, as well as a detailed explanation of the processes programmed in these modules (Figure 4 and 5).

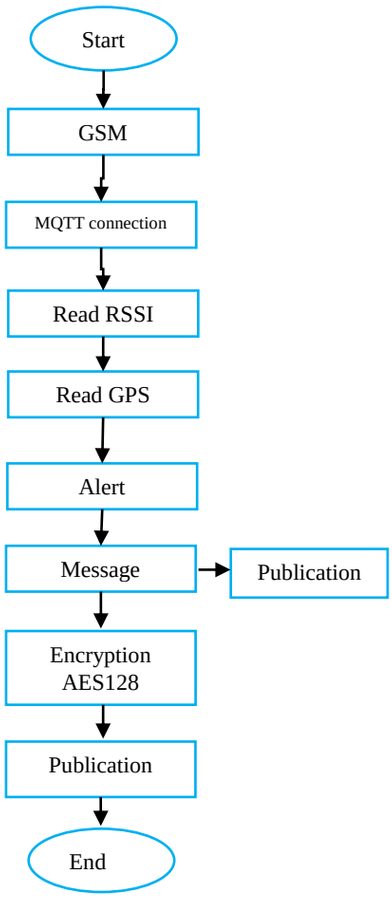

Figure 4 ESP32 logic diagram
Source: Own Elaboration

Algorithm in ESP32

First the embedded device configurations are initialized, as for MQTT it is given its connection credentials with the server and in turn the SIM800L unit is configured with its corresponding libraries. The GPS information is read through functions and the GSM module reads the RSSI through AT commands. Once this information is ready, the structure of the unencrypted message is formed (example: *RSSI:22,lat:27.321077,lon:-09.721893,Alert:1*), a bus for the message payload of 40 bytes is given, once the message is published under the mentioned topic. The encryption is done in four parts where each one is a separate variable (this is done in order to take advantage of the 16 native bytes of the algorithm) and they are put together to make a single publication requiring a bus of 129 bytes to send the complete encrypted message. Once the last process is done, the system enters a return cycle towards the reading of the values until the publication of the encrypted message.

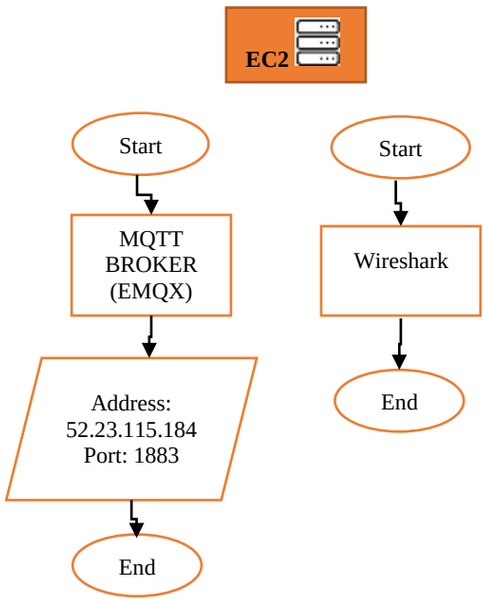

Figure 5 Processes executed per server
Source: Own Elaboration

Server: The server is in charge of three tasks:

1. Establish the broker.
2. Sniffing with the wireshark tool during the experimentation period to perform the analysis with the collected information.

To manipulate the hardware and software of the server, the SSH protocol is used, and also the FTP protocol to download the analysis data sheet.

VI. Results

The experimentation is carried out in a strategic road section where signal strength values of any magnitude can be shown. Figure 6 (*Coverage Map - Corporate | Telcel World, 2022*) shows the 2G coverage map, denominated by the company as yellow zones where there is no guarantee of communication and green zones of guarantee determined by the infrastructure.

As performance metrics of the proposed system, the throughput known as the ratio between transmitted information and received information; and packet errors are used.

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Figure 6 Experimental field
Source: (Coverage Map - Corporate | Telcel World, 2022)

Encryption

The AES-128 algorithm was implemented independently in ECB block mode to test the behavior of the embedded device.

The encryption algorithm with a 16-byte private key and a payload of the same size resulted in an average time of 30.5ms.

Measurement tool for communication.

To obtain the communication metrics, sniffing was done with the protocol analysis tool Wireshark, which was seated inside the server and intercepted the communication packets via MQTT published by the ESP32 during the experimentation period.

RSSI during the run

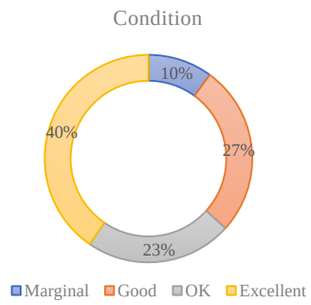
A distance of 266 km was covered with a duration of approximately 3h 12min, during which time the ESP32 was in operation and during which time the network traffic of the server was monitored.

During the experimentation, the following RSSI values were obtained, shown in Figure 8, for the SIM800L module, referring to the values tabulated in Table 3 of (AT+CSQ - Signal Quality | M2MSupport.Net, n.d. 2022).

Value	RSSI dBm	Condition	Value	RSSI dBm	*Condition*
2	-109	Marginal	17	-79	Good
3	-107	Marginal	18	-77	Good
4	-105	Marginal	19	-75	Good
5	-103	Marginal	20	-73	Excellent
6	-101	Marginal	21	-71	Excellent
7	-99	Marginal	22	-69	Excellent
8	-97	Marginal	23	-67	Excellent
9	-95	Marginal	24	-65	Excellent
10	-93	OK	25	-63	Excellent
11	-91	OK	26	-61	Excellent
12	-89	OK	27	-59	Excellent
13	-87	OK	28	-57	Excellent
14	-85	OK	29	-55	Excellent
15	-83	Good	30	-53	Excellent
16	-81	Good			

Table 3 RSSI values through AT commands by GSM module
Source: (AT+CSQ - Signal Quality | M2MSupport.Net, n.d.)

The minimum RSSI value recorded with which it was possible to send the message is four (Marginal), the maximum value obtained was 30 (Excellent), giving an average of 18 over the entire route.



Graph 1 RSSI values
Source: Own Elaboration

The signal with which the GSM module operated was of excellent quality in most of the route, on the other hand, marginal RSSI values where the module was able to transmit information occurred less frequently, the other conditions: "OK" and "Good" were presented in a similar way Figure 9 in which 1836 rows of data are recorded. The route began its journey from the exit of the city of Obregon Sonora, to the beginning of the square of the city of Los Mochis Sinaloa. The GPS information depended on the GSM module to be transmitted, while this module is with established link to the internet, the periods of time in which the GSM does not establish connection were present in the route since it depended on the infrastructure of the cellular connection service provider in this case TELCEL under its 2G signal emitters.

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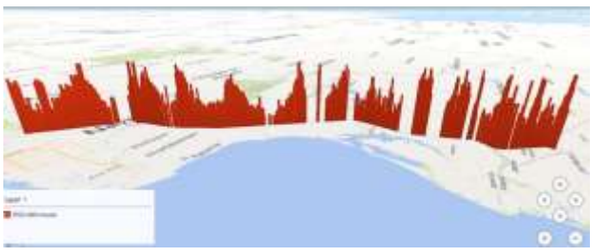

Figure 7 Map drawn by the information received from the GPS module
Source: Own Elaboration

Two MQTT topics were established with QoS(0), "msj_secure" and "msj_not_secure". The first topic is given with the purpose of obtaining the information without encryption for monitoring purposes since this project does not cover the decryption part (Figure 10).

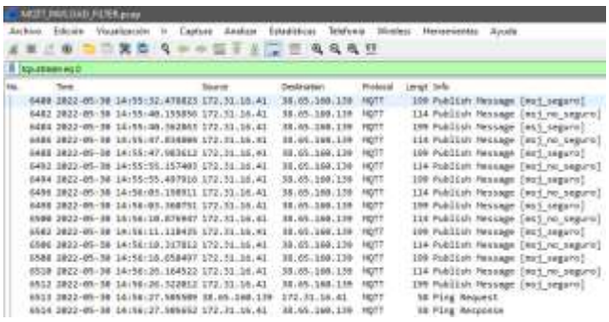

Figure 8 Server network traffic analysis.
Source: Own Elaboration

Two patterns are identified in the graph in Figure 11, where the information packets arrive at two over seconds, and where they arrive at four over seconds, this is because the data is sent by two topics, in the "msj_no_secure" one there is a 40-byte bus to send the plain text with the unencrypted information, while in "msj_secure" the bus is 129 bytes where the encrypted information travels.

Also in the lower ridges we can see the operation of the keep alive, a method belonging to the MQTT protocol to identify the existence of connection with the client. These two patterns mentioned above denote a behavior where the transmitted packets use a minimum of bandwidth in the communication despite a constant update of the data.

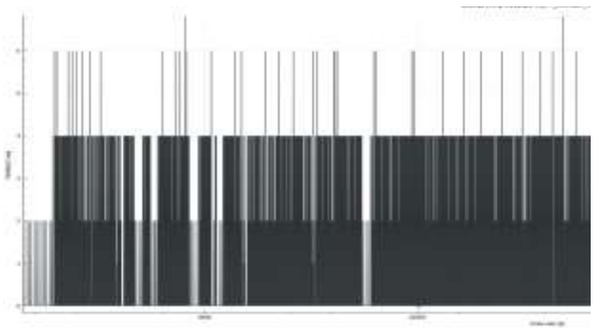

Figure 9 Input-output statistics
Source: Own Elaboration

With the *Endpoints* tool displayed in Figure 12, the ESP32 and the server with their respective IP addresses. There were 3,886 packets transmitted by the ESP32 and 3,328 packets received by the server, a *troughtput* of 85.64%.

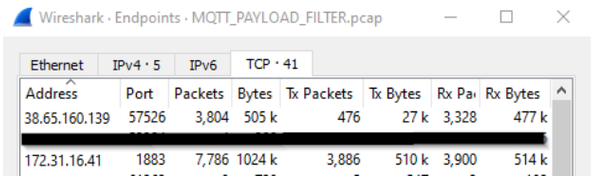

Figure 10 Received-transmitted packet analysis
Source: Own Elaboration

In the prototype model, the components or modules with their respective antennas that make up the embedded system are mounted on an experimental board (Figure 13).

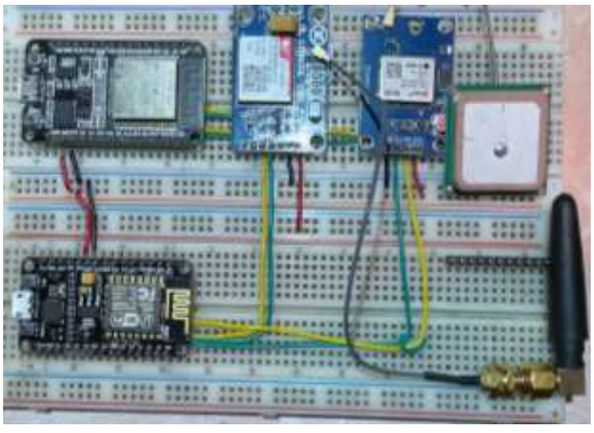

Figure 11 Experimental hardware prototype
Source: Own Elaboration

It is worth mentioning that the previous figure shows an ESP8266 board that was not used and was intended as a backup board.

Conclusion

A secure system was developed that granted confidentiality to messages with emergency nature in vehicles under a C-V2X system. The communication between vehicle and internet was established through the MQTT messaging protocol by the ESP32. This ensures the transmission and reception of messages between V2V, V2I and other units. An efficient response time was achieved, without deviating from the requirements demanded by emergency events. In addition, thanks to MQTT, a minimum use of bandwidth over the communication medium was demonstrated.

The GSM module was able to establish stable communication in a wide range of values even in conditions of low RSSI level and even null level, this was present in all the evaluated route. Although AES-128 in its ECB mode is not advisable to use since it results in evident patterns in the messages, it remains as future work to improve its structure and operation mode, as well as the security scheme to provide other pillars of computer security.

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Automated notification management: Case study Advertising Agency CC2México

Gestión automatizada de notificaciones: Caso de estudio Agencia De Publicidad CC2México

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Abstract

The project presented is based on the implementation of a web system with a mobile application for the management of work orders in the CC2México Advertising Agency. Which it will allow customers to register, learn about the services offered and set up a customized service (at no cost, for a limited time) and in which they can generate their ODTs by this means. Once the period is over, a company advisor will follow up with the client, offering various plans. It is considered an innovative project due to the incorporation of technology through five modules that streamline the entire management process, guaranteeing the coordination of the actors in the process and the optimization of their activities. For the development, the incremental agile methodology was used, coding with a JavaScript and Ionic framework for the development of hybrid applications. The added value in this project is the integration of a RestFull API software architecture that will allow this application to connect to the rest of the CC2 Mexico corporate ecosystem and to third parties in a secure manner to continue exchanging data.This application will have a positive impact on the company and will allow managers to make the best decisions through relevant consultations.

Web System, ODT, Automation, Development, Coordination

Resumen

El proyecto presentado se basa en la implementación de un sistema web con una aplicación móvil para la gestión de órdenes de trabajo en la Agencia de Publicidad CC2México. El cual permitirá que los clientes se registren, conozcan los servicios que se ofrecen y establezcan un servicio personalizado (sin costo, por un tiempo limitado) y en el cual podrán generar sus ODTs por este medio. Una vez finalizado el periodo, un asesor de la empresa hará un seguimiento del cliente, ofreciéndole diversos planes. Se considera un proyecto innovador por la incorporación de tecnología a través de cinco módulos que agilizan todo el proceso de gestión, garantizando la coordinación de los actores del proceso y la optimización de sus actividades. Para el desarrollo se utilizó la metodología ágil incremental, codificando con un framework JavaScript y Ionic para el desarrollo de aplicaciones híbridas. El valor agregado en este proyecto es la integración de una arquitectura de software RestFull API que permitirá que esta aplicación se conecte con el resto del ecosistema corporativo de CC2 México y con terceros de manera segura para seguir intercambiando datos.Esta aplicación tendrá un impacto positivo en la empresa y permitirá a los directivos tomar las mejores decisiones a través de consultas pertinentes.

Sistema Web, ODT, Automatización, Desarrollo, Coordinación

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† Researcher contributing as first author.

Introduction

Automation has acquired enormous potential for the advertising sector, especially in process management. This project describes the functionality of a management system for the CC2México Advertising Agency, which is dedicated to designing advertising campaigns, advertising articles, media dissemination and direct marketing through digital marketing strategies for different brands.

Being a company with a national presence at times, it is impossible to give due attention to potential clients who request quotes from the administrative area where the account executives raise the requirements that the client needs; and subsequently carry out the assignment, download, distribution and monitoring of service orders. When done with various applications such as spreadsheets, electronic formats or email and as requests and customers grow in size, complexity also increases and that is why automation of the commercial area is proposed through a web application and an application mobile, which will integrate all the information and allow the various users to verify at any time the status of the open request, the material to be used and the final delivery time. The added value is defined at this stage, since currently the authorization of a quote requires waiting for the manager's approval before starting the work, which can often cause delays if they are out of the office. With the implementation of this project, the approvals will be immediate, once the responsible people of the company receive the notification to their mobile device, they will be able to review it, authorize it or reject it as the case may be (GCFGlobal, 2021).

All this innovation will mainly reduce human errors that are made when manually entering and manipulating data or sharing files; which generate costs that can be very high for the business and result in losses for it, not to mention that the fact that manual data entry tasks are automated leads to greater productivity, a fact that will also allow an increase in quarterly indicators and logically well-founded business decision-making by managers when they access accurate reports that can be updated in real time, if any of the data associated with it is modified, creating transparency for the benefit of the CC2México Advertising Agency (Latino, 2021).

The document presented is organized into sections that range from the theoretical foundation that guided the development of the case study, the activities carried out during the phases defined by the incremental software development methodology (Méndez & Garrido, 2006) ; with four increments that include the stages of: Communication, Planning, Modeling, Coding and Deployment.

Finally, the results obtained are shown, through the interfaces, system tests, the conclusions obtained with the implementation of the system and the impact on the automated processes that contribute to the achievement of the general objective when developing a web system and mobile application for the management of the work orders in the CC2México Advertising Agency, the thanks given to the National Technological Institute of Mexico, the Technological Institute of Oaxaca and finally, the references consulted in the preparation of the following article.

1. General objective

Develop a mobile application and web system for the administration of work orders (ODT) of the company CC2México.

2. Specific objetives

- Analyze the service offering process by account executives.
- Apply the incremental software development methodology for the control and monitoring of ODTs in CC2México.
- Incorporate a tool that allows monitoring and notification of ODTs.
- Incorporate a tool to notify clients about the requested quotes.
- Incorporate a tool to notify coordinators of a new ODT in their area.
- Analyze tools for the development of multiplatform mobile applications.

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3. Methodology

Once the analysis of at least 4 methodologies has been carried out and taking into account the development time, the use of the Incremental Model is proposed, for the realization of this project because it establishes partial deliveries through a predefined calendar with the client (Beck, 2000); through which, the evolution of the product and the requirements with which it was built will be followed up; this phase called increment, will have new functionalities that will be added to the previous product to make way for another increment and so on until the final product is obtained. In the present work, each increase has been achieved following the marked stages or phases, namely: Communication, Planning, Modeling, Construction and Deployment. Figure 1.

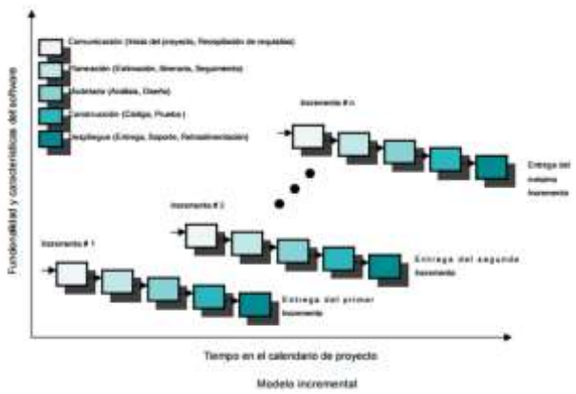

Figure 1 Phases of the incremental methodology
Source: (Pressman, 2010)

4. Development

This section shows the development of the project that includes the description of the development environment, description of the activities and their results. Given the needs of the CC2México Advertising company and for the development of this web solution, the directors and expert staff ask the project developers to allow changes to the requirements at any point in the project, because it guarantees them to have a closer approach (Swattwer, 2021). realistic, and not invest efforts in the control of changes.

The system in general aims to automate and streamline the processes according to the problem statement and the scope is included in the following modules:

- Customers
- Employees
- Payments
- Service Orders (ODT)
- Quotes
- Reports
- Services

Therefore, once the expected objectives have been defined and the scope and limitations of the project have been identified; through linear communication, the stages and processes considered for the achievement of the project were integrated (Prunn, 2020), and which are described below:

a. First increment

In meetings held, it was agreed to use various components for the development environment, which are indicated below:

- WEB server: Node JS: Event-based server-side javascript environment used as the system's web server.
- Express.js development framework: Web framework for Node.js used to program the system logic.
- Non-relational database: Mondo BD. Document-oriented NoSQL database in JSON format used to store system information
- Below is Table 1 for the planned user story master list for the project.

Number of history list	Task name
1	Interface design to register an ODT.
	ODT data validation.
	Adaptation of the database.
2	Design and implementation to consult an ODT.
3	Updating the data of an ODT.
4	Design and implementation to eliminate an ODT.
5	Interface design to register a Client.
	Customer data validation.
	Adaptation of the database.
6	Design and implementation to consult a Client.
7	Update of customer data.
8	Interface design to register a Quote.
	Validation of the data of a Quotation.
	Adaptation of the database.
9	Design and implementation to consult a Quote.
10	Updating the data of a Quotation.
11	Design and implementation to eliminate a Quote.
12	Interface design to add an employee.

	Validation of employee data.
	Adaptation of database for the employee.
13	Update of employee data.
14	Design and implementation for an employee consultation.
15	Design and implementation to terminate an Employee.
16	Assignment of roles for employees.
17	Notifications to coordinators when an ODT is assigned to their department.
18	Notify customers by email of your quote.
19	Hybrid application programming.
20	Manage services.
21	Manage tasks.

Table 1 User history master list
Source: Own Elaboration

User stories encompass a series of specific properties that must be met for their execution, once all user stories have been defined. After the analysis of the user stories and a brief feedback with the main actors and with the coordinator of the company's web development department, the interfaces are made with the Mockflow WireframePro tool. Figure 2 and 3.

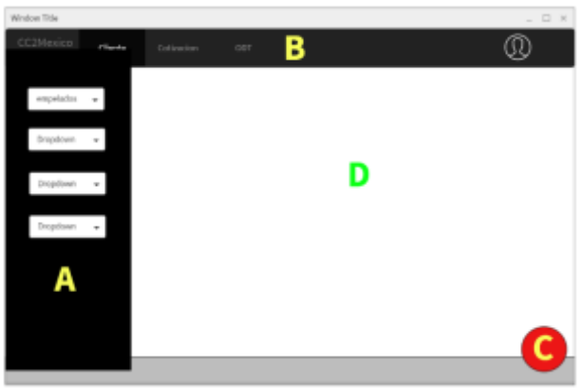

Figure 2 Dashbord planned view
Source: Own Elaboration

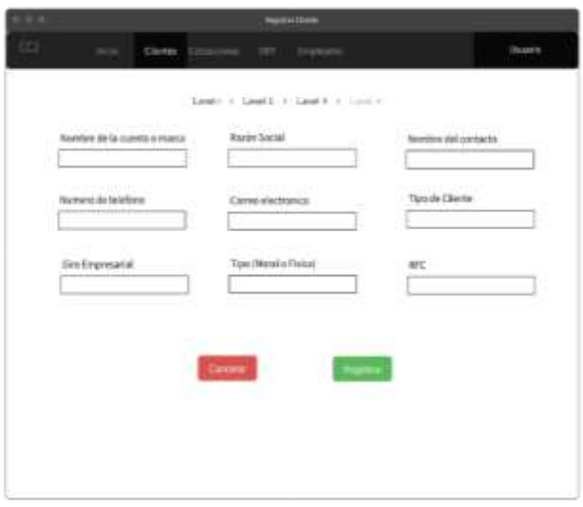

Figure 3 Customer form view
Source: Own Elaboration

Once designed and accepted by the client, they were coded in the selected language. For the performance tests, in this increase, black box tests were carried out on the first modules developed, which are described below:

– **Customer Interface:** Module that is responsible for inserting and editing customer data.

Figure 4 Successful registration message
Source: Own Elaboration

– **Customer Table:** Module that is responsible for listing all customers and contains a button that takes us to the edit view.

– **ODT Interface:** Module that is responsible for inserting new work orders, in addition to searching for the approved quote for which the ODT is created.

Figure 5 Warning message for empty fields
Source: Own Elaboration

– **Table: ODT:** Module that is responsible for listing the work orders that have been registered, it contains a menu with two options to show them according to their status (execution, finished), where we find buttons to edit and finish the work order.

– **Quote Interface:** Module that is responsible for inserting and editing quote data.

Figure 6 Message indicating requeried fields
Source: Own Elaboration

– **ODT:** Module that is responsible for consulting, editing, and subsequently updating the status of the quote (sent, approved, completed or cancelled). here we find the data of the work order, such as the ID of the quote to which the ODT will be associated, start and end dates, and a table where the tasks to be performed will be attached, each with a detailed specification.

Figure 7 Registering post order
Source: Own elaboration

b. Second increment

Once the first increment has been completed and validated, managers are presented with the functionality of each of the modules, integrating the phases of the methodology to verify correct data and suggestions for pertinent changes; giving guidelines for the integration of the activities of the second increment, whose objective is to create the employee management module that includes the consultation of registered users and the form for the creation of new users and which are described below:

– **Planning:** In this phase, the master list of user stories, requirements and the master list of tasks (activities) to be carried out are described, as shown in tables 2 and 3.

Sec. number.	User history	Priority
12	Add employees.	High
13	Update Employee.	High
14	Consult employee.	Medium
15	Delete employee.	Medium
16	Assign permissions to each type of user.	High

Table 1 Second increment user history master list
Source: Own Elaboration

Task number	User history	Task name
18	12	Interface design to add an employee.
19		Validation of employee data.
20		Adaptation of database for the employee.
21	13	Update of employee data.
22	14	Design and implementation for an employee consultation.
23	15	Design and implementation to terminate an Employee.
24	16	Assignment of roles for employees.

Table 3 Second increment master task list
Source: Own Elaboration

– **Modelling:** After analyzing the user stories, the low-fidelity interface layout is performed using the online WireframePro Mockflow tool, as shown in figure 8.

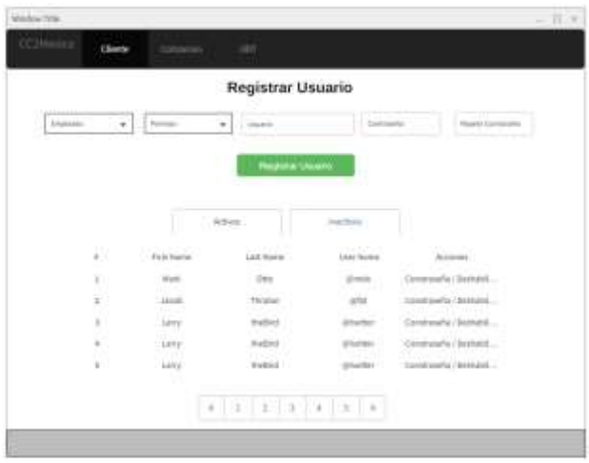

Figure 8 Proposed view, user creation
Source: Own Elaboration

– **Coding and tests:** Captures of the tests carried out on each of the components are shown, its rendering, speed and weight for the virtual DOM are tested, in addition to evaluating the main functions. As shown below.

Figure 9 Test view registering employees
Source: Own Elaboration

c. Third increment

The main objective of this increase is the creation and configuration of notifications to employees and clients when they generate a work order, which implements a traffic light that connects the client with the area coordinator for follow-up. A notification management module is included that will allow the status of the notification to be changed automatically within the system until the request for the requested service is completed. The management of ODT and Quotations is included, in addition to specific reports. The interface is shown below:

Figure 10 Generating a quote
Source: Own Elaboration

For work orders and when the ODT is created, notifications are sent to the coordinator of the assigned department, who will be responsible for updating the status. Figure 11.

Figure 11 Closing a quote
Source: Own Elaboration

d. Fourth increment

The primary objective of this increase is the creation and configuration of the mobile application in which the services offered are managed, in a productive environment; The implementation process of the finished prototype, in addition to simplifying the process to generate and authorize quotes, was designed to meet the needs of the company by offering third-party proposals and integrations. Finally, unit tests were carried out on the functionalities and performance, recovery and fault tolerance tests on the web and mobile application. See figure 12.

Figure 12 Main menú in the app
Source: Own Elaboration

5. Results

The results obtained here indicate the conclusion of the planned activities in each increment. In this work, two applications were obtained as a result of the requirements set by the client: The Web System and the mobile application. Both have the requested modules, as well as the incorporation of established business rules, in friendly and intuitive interfaces (Virtual, 2021). Among the results obtained we can list the following:

a. The application of agile development methodologies leads to greater interaction between clients and developers, and therefore faster results are presented. Optimizing development time and improving project deadlines and costs.

b. The implementation of the project called Automated Notification Management: Case Study Advertising Agency CC2México is considered successful because it provides considerable benefits to the company, mainly economic in the management of its processes.

6. Gratefulness

We thank the National Technological Institute of Mexico - Oaxaca Technological Institute, for the facilities granted to carry out the project.

7. Conclusions

It is concluded that the project called Automated Notification Management: CC2México Advertising Agency Case Study manages to have the planned scope and expectations due to the implementation of dynamic and easy-to-use processes; that allow the company to meet the request of its customers effectively.

Due to the foregoing, the developed tool becomes fundamental because it supports the stage of attention to online quotes and work orders, giving an opportunity to the effective closing of budgets and sales prospects and saving time for the collaborators who attend to these requests. so that they can be integrated into other priority tasks of the company.

The Web and Mobile applications are already in production, fully incorporated into the company's comprehensive platform (Torres, 2021), in the first phase in the city of Oaxaca, considering that with the results obtained it can be replicated in other entities in which CC2México has a presence.

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Development of a Web Application for the management of Georeferential Information regarding Biological Traps against the Fall Armyworm of the Center for Innovation and Technological Development of the Mezquital Valley

Desarrollo de una Aplicación Web para la gestión de Información Georreferencial referente a Trampas Biológicas contra el Gusano Cogollero del Centro de Innovación y Desarrollo Tecnológico del Valle del Mezquital

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Abstract

Today information technologies in the agricultural sector are widely used and this paper presents the development of a Web application that aims to manage the information generated by the application of biological traps that are installed in plots contaminated by the worm plague. armyworm (Spodoptera Frugiperda), these are developed by the Center for Innovation and Technological Development (CiDT) and distributed to corn producers in the Mezquital Valley to combat the plague. The Web application was developed with the agile development methodology called incremental, PHP technology, the MySQL Database Management System and the Here® WeGO API for manipulating georeferenced maps. To guarantee the functionality of the Web application, unit tests were implemented, defining use cases with information provided by CiDT. This Web application represents the first stage of a Hybrid Information System whose goal is to serve CiDT as a tool for monitoring and analyzing the behavior of the fall armyworm plague.

Web Application, Precision Agriculture, Spodoptera Frugiperda

Resumen

Hoy en día las tecnologías de información en el sector agrícola son muy utilizadas y el presente trabajo presenta el desarrollo de una aplicación Web que tiene como objetivo gestionar la información generada por la aplicación de trampas biológicas que se instalan en parcelas contaminadas por la plaga del gusano cogollero (Spodoptera Frugiperda), éstas son desarrolladas por el Centro de Innovación y Desarrollo Tecnológico (CiDT) y distribuidas a los productores de maíz en la región del Valle del Mezquital para combatir la plaga. La aplicación Web fue desarrollada con la metodología de desarrollo ágil denominada incremental, tecnología PHP, el Sistema Gestor de Base de Datos MySQL y el API de Here® WeGO para la manipulación de mapas georreferenciales. Para garantizar la funcionalidad de la aplicación Web se implementaron pruebas unitarias definiendo casos de uso con información proporcionada por CiDT. Esta aplicación Web representa la primera etapa de un Sistema de Información Híbrido que tiene como meta servir en el CiDT como herramienta para el monitoreo y análisis del comportamiento de la plaga del gusano cogollero.

Aplicación Web, Agricultura de Precisión, Spodoptera Frugiperda

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Introduction

Currently, technology in the agricultural field has many applications, either to improve the production of fruits and vegetables, or to prevent and counteract pests that harm production. This paper presents the work carried out for a Web application whose purpose is to serve as a computer tool to manage and store the information generated by biological traps that are built and distributed by the Center for Innovation and Technological Development (CiDT) among producers. of corn to combat the plague of the fall armyworm (Spodoptera Frugiperda) in the plots of the Valle del Mezquital region.

This pest has the characteristic of destroying the corn plant by eating its bud, causing the loss of parts or the entire plot. Given this situation, the CiDT developed a biological trap in which it eliminates the female butterflies through pheromones, thus preventing their spread. The use of these traps is beneficial since it avoids the use of insecticides that harm the health of both the plants and the soil, as well as the people who apply them. However, the CiDT does not have a computational tool that allows it to collect, store and process information generated by the traps to carry out an analysis regarding their distribution in order to have better performance.

In the market you can find different Web and mobile applications that deal with pest control, however, some of them require the acquisition of components for their operation, such is the case of Intagri S.C. (Intagri S.C., 2022)and DEGESCH (PRESERVE, 2022), these solutions represent a good option but given the economic situation in the region's producers, it is difficult to acquire and maintain the necessary components for operation.

There are also other solutions that use Information Technology (IT) such as iGEO ERP (IGEO ERP Cloud Platform, 2022), Kizeo (Kizeo, 2022)and Evisane (Evisane, 2022); however, despite being good solutions, acquiring a license for the use of these applications implies taking advantage of all the services they offer to take advantage of and in this case, given the requirements established by the person in charge of the CiDT, many of the services offered would not be used.

For this reason, a Web application was developed as the first part of a Hybrid Information System whose global objective is to be the tool that solves the needs that CiDT has with traps and thus avoid the use of insecticides in the plots.

To detail the work carried out in the Web application, this document is included in the Methodology to be Developed section, where the methodologies, tools and technologies used are detailed. The Results section where the functional tests and the results obtained from them are described. The Conclusions section where, based on the results obtained, the functionality of the application is concluded. Acknowledgments section for those who supported or guided the development. The Financing section where the economic support that the project had to develop the presented Web application is mentioned. And finally the References section.

Methodology to develop

The Web application was developed with the implementation of the agile development methodology called incremental with PHP technology (php.net, 2022), the MySQL Database Management System (DBMS) (ORACLE, 2021) and the Here® WeGO API (Here Technologies, 2021)for manipulating georeferenced maps.

The busy incremental methodology is the one commented by (Pressman, 2010) where he mentions that software development is divided into functional increments where each one is made up of five stages: communication, planning, modeling, construction and deployment. In this case, the Web Application was developed in 7 increments in which each one has a specific function according to the established requirement. The development of each increment was carried out using the PHP, HTML, CSS, JavaScript and SQL languages for the persistence of the information through the use of the DBMS MySQL.

The first increment includes the user registration module, it includes the roles: Administrator, Producer, Technician and Guest. A sample of this increase can be seen in figure 1.

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Figure 1 User Registration
Own Elaboration

The second increment contemplates the functionality for access to the Web application where the RFC of the person to be registered is taken as the username. Figure 2 shows the login screen.

Figure 2 Login
Own Elaboration

The third increment is formed by the personal data module that has the function of updating the data of the user who has logged in, a screenshot of this module can be seen in figure 3.

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Figure 3 Personal data module
Own Elaboration

In the fourth increment, the parcel module was considered, where the information of the parcels that belong to the corn producers in the Valle del Mezquital region is managed, as part of the information it includes the georeferential data of the parcel in order to locate it with a georeferencing system. The data of the parcel that is managed are name, municipality, surface, RFC and name of the producer. This module implements the API offered by Here® WeGO for manipulating georeferenced maps in the Web application. Figure 4 shows the screen where parcels are added and the location of the parcel on the map.

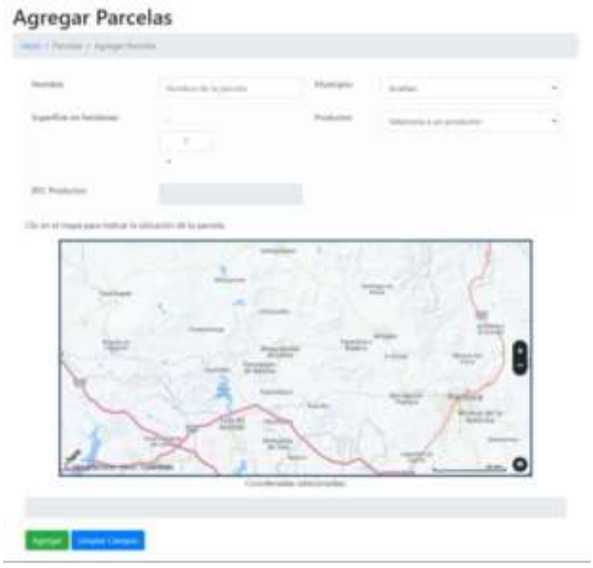

Figure 4 Add parcels
Own Elaboration

The traps module was developed in increment five and comprises the functionalities to add, install, uninstall and delete acquired biological traps. In each function, the general information of each trap is managed, but its georeferenced information is also considered in order to locate it on the Here® WeGO maps.

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Figure 5 shows the main screen of the module where the location and information of each trap installed in the plots can be consulted.

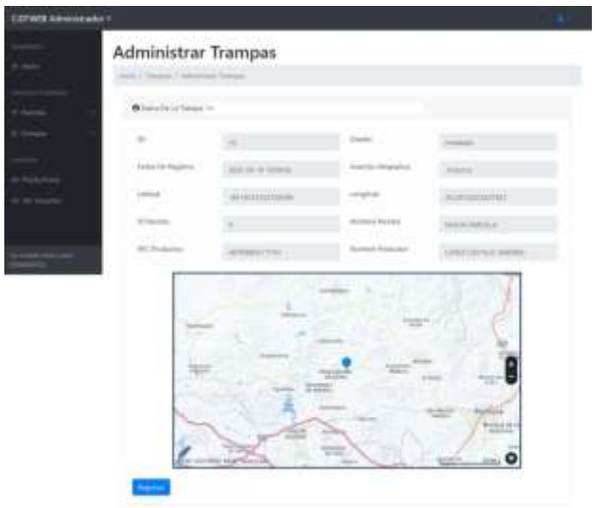


Figure 5 Trap management
Own Elaboration

The report module is contemplated in increment six and contains the function of recording the temperature and the number of butterflies that are captured in each one of the traps installed in the plots, these records are important to generate a database that allows an analysis of the behavior of the fall armyworm pest in the plots of the region.

In Figure 6 you can see the interface to record the information of a trap and in figure 7 you can see the report of each record made to a specific trap.

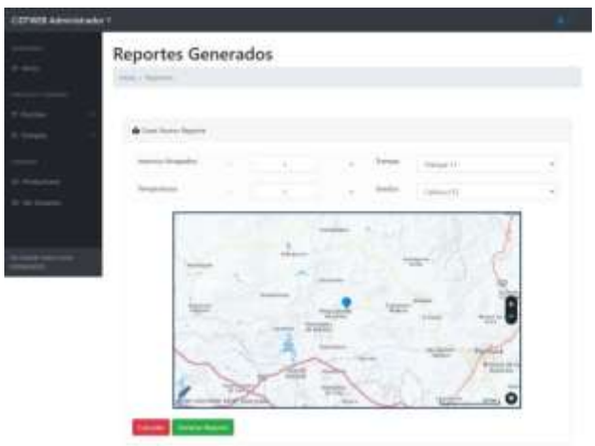


Figure 6 Reports generated by biological traps
Own Elaboration

Figure 7 Report of records generated by a biological trap
Own Elaboration

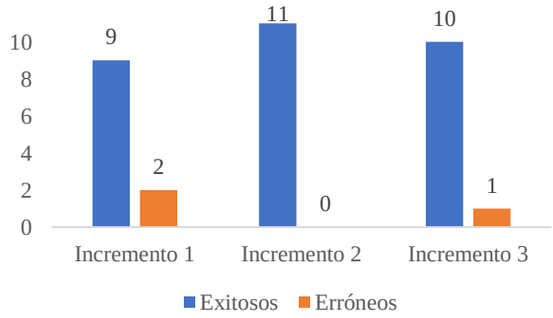
In the last increment, the module for managing the users of the Web application was developed. This module is used only by the administrator of the Web application and allows managing the information of each registered user through the functionalities to add, update, delete and assign role. Figure 8 shows the main interface of the module.

Figure 8 Report of registered users
Own Elaboration

Once the increments were developed, they were integrated into the Web application to apply a set of tests to guarantee their functionality, this activity is described below.

Results

During the development of each increment in the deployment stage, a set of so-called unit or component tests were carried out, where eleven test cases were defined for each increment with different input data provided by the CiDT. Graph 1 shows the results of the tests carried out for increments 1, 2 and 3.



Graph 1 Executions of test cases in increments 1, 2 and 3
Own Elaboration

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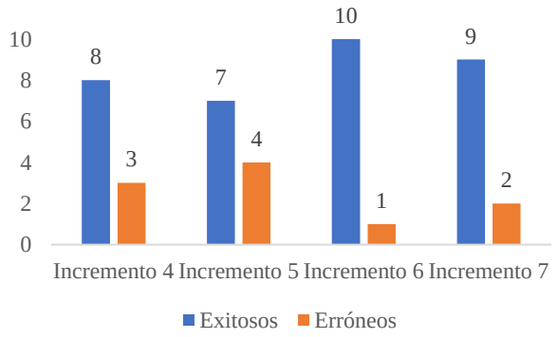
As can be seen, the increase presented two errors since the format of the RFC data was not validated, which is important since it is taken as a username. For increment 2 there were no errors since it consists of access to the system. For increment 3 there was an error related to the RFC syntax since it was not validated. Graph 2 shows the results when implementing the use cases at increments 4, 5, 6 and 7.



Graph 2 Executions of test cases in increments 4, 5, 6 and 7
Own Elaboration

Observing the results, it can be mentioned that increments 4 and 5 presented several errors because they are the most relevant of the Web application since they implement the Here® WeGO API for the management of georeferenced maps, the errors found in the executions were related to accessing maps, taking the position of a point, placing a point on the map and creating areas on the map; about the latter was due to the fact that since the free version is used, Here® WeGO does not allow the use of areas in its maps.

Conclusions

Despite obtaining errors in the test cases, these were corrected in the Web application in order to ensure its operation before being applied in a real environment.

The errors found caused deepening the knowledge for the implementation of the Here® WeGO georeferenced maps and thus enriching the domain of these for future projects. The implementation of the agile methodology called incremental allowed a development of the Web application through increments that were delimited according to the modules identified by the work team and the CiDT, each increment was planned, developed and tested according to the functional requirements requested.

The implementation of unit or component tests in each increment, allowed to ensure a correct operation guaranteeing an acceptable quality in the developed Web application.

Finally, it is important to mention that the developed Web application is the first part of a hybrid information system that aims to serve as a tool in the CiDT for monitoring and analyzing the behavior of the fall armyworm plague within the Mezquital Valley. Therefore, the use of georeferenced maps for the management of information generated by biological traps, allows the collection of relevant information for the CiDT.

Gratitude

Thanks to the Center for Innovation and Technological Development (CiDT), especially Eng. Jaime Ortega Bernal, for the support and facilities provided for the development of this Web application.

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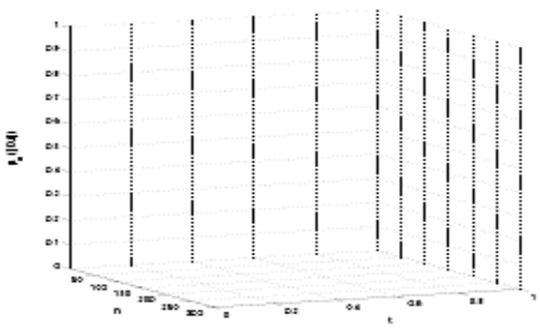

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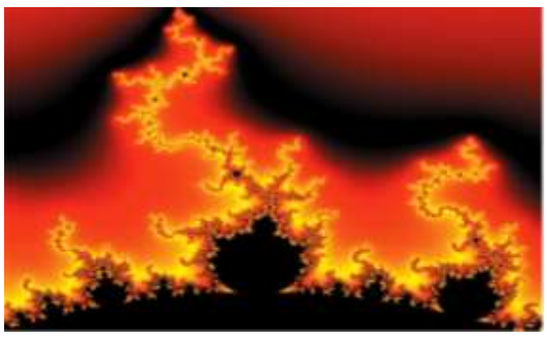

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