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PAPER

ESPE Security: Mobile and Web Application to Manage Community Emergency Alerts

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ABSTRACT

This study presents the implementation of "ESPE Security," an application designed to manage community emergency alerts. A data collection technique was employed to understand frequent incidents in the Luz de América parish in the Santo Domingo de los Tsáchilas province. A sample of 440 residents was gathered through surveys covering an age range of 15 to 60 years, including various demographic groups such as students, traders, and the general population. The collected data revealed that approximately 87.95% of the surveyed rural parish population desires an application to report community incidents, as they have reported incidents such as traffic accidents, thefts, crimes, health issues, and homelessness. Based on these findings, a mobile and web application was developed to notify incidents in real time. The design and development of these applications involved technologies such as MongoDB, React, and Node.js, focusing on providing an intuitive user interface. Tests were conducted with 69 end-users and seven experts, employing quantitative techniques to assess design and usability. The results for design were 90%, and for usability, it was 66.70%. Therefore, mobile and web applications are helpful for real-time notification of critical incidents and will contribute to the community.

KEYWORDS

ESPE security, community emergencies, mobile and web, Node.js, React

1 INTRODUCTION

Managing emergencies and critical situations has become a priority for communities, given that the safety and protection of citizens are fundamental pillars [1]. In Ecuador, we face various challenges, from the increase in crime, kidnappings, and criminal acts that threaten citizen security to natural phenomena and accidents that represent additional risks [2] [3] [4].

This study arises in response to a worrying reality: approximately 4,660 cases of disappearances have been reported in the country, according to the Ministry of the Interior in its last update in July. However, it is encouraging to know that around

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4,033 of these missing people were located between January and July. Despite this, 527 people are still missing [5]. In addition, data from the newspaper Primicias reveals an alarming 74% increase in violent deaths during the first half of 2023, especially at night. In the period between January 1 and July 2, 2023, 3,568 violent deaths were recorded nationwide. The worrying increase of 26.15% in violent deaths in the province of Santo Domingo de los Tsáchilas compared to 2022 stands out, where crimes are committed more at night. In addition, between January 1 and July 2, 2023, 3,568 violent deaths were recorded in the country. Only in the province of Santo Domingo de los Tsáchilas was an increase in violent deaths recorded by 26.15% compared to 2022 [6]. Given this alarming reality, it is imperative to have a technological application for managing community emergency alerts that allows the different inhabitants of the Santo Domingo canton to control and prevent risk situations.

This research stems from the social project entitled "Implementation of Web and Mobile Applications for the Management of Community Emergencies in the Province of Santo Domingo de los Tsáchilas," which proposes to develop a web and mobile application for the management of community emergency alerts in Ecuador, specifically in the province of Santo Domingo de los Tsáchilas. The main objective of this application is to offer a comprehensive solution that allows the community to report emergencies and request help in real-time in an effective manner so that, together with the community authorities, the necessary emergency protocols can be activated to protect and safeguard the integrity of citizens [7].

The application comprises two fundamental components: a backend for internal information management and a frontend facilitating community interaction with emergency alerts. Its development is based on exhaustive research and approaches aimed at satisfying the real needs of users.

This study aims to close the technological gap in emergency management in Ecuador, offering a specific solution adapted to the needs of a particular community. The discoveries of this research will not only positively impact Santo Domingo de los Tsáchilas but will also lay the foundation for improvements at the national level. This will contribute significantly to the country's community safety and emergency management. The generated alert reports will identify areas with the highest incidents, divided into security and community. The security category covers incidents such as burglary, personal robbery, vehicle theft, traffic accidents, medical emergencies, firefighting emergencies, drug-related cases, and suspicious activities. On the other hand, the community section includes problems with sewage, garbage, energy, telecommunications, public transportation, positive actions in the community, and reports of lost pets.

These reports will become fundamental tools for decision-making by the authorities, which will allow specific and focused action. This classification will facilitate the efficient allocation of resources according to the type of incident, allowing a more effective response to the particular needs of each situation.

2 STATE OF THE ART

2.1 Ecu 911

Ecuador's Integrated Security Service Ecu 911 offers a mobile application that facilitates the transmission of alerts to entities such as the Police, Transit, Health, and Fire Departments through geolocation tools, using tracking and management phases [8]. The primary considerations, according to González and Romo [9], highlight the need for mobile devices with unlimited Internet connections for complaints or requests for attention, ensuring constant communication between operators

and users. Furthermore, activated GPS is necessary for real-time geolocation to monitor users effectively in critical situations.

2.2 Alertcops

This mobile application, directly connected to the Spanish National Police, allows reporting as a victim or witness through photographic evidence and geo-referencing. It works through levels of protection, which consist of allowing interaction with the authority through video or chat, sharing locations and the audio of the device for the follow-up of the complaint, facilitating the issuance of alerts with geolocation, and making it possible to notify complaints only through the use of the mobile application [10].

The system provides a wide range of functionalities, including geopositioned alerts for monitoring emergency services, security notifications for application managers, citizen collaboration, and the activation of up to ten public or private guardians with recurring location information. In addition, it offers specific alerts for robberies, assaults, physical, sexual, and verbal aggression, gender violence, hate crimes, illegal invasion of territory, animal abuse, vandalism, scandals on public roads, bullying, and disappearances. In technical terms, the application prioritizes reliability, resource consumption, security, performance, and compatibility. Although it has high battery consumption and does not support a saving mode, it offers an immediate response to notifications. However, workload or the volume of waiting messages may affect the speed of the response. It is available in seven languages for Android devices and only on iPhones for iOS [10].

2.3 Sosafe

It is a mobile application and community safety software that manages responses by keeping complainant data private [11]. It has the territorial prediction services of InstaGIS, which controls the application in a proportion of 60% [12]. The intelligence of the software makes it possible to generate alerts from the application to respond to users through smartphones; parallel to this, it creates coverage territories and enables operators and administrators to process and respond. The application had an estimated 900,000 users as of May 2020 and a score of 4.5/5 in the App Store. Sosafe is characterized by promoting cooperation between community members, unifying communication channels in a single medium, improving public perceptions of safety, analyzing patterns to identify critical areas and protection zones, and offering crucial data for decision-making [13].

2.4 Life360

Its functions are to locate family members and communicate with them by issuing emergency alerts. Its most essential roles are providing data on shelters and safe areas, geolocating other members' positions, and enabling monitoring through audio and video broadcasting. The application offers the transmission of the location through a map with the help of GPS and, at the same time, observes the area at the current time with high accuracy. In addition, it provides instant connection services through group or individual messaging, an alert with a panic button that communicates the complainant with the emergency services, accident detection through sensors that notify the authorities, location registration, and the location of the mobile device in case of loss or theft [14] [15].

3 METHODOLOGY

The methodology used to develop the web and mobile application for community emergency alert management is structured in four stages according to the waterfall software development model: analysis, design, implementation, and testing [16].

3.1 Analysis

The initial phase involves researching and documenting customer needs and system requirements to clearly understand the expected functionalities of the software [17].

Research, surveys, and data collection were carried out to understand the needs and requirements of users. This included identifying the types of common community emergencies and critical areas to address. In addition, an analysis of similar applications on the market was carried out to obtain information on features valued by users [18].

The problem to be solved is the lack of a comprehensive and accessible solution for managing emergency alerts in the Luz de América parish. Threats to citizen security, such as theft and medical emergencies, are identified, along with a lack of awareness about the existing ECU 911 application.

The proposed solutions include the development of a mobile and web application called "ESPE Security." Its features include geolocation integration, an "SOS" emergency button, personalized user groups, news updates and community emergencies, privacy and data security measures, and integration with existing emergency services.

3.2 Design

This stage focuses on planning and creating the software's structure, architecture, and appearance based on the requirements defined in the analysis stage [19].

The mobile and web applications were defined in terms of functionality and suitability by creating prototypes representing the user interface. Key features such as real-time alert management, communication with competent authorities, and geolocation were designed. Interfaces were created to manage addresses and profile settings, and web application prototypes were developed.

3.3 Implementation

This is the stage that involves translating the design into actual source code. The programmers are responsible for developing the software following the specifications and guidelines established in the previous steps [19].

Software development tasks based on the designs were carried out at this stage. Various technologies and tools were used, such as React, Next.js, Node.js, Tailwind CSS, MongoDB, and Mongoose. Planned features have been implemented in the mobile and web applications, including account creation, login, alert management, news viewing, group communication, and address management. Connections with hosting services were also established, and Google mapping and authentication capabilities were implemented in the mobile application.

3.4 Tests

This stage focuses on testing the applications to ensure proper functioning and compliance with the defined requirements. Load, security, privacy, performance,

and usability tests were performed to evaluate the user experience and gather feedback. Security and privacy features were verified, and efficiency and user acceptance were confirmed to make final improvements [16].

3.5 Maintenance

The maintenance phase, performed after implementation, focuses on correcting errors, updating functionality, and adapting the software to changes in the environment or requirements over time. The applications were corrected and improved when errors were detected during testing to guarantee their correct functioning and continuous adaptation.

4 RESULTS

4.1 Analysis

To evaluate user needs and define the requirements that the mobile and web applications would address, a survey was carried out in the Luz de América parish. This survey was applied to 440 people, and various analysis techniques were used to deeply understand the expectations and requirements of the community.

In addition, a systematic review of the literature was carried out to analyze the existing characteristics of tools such as ECU 911, SOSAFE, ALERTCOPS, and LI-FE360. This analysis allowed us to understand the features valued by users in this type of application, defining the following key needs and requirements:

- Ability to Report Community Emergencies in Real Time
- Effective Communication with the Competent Authorities
- Easy to use
- Geolocation functionality
- Access to Updated Information on Community Emergencies
- User Groups
- Privacy and Data Security
- Updated News and Alerts

These findings and the results obtained from the Luz de América parish survey provided a solid basis to define the main parameters and functionalities that the "ESPE Security" application had to address. Below, a summary of the results obtained is presented in Table 1, which details the most relevant findings from the survey.

Table 1. Summary of survey results in the Luz de América parish

Incidents	Surveyed	Percentage
Thefts	67	15.63%
Medical emergencies	50	11.36%
Fires	7	1.59%
Natural disasters	7	1.59%
Traffic accidents	19	4.32%
No incidents	280	63.31%
Others	10	2.2%
Total	440	100%

These results served as the basis for designing and developing the community emergency alert management solution, ensuring that "ESPE Security" meets the needs and expectations identified by the literature review and survey responses.

4.2 Design

In the design of the mobile application, priority has been given to creating an intuitive and highly functional interface to provide an optimal user experience. A robust registration and login system has been developed, ensuring accessibility for all users. The main interface has been designed to offer quick and direct access to essential functions, such as emergency alerts and community reports. The ability to manage and detail various safety and community reports has also been implemented. A new section has been integrated to keep users informed and encourage interaction.

The creation and administration of chat groups have been simplified, which is especially useful for effective communication in emergencies. The app also allows you to store and manage addresses for accurate location alerts. Additionally, the design has been completed with a drop-down menu that offers convenient access to critical sections of the application. These functionalities have been intertwined to provide a comprehensive and versatile tool that addresses security and community collaboration needs. This approach has been fundamental to improving the user experience and the overall effectiveness of the application. (see Figure 1).

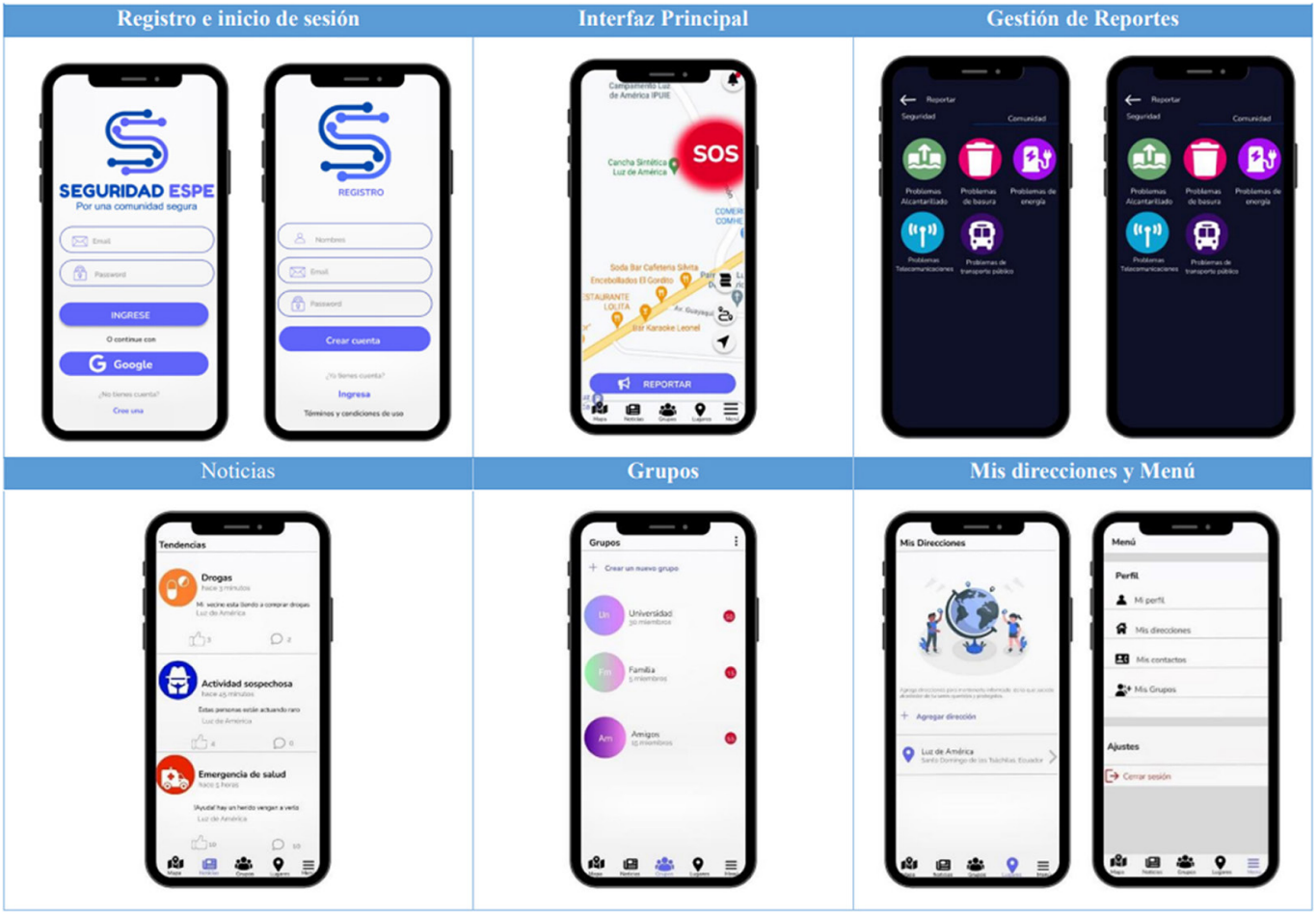

Fig. 1. Design of the final prototype of the mobile application

The web application and the mobile version offer users an additional platform to access relevant information. Its interface provides an overview of fundamental capabilities and informative sections about the institution and the development team. Additionally, the contact section offers various options to contact technical support.

Users can view and apply filters to emergency alerts. In addition, they can download reports in various formats for more detailed analysis (see Figure 2).

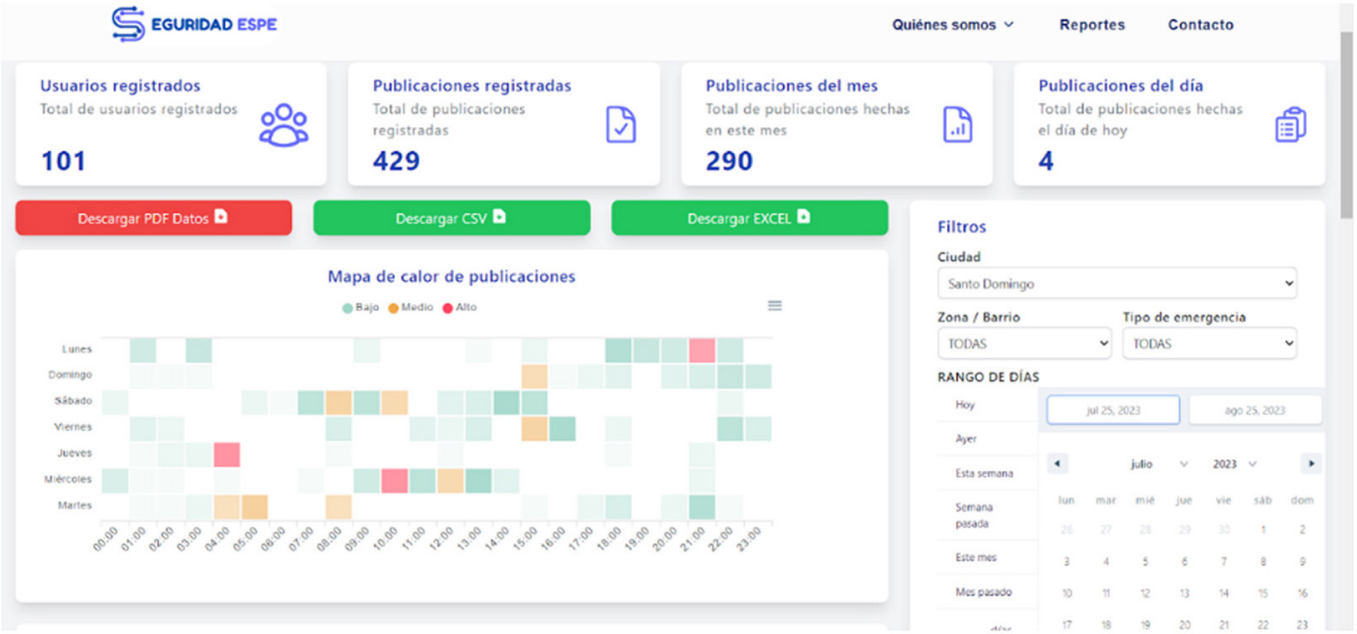

Fig. 2. Reporting interface

An architecture was established so that users can access the applications via the Internet and mobile devices. Users report community emergencies while making filters in the web application in such a way that the applications hosted on the server will process the reports. Additionally, they can send emails, which will be sent using the server SMTP (see Figure 3).

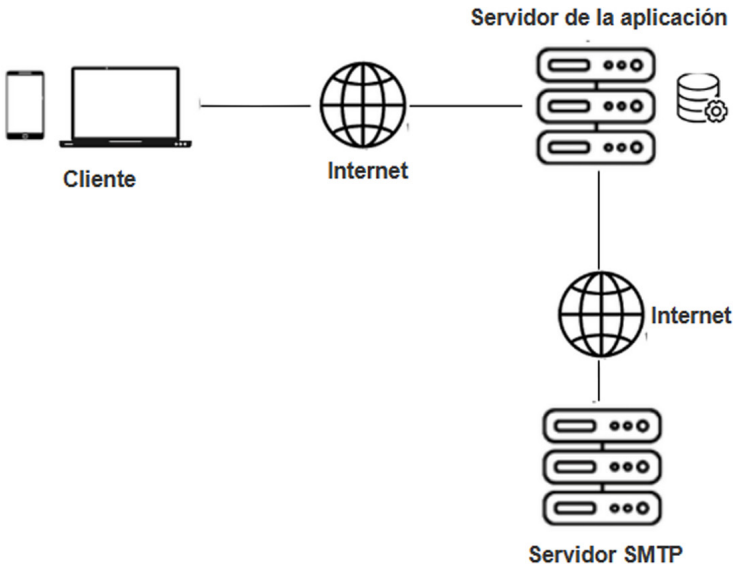

Fig. 3. Web and mobile system architecture

Both designs focus on ease of use, effective emergency communication, and quick access to relevant information to provide users with a comprehensive and satisfactory experience.

For the application to work, MongoDB is used to manage the information about the applications. Figure 4 shows the database schema with its respective relationships.

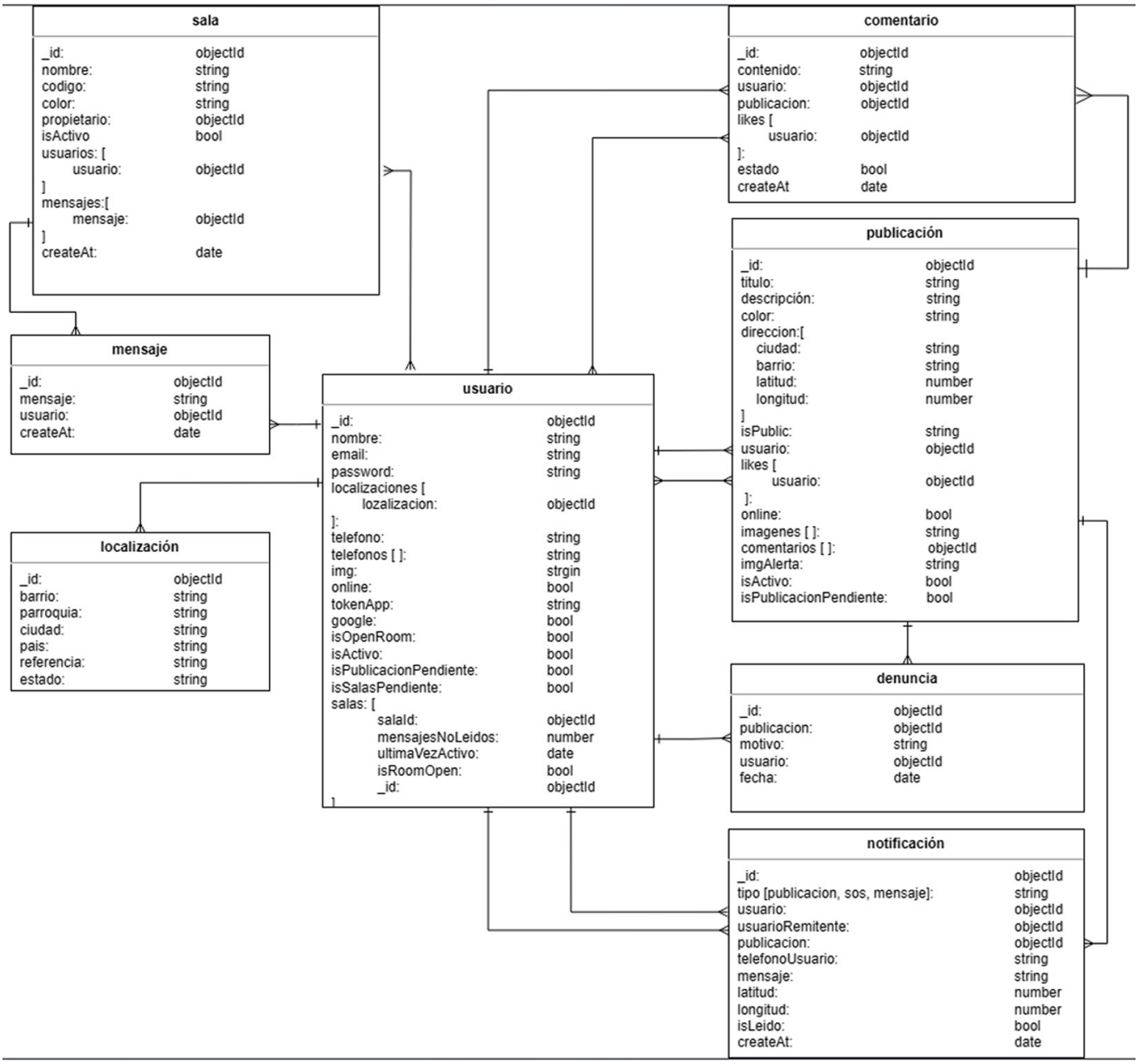

Fig. 4. Database schema

4.3 Implementation

Implementation of the application involved a variety of tools and technologies. MongoDB was used as the database manager on the server and database side, and

Mongoose interacted with it. For web development, technologies such as React, Next.js, Node.js, and Tailwind CSS were used to create the user interface and manage the client logic. Express.js was used to make the web server.

Figma was used to create and visualize the application designs in the design and prototyping areas. Additionally, a REST server was implemented to handle HTTP requests. Regarding infrastructure, the application was hosted on a Dell PowerEdge R740 server. Flutter was used as the primary development framework, along with the Dart programming language, for the development of the mobile application. Technologies such as the Blob API for handling binary data and Google authentication were also used to allow access to users through their Google accounts. Additionally, Mapbox was used to integrate mapping capabilities into the mobile app. Figure 5 shows the technologies used.

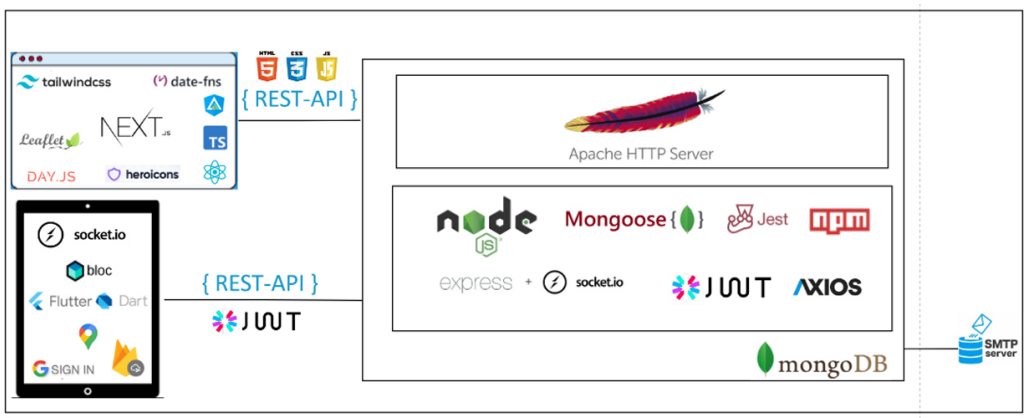

Fig. 5. Technologies and tools used

4.4 Tests

Usability tests. At the end of the development of the applications, a usability evaluation was carried out through surveys with a group of 69 end users, including three experts in mobile application development and four experts in statistics. The purpose was to collect data and obtain an accurate perception of the user experience that users experienced when interacting with the mobile applications and the web version (refer to Tables 2 and 3).

Table 2. Mobile app usability test results

Criteria	Rating Scales		
	Excellent	Well	Acceptable
Design	76%	24%	–
Accessibility	62%	30%	8%
	Very easy	Easy	Acceptable
Easy to use	66%	34%	–
Overall Ease	58%	34%	8%

Table 3. Web application usability test results

Criteria	Rating Scales		
	Excellent	Well	Acceptable
Design	89.9%	11.1%	–
Content	77.8%	22.2%	–
Structure and organization	66.7%	33.3%	–
Filter options	83.3%	16.7%	–
Filters	72.2%	27.8%	–
Usability	66.7%	33.3%	–

Load tests. Load tests were executed using LoadUI software to simulate loading requests to the different sections, including the main page. Ten requests per second were configured for these tests. The collected results indicate no significant changes were observed in response time (refer to Table 4).

Table 4. Load testing on mobile and web application

Load Test	Requests Per Second	Total Requests
Mobile App	10	5,042
Main Page (Web)	10	4,454
Institutional Philosophy (Web)	10	1,996
Our Team (Web)	10	2,465
Reports Page (Web)	10	3,036
Contact Page (Web)	10	4,003

Acceptance criteria test. An expert mobile and web application user at the University of the Armed Forces ESPE, Santo Domingo headquarters, evaluated the acceptance criteria. Twenty-two specific acceptance criteria were proposed and assessed (refer to Table 5) to verify the correct functioning of the applications.

Table 5. Final acceptance criteria test

Criterion	Event	Obtained Result
CA1-01	Create an account.	Correctly validated fields.
CA1-02	Register an account.	Successful user registration.
CA2-01	Log in.	Validated credentials.
CA2-02	To access.	Successful access to the application's functionalities.
CA3-01	Send alerts in real-time.	Reports were sent successfully.
CA3-02	Receive confirmation.	Confirmation of the report published in the news.
CA4-01	Open application.	Display of current location.
CA4-02	Report emergencies.	The sent report contains the user's location.
CA4-03	Add a place.	Location successfully entered.

(Continued)

Table 5. Final acceptance criteria test *(Continued)*

Criterion	Event	Obtained Result
CA4-04	Report emergencies.	Successful notifications to report users.
CA5-01	A comment is posted.	Successful receipt of comment notifications from other users.
CA5-02	Messages are sent.	Success in receiving notifications when messages arrive.
CA5-03	Send messages.	Successful real-time communication.
CA5-04	An Send Out Soccour (SOS) alert is sent.	Successful receipt of instant notifications.
CA6-01	Send messages.	History of successfully saved messages.
CA6-02	Open the web application reports page.	You are viewing graphs and visible filters.
CA7-01	Apply filters.	Filters successfully applied based on specified criteria.
CA7-02	Apply filters.	You are viewing the location of the emergency.
CA7-03	Emergency monitoring.	Emergencies show your current status.
CA8-01	Close emergencies.	The alert statuses change to closed.
CA9-01	Download reports.	Download statistical reports.
CA9-02	Review reports.	Download detailed and coherent reports.

4.5 Maintenance

The results obtained from the acceptance criteria tests revealed that unsatisfactory results were observed in only five cases, indicating that the expert user managed to complete most of the tests.

Among the findings identified, some specific errors stand out. Acceptance criteria CA3-01 and CA3-02 were related to the server, while criterion CA5-04 required the addition of a new function to allow notifications from sources external to the device. On the other hand, during the testing of the web application, improvements were made to criteria CA6-02 and CA7-01 by using the ApexCharts.js library, and in criterion CA9-01, a change was implemented in the package to improve the PDF presentation.

5 DISCUSSION

Load testing has demonstrated the applications' ability to maintain a stable and fast response by processing a specific number of requests every 10 seconds. This aspect highlights the efficiency and stability of the platforms. Likewise, successful tests were carried out after implementing improvements based on the acceptance criteria that validated the functionality and compliance with the predetermined requirements.

Tests of the 22 acceptance criteria were run with expert users, revealing only six unsatisfactory results; however, they were corrected, and the specialist user passed the tests successfully, validating the solidity and effectiveness of the applications.

In general terms, the results obtained from surveys, load tests, acceptance criteria, and evaluations with expert users highlight a positive reception regarding the design, usability, functionality, and performance of mobile applications and the Web.

The initial absence of an API containing province-specific locations limits the mobile app. Given this lack, the decision was made to develop an API from scratch and incorporate 28 locations necessary for testing. For future research, it would be crucial to continue growing the API that hosts the detailed locations of the province. This integration would allow users to accurately display their location from any point within the province, thus strengthening the functionality and usefulness of the developed applications.

6 CONCLUSION

It is determined that the web and mobile applications are accessible to a wide variety of regular users and emergency response personnel, all of whom will be able to interact effectively with the applications in critical and everyday situations alike. The objective of developing two applications that provide the community with the ability to inform and stay informed about community emergencies was met.

The implementation and testing phases were measured with surveys directed at 69 end users, and seven experts revealed a significant level of acceptance, ranging between 60% and 90% in critical aspects such as design, usability, and ease of use. They show that the mobile application allows users to report emergencies in real time, and the web application will enable authorities to visualize and analyze the data to make effective decisions. In the case of functional tests carried out with the collaboration of expert users, most of them gave satisfactory results. However, valuable recommendations emerged that triggered significant improvements in the applications.

Load testing demonstrates the stability of applications under a significant load of requests. During testing, it was noted that the applications maintained stable performance, even under intense requests. This indicates that mobile and web applications are prepared to face high-demand situations without compromising their operation or user experience.

Using different development technologies allowed us to obtain a solid and diversified technological approach for implementing front- and back-end applications. Essential technologies such as React and Next.js have been employed on the web front, along with libraries such as Axios and Tailwind CSS, ensuring an efficient and responsive user experience. On the other hand, on the mobile front, the use of Flutter has provided a solid foundation, supported by a series of specialized packages and libraries that address various functionalities and features. Finally, on the backend, Node.js has been used with Express to build a robust API, supported by various libraries, such as Mongoose and Socket.io, to manage business logic and real-time communication.

7 FUTURE WORK

Various modules could be implemented to make the ESPE Security application much more complete. During the development of the applications, several proposals for modules arose to integrate into the applications that have been left open and are

expected to be incorporated in the future. Below are some future projects that can be developed to complement and improve the application:

- Integrate an inclusive chat in the mobile application, which allows different users to communicate in an accessible way and can benefit from the chat function.
- In groups, add the option to attach photos and videos and record content directly in the group chat for more fluid communication.
- Incorporate the functionality to create individual chats with application users without creating groups, providing more personalized communication.
- To access groups, include access links, allowing users to share and access groups more quickly and conveniently.
- Develop an administrative page that allows you to configure the number of complaints necessary to block a user from the application.
- Develop the option to change the application's visual appearance from light to dark tones to improve the user experience.

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