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Tesis

Development of an Interoperable Web Application to Work in Areas with Limited Connectivity in the Admissibility Processes of Activities, as a Complement to Smart Cities

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Development of an interoperable Web Application to work in areas with limited connectivity in the Admissibility Processes of Activities, as a complement to Smart Cities*

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Abstract

Smart cities are characterized by comprehensive connectivity, for which a level of integration is needed, for which integration must mature. In this sense, we find connectivity problems that occur in the areas of the Peruvian jungle, with interferences that cause cuts in the different services that use the Internet connection, such as web systems, for which the National Commission for Development and Life without Drugs (DEVIDA) is a public entity, has its headquarters in a district of the Peruvian Amazon jungle. The admissibility of activities is the registration of all activities to be carried out. These activities are characterized by controlling coca leaf plantations, as well as their eradication campaigns, being important to have the information in real time. Carrying out an analysis of similar works, we found works where XML messaging is used to achieve interoperability between the various systems, which is adopted in the present work. A web system has been designed that integrates connectivity detection functionalities in order to send information through an alternate mechanism, based on the exchange of information via XML messaging. The results indicate that it is possible to have information in real time, in all locations, which achieves interoperability between different systems.

Keywords

Smart Cities, web system, interoperability, processes, connectivity, real-time access.

1. Introduction

Analyzing the state of the art on the application of Smart Cities concepts, we found works where there is a need to optimize the design of buildings to improve energy efficiency and the quality of the urban environment, for which a simulation analysis of the wind environment and heat transfer was carried out using a CFD model, with the help of the Ecotect software together with the WinAIR plugin to simulate the air flow and thermal conditions around the building, having as results in the simulation that the distribution of wind and temperature were aligned with real conditions, validating the accuracy of the model, concluding that the simulations provided a reliable basis to guide architectural design and improvements in energy efficiency, contributing to sustainability goals in smart cities [1].

With the need to evaluate the impact of smart city policies on urban resilience in Chinese cities, a multi-period double difference model was applied to mitigate selection biases and evaluate the effect of policies, defining urban resilience indicators and a mediation analysis with the update of the industrial structure; Finding that smart city policies significantly improve urban resilience, with a mediating effect of industrial upgrading, concluding that smart city policies are effective in increasing urban resilience, and their expansion and strengthening of industrial upgrading are recommended [2].

Cybersecurity of physical devices in cyber-physical systems is vulnerable to attacks, for which an Intrusion Detection System (IDS) was integrated with a Digital Twin (DT) to simulate and monitor attacks in a controlled environment, using Eclipse Ditto as a DT platform and Snort as IDS, together with a Raspberry Pi and a Kali Linux virtual machine to carry out cyber attacks, resulting in the IDS effectively detecting Hping3 flood attacks, but showed limitations in identifying NMAP scans, with a significant increase in CPU and memory usage during attacks, concluding that the integration of DT and IDS represents a valuable innovation for cybersecurity in the IoT field, although improvements are required in the detection of certain types of attacks and in the recovery of system resources [3].

The need for a secure and efficient system for data processing in smart city environments, facing cyber threats and limitations of current IoT frameworks, for which the BFLIoT system was developed, which combines federated learning and blockchain to decentralize data processing and improve security, ProVerif was used for formal verification of the security of the BFLIoT protocol, ensuring the integrity and confidentiality of communications; A system was achieved that maintains high transaction rates and low energy consumption, with a robust anomaly detection framework, the BFLIoT represents a significant advance in IoT technology, offering a scalable, secure and efficient solution, with the potential to be applied in various sectors beyond smart cities [4].

The integration and visualization of BIM (Building Information Modeling) and GIS (Geographic Information Systems) models on web platforms for smart cities is complex and requires effective visualization solutions. A 3D web client based on Cesium was developed, using HTML5 and WebGL technologies, allowing the visualization and interaction with 3D models of cities in web browsers without the need for additional plugins, using the Cesium visualization engine and the virtualcityMAP platform, together with photogrammetric techniques to create 3D models and BIM-GIS integration tools, obtaining that the web client managed to visualize 3D models of cities and infrastructure data, improving the interoperability between BIM and GIS and allowing users to interact with data effectively in real time; it is concluded that the solution is effective for visualizing 3D models on web platforms, but greater interoperability between BIM and GIS is required to improve analysis such as disaster management, energy analysis and indoor navigation [5].

The integration of drones into urban transportation systems presents significant challenges such as air traffic management, conflict detection and obstacle resolution, as well as the need for safe landing protocols in complex urban environments, an Intelligent Total Transportation Management System (ITTMS) was developed that incorporates drone operations, using emerging technologies such as the Internet of Things (IoT) to optimize urban mobility and traffic management, drone tracking models, real-time monitoring, advanced air traffic management and detailed landing protocols were implemented to ensure the safety and efficiency of drone operations in smart cities, as a result of the simulations showed that the proposed drone tracking models and landing protocols improved drone traffic efficiency and safety, enabling effective management of multiple drones in urban airspace; Concluding that the proposed solutions proved effective in simulations, it was concluded that further research

is needed to refine these systems and address the complexities of drone management in urban environments, ensuring safe and efficient operations [6].

The need for an assessment framework for smart building (SB) integration in smart cities (SC) that considers multiple performance and sustainability factors, for which a two-round Delphi survey approach was used to validate and improve the assessment framework, collecting opinions from experts in the field, where generative artificial intelligence models, specifically ChatGPT-3 and Google Bard, were employed to assess the impact of different factors on smart city performance; a consensus was reached among experts on the importance and impact of various criteria in assessing SB integration in SC, as well as identifying areas for improvement in the proposed framework; concluding that combining AI methodologies with human expertise can address bias challenges in generative language models, and the validated framework provides an effective tool to assess smart building integration in the context of smart cities [7].

Carrying out a literature review on the different systems that work with different interoperability methodologies between systems and devices, we find in the integration of legacy systems in an industrial environment, proposing a solution divided into four main areas. The first part focuses on the incorporation of the Open Platform Communication Unified Architecture (OPC UA) protocol, widely used in the industrial environment. The second sub-section suggests the implementation of an OPC UA—Message Queue Telemetry Transport (MQTT) wrapper to enhance current digital transformation trends. The third part highlights the obsolete practices of the HTTP protocol and the legacy systems based on them, and finally, an event-based approach for data acquisition and storage without a transmission protocol is presented. The study concludes that the integration of these legacy systems can result in a significant cost reduction, especially in the data acquisition phase, which is based on obsolete technologies. Furthermore, the integration of appropriate artificial intelligence models is suggested to apply customized levels of logic, allowing the incorporation of contemporary modules [8].

In solutions based on the integration and operation of the Publish@Ionio ecosystem, focusing on the experience of participants and their roles within the system. The importance of the module-based data structure is highlighted, which allows for efficient and compartmentalized management of access rights and responsibilities. In addition, the need to establish clear guidelines for publishing on social networks and managing content requests is mentioned, in order to avoid misunderstandings and internal conflicts [9].

The importance of standardization and collaborative integration in the implementation of Industry 4.0. In this context, the Open Communications Platform Unified Architecture (OPC UA) standard plays a crucial role by enabling the development of heterogeneous systems and facilitating the fluid exchange of data between devices. To take full advantage of OPC UA capabilities, it is necessary to unlock other application services, such as cloud computing, allowing for greater flexibility and efficiency in data management [10].

The integration of OWL reasoners into frameworks containing probabilistic reasoners written in Prolog, such as TRILL, to manage the non-determinism of tableau methods implemented by Semantic Web reasoners. Furthermore, the importance of semantic annotations of processes to enable interoperability is highlighted, citing works that show how digital transformation plays a strategic role in simplifying relationships with citizens and businesses, and in growing the community and the economy. The need to redesign processes or create new ones to ensure that

a public service responds to the specific needs of different citizens is mentioned using a semantic approach to BPMN annotation with domain ontologies. The paper also reviews several works that combine OWL ontologies with more powerful logic languages such as FOL, and presents recent methods that use Prolog directly within OWL reasoners. An example is the extension of the Nova Hybrid Reasoner (NoHR) that answers queries about hybrid theories composed of an OWL ontology. In addition, OWL-S, an OWL ontology for the description of Semantic Web Services, is described, which allows the declarative specification of the semantics of web services described syntactically with WSDL. OWL-S describes web services from three points of view: the service profile, the service model and the service ontology, thus facilitating the discovery, use and composition of web services [11].

An innovative architecture for a Home Energy Management System (HEMS) is presented, which aims to improve energy efficiency and reduce environmental impact. The proposed architecture includes a combination of flexible hardware and open middleware, allowing the implementation of new energy-efficient policies and strategies. Furthermore, proofs of concept have been performed to validate the integrity of the system and its ability to adapt to future trends and technological evolutions [12].

In comparing the use of CDA R2 and FHIR standards in electronic medical record exchange in Taiwan, CDA R2, defined in 2005, is based on the XML format and is used for clinical document retrieval between institutions. However, this standard has limitations, as it only supports clinical document exchange and requires packaging all data into a single XML file, which can be a slow and cumbersome process. On the other hand, FHIR offers greater flexibility and compatibility with modern web technologies, using formats such as XML, JSON, and Turtle. FHIR allows medical records to be divided into multiple resources, making it easier to select and access specific data. In addition, FHIR supports mobile devices and resource-constrained systems, and its implementation and testing are more accessible and faster thanks to its RESTful API and the availability of test servers [13].

The need to standardize the structure and content of electronic health records (EHRs) to facilitate information exchange between medical institutions. Existing standards such as openEHR, HL7, and CEN TC251 EN 13606 are mentioned, which seek to achieve data independence and semantic interoperability. These standards use archetype-based technology to define clinical knowledge, and the study examines suitable formalisms to describe, represent, and reason about these archetypes. Furthermore, the paper highlights the importance of Semantic Web technologies in managing clinical knowledge related to EHRs. The use of platforms such as ResearchEHR is mentioned to practically apply these standards. Although it is acknowledged that information exchange is limited to specific partners, it is suggested that future research could explore intelligent and semi-built knowledge graph frameworks in the context of e-health, addressing issues such as data insufficiency, explainability, and inconsistencies [14].

In related work, the application of an Ocean Digital Twin aims to monitor environmental conditions, such as water quality and biological events. Using a combination of fixed and mobile sensors, including autonomous underwater vehicles (AUVs), the aim is to integrate and analyse data in real time to provide useful information to researchers, policy makers and industry. The implementation of a medallion data model allows the transition of raw data to formats optimised for analysis, facilitating interoperability and access through standardised APIs [15].

We found works related to the modular use of hardware in heterogeneous environments. Most of the components of this solution were developed using the ROS framework, known for its wide range of drivers, algorithms, libraries and useful features such as APIs for parameters. The architecture of the solution defines a clear division of areas within the ROS domain of the gateway, which is essential to define the purpose of each component and promote reuse. The analysis of the current literature reveals a notable absence of relevant information, especially regarding hardware modularity in robots. The only comparison found in other articles concerns the physical adaptability of the robot to its mission, rather than managing the required payloads on demand. This makes the proposed solution a promising representation of possible improvements in the field of robotics that can be solved based on interoperability between the different APIs [16].

In organizing design patterns for privacy, we present a taxonomy of pattern types that can be used to create robust and versatile systems. Patterns such as Device Gateway and Edge Computing are highlighted, which improve the effectiveness of data acquisition and local processing, respectively. In addition, the dependencies and interactions between these patterns are explored, providing a comprehensive mapping that is essential for architects and designers in applying pattern languages to real-world scenarios, which enables the use of different interoperability techniques [17].

We find work related to efficient communication between WebAssembly modules (WASM) by implementing a new interface description language (IDL) and its own communication protocol, known as Karmem. This approach seeks to improve efficiency and interoperability in distributed applications built on top of WASM, allowing effective communication between modules written in different languages. The paper details the development of Karmem, its features, and the tests performed to assess its ability to address the challenges related to efficiency and interoperability in data communication [18].

We found papers presenting an innovative methodology for the development of a hybrid machine tool system that integrates machining and surface heat treatment processes. In situ experiments and techniques such as optical microscopy, mechanical and X-ray methods were used to determine residual stresses, as well as a profilometer to measure shape deviations and surface roughness. The results indicate that the implementation of this system can increase productivity by 1.9 times and eliminate the possibility of waste during finishing [19].

In the blockchain-based framework for electronic health records (EHR) management, highlighting its ability to improve security, efficiency, and interoperability in handling patient data. It focuses on overcoming the limitations of centralized systems, such as the risk of a single point of failure, by using smart contracts and distributed storage through IPFS. In addition, a cost analysis is performed to assess the economic viability of the proposed framework [20].

Among the growing challenges in urban mobility management as urban populations increase, an AI-based Decision Support System (DSSU) is proposed that enables planners and policy makers to assess and prioritize urban mobility modifications using city-specific multi-criteria criteria. Through case studies in Helsinki, Amsterdam, Messina and Bilbao, the transformative potential of the recommendation engine to improve mobility policies and foster more livable and resilient urban environments is demonstrated, with a smart city approach, allowing the exploitation of different architectures based on interoperability [21].

We found works presenting the LAAFFI protocol, designed for the authentication and authorization of IoT devices in federated environments, such as those involving civil and military organizations. The design requirements, formal security validation, and the resilience of the protocol against various attacks are discussed. In addition, a prototype is implemented to evaluate performance metrics such as latency and throughput in terms of operations per second [22].

The problem is related to the poor connectivity in the Peruvian jungle areas, which is why computer systems have difficulty saving and updating data in their databases, causing the data to not be updated. The National Commission for Development and Life without Drugs (DEVIDA) is a public entity, attached to the sector of the Presidency of the Council of Ministers, responsible for guiding the national policy against drugs to the year 2030 and becoming the national counterpart of all international funding destined for the fight against drugs. Currently, it has its headquarters in a district of the Peruvian Amazon jungle.

This problem is solved in the present work, through the implementation of a procedure based on XML messaging, which allows to always have updated information, so when an attempt is made to perform an information registration process, and the lack of connectivity is detected, the system collects all the information to be sent, packages it in an XML file and sends it by alternate means, in order to solve the problem and always have access to the information.

2. Methodology

We begin the description of the methodology with the analysis of the functional requirements that we present below:

2.1. Target population

The web system is aimed at solving the problem of intermittent connectivity and access to the Internet, in web systems that require real-time information on the different financing requests made by executing entities belonging to the districts located in the departments that are in the areas located in the Peruvian Amazon. In this way, the efforts of the activity are directed towards solving the problem of illicit crops that are part of the drug trafficking value chain, through the availability of real-time information.

2.2. Description of the development methodology

The description of the proposal is based on being able to explain the technological tools used for the development of the web system, considering the development mode, the configuration of the web system, the messaging services and the working mode of the interoperability function, which allows the information to always be available in real time.

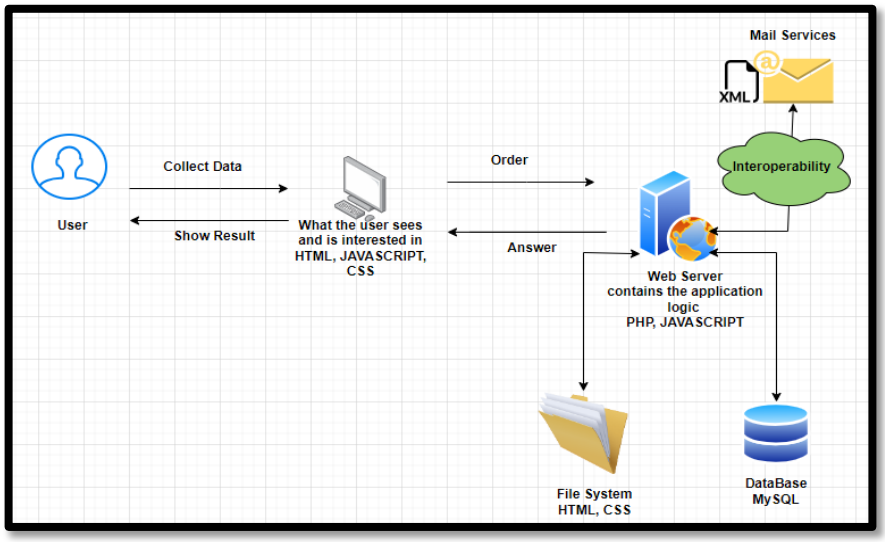

Figure 1: Description of the architecture of the development proposal.

Figure 1 shows the architecture of the system, based on the flow of information between the server and the user for the storage of the database with the characteristic of interoperability, based on the exchange of XML messages.

The development of the web application for the eligibility of activities in the investment area of DEVIDA, based in the city of Pichari, was carried out using standard web technologies, such as HTML, CSS, JavaScript, PHP, and additional frameworks or libraries as needed. Finally, extensive testing was carried out to verify the correct functioning of the web application, as well as to ensure its quality and usability. Next, we are going to present the screenshots of the web application development process, according to the following detail:

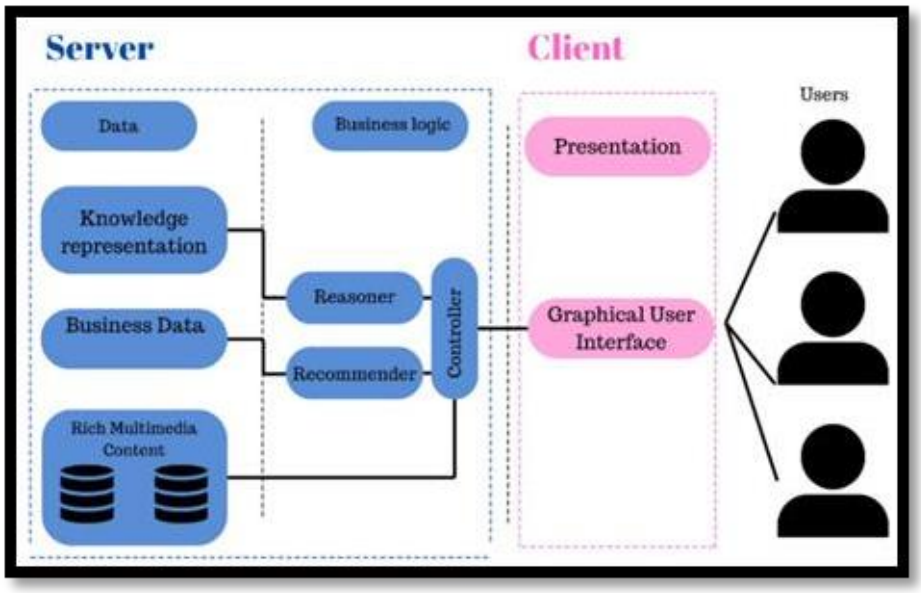

Figure 2: Connectivity diagram.

Figure 2 presents the connectivity model between the different components where the model is verified from the server and client views. In the server view, the presence of the database, the business model and the information containers, as well as the business model, can be seen. For the client view, the presentation mode can be seen, which is based on the representation of the GUI, which is the graphical user interface that is the means of communication between the different users and the system.

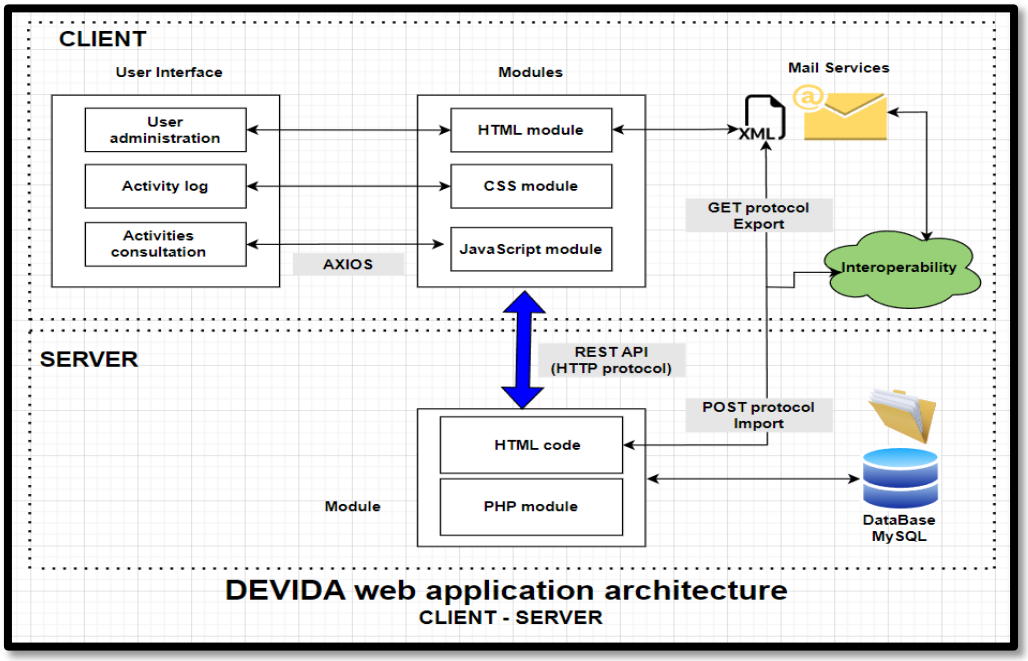

Figure 3: Connectivity tools.

Figure 3 shows the development of the web application. It was carried out using the client-server architecture, supported by the Laravel VueJS Stack, which provides the necessary and easy-to-use tools for the construction of both the client side (Front end) and the server side and the database (Back end).

On the server side, we have worked with the PHP programming language, guided by its Laravel framework, with the intention of taking advantage of the security tools, speed in the execution of tasks and the working mode that is very orderly and sequential.
On the client side, we have worked with the HTML tag language, CSS cascading style sheets and JavaScript accompanied by its VueJS framework, in order to give greater dynamism to its components and show an elegant style.

MySQL has been used for database management, because there are currently more servers that support MySQL and it is better suited to systems developed with the PHP language. In the communication between the Back end and the Front end, a REST Application Programming Interface (API) (with HTTP protocol) has been used, which was developed in the Front end and the queries are made from JavaScript using Axios, which is a very necessary library to make operations easier.

We adapted the Extensible Markup Language (XML) in the development of the system, with the intention of exchanging data in rural areas where there is no internet connectivity. Thus, we stored a button in the Front end, which has the function of making a Get request to the Back end, sending the ID of the activity that we want to export, then the Back end receives the ID through said Get protocol, to extract all the information of the selected activity that is in the Database, to be exported in XML format. Likewise, to import an activity, a file-type button was inserted, which allows uploading an XML file, using the POST protocol that carries all the information of said activity, proceeding to structure an HTML that can be understood by the Back end and store it in our Database, without any inconvenience.

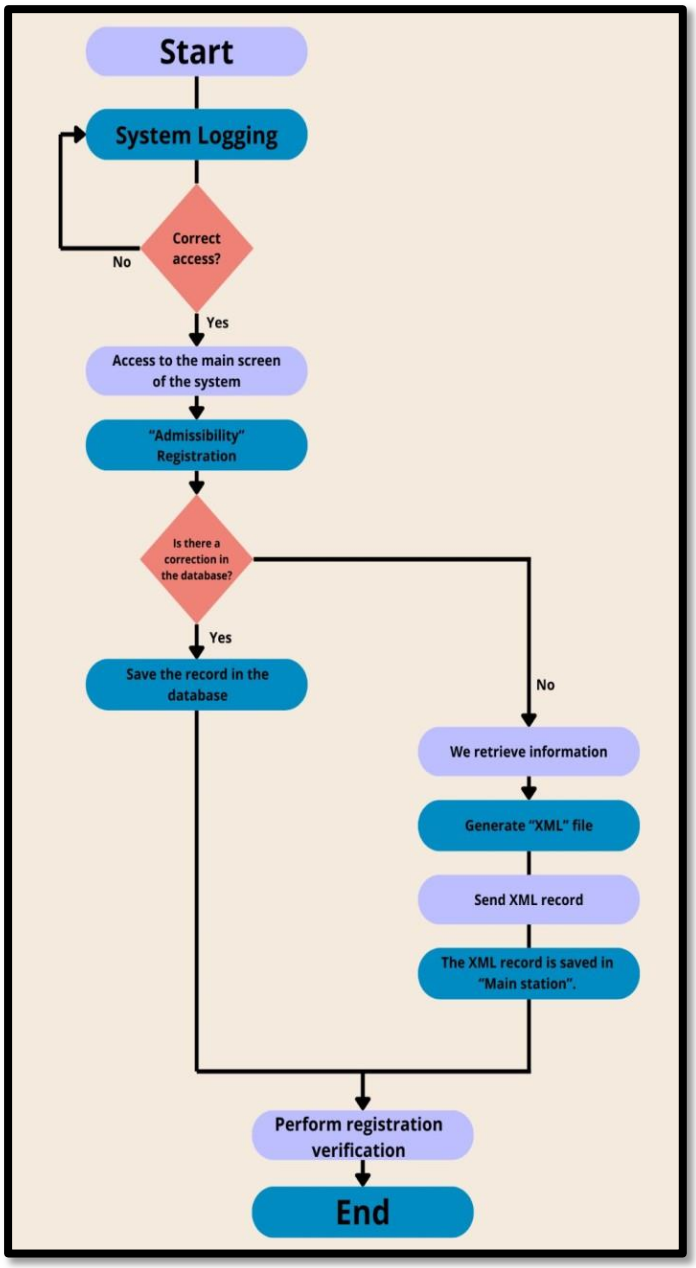

Figure 4: Flowchart of the we system.

In Figure 4, the flow chart of the interoperability solution is presented, where there are two control points, the first related to access to the system, which limits access to the system, the second is related to the functionality of the system in order to decide whether to send the information through the system itself when connectivity is present, and when connectivity is not present, the XML message is created to be able to send it through alternate means.

Figure 5: Pseudocode of the we system.

In figure 5, the pseudocode corresponding to the flow chart is presented, where we describe the processes and functionalities so that they can be implemented at the time of programming, the two decision factors are considered, the access to the system and the functionality of sending information through XML messaging.

3. Results

The results we present are dedicated to presenting the mode of use of the implemented web system, with the functionalities of interoperability through the use of XML messaging.

Figure 6: Main screen of the web system.

Figure 6 shows the main screen of the developed web system, where the main processes are displayed. It is an essential requirement to have a username and password to access the system.

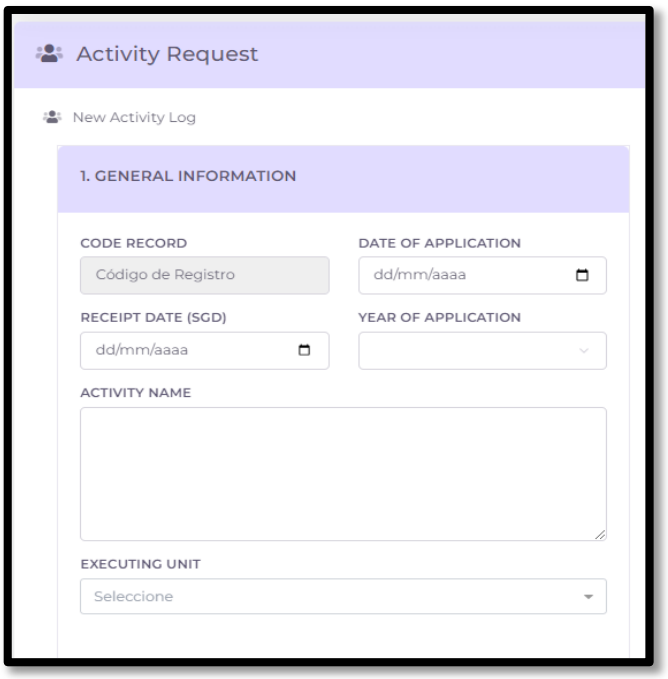

Figure 7: Main screen of the activity request.

In Figure 7, we present the screen where a request for an activity is made, where the main data, typology and location are shown. This information is important, as it is a requirement to have the information of the place where the registration is made and the registration date, in order to have relevant information for decision-making.

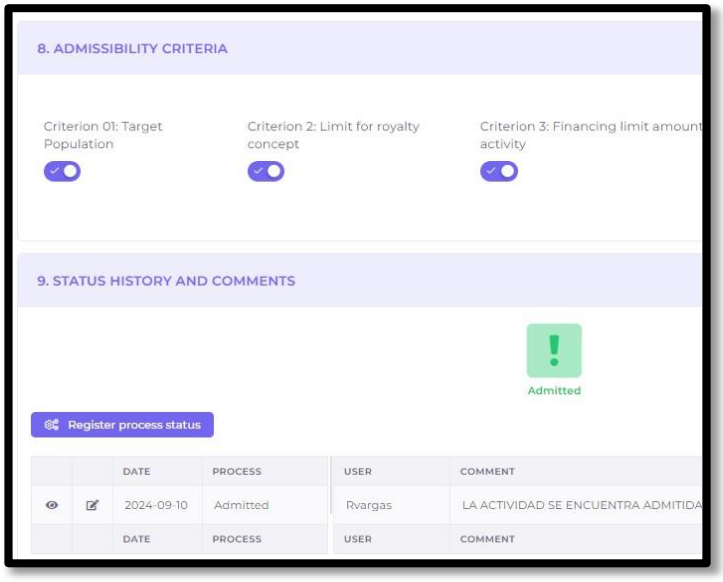

Figure 8: Record of the processes.

Figure 8 presents the eligibility criteria, which is the starting point for having a record. The form allows the selection of a criterion, it also allows the status of the record to be shown and the report of the records made.

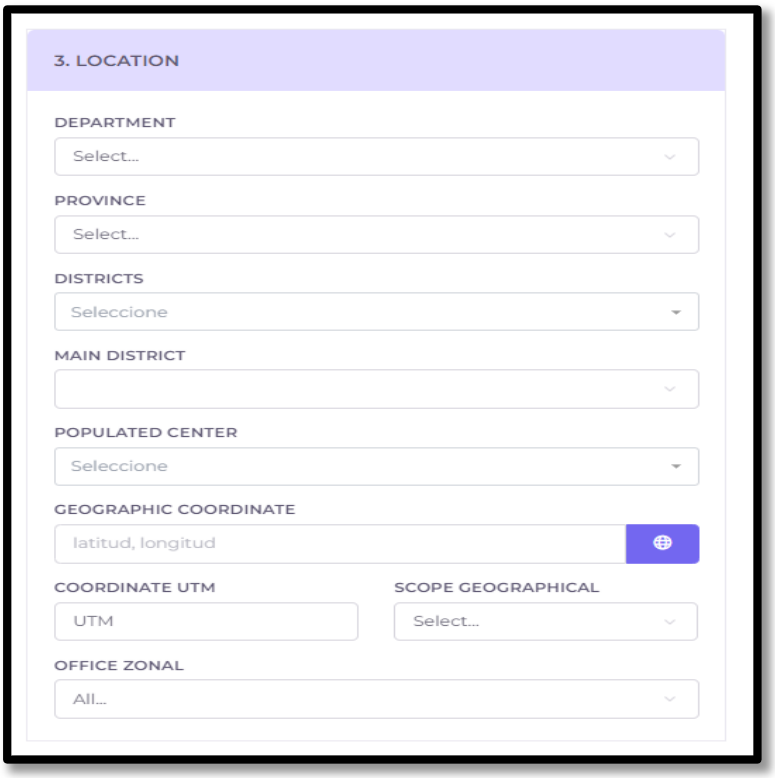

Figure 9: Location record.

Figure 9 shows the form for registering the location. This information is important to know where in the Amazon rainforest the registration is being carried out.

Figure 10: Record of the processes.

Figure 10 shows the completion of entering information for a complete record. It shows that the information is in the database, so it can be accessed from anywhere as long as there is connectivity and access to the system.

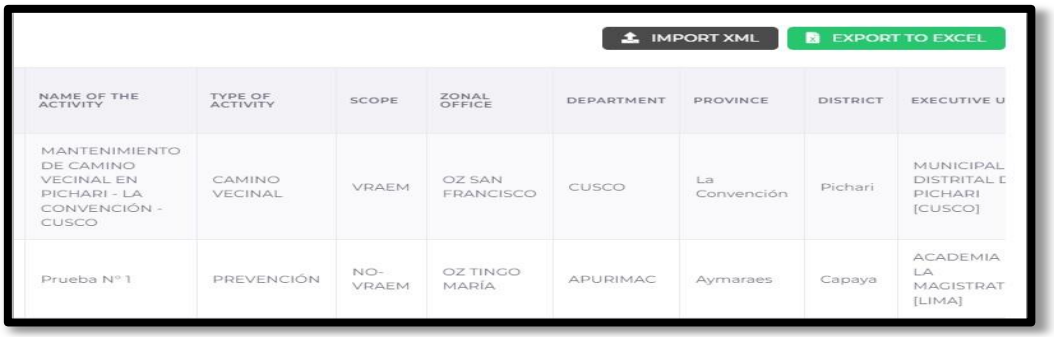

Figure 11: Interoperability option.

Figure 11 presents the interoperability option. This option is used when it is not possible to save directly in the database. With the option of exporting via XML file, we can send the information via alternative means, in order to update the system.

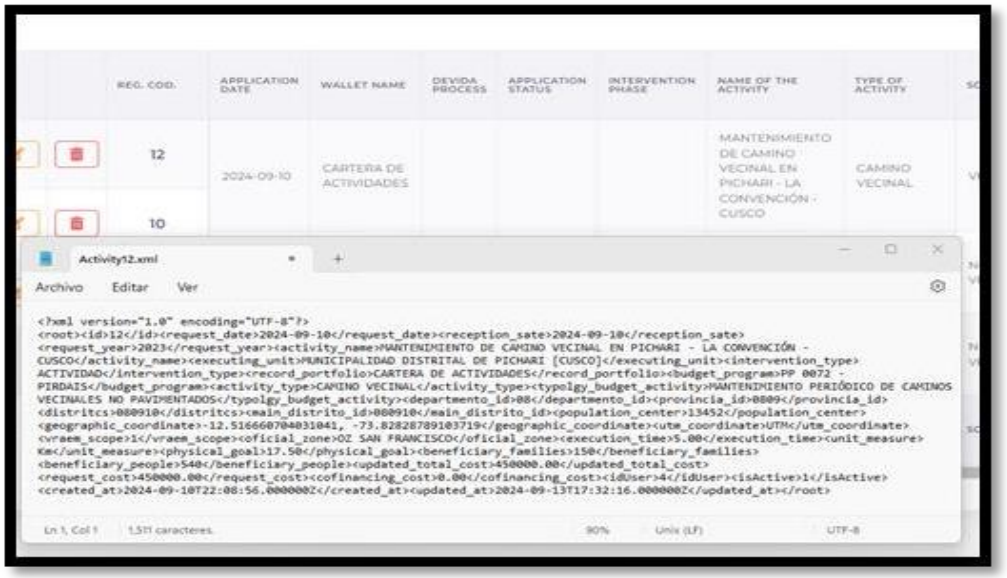

Figure 12: XML file.

Figure 12 shows the XML file containing the record information to be exported and sent via alternate means for inclusion in the system.

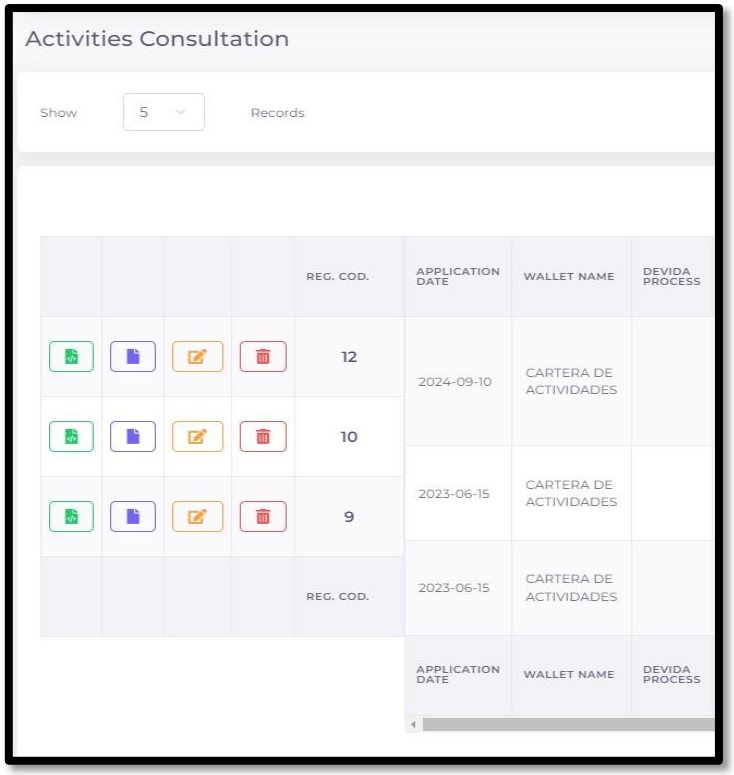

Figure 13: Search for records.

Figure 13 shows the details of the information search, after having updated the exported files through XML messages. With the update of the files, the records can be accessed from any location that has connectivity with the system.

4. Discussions

The discussions we present are related to the analysis of the use and exploitation of the system. In the tests carried out, it was possible to demonstrate that the interoperability functionality eliminates downtime in the search processes, due to the lack of connectivity in the registration process.

By exporting the information of each record in an XML file, the system can be updated. The alternate means described can be email, shared files, file exchange platforms, among others,

using mobile or alternate connectivity. By carrying out the analysis from the central office, it can be demonstrated that the information is always available, which optimizes the search and analysis process of the activities carried out in the Peruvian Amazon rainforest, so that decisions can be made from the highest levels of government.

Regarding the performance of the system, it is observed that it works according to the design, with which the system works on the available computers without delays, because it has a local database, which improves the performance in search time mainly in local records, functioning as a decentralized database.

5. Conclusions

The conclusions we reached at the end of the investigation are determined to be able to demonstrate the use of interoperability between systems, based on the use of XML messages, which allows communication between systems that are in different physical locations. It was shown that alternative solutions can be considered in the absence of connectivity. In a normal situation, one has to wait for a connection to be available to update the records. These downtimes can cause a failure in decision making, affecting the tasks related to the control of coca leaf crops in the Peruvian jungle.

We recommend replicating the proposed methodology for situations where communication between different systems is required, using the different interoperability techniques. Many alternatives are available, including commercial solutions, libraries, and even proprietary solutions based on the XML language. Using a communication protocol at the time of writing and reading the files, we can achieve communication between different systems.

In the process of developing the user interface of the web application, moderate usability tests were carried out remotely, in which together with the users we found small details in the creation of new users (functions and roles), chronological disorder in the list of activities when queries were made and inconveniences in rural areas, where there are low levels of internet connectivity. These findings allowed us to better adapt the code by simulating the real process carried out in the investment area of DEVIDA, then two buttons were implemented to import and export activities through the extensible markup language (XML), in order to always have updated information on the files that are subject to constant evaluation by the area in charge of DEVIDA. With the latest version of the web application, users showed comfort in handling the system, who indicated that the activities they carried out physically, they can now do digitally, in an automated way, having the files to be evaluated at any time, which allowed them to spend less time in the admissibility of activities. This technological implementation also contributed significantly to the productivity of the company DEVIDA, being the beginning of an appropriate escalation to achieve effectiveness in the work of the DEVIDA staff based in Pichari.

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