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Mobile application for geolocation of healthcare, Evaluation of your performance efficiency

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Summary

The Internet is a fundamental tool for the search for information, even being useful for daily activities; However, finding the desired information may take longer than expected. An

example of this drawback is presented in the search for places of medical care in the city of Riobamba (Ecuador), mainly because several web pages must be accessed to find the data of interest. This article deals with the development of a mobile application called GEOLAM using the geolocation technique, which allows the search for information on public and private health care places in the city of Riobamba. In the development of the mobile application, the Scrumban methodology was used with the Model-View-Controller design pattern. The Java programming language was used for the coding of the mobile application, as well as the MySQL database manager and REST web services. The evaluation of the quality of the software was carried out by measuring the characteristic "performance efficiency", through the subcharacteristics: behavior over time and use of resources, based on ISO/IEC 25010. The resulting averages were interpreted based on the evaluation indicators, obtaining a performance efficiency of 87.38%, a value that represents "very good performance efficiency".

Keywords

Mobile application, geolocation, GPS, geolocation, healthcare, ISO/IEC 25010, scrumban.

1. Introduction

Currently, mobile devices have become a very important tool for people, since they have applications that facilitate many activities in different areas of daily life, optimizing resources, such as time and economic expenses. Society in general has witnessed the benefits of mobile application development, because they allow access to various services, obtain location through geolocation, be aware of what happens worldwide, maintain timely communication, among others, depending on the purpose for which they were developed (Román, 2017).

While it is true, the search for useful information to fulfill daily activities is easier to perform through the use of the internet; however, having to locate and review information scattered across multiple sites entails the use of a greater amount of time and other resources to find the expected results (Barba et al., 2018). For example, this problem arises when looking for places of medical care in the city of Riobamba (Ecuador), people who need the location and details about a health facility, must access one or more web pages to find relevant data and in some cases the sources are not official.

According to the publication of the Agency for Quality Assurance of Health Services and Prepaid Medicine (ACESS, 2022), in Ecuador there are 25590 health establishments of first, second and third level of care; which are divided by typologies, such as: general and specialized offices, health posts, health centers (type A, B and C), outpatient (level 2 and 3), hospital (level 2 and 3), among others. There are also facilities providing direct and indirect support services, mobile care services and home health care services. With regard to the city of Riobamba, 678 private and 43 public health facilities with a valid operating permit are private; of which, those that have the greatest population coverage and that are not within other

establishments, such as clinics, are of interest for work. Hence, the establishments of interest are: General hospitals, basic hospitals, specialized hospitals, type B health centers and type C health centers.

Therefore, the objective of this work is the development of an efficient mobile application using the geolocation technique for devices with Android operating system called GEOLAM, which allows searches on the places of medical care in the city of Riobamba, avoiding that people spend a lot of time in the search and allowing the information of the places to be adequate. An analysis of the characteristics of geolocation allowed to define GPS geolocation as the appropriate technique for the project, in addition information was collected from official websites, media and physical places. For the development of the application, the Scrumban methodology, the MVC design pattern, the MySQL database manager, REST web services and the Java programming language were used. Finally, ISO/IEC 25010 was used to measure performance efficiency.

The article is organized as follows: The literature review is provided in section 2, and the development methodology in section 3. Materials and methods are described in section 4. The results and discussion are discussed in section 5. Finally, the conclusions of the study are presented in section 6.

2. Literature Review

Mobile App

Mobile applications according to Puetate et al. (2020), play a fundamental role since the insertion of smart devices in our society, since they are frequently used to facilitate communication and execution of various tasks. They also provide a computer solution, since it is possible to automate processes that can be difficult such as managing a warehouse (Gargate, 2019).

Geolocation

Geolocation according to Beltran (2015), is a technology whose purpose is to locate an object in space and is measured in coordinates of latitude, longitude and height. In addition, Palma et al. (2020) argue that geolocation allows establishing the geographical position through the use of a device that has a correct synchronization between software and hardware.

According to Polanco and Cuenca (2021), there are three types of geolocation: GSM, GPS and WPS. Each type is distinguished by the medium in which the real-time location can be obtained. Likewise, Gutierres et al. (2021) agree with the three types of geolocation and add that depending on the field of application and the scope that you want to generate with the development of a specific project, it will depend on the type of geolocation that is required to be used, because, although the objective is the same, to provide the exact location and in real time, There are also important factors such as accuracy, speed, resources or environment, so it is necessary to analyze the situation and choose the type of geolocation appropriate to the

requirements. According to the literature review, Table 1 summarizes the characteristics identified for the types of geolocation: GSM, GPS and WPS.

Currently, most mobile devices have GPS so geolocation applications consider it as the first option required when it comes to prioritizing accuracy and it is important that the sky is clear so that the device does not have any problem receiving the signal from satellites (Cornejo, 2021).

Table 1 Characteristics of geolocation types.

Type of geolocation	**Characteristics**		
GPS Global Positioning System	Location-based satellite so it is possible to obtain a global position in real time. To get the location you Calculate the time of response you get as a result of the connection of at least four satellites.Commercial devices who most use this technology today are mobile devices,Because, companies developers integrate almost all products the GPS system (Arciniegas,2020).	It has three components: Satellites in orbit, ground stations tracking, control, receivers GPS.The services of emergency and relief depend on GPS for Save lives. There is no limit on the number of simultaneous users.Recipients provide by separated the data,such as: latitude,longitude and altitude, also local time (GPS.GOV, 2022).	It is necessary to longitude and latitude to get the location.Latitude is representation in Position grades North-South and the longitude in degrees of the East-West position (Quintero et al., 2015).
GSM Global System For Mobile Comunication	It is a standard referring to digital mobile technology. It belongs to the second generation for the transmission speed with which Works. Use SIM cards to locate an object (Gutierres et al., 2021).	The approach to cell towers influences the location of a device.The time it takes for the signal to arrive from the tower is calculated to the exact point (Cortés et al. 2019).	Signal strength received is also an indicator to be able to determine a location (Castro et al., 2019).
WPS Wifi Protected Setup	The location of a device is obtained thanks to the IP address of the router.The accuracy will depend on the distance between the wireless network and the device (Perez, 2010).	Is network-based wireless of the surroundings.It is used when GPS does not work due to a blockage of signal (Well, 2018).	Because the device connects to an Internet network, this emits a signal that identifies it, thanks to this you can obtain the Location by your IP.It has a margin of error, since the location is not exact (Molina, 2020).

Scrumban Development Methodology

The Scrumban agile development methodology combines the most relevant and important aspects of other agile methodologies such as Scrum and Kanban, where the schedules that are executed in the short and medium term are managed through Scrum, while urgent tasks or modifications are developed naturally based on Kanban throughout the process. The agile approach was designed for small teams, with reduced deadlines, volatile requirements, new technologies and for small or medium-sized projects (Sepúlveda, 2016).

The process that is carried out with the agile Scrumban methodology is shown in Figure 1. This process begins with the list of customer demands, thus defining the requirements of the product to be developed. Then, in the user queue or backlog the tasks of the team are planned, user stories can be made according to the previously raised requirements. Then, short-term sprints ensure that developers easily adapt to making changes if needed. Once all the planned springs have been successfully completed, the product deployment proceeds. Finally, in the closure phase, all tasks planned and successfully deployed are marked as "done" (Guzmán et al., 2014).

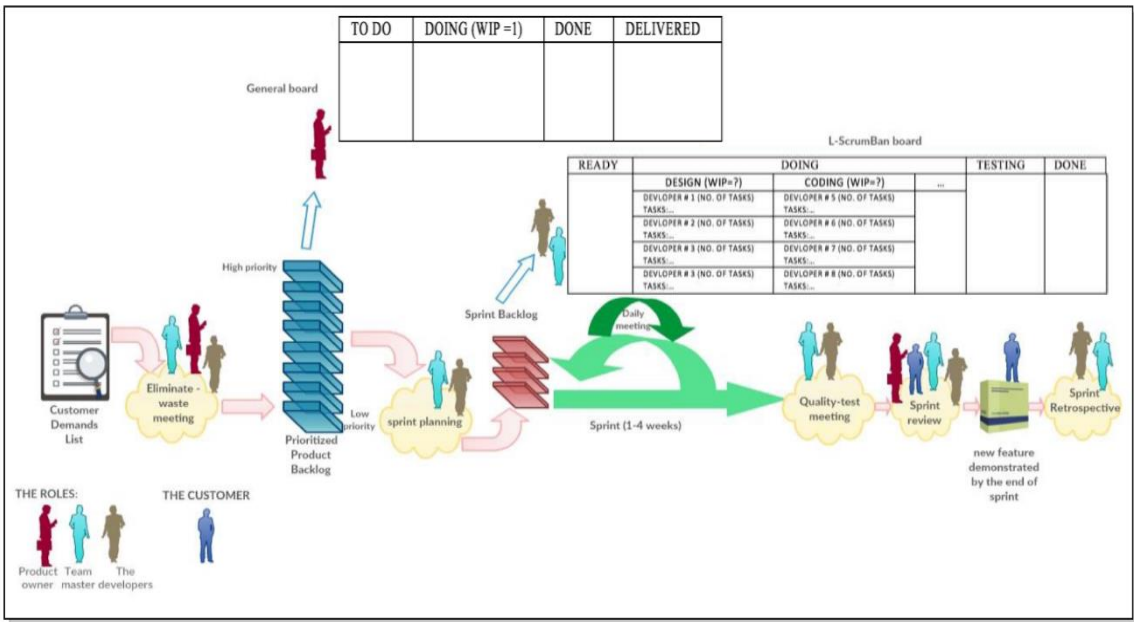

Figure 1 Scrumban Process (Albarqi & Qureshi, 2018).

Development Tools

In software development it is essential to have tools that facilitate, improve and optimize performance in each of the phases of the project to be built. The functionalities, features and solutions provided by each one is applicable in tasks from the simplest to the most complex and a correct choice can improve time management by up to 38%, being a model to follow in the software development industry keeping the workflow in a simpler way (Villavicencio et al., 2018). The technological tools used for the development of the mobile application are described below.

Android Studio

Android Studio is the official Integrated Development Environment (IDE) for developing

applications of mobile devices that have Android operating system and is based on IntelliJ IDEA. In addition, it has a powerful code editor and IntelliJ tools that offer different features to increase productivity when developing applications (Developers, 2022).

MySQL Database Manager

The MySQL relational database manager is a free, open source server, with good performance and very easy to use, since it is extended in web servers, it is multithreaded and multiuser, so the development of projects in MySQL means that there will always be a place where the data to be used can be stored. It allows you to interact with the most used languages such as PHP, Java and Perl. In addition, it can be integrated into different operating systems (Vegh, 2010).

MVC Model-View-Controller Design Pattern

The MVC design pattern establishes a formal method for dividing the communication management modules with the database, business logic, and user interfaces; In addition, it establishes the form of communication between these modules with well-defined functionalities. It is based on the concept of code reuse and concepts to later make it simpler to manage tasks in the development and construction of software applications, added to it simpler and more focused maintenance activities to save resources (Gonzales, 2020).

Web service

A web service is defined as software that supports the interaction between several systems in the network, usually web services are APIs (Application Programming Interfaces) that can be consumed by software products and are accessible through the internet because they are usually hosted on servers. The behavior of web services can be summarized as the exchange of messages by two machines, that is, the sending of information between a client and the server, which, in turn, is very useful when it is required to exchange information and has applications coded in different programming languages and platforms (Arsaute et al., 2018).

Servicio web REST (Representational State Transfer)

Offering software in the form of web services has gained immense popularity due to the evolution of cloud architectures. REpresentational State Transfer (REST) comprises a set of rules and practices that provide simple and comprehensible APIs, clear representational structures, and scalable services for use in web services engineering. Due to its simplicity

and scalability, the REST architecture has become increasingly popular among web-service developers (Deljouyi & Ramsin, 2022).

Norma ISO/IEC 25010

The ISO/IEC 25010 standard is part of the ISO/IEC 25000 family of standards called SQuaRE (System and Software Quality Requirements and Evaluation) and aims to create a common framework to evaluate the quality of a software product, has five divisions, including ISO/IEC 25010 used for the internal quality model, external and software product use (ISO/IEC 25000, 2005).

The ISO/IEC 25010 standard presents the quality model that is made up of 8 characteristics, which are: Functional Adequacy, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability and Portability. In turn, each of these has its own subcharacteristics (ISO/IEC 25010, 2011). This article focuses on the performance efficiency feature.

Performance Efficiency

According to ISO/IEC 25010 (2011), performance efficiency is a feature of great value in the software field because the fact of obtaining a correct answer in the shortest possible time is synonymous with product quality and customer satisfaction, in order to measure it, response and processing times must be taken into account. Software parameters, performance rates and the types of resources used.

The efficiency of the performance established in the ISO/IEC 25010 standard is defined as the efficiency in relation to the cost of the resources used under stable conditions, in this way it contemplates the subcharacteristics: the performance of the product according to its behavior over time, the use of resources and the maximum operating capacity it can have. Table 2 details the metrics corresponding to the subcharacteristics of performance efficiency; for this article we have considered evaluating the subcharacteristic Behavior over time, with the metric Response time, and the subcharacteristic Resource utilization with the metrics Memory utilization and CPU utilization.

Table 2 Subcharacteristics and metrics of performance efficiency.

Subcaracterística		**Metric**
Behavior over time		Response time
		Timeout
		Yield
Resource utilization		CPU utilization
		Memory utilization
		Using input and output (I/O) devices
Capacity		Number of online petitions
		Number of simultaneous accesses
		Bandwidth transmission systems
Source**:** (Llamuca Quinaloa et al., 2021)		

Related Works

In the research developed by Lara et al., (2021), the development of a mobile application for Android is evidenced that allows you to search for medical professionals who are close to the location of the mobile device in real time to reduce the search time and, in addition, shows information, such as: consultation price, specialty, comments, among others. For this, Firebase technologies were used, the Google Maps API in Angular 9 managed by the Ionic 4 framework, they mention that the technologies were the best options, since, they were easy to learn, had extensive documentation and a multitude of components.

Sánchez (2017) developed a mobile application for georeferencing and searching pharmacies in Ecuador, for iOS and Android operating systems. The App provides basic information: address, telephone and the shift of each pharmacy, in addition, it shows the pharmacies that are 10 km from the user's location. For the construction of the application, the Mobile-D agile methodology was used, which allows us to focus more on the development of applications, this thanks to the fact that not too much documentation is required. Among the tools that were used are Google services related to geolocation.

The research developed by Molina et al., (2021) presents as its main objective the study of the extraction of relevant data from each framework, performing an analysis of the development methodology for the construction of mobile applications, a study that considers parameters such as phases, scale, team size and roles, for which, among the methodologies that stand out the most are: Scrum, Kanban and Scrumban, concluding that both Scrum and Scrumban meet the most remarkable characteristics for the development of this type of applications. Finally, since during the process the client keeps giving feedback to the development team, an improvement in satisfaction is obtained on their part.

3. Development Methodology

The development process of the GEOLAM mobile application is based on the agile Scrumban methodology with the Model-View-Controller architectural pattern, therefore, each of the phases are exposed in this section.

To.Preliminary analysis

The software requirements were defined through a survey that was carried out through a non-probabilistic convenience sampling of 77 volunteers from the city of Riobamba, 32 functional requirements were defined. In addition, the availability of software and hardware was determined through the feasibility study establishing that the implementation of the GEOLAM mobile application is viable. To determine the feasibility of the project, the estimation of projects was applied by the function points method, obtaining 1568 Hours / Man.

B.Planning

The Product Backlog shown in Table 3, was elaborated by prioritizing the characteristics to be developed, which are represented by User Stories (HU), in total 18 characteristics were identified that were distributed for 14 weeks that were estimated by means of the function points technique. The development ended in week 12 with a total of 5 sprints.

Tabla 3 Product Backlog.

ID	Description	Priority
HU-1	Registration of health care locations	Loud
HU-2	Typology registration	Casualty
HU-3	Registration of specialties	Media
HU-4	Registration of doctors	Casualty
HU-5	User Registration	Loud
HU-6	Login	Loud
HU-7	Geolocation	Loud
HU-8	Updating Health Care Locations	Loud
HU-9	Elimination of health care locations	Media
HU-10	List of typologies	Casualty
HU-11	List of specialties	Media
HU-12	List of doctors	Casualty
HU-13	User Management	Loud
HU-14	Information from places of health care	Loud
HU-15	Search	Loud
HU-16	Assignment of specialties	Loud
HU-17	Assignment of physicians	Loud
HU-18	Review management	Casualty

Development

In the Analysis, the tasks planned for each sprint were executed, for which the Scrumban team held frequent meetings and managed the Scrumban Board to confirm that the proposed activities were carried out according to the established schedule.

For the design of the database, the snake case convention was used, while for the coding Camel-Case was used, since the language is Java. As for the development environment, Android Studio has its own coding conventions in certain spaces, for example: the names of the image files cannot have capital letters, the name of the XML file of the interfaces places the word activity and the name of the activity; for this reason, in the required cases the default convention is used.

Figure 2 shows the architecture of the application, the client corresponds to the mobile device, that is, the application. It communicates with the server side using Java, setting an HTTP type request to the REST service. On the other hand, the server

receives the HTTP request and returns the information in JSON format, so the application is able to obtain the necessary information and display it to the user. The server sends HTTP requests from the interface and information is returned in JSON format, where the interface controller must extract the data and display it correctly.

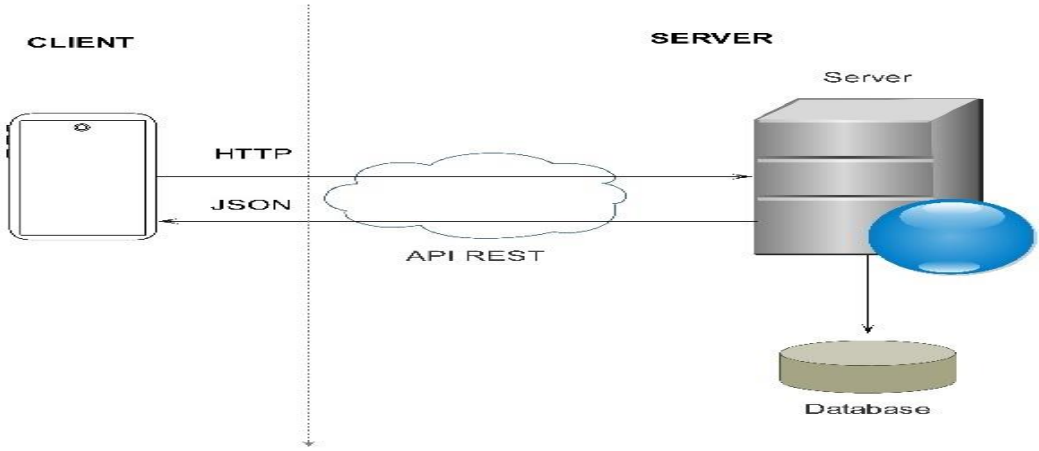

Figure 2 Physical Architecture.

The component diagram (client, server and third-party systems) can be visualized in Figure 3, the file contains 2main components, the Graphical Interface is provided from .xml files and is related to the Model that manages the database and is a java file, fulfills the function of connecting to the REST API and obtains the data that will later be displayed in the interface. On the other hand, in the server components it is visualized how the MVC is developed. The database that is relational type is in MySQL and corresponds to the model and on the other hand the controller is the DB Manager that has a PHP format, which is responsible for communicating with the database and returns the information requested in the server interface in the JSON format. Finally, the interface is responsible for extracting and displaying the data properly. In the third-party system it is observed as components: The Map and the Google Maps API where the first component includes running the Google Maps API to obtain information from the user's location.

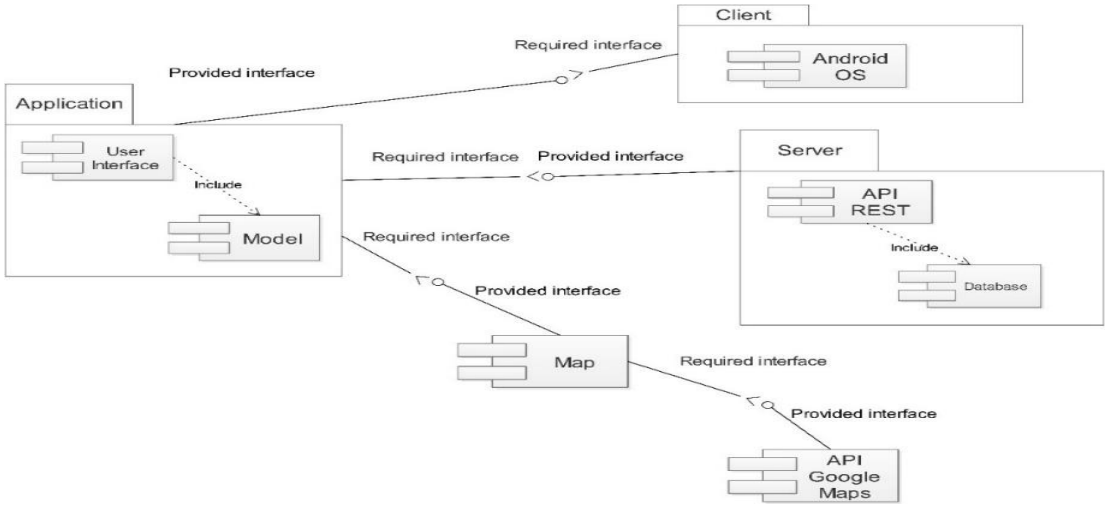

Figure 3 Component Diagram.

The database consists of 13 tables with the necessary attributes for the GEOLAM mobile application, in terms of the design of the user interfaces, all the interfaces of the mobile application were designed with the necessary elements for user navigation, Figure 4 shows the Login Prototype, registration, the main user and administrator interface.

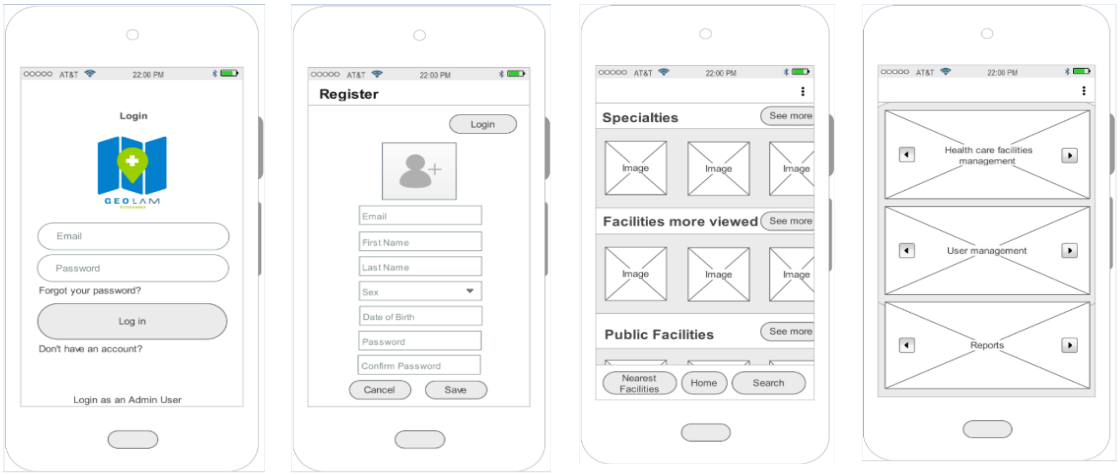

Figure 4 Designing GEOLAM application interfaces.

To code the GEOLAM modules according to the requirements, the Model-View-Controller pattern was used, through the REST APIs the connection of the application with the MySQL database that is hosted on a CPanel server together with the Web Services is made.

Within the application all the classes used are organized by packages, for the part of the Model there is a package with the same name, in which the classes corresponding to data access are located, which connect to the developed web services; the REST APIs coded in the PHP language contain the necessary queries to create, extract, modify and delete the data in the MySQL database. Likewise, there are the classes corresponding to the business logic, with processes for geolocation, distance calculations, validations at the logic level, modules for data management (CRUDs), adapters and data access classes (Getters and Setters).

In the Controller there is another package that contains the classes to connect the views with the classes of the Model, in them the variables are declared with which the different identifiers of the files in XML (views) can be accessed and through objects access all the methods of the classes of the business logic and data access (model), in order to integrate and enable the functionalities with which users can interact and make the respective requests. Similarly, in each of the classes a main method for its execution is declared.

The Views are made in the XML metalanguage and through the integrated environment Android Studio you can view each of the modifications that are made at that moment, in this case, all the files, called activities, are in the layout package, in each file the distribution of the content on the screen is defined, establishing, colors, fonts, styles, themes, images, vectors, icons and the different elements that will allow the user's interaction with the application. In addition, there are packages

with the elements described above, as well as packages where you can implement the different libraries and APIs for the software.

Additionally, there is a package in which the necessary permissions for the application to run are declared, among them, permissions for internet access, requests for the mobile device and the declaration of each of the classes that are required to be displayed. In addition, the token is placed with which the application can integrate and make use of the Google Maps API with which geolocation is accessed, that is, the location of the user's device in real time.

The acceptance tests are executed in order to validate if the developed software meets the proposed performance requirements, to subsequently proceed with the acceptance of the product. To carry out the tests, the acceptance criteria of each of the user stories are taken (Table 3). All the necessary acceptance tests for the validation of GEOLAM were carried out and duly documented.

Figure 5 shows the deployment diagram, where you can visualize the server, mobile device and data center – Google Maps as nodes. The server hosts the application database and the artifact that has the connection configuration with the server, while on the mobile device with Android operating system the geolam.apk device is displayed, which maintains a dependency relationship with the AndroidManifest.xml artifact. In the last node is deployed the Google Maps Server artifact that provides information on the location of health care places. Additionally, the general characteristics of the mobile device are presented so that the apk can be executed.

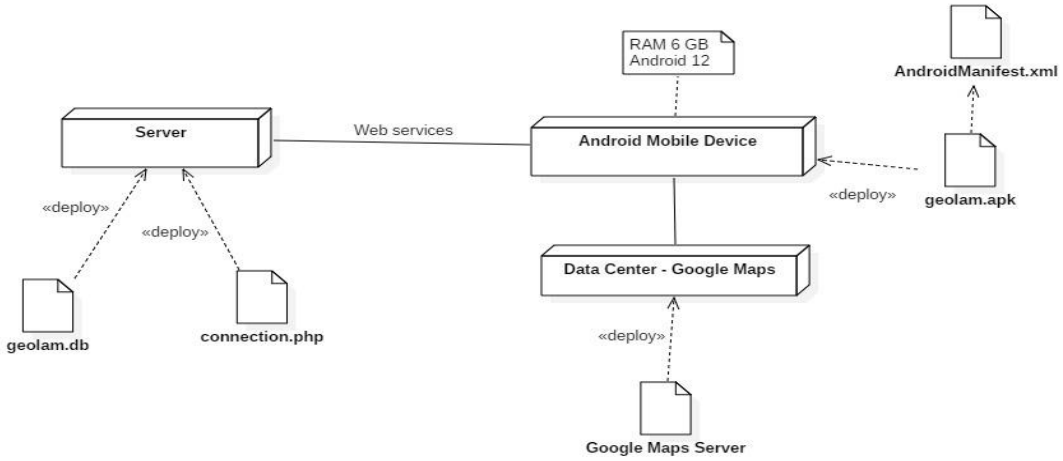

Figure 5 Deployment diagram.

Regarding the management of the project, the Burndown Chart diagram was made, which consists of a graphical representation of the speed of development with which the team advances based on the weeks. It captures the description of a feature from the perspective of the end user and shows the total effort in relation to the amount of work for the estimated time, in order to publicize how the project was progressing and with what speed it was worked, in this way it was possible to organize, plan, evaluate and control factors of the development.

In Figure 6, you can see the BurnDown Chart diagram with points based on the weeks of development, which represent the speed of the project; the blue line indicates the ideal points with which the initial schedule was raised and the orange line represents the actual points with which the development of GEOLAM was carried out.

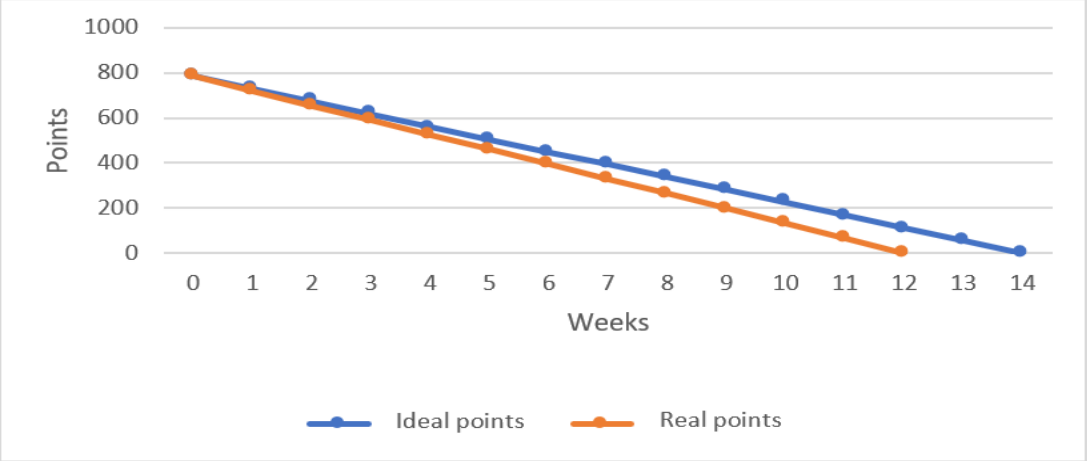

Figure 6 BurnDown Chart.

Figure 7 shows screenshots of the GEOLAM application for Manager Login, User Registration, Startup, and Settings

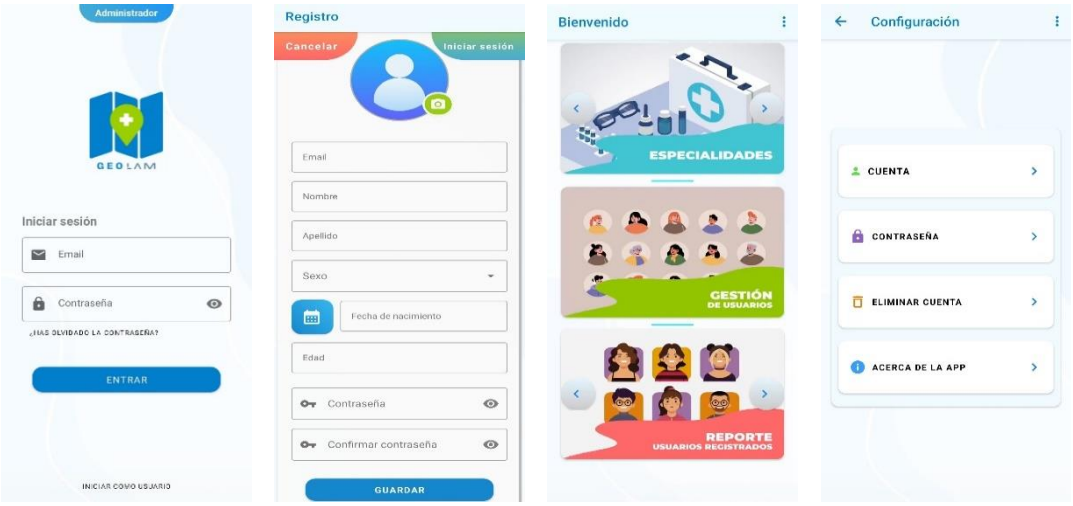

Figure 7 Cscreen aptures. GEOLM application.

4. Materials And Methods

With a non-probability convenience sampling, a survey was conducted among seventy-seven volunteers in the city of Riobamba, in order to select the health facilities that will be registered in the application.

For the evaluation of the performance efficiency characteristic according to ISO/IEC 25010, the Behavior over time subcharacteristic with the response time metric and the resource utilization subcharacteristic with the CPU usage and memory usage metrics were considered.

The interactions that can be performed in each module of the mobile application have been considered as a population for the measurement of the performance efficiency characteristic. The five modules to be considered are: Authentication, User Management, Information Management of Health Care Sites, Geolocation and Search.

Taking into account that the population is infinite, it was contemplated to carry out a stratified sampling, where, the modules of the application are considered as strata and the establishment of the sample size was calculated with the formula of infinite population, obtaining as a result the minimum sample to apply corresponding to 385 interactions.

$$n = \frac{Z_{\alpha}^{2} * (p) * (q)}{e^{2}}$$

$$n = \frac{1.96^{2} * (0.5) * (0.5)}{0.05^{2}} = 384{,}16 \equiv 385$$

Table 4 details the stratification and division of the number of samples made by each module of the application. It is important to emphasize that the samples correspond to the number of requirements associated with the module.

Table 4 Distribution of Samples by Application Modules.

Modules	Functional requirements	Percentage %	Samples
Authentication	1	3,1 %	12
User Management	4	12,5 %	48
Information Management of Healthcare Locations	18	56,3 %	217
Search	6	18,8 %	72
Geolocation	3	9,4 %	36
Total		100 %	385

For the interpretation of the results of the measurements carried out with the response time metric, subcharacteristics of quality behavior over time, the indicators shown in Table 5 proposed by (Khaharsyah, 2019; Wulandari, 2021), where the response time is measured in seconds with a qualitative assessment for each range and a percentage measurement scale, where "t" represents the value obtained on a time scale, and "x" the measurement scale obtained for "t".

Table 5 Response time evaluation indicator.

Response time (t)(seconds)	Measurement scale (x)	Quantitative value
0 – 2.99	75% < x <= 100%	Very satisfactory
3 – 8.99	55% < x <= 75%	Satisfactory
9 – 11.99	40% < x <= 55%	More or less satisfactory
t > 12	x <= 40%	Nothing satisfactory

For the subcharacteristic resource utilization and its metrics memory usage and CPU usage, the evaluation indicators proposed by Gómez et al. (2020) were

applied. In this way, Table 6 presents the interpretation given to the results of the measurements for memory use by means of a scale of rating percentages according to the memory ranges in megabytes established and the qualitative values assigned to each percentage. Also, the table shows the ranges expressed as a percentage for the CPU usage metric.

Table 6 Evaluation indicators for memory usage and CPU usage.

Qualification	Memory usage (MB)	CPU usage (%)	Qualitative value
100%	[0-150]	[0-0.5]	Excellent
90%	[151-250]	[1-1.5]	Very good
75%	[251-350]	[1.6-2.5]	Well
50%	[351-450]	[2.6-3.5]	Acceptable
20%	[451-550]	[3.6-4.5]	Regular
0%	[551 - ∞]	[4.6 - ∞]	A little

The measurements of the subcharacteristics Behavior in time and resource utilization were made with the support of the Apptim tool, which allows to find performance problems, measure the use of device resources and processing times. The respective tests were performed by connecting the USB cable from the cell phone to the computer (Apptim), the whole process is recorded and the data is collected to later obtain a detailed report.

For the evaluation of the performance efficiency characteristic of the GEOLAM mobile application, the measurements according to the metrics of each of the aforementioned subcharacteristics are weighted according to the percentages of Table 7. Then, based on Gómez et al. (2020), the sum of the weighted percentages obtained is qualified according to the indicators in Table 8.

Table 7 Weighting of the Subcharacteristics of Efficiency.

Feature	Metric	Percentage
Behavior over time	Response time	50%
Resource Utilization	CPU usage	25%
	Memory usage	25%
Total		**100%**

Table 8 Indicators to measure performance efficiency.

Measurement scale	Qualitative value
91% - 100%	Excellent
76% - 90%	Very good
51% - 75%	Well
21% - 50%	Acceptable
11% - 20%	Regular
0% - 10%	A little

5. Results And Discussion

The performance efficiency quality feature of the GEOLAM mobile application is measured according to metrics for each of the subfeatures: Behavior over time with the response time metric and the resource utilization subcharacteristic with the CPU usage and memory usage metrics . For this purpose, 385 samples were taken distributed in the modules of the GEOLAM application, depending on the number of defined functional requirements, as shown in Table 4.

Figure 8 shows the measurement of response time, RAMand CPU in the tool module using the Apptim tool.

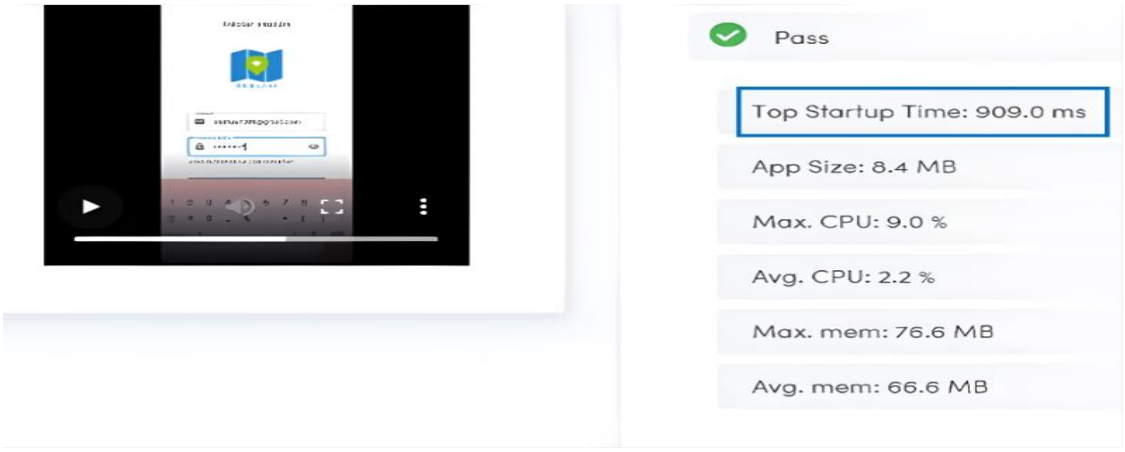

Figure 8 Apptim Measurement inAuthentication Module

Response time

According to the measurements made, the response time obtained by evaluated requirement is averaged according to the samples taken for each of the modules of the application (Table 4); which, in turn, are averaged to obtain the total value of response time of the application . Table 9 shows the values obtained by each module, and the total average is 1.53 seconds; according to the evaluation indicators of Table 5, with a value of less than 3 seconds, so it is determined that it has a percentage of 87.25%, with a qualitative assessment corresponding to very satisfactory.

Table 9 Results. Response times, RAM and CPU usage

Application modules	Time (seconds)	RAM utilization	CPU utilization
Authentication	1.57 s	65.88 MB	1.87%
User Management	1.61 s	72.39 MB	1.96%
Health Care Information Management	2.34 s	118.87 MB	2.12%
Search	1.05 s	74.56 MB	2.98%
Geolocation	1.10 s	109.64 MB	3.26%
Average	**1.53 s**	**88.27 MB**	**2.44%**

Memory usage

Table 9 presents the detailed results of the use of RAM for each module of the mobile application, 88.27 MB corresponds to the total average of the amount of RAM used in each module. According to the evaluation indicators of Table 6, the average is within the scale of [0-150] MB, therefore, it is considered as Excellent with a rating of 100%.

CPU usage

From the values averaged by each module of the application, the total of 2.44% CPU utilization is obtained, which can be seen in Table 9. According to the evaluation indicators in Table 6, the total average is within the scale [1.6-2.5] corresponding to Good with a score of 75%.

Performance efficiency of the GEOLM application

The values obtained from the measurements of each subcharacteristic of performance efficiency were weighted according to Table 7 as shown in Table 10. Hence, the performance efficiency of the GEOLAM mobile application reaches 87.38%, within the scale [76% - 90%] of the indicators to measure performance efficiency (Table 8), the qualitative assessment corresponds to Very Good.

Table 10.Performance efficiency results.

Feature	Subcaracterística	Metric	Percentage Measurements obtained	Percentage Weighted
Performance Efficiency	Temporal Behavior	Response Time	87.25%	43.63 %
	Resource utilization	CPU	75%	18.75 %
		RAM	100%	25.0 %
Total				87.38 %

Figure 9 shows the percentage values, the GEOLAM mobile application has a performance efficiency of 87.38% as a result of the measurement of: response time (43.63%), CPU utilization (18.75%) and RAM utilization (25%).

Figure 9 Performance efficiency results.

6. Conclusions

GPS geolocation was successfully coupled in the development of the GEOLAM mobile application by obtaining a global position based on latitudes and longitudes in real time, working with orbiting satellites, tracking ground stations and receivers.

According to the research carried out on public and private health care places in Ecuador, there are 25590 establishments with the current operating permit, distributed in three levels of care and support institutions. In the city of Riobamba there are 721 establishments, of which 535 are part of the levels of care. General hospitals, basic hospitals, specialized hospitals, type B health centers and type C health centers were taken into account, in addition a survey was applied, to define the 18 places from which information was collected on official websites, media and physical places.

For the development of GEOLAM the Scrumban methodology was used with a total of 5 iterations. The MVC design pattern was applied, the model contains the packages for connection to the database through web services and business logic, the controller owns the classes necessary for communication between the view and the model, and the view owns the xml files of the interfaces. Regarding the validation of user stories, acceptance tests were used and through the Burndown Chart diagram the speed with which the project was carried out was represented, allowing to culminate with the 5 main modules: Authentication, Information Management, User Management, Search and Geolocation, distributed in administrator and user roles.

The evaluation of the GEOLAM application was carried out using the ISO/IEC 25010 Standard, the characteristic measured was performance efficiency with two subcharacteristics: behavior over time with a value of 43.63% and resource utilization with a value of 43.75%, determining a total percentage of 87.38% for the feature, which indicates that the application has a very good performance efficiency.

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