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Multiplatform system oriented to telemedicine

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ABSTRACT

The research arises from the need that was seen in people in recent years due to COVID-19, since remote medical care was required to avoid contagion, that it was developed with the Flutter tool and it is oriented towards telemedicine, which provides a medical evaluation service between patients and doctors. For the development of the methodology, the agile methodology of extreme programming "XP" was implemented, since it is of great help for the development of the system, the proto-types, and their different phases, since, compared to other methodologies, XP was the that gave more results in less time, which allowed us to have a faster development. The objective of the research is to implement a multiplatform system oriented to expert telemedicine. It has been possible to develop a basic demonstration of the system that would be the video calls, one of the most important functions of the entire system, and its operation has been effective as has been demonstrated in the results of this project, in which it was carried out carried out a survey of 50 questions and 95% agreed with the multiplatform system, since it would be of great help for several people.

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1. INTRODUCTION

Many studies have found a society about telemedicine that became very important in the year 2020. Due to the presence of the new COVID-19 virus, this made telemedicine evolve very quickly in these years, becoming an indispensable tool at an international level to avoid infections and to be able to monitor the recovery of patients remotely. Unlike Peru, the not many web systems have been developed that provide this telemedicine service, and the problem arose when all hospitals began to create their own web system, making the patient unable to get everything he wants in a single system [1].

On the other hand, the methodology that will be carried out in the research work is the extreme programming (XP) methodology, because such a methodology was chosen, because it emphasizes the technical aspects of software development and in turn guarantees customer satisfaction. Also delivers higher quality software and manages projects in an efficient way in which it helps in the development of software. Likewise, speaks that in Peru telemedicine services have not been implemented [2]. This new service would deepen medical services to reach the most vulnerable and remote populations, this service also helps new professionals to perform in their career. This way you can help improve people's health and make it more profitable for them.

On the other hand, telemedicine is one of the health services that are used in different systems and from simple applications that are helped by telephone networks, such as tele radio in the Amazon of Colombia and Peru [3]. As well as in several countries such as New Zealand, Argentina, Costa Rica they use telemedicine. The World Health Organization (WHO) agrees that telehealth as telemedicine is a service that provides remote

help and favors patients and doctors who cannot attend their appointments, currently in Peru through the Ministry of Health (MINSA) system at the national level telemedicine is being prioritized in remote areas.

Likewise, this new model could be generalized at the national level and be part of a solution to the discrepancies in care in Peru [4]. Since through the use of telemedicine policies in prenatal people care would facilitate since are in the stage of a global pandemic in which prenatal people are at greater risk than the elderly. Telemedicine has great potential to benefit both patients and medical professionals, the author mentions that there are also ethical challenges that weaken the medical patient relationship. By which he studies and seeks the way in which the fundamental ethical responsibilities in the field of telemedicine are fulfilled in the Peruvian context [5].

The importance of this research is to promote the telemedicine system at the national level in order to contribute to people and give the benefit to patients and doctors. Likewise, in Peru and in all health centers they can contribute and help patients with their appointments and medical consultations. The objective of this work is to develop a multiplatform system oriented to telemedicine that provides a service of help to patients and doctors, so that at a long distance they can be attended virtually and at the comfort of the patient.

2. LITERATURE REVIEW

The research work will be oriented to the development of a medical appointment system to take advantage of new remote communication technologies and achieve a multiplatform development. The intention of helping thousands of people to have an appointment in real time with their preferred doctor through a video call or also with the possibility that they can request a consultation at home. In this way the benefits provided would be the comfort of the patient, its flexibility, save time and money.

Moreover, this research work is aimed at the integration of the services provided by several private hospitals, for this reason made a main approach which is to design a prototype for a web application based on providing a strategy of an implementation in the development of an integrated solution [6]. Likewise, telemedicine has evolved significantly in recent decades to encompass online consultations, in turn intensive care monitoring, mental health monitoring, chronic disease management and providing an alternative help to traditional visits to hospitals, posts and doctors [7]. On the other hand, telemedicine is a field of growth and the identification of the latest developments of growing trends that are a challenge, however, bibliometric analysis facilitates the evaluation and identification of diseases.

Video calls are made through a free tool created by Google. This tool is web real-time communication (WebRTC) and allows to establish a point-to-point communication to be able to transmit audio and video through the established link, for this reason Tarim and Tekin [8] makes use of this tool to establish a communication between patient and medical professional remotely. This service is called "telemedicine" and makes use of technological tools to provide advanced medical services. The authors also do different tests to assess the stability of connections on different types of networks and in different web browsers.

Information technologies have revolutionized medical assistance in what has led to the supply in e-health facilities remotely, for this reason, makes use of information and communications technology (ICT), since it plays a very important role. Since it helps to reduce the waiting time for consultations from patients to doctors [9], however in developing countries where the majority of the population does not have the necessary resources and find it difficult when they are in contact with dating methods, it is enormously important to better understand how to design a user interface that allows users who do not have the necessary resources to perform tasks effectively. Therefore, there is an authoritarian need to develop a simple, effective and easy-to-learn user interface of an online appointment system for beneficial doctor-patient consultation.

On the other hand, focuses on making a web system in which he can integrate the service of multiple hospitals and so patients can manage their appointments and can also choose the hospital that suits them best [10]. The main focus of this research is to design the prototypes so that they can analyze what would be the best strategy for the implementation of this integrated solution. The aim of the research is to serve the Omani community and give patients flexibility to purchase the varied services of hospitals with ease and to be able to manage their appointments and medical records from home.

One of the solutions to make applications multiplatform, an analysis of contemporary technologies and methods was made considers the development of applications both on the server side and for the different operating systems that currently exist [11]. The author also understands that web development is compatible with almost all devices, due to this cross-platform development arises. The goal is to find the methods that allow web development to be transpired in different languages and in this way an application can run on each operating system natively.

Due to the great growth of mobile devices and the millions of applications that have been created, it has been seen that the mobile application market is very large and has become something very important today. Because of this, tries to make comparisons between cross-platform applications and native applications and

has managed to identify that cross-platform applications are increasingly stronger competitors and give the possibility to create applications quickly and what can work on multiple systems [12]. The development of these applications would be done simultaneously using a single tool which allows it to be compiled for different operating systems. In which the fundamental basis of these cross-platform applications is that you can include html5 and also use plugins such as the WebSocket.

In this sense the important thing about mobile applications is the design that has in many of the cases frameworks that are closed architecture are used preventing the designer from creating his own interface, the problem with these frameworks is that they already come with a limited set of components, and it is very difficult to add new components, this can make the final result of the system unattractive or have low productivity. In the same way, has made the development of new components in cross-platform applications since they are faster, reliable and also scalable, in this way simplifies the development of the user interface using specialized components that allow to improve the user experience and facilitate integration to other tools such as React [13]. This way you can reduce application costs, since developing interfaces in native applications is much more complicated and laborious, but by doing so in cross-platform applications they are much faster and easier to integrate.

Likewise, videoconferences based on the WebRTC are seen in which the performance and efficiency of this tool is evaluated since it is a capable tool, because it is a web tool, so this tool can be used in the development of multiplatform applications since its base itself is the web. In this sense, makes exhaustive tests of the tool both in wireless, wired and emulated networks using transmission control protocol (TCP) and user datagram protocol (UDP) data streams [14]. In the evaluation that was made it was seen that the tool has better results when working on TCP flows, the tool performs in an expected way the only problems that have been found is when you use the VP9 and H264 video codecs that do not work as expected.

Another important point in telemedicine is to understand users and know their usage patterns on the platform, makes a study of all patients who attend an office to see which sex uses the platform the most and has detected that woman use the platform more, it has also been identified which young people use most of this telemedicine service [15]. Telemedicine makes it possible for the patient to save time and money and have better care since doctors respond much faster. The results obtained from this research are that young people who already know the clinic and have knowledge about the telemedicine service, then make use of this service before going to the clinic.

On the other hand, one of the things that telemedicine was able to enable is the incorporation of the internet, which allows remote control of health through peripherals it uses, such as physical activity bands, remote heart rate sensors and devices that maintain and send updates on any artificial organ implanted within the human body [16]. In addition, telemedicine applications cover a number of health areas such as tele radiology encompassing tele neurology and tele cardiology, tele dermatology, skin telecare, and mental telehealth, all-encompassing telemedicine applications that provide a service to the patient with their evaluations with the physician [17]. Finally, it has been concluded that telemedicine has become a very important medicine technology in times of COVID-19 [18]. Thanks to telemedicine has helped to combat COVID-19, the transmission of this virus has also been prevented, thus helping families and doctors. This way doctors could provide better care to COVID-19 patients, ensuring that these vulnerable populations could receive care remotely.

3. METHOD

In this section, the XP methodology has been used since it allows a more technical work with short iterations and that allows modifications of the interactions in the course of the project. It also allows tasks to be sorted according to requirement. On the other hand, this methodology allows the works in pairs thus delivering a better experience and quality of software in the shortest time. The XP methodology becomes part of the agile methodologies, this methodology guarantees customer satisfaction, also delivers higher quality software and manages projects in an efficient way. The size of the team in the XP methodology is usually small. This methodology is focused on dynamic software development that allows the integration of new features [19].

3.1. The XP methodology has different phases

3.1.1. Planning

It defines the general scope and what is sought is to understand what the client needs. The way in which you look for what the customer requires, is done through user stories [20]. On the other hand, those who estimate the time in which the project is going to be carried out are the programmers. The estimates must be very clear in this phase since it is the general idea of the whole project, but this does not mean that the idea ends there, since when carrying out a more detailed analysis of each of the processes you can find variations that modify the general idea of said process.

3.1.2. Design

In this phase it is recommended to make the designs in the simplest way to facilitate the time of understanding and this helps to reduce the time in development. It is also recommended to use glossaries to understand the names of the methods and classes, this will facilitate faster understanding of the design. You should make use of C.R.C cards, this helps programmers to concentrate on development helping to improve habits and allow object-oriented programming [21].

3.1.3. Codification

In this phase the programmer and client must be in constant communication, since the client is the one who will give the detailed specifications of what he wants. You could say that the customer becomes part of the development team. To bring a better structure of the code and this can be understood by other programmers is made the use of standards, this will also allow the project to be scalable [22]. This phase focuses on making a correct code for the function, which allows to pass the test, then it can be optimized.

3.1.4. Test

All code must be tested before its implementation to verify and verify its correct operation. If a code does not pass the test, it cannot be published in any repository and cannot be implemented, in this way it is ensured to make collective use of codes that have an optimal operation. Another important point to do the tests is to make the code that is going to be tested does not depend on other codes and you should not do a test thinking about a future code that is going to be implemented.

What sets XP apart from other agile methodologies is that it emphasizes the technical aspects of software development. Extremely "XP" programming specifies how engineers work, for the following engineering approaches allow teams to deliver high quality code at a sustained pace. In Figure 1 we observe the processes of the XP methodology, on which the estimation, stories, requirements, test scenarios, iterations, acceptance of the test are based, customer approval and release of small releases.

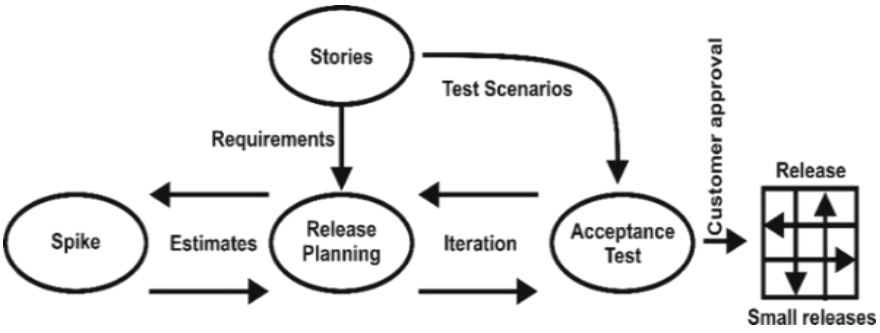


Figure 1. Extreme programming methodology

4. CASE STUDY

In this section the development of the prototypes of the application in its different cross-platform versions has been carried out, each of the functions will also be explained in detail. The different steps of the XP methodology that will be applied in this research work will also be discussed. As a first part, the user stories will be made.

4.1. Planning

Planning is a brief phase in which the client, the manager, and a team of developers agree on the order in which user stories should be executed and those associated with them, the deliverables. Typically, this phase includes one or more group planning meetings. The phases are explained below.

4.1.1. User story

User stories represent a brief description of system behavior. Where they are implemented for each of the main functions of the system and are also used to meet time estimates and system release plans. Each user story should be easy to understand so that developers can implement it in a few weeks as shown in Table 1.

Table 1. Table of prioritized stories

Nª	Description
1	As an administrator, I want the application to allow user registration, so that they can access the system.
2	As an administrator, I want the app to be able to run on any computer or device to give users more options and not limit them.
4	As an administrator, I want the app to have a login so I can save information for each user.
5	As an administrator, I want the app to allow the doctor and patient to make video calls to improve communication and if the patient has something to show, the doctor can see it.
6	As an administrator, I want the app to have a chat so that the patient can write to the doctor so they can coordinate in a faster way. X
7	As an administrator, I require the patient to view the list of health specialists in order for them to have access to care.

4.2. Design

This section will discuss cross-platform software architectures and prototypes. Detailing each one of them. In this way, the architectures and prototypes are made explicit.

4.2.1. Architecture

This section shows the different architectures that are necessary and important to establish the connection between doctor and patient. The connection between the points (A-doctor, B-patient) is done through the internet, but for these three important services are required. In Figure 2 we can see two important services, one of them is the STUN server and its function is to identify the IP addresses of both points (A-Doctor, B-patient) to inform each point which is the internet protocol (IP) address of the other. We can also observe another server that is responsible for exchanging necessary information between the two points (A-doctor, B-patient) in order to establish the connection.

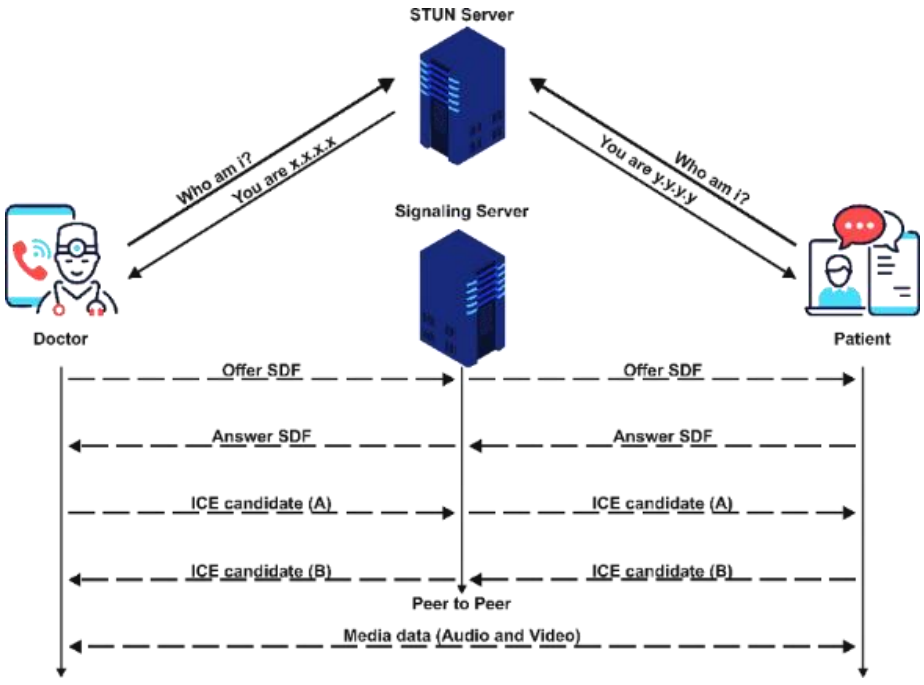


Figure 2. Architecture of the STUN server and information exchange server between points (A, B)

This architecture works efficiently in a local network, but it is inefficient in a global network, for this reason a third service is added that can be seen in Figure 3, which is the TURN server, and its function is to retransmit the traffic of the points. This means that the audio and video data sent by point A (doctor) will be sent to the server in an encoded manner and then the server will send this data to point B (patient) and vice versa. In this way it is possible to evade most of the restrictions of the firewall and a connection can be established in a global network.

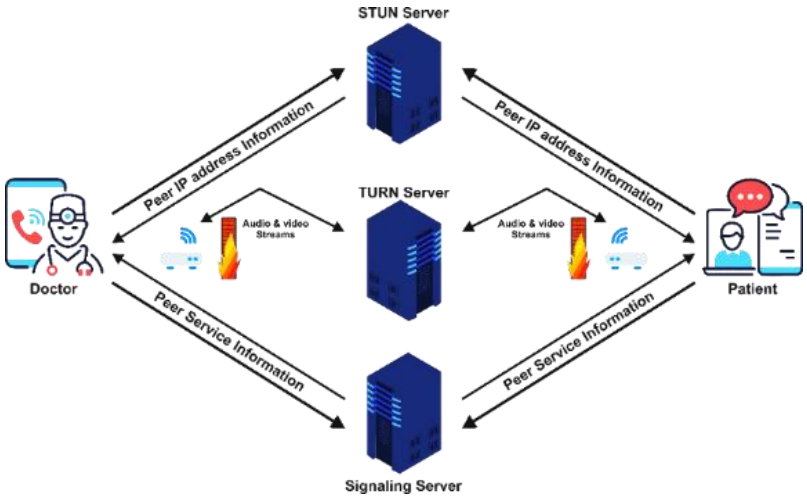


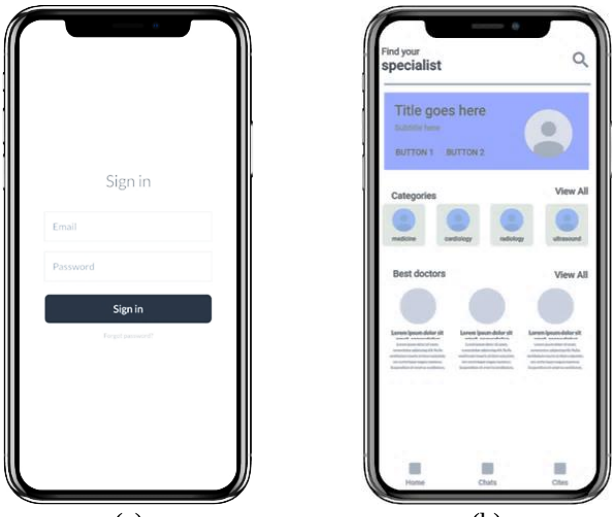
Figure 3. TURN server architecture

4.3. Prototypes

In this section the prototypes were developed in order to detect errors in the program, it was developed with the Marvel App tool, in which they were designed and implemented through user stories, where this will help users who use the App and thus have access to everything that the application provides. Likewise, each design has its description to understand the function it performs. Also shown are the designs that will be for mobile devices and for desktop devices.

4.3.1. Prototypes for mobile devices

This section will show the development of the prototypes that were designed for mobile devices in order to provide help through telemedicine. Designs that were made for desktop devices will also be displayed. In this way we are covering with multi-platform designs. In Figure 4, can see the start view of the section, through which the patient will enter their credentials to access the system (see Figure 4(a)). We can also see that once entered, the main panel of the application is displayed. The main panel shows the different lists such as the best doctors, care categories and top rated doctors (see Figure 4(b)).



(a) (b)

Figure 4. Mobile application: (a) login views and (b) main panel

In Figure 5, can see the list of specialists with whom the patient has contacted (see Figure 5(a)). We can also see the view where the patient will exchange communication with the doctor through a chat (see Figure 5(b)). You can see the design has the basic functions of a chat.

(a) (b)

Figure 5. Mobile application specialist view of the (a) list of specialists with whom you interacted and (b) chat with they

In Figure 6, the view of both the patient and the doctor when they establish a video call is shown. You can also see that it has the basic function buttons of a video call. This design refers to mobile devices.

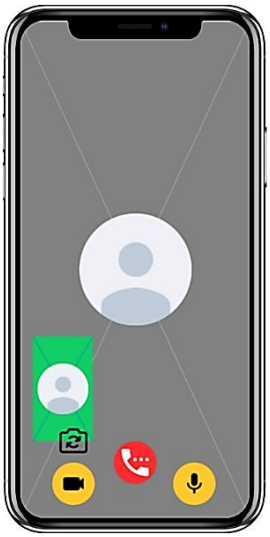


Figure 6. View of the video call between patient and doctor of the mobile application

4.3.2. Prototypes for desktop devices (native applications (Windows, Linux, Mac) and web)

This section will show the developments of the prototypes that were designed for desktop devices or laptops. The explanation of the views on both mobile and desktop are the same since they are the same processes and only the graphical interface changes depending on the platform. In Figure 7, we can see the start view of the section, through which the patient will enter their credentials to access the system.

We can also observe in Figure 8, that once entered, the main panel of the application is shown, where different lists will be shown such as the best doctors, the categories of care and the best rated doctors. In Figure 9, you can see the list of specialists with whom the patient has contacted. We can also see the view where the patient will exchange communication with the doctor through a chat. In Figure 10, the view of both the patient and the doctor when they establish a video call for the medical evaluation is shown.

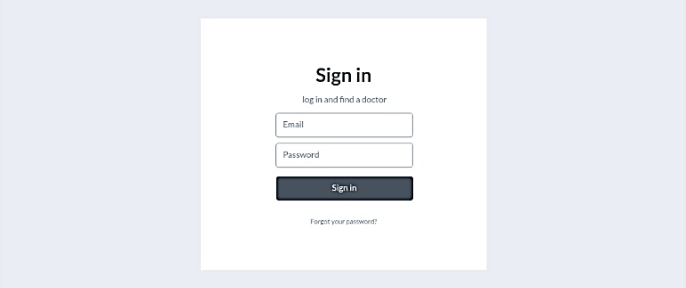


Figure 7. Desktop app login view

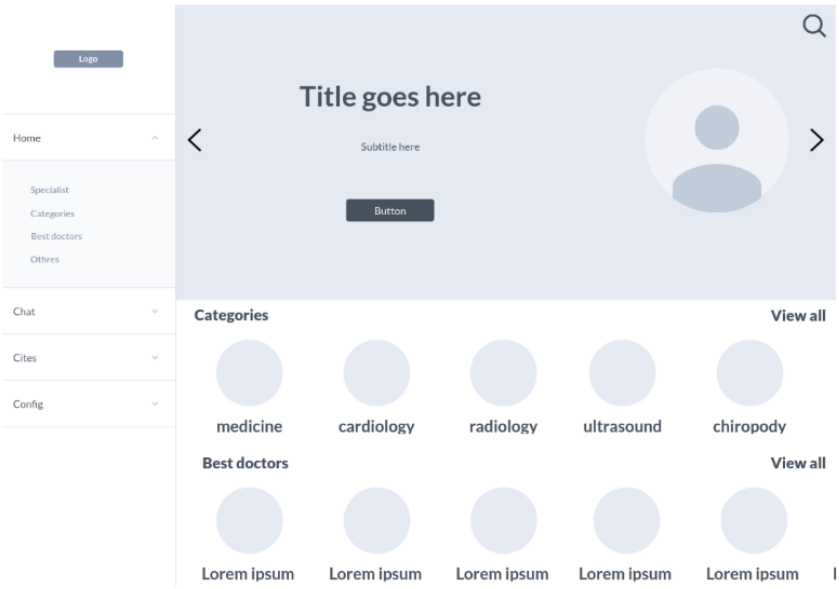


Figure 8. Main panel view of the desktop application

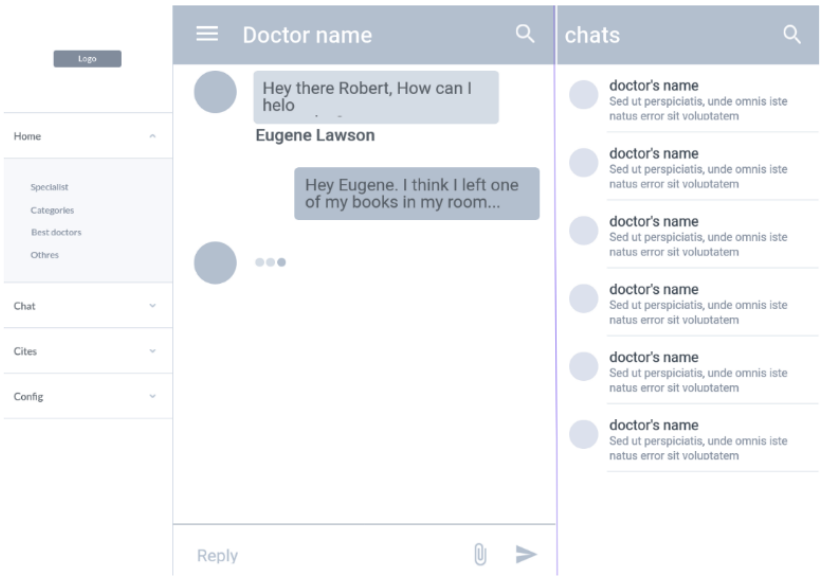


Figure 9. View of the list of specialists with whom you interacted and view of the chat with the desktop application specialist

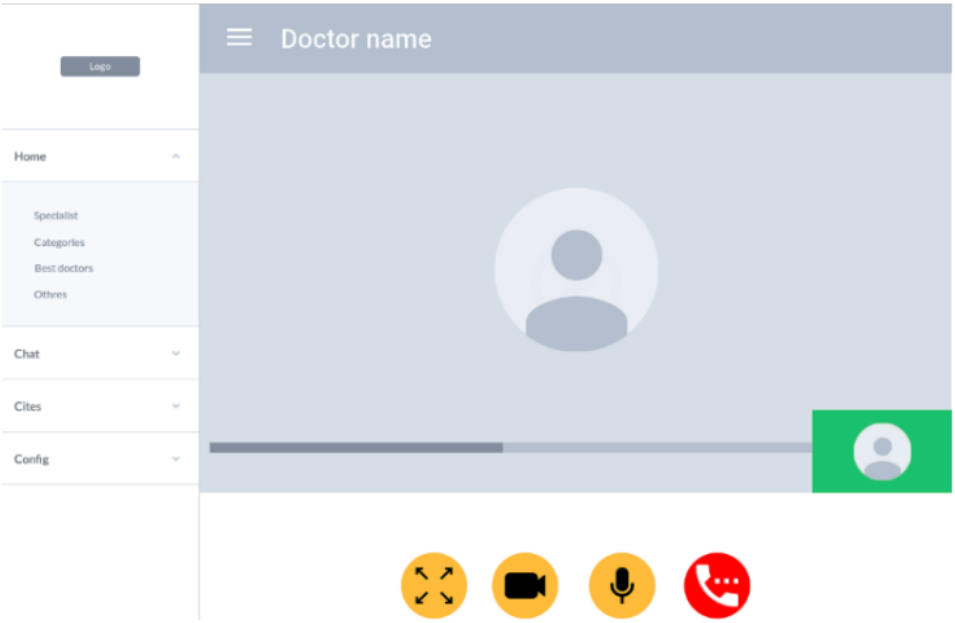


Figure 10. View of the video call between patient and doctor of the desktop application

4.3.3. Codification

Based on the architecture shown in the figures (Figure 2, Figure 3) some fragments of code will be shown that allows us to make the appropriate configuration to be able to interact with the different services and to be able to carry out the communication between the points (A, B). In Figure 11 we can see the way in which the parameters are configured to be able to establish the connection with the STUN and TURN servers. Figure 12 shows the code snippet that allows you to prepare the data stream from the video camera and microphone that will then be transmitted to the TURN server for retransmission.

```
Map<String, dynamic> configuration = {
  'iceServers': [
    {
      'url': "stun:openrelay.metered.ca:80",
    },
    {
      'url': "turn:numb.viagenie.ca",
      'username': "***********@gmail.com",
      'credential': "********",
    }
  ]
};
```

Figure 11. Configuration code for STUN and TURN servers

```
final Map<String, dynamic> mediaConstraints = {
  'audio': {
    'echoCancellation': true,
    'noiseSuppression': true,
  },
  'video': {'facingMode': 'user'},
};
MediaStream stream =
    await navigator.mediaDevices.getUserMedia(mediaConstraints);
localRender.srcObject = stream;
return stream;
```

Figure 12. Configuration code that allows you to take the audio and video of the device for transmission

4.4. Test

In this section the brief explanation of the tests will be made in the part of results and discussions. The screenshots of the tests carried out on the phones will also be shown. In the tests we demonstrate the correct functioning of the WebRTC service.

5. RESULTS AND DISCUSSION

We agree with the information provided by the author [8], since we have made use of the WebRTC tool. We have also verified that the stability tests mentioned by the author are supported. So, we are satisfied as we have managed to establish the remote connection through that tool.

5.1. Prototype testing

In this Section the demonstration of video calling service working is done, being part of a test is not subject to the final design of the application. In Figure 13 we can observe the status before the video call and when it is already in one. On the other hand, in Figure 14 we can observe the different states for which you receive the video call.

Figure 13. Video call test on device 1 (Huawei Y9A)-start the call

Figure 14. Video call tests on device 2 (Iphone 13) accepts the call

On the other hand, the author [10] focuses on making a web system in which he can integrate the multiple service of hospitals and so patients can manage their appointments and can also choose the hospital that best suits them. The main focus of this research is to design the prototypes so that they can analyze what would be the best strategy for the implementation of this integrated solution. In Figure 13 shows the test of the video call made between the patient and the doctor. In Figure 14 the second test of the video call is performed in which it was accepted by the Iphone 13 device.

5.2. Multiplatform system

The application had a good performance in the different systems that were tested, the first place was tested on an Android device, then it was tested on a desktop computer, which had Windows 10 as an operating

system and also ran the application in the Chrome web browser. So, we can say that the functionality in the different systems is efficient. On the other hand, one of the solutions to be able to make applications with a multiplatform system, an analysis of the technologies was carried out in which the author [11]–[13] considers the development of applications both on the server side and for the different operating systems that currently exist in the development of new components in cross-platform applications since they are faster [23], more reliable and also scalable, in this way simplifies the development of the user interface using specialized components that allow to improve the user experience and facilitate integration to other tools such as React, also the author understands that web development is compatible with almost all devices, be-cause of this it arises in cross-platform development [24]. With the aim of finding the methods that allow web development and in turn be transmitted in different languages and in this way an application can run in on each operating system natively, the development of these applications would be done simultaneously using a single tool which allows it to be compiled for different operating systems. In which the fundamental basis of these cross-platform applications is that you can include html5 and also use plugins such as the WebSocket [25].

5.3. Service survey

A survey of 50 questions was carried out to a group of more than 100 people, which helped us a lot to carry out the development of the prototypes, in which 95% of the people opt that the multiplatform system would be of great help for several people since it can be used almost on any device or web and they would not have to leave their homes to be attended and evaluated since this will be done through video calls, likewise another group ensures that telemedicine in other countries has been of great help in times of pandemic, since thus patients were treated by video call and evaluated. Another of the surveys was oriented to the service provided by this multiplatform application and 100% of the participants agreed that this type of services be implemented in health centers to improve the speed of their care.

On the other hand, Habsi and Ahmed [6] also conducted a survey of patients visiting several hospitals, in which the answers given by patients about their level of satisfaction with the existing services of the hospital were 90% who did not agree and 10% who did agree with the existing services that the hospital had. In addition, the same author asked another question in which the answers given by patients showing the need for integrated services for several hospitals in a single web application, 90% if they agreed that a web application based on integrated services should be made for several hospitals, and 10% did not agree that the web application be made.

5.4. Methodology comparison

In this section, some methodological comparisons are made in which three methodologies are shown, such as the XP methodology, the Scrum methodology and the Cascade methodology, in which a comparison of their brief description and their phases will be made as shown in Table 2. On the other hand, Sikandar *et al.* [7] in his research searched for information in a bibliometric way using the Scopus database from 2011 to 2020 where the keywords were health and telemedicine. This allowed him to analyze this theme for the deepening of his research.

Table 2. Methodology comparison

XP methodology	Scrum methodology	Waterfall methodology
The XP methodology is an agile software development framework aimed at creating high-quality software to improve the efficiency of development teams. This is a development method intended to encourage the application of appropriate engineering techniques for software creation.	Scrum is a framework used by teams working on complex projects. In other words, it is an agile work methodology, oriented to deliver value in the short term, and is based on three pillars: transparency, validation and adaptation.	The cascade methodology is a linear model that goes through a series of phases one after another and has no return. In a linear model, the product is defined, designed, developed, presented in this order and has no opportunity to validate in the previous phase. Linear processes are best used in projects with minimal changes and feedback.
The XP methodology was developed with five core values in mind. The goal of these values is for development teams to work together to create high-level products under a common mindset.	Scrum in framework types is developed taking into account the management and development of software, based on an iterative and step-by-step process of creating a project. Scrum can be used to develop solutions for any industry and any type of project, regardless of its complexity.	The waterfall methodology produces a finished product in which each phase begins the next phase. The product continues as a cascade until the end of the process. The process cannot be started until the previous process is completed and the product is produced.

6. CONCLUSIONS

In conclusion, each of the authors significantly benefits telemedicine research, both in the analyses that allow video calls and in the analysis of how accepted the idea can be, also mentioning that it helps to meet the objective of being able to offer this telemedicine service in a generalized way. Likewise, the use of the extreme programming methodology and its different stages, helped to have results much faster since the different tests of the software could be carried out. It should also be mentioned that the project has some limitations, since it requires external servers to be able to make video calls globally, and signalling servers, you could well build your own servers or rent them, both ways it has a significant cost. The research has many ideas for improvements, one of our suggestions would be to implement artificial intelligence to analyze each of the consultations and in the future to be able to make rapid diagnoses to identify diseases according to a pattern of symptoms.

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