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Real-time Remote Monitoring For Emergency Management In Smart Cities

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Thank you Allah (my God) for giving us the ability

to write and think, the strength to believe in it, the patience

to go until the end of the dream and the happiness of raising our hands to the sky and say "Ya Kayoum".

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Abdelghani

Amine

Dedication

First of all, I want to thank Almighty God;

I dedicate with great pleasure this modest work:

To my father;

To my dear mother;

To my dear sisters and brothers;

To all my family;

To my partner in this work, Mohamed Amine;

And to all my close friends and colleagues in the M2 ISTW computer science specialty, promotion 2021.

TALES AbdElGhani



Dedication

First of all, I want to thank Almighty God;

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And to all my close friends and colleagues in the M2 ISTW computer science specialty, promotion 2021.

MOHAMED AMINE EULDj



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Notation

CDHP: Consumer-Directed Health Plan

DTLS: Datagram Transport Layer Security

DHCC: Dubaï Health Care City

DHCC: Dubaï Healthcare City

DHCA: Dubaï Healthcare City Authority

E-Santé: électronique santé

HTM: HyperText Markup Language,

IETF: Internet Engineering Task Force

ICT: Information and Communication Technologies

NASA: National Aeronautics and Space Administration)

NICT: New Information and Communication Technologies

OMG: Object Management Group

P2P: Peer-to-Peer

PHP: Hypertext Preprocessor

PSTN: Public Switch Telephone Networks

RUIS: Réseaux universitaires intégrés de santé

SIP: Session initiation protocol

STUN: The Session Traversal Utilities for NAT

TURN: Traversal Using Relays around NAT

UM: Unified Modeling Language

XMPP: Extensible Messaging and Presence Protocol

XHR: Xml HttpRequest

WebRTC: Web Real Time Communication

WHO: World Health Organization

W3C: The Worldwide Web Consortium

Abstract

The development of Information and communication technologies (ICT) is an indisputable reality today. The ICT and the rise in the field of medicine has led to the birth of telemedicine. This new medical technique has given rise to new forms of consultation and diagnosis. In this work, we propose an application that assists the doctor in remote medical diagnosis and detecting the emergency cases from the symptoms of the patient.

Key words: telemedicine, telediagnosis, information and communication technologies, emergency cases, symptoms of the patient.

Résumé

Le développement des technologies de l'information et de la communication est aujourd'hui une réalité incontestable. Les TIC et l'essor du domaine médical a conduit à la naissance de la télémédecine. Cette nouvelle technique médicale a donné lieu à de nouvelles formes de consultation et de diagnostic. Dans ce travail, nous proposons une application qui assiste le médecin dans le diagnostic médical à distance et détecter les cas d'urgence à partir des symptômes du patient.

Mot clés: télémédecine, télédiagnostique, technologies de l'information et de la communication, cas d'urgence, symptômes du patient.

ملخص

إن تطوير تقنيات المعلومات والاتصالات هو واقع لا جدال فيه اليوم، وقد أدى تطورها في مجال الطب إلى ولادة التطبيب عن بعد. أدت هذه التقنية الطبية الجديدة إلى ظهور أشكال جديدة من الاستشارة والتشخيص عن بعد. في هذا العمل، نقترح تطبيقًا يساعد الطبيب في التشخيص الطبي عن بُعد واكتشاف الحالات الطارئة من خلال أعراض المريض.

الكلمات المفتاحية: التطبيب عن بعد، التشخيص عن بعد، تكنولوجيا المعلومات والإتصالات، الحالات الطارئة، أعراض المريض.

General Introduction

In recent years, new technologies have invaded our daily lives. This technological revolution is impacting all sectors of activity (transport, audio-visual, services, etc.) and over the coming years the large-scale deployment of telecommunications networks would have a considerable influence on individual and collective behaviour. The impact of Information and Communication Technologies (ICT) on medicine and surgery is certainly remarkable.

As part of our work, we will try to build and implement a Telemonitoring platform allowing the monitoring of patients in emergencies and providing guidance. That is by establishing a remote medical diagnosis between the various medical staffs. This platform could be very helpful, mainly when the patient is located in isolated sites.

Research question

The strong population growth in Algeria has prompted the construction of many of them Sanitary structures even in scattered areas. However, these structures define a severe shortage of medical personnel, especially specialists, and medical equipment. Also, there are many traffic accidents, gas suffocation and other daily accidents. this is It created many problems in the medical diagnosis of diseases among which:

- Transporting patients to distant hospitals for simple medical advice.
- Wasting a lot of time waiting for the ambulance, which may lead to health complications and death of the victim.
- Refer the injured to a remote or overcrowded hospital for emergency cases, which leads to wasted time and unknown health complications.
- usion Confusion to the attending physician led him to make the wrong decision about it Diagnosis.
- Difficulty making decisions about some diseases.
- Difficulty detecting disease based on few symptoms.
- The problem of communication between doctors of different specialties.
- A decision about a patient with many problems.

Objectives

The main objectives of remote diagnosis and monitoring:
Therefore, the goal of our work is to create a remote monitoring and diagnostic Application. The medical file with health structures allows communication between doctors as well as between doctors and patients for a remote diagnosis; as well as to guide them in urgent cases by giving him a tool for diagnosing diseases based on the patient's symptoms. Some targets have been set to address the above issues, namely:

- Improving access to high-quality diagnostics across the region national, especially in landlocked and isolated areas.
- Allow better patient care by limiting their travel.
- allow the assessment of the patient's condition or data relating to him, without direct physical interaction, via a communication system.
- Distinguish between urgent cases and others.
- Directing cases to the nearest hospital services and the least crowded with patients.
- Reducing pressure on some hospital interests.
- Encouraging better coordination between different stakeholders fixed and mobile health structures.
- Rapid intervention and shortening of time.
- Early recovery and avoiding further unnecessary complications.

Organization of the thesis

Our thesis is structured in five chapters, the first is devoted to a bibliographical synthesis on the generalities of telemedicine; the second one presents the concepts of telediagnosis, medical remote monitoring, and ICT implemented as part of carrying out this work; In the third chapter, we give an overview of the WebRTC technology; the fourth chapter presents our design thinking of our system which it’s implementation is presented in the last chapter. We end this report with a general conclusion which presents the main perspectives envisaged for the pursuit of this theme.

.

Chapter I

Telemedicine

I.1 Introduction

The emergence of new information and communication technologies (ICT) and the rise of the latter in the field of medicine have enabled the birth of telemedicine. In particular, it could fundamentally modify medical practices and the organization of health care offered to the population.

This medical activity encompasses a wide variety of services. It is possible to use telemedicine in various medical fields ranging from internal medicine to surgery, including dermatology and radiology. It is interesting to note that psychologists, speech therapists, occupational therapists, nurses and many other health professionals can use telemedicine in their practices, as well as in emergency medical services.

In this chapter, we will start with some general notions concerning telemedicine with its different tasks, we will then present the factors that meet the needs of the actors, the principles and certain sites of telemedicine, the benefits of telemedicine, the ethical issues and the fields of medical application of telemedicine techniques, finally we will end with the obstacles to the development of telemedicine.

I.2 Telemedicine

There are many definitions of telemedicine, including:

- Telehealth (telemedicine) is a generic term to define any use, at a distance, of information and telecommunications technologies in the field of health.
- E-Health, for its part, refers to open access digital content related to health (internet discussion forums, medical information sites). Finally, m-health refers to all applications on mobile phones relating to health.

While the terms telemedicine, telehealth, e-health and m-health are frequently used as synonyms, they actually cover very different definitions [1]. Telemedicine etymologically covers the exercise of this medicine practiced at a distance, from the Greek prefix «tele» meaning «far from». According to the definition proposed by The College of Physicians of Quebec, it is characterized as «the practice of medicine at a distance using means of telecommunications» [2].

According to the World Health Organization (WHO., 1997), « Telemedicine refers to the part of medicine which uses the transmission by telecommunication of medical information (images, reports, recordings, etc.), with a view to remotely obtain a diagnosis, a specialist opinion, continuous monitoring of a patient, a therapeutic decision» [3].

According to Article L. 6316-1 of the public health code, which is more restrictive, specifies that the telemedicine is a form of remote medical practice using information and communication technologies. It puts one or more healthcare professionals in contact with each other or with a patient, including necessarily a medical professional and, where applicable, other professionals providing care to the patient [1].

The telemedicine makes it possible to establish a diagnosis, to ensure, for a patient at risk, a follow-up for preventive purposes or a post-treatment follow-up, to request a specialist opinion, to prepare a therapeutic decision, to prescribe products, to prescribe or to perform services or acts, or to monitor the condition of patients [4].

I.2.1 History of telemedicine

If we consider that telemedicine is any medical activity carried out at a distance, regardless of the mode of information transfer, we find that its history is older.

Indeed, from the appearance of the first means of communication, some have expressed their will. To apply to the medical field this formidable possibility huge potential which was offered to them to be able to communicate and exchange information at a distance.

Throughout history, medicine has always tried to take into account technological developments, with the aim of improving the practice of its art. The development of telemedicine is by definition closely linked to technological development, in particular NTIC (new technique of information and communication) [5].

The concept of telemedicine is not new. Indeed, some believe that its origins can be found in the discoveries of the telephone and the telegraph at the beginning of the century (1900s) But the most concrete stage began in the 1920s, when troops at sea benefited remote medical care, assisted by physicians using Morse coded transmissions. This remote assistance is still in force, since it is used by sailors sailing alone.



Figure I.1. First electrocardiogram transmitted via a telephone channel in 1905 by Willem. Einthoven.

The N.A.S.A (National Aeronautics and Space Administration) then demonstrated that the physiological functions of an astronaut could be recorded remotely from the earth (heart and respiratory rates, blood pressure, temperature etc.). Initially reserved for the experimental monitoring of subjects not subjected to gravity, these data were used as support for the diagnosis and treatment of emergency medical situations during space flights.

In 1957, in the United States, an interactive video link was established between a psychiatric establishment in Omaha (Nebraska psychiatry institute) and a state hospital in Norfolk, both 180 kilometers apart. This trial was part of a medical education program. Then in 1967, we find traces of a rather particular experiment, since a hospital radiologist, from the

state of Massachusetts, had succeeded in setting up a video transmission terminal connecting the general hospital and the Boston airport.

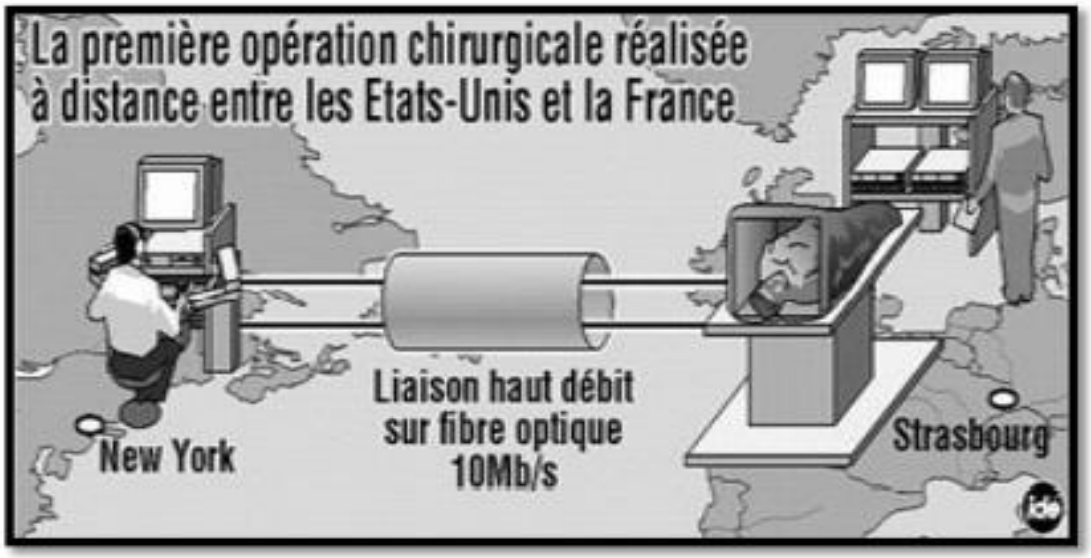


Figure I.2. First surgical operation performed remotely from Strasbourg and New York.

Thus, doctors were invited to take X-ray images in front of a black and white video camera connected to a video screen of the hospital radiological department. They could then discuss the clinical case with the radiologist through a traditional telephone call. This is a first example of tele radiology. It was in January 1976 that the HERMES satellite was launched by the Canadians, which was used 3 times as a relay for teletransmission tests of medical information (with remote monitoring) [6].

I. 2.1.1 Development of Telemedicine

The recent evolution of information and communication technologies has strongly favored the development of telemedicine, we can divide the stages of telemedicine into four phases based on the use of information and communication technologies. These steps are described in the following table [5]:

Development phase	**Approximate period**
Telegraphy and telephone	1840-1920
Radio	The 1920s and after (main technology until the the 50's)
TV / space technology	The 50s and after
Digital technologies	The 90s and beyond

Table I.1. Stages in the development of telemedicine.

I.2.2 Telemedicine tasks

Telemedicine has today found many fields of application, and comes in different terms for which it is difficult to determine a unanimous typology. We present some categories of applications in telemedicine: teleconsultation, tele expertise, telemonitoring and urgent medical response etc. Tele-assistance is not always a medical act [7].

I.2.2.1 Teleconsultation remote consulting

It consists of the evaluation of a patient, or data concerning a patient, without direct physical interaction, via a telecommunication system. The field of Teleconsultation and remote consulting is vast; we can cite requests for a second opinion from a colleague, the organization of emergency care, the referral of a patient and the arrangement of a possible transfer, but also primary care if the doctor is not available.



Figure I.3.Teleconsultation.

Two types of teleconsultation can be distinguished [8]:

a) Type 1 teleconsultation: a patient consults a doctor through a network of communication interposed.

b) Type 2 teleconsultation: the consulting doctor requests a diagnostic opinion (remote diagnosis) and / or therapeutic (remote expertise) with another practitioner located at distance.

I.2.2.2 Tele-expertise

Tele-expertise has often been limited in its definition to exchanges between specialists to obtain a second opinion. This definition can be extended to any diagnostic or therapeutic act that takes place outside the presence of the patient (in deferred time). The tele-expertise medical act is described as an exchange between two or more doctors, who together make a diagnosis based on clinical, radiological or biological data which appear in a patient's medical file [3].



Figure I.4.Tele-expertise.

I.2.2.3 Tele-surgery

We can define ourselves as being the recourse to an external surgical intervention, carried out remotely, and using the tools of the new information and communication technology, allowing an expert surgeon, geographically distant, to provide his help and carry assistance to an "effector surgeon" directly responsible for undertaking and performing all surgical operations on the patient, under the control of the first (i.e. the expert surgeon located outside, far from the operating theater).

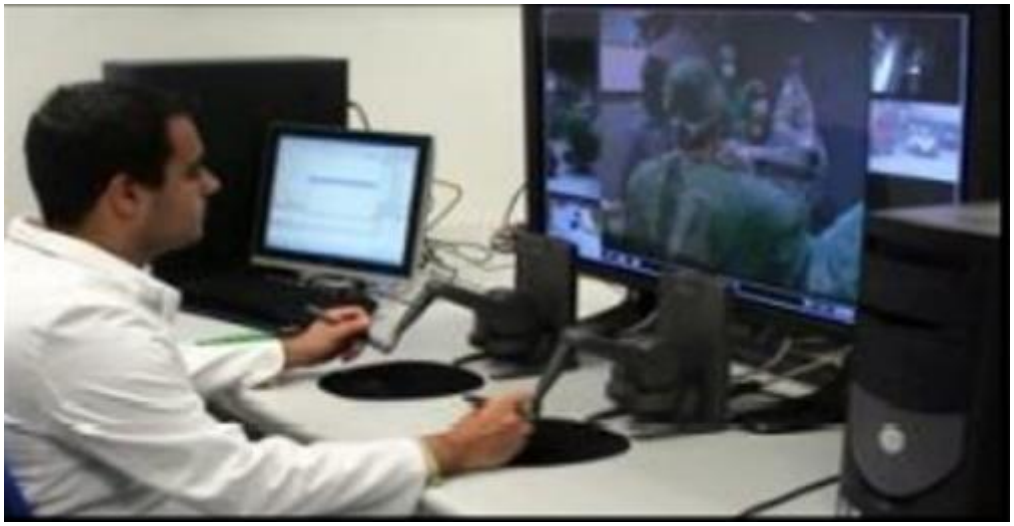


Figure I.5.Tele-surgery.

I.2.2.4 Tele-assistance

Tele-assistance can be a medical act when a doctor assists, remotely, another doctor performing a medical or surgical act. The doctor can also assist another healthcare professional who performs an act of care or imaging, or even, in the context of an emergency, assist, remotely, a first-aid worker or any person providing assistance to a person in danger, in waiting for a doctor to arrive [3].

I.2.2.5 Tele- training

It is a synchronous or asynchronous telecommunications service; telephony, videoconferencing, messaging, forums, image servers. These distance learning services, aimed at students or health professionals, allow access to know-how or knowledge, whatever their location (medical database on the web, training modules). e-Learning, surgical interventions viewed remotely by interns, etc.) [9].



Figure I.6.Tele-training.

I.2.2.6 Remote monitoring

Medical telemonitoring, the purpose of which is to allow a medical professional to remotely interpret the data necessary for the medical monitoring of a patient, and, if necessary, to make decisions relating to the care of this patient. The recording and transmission of data can be automated and carried out by the patient himself, or by a healthcare professional [10].

I.2.2.7 Remote diagnostics

Remote diagnostic assistance is possible and known in various specialties (tele-cardiology, tele-dermatology, tele-endoscopy, etc.). In this case, the medical examination must be carried out by a doctor present on site. The patient benefiting from this application could be in a rural location where there is no specialized center, on a plane or on a boat [5].

I.2.2.8 Urgent medical response

The purpose of urgent medical is to allow a medical professional to remotely solicit the opinion of one or more medical professionals because of their training or their particular skills, on the basis of medical information related to the care of a patient.

This simplified framework for the exercise of telemedicine as a remote medical act makes it possible to clarify the legal responsibilities involved in each of these acts illustrated in the Figure1.7: Remote monitoring,Teleconsultation,Tele-expertise.

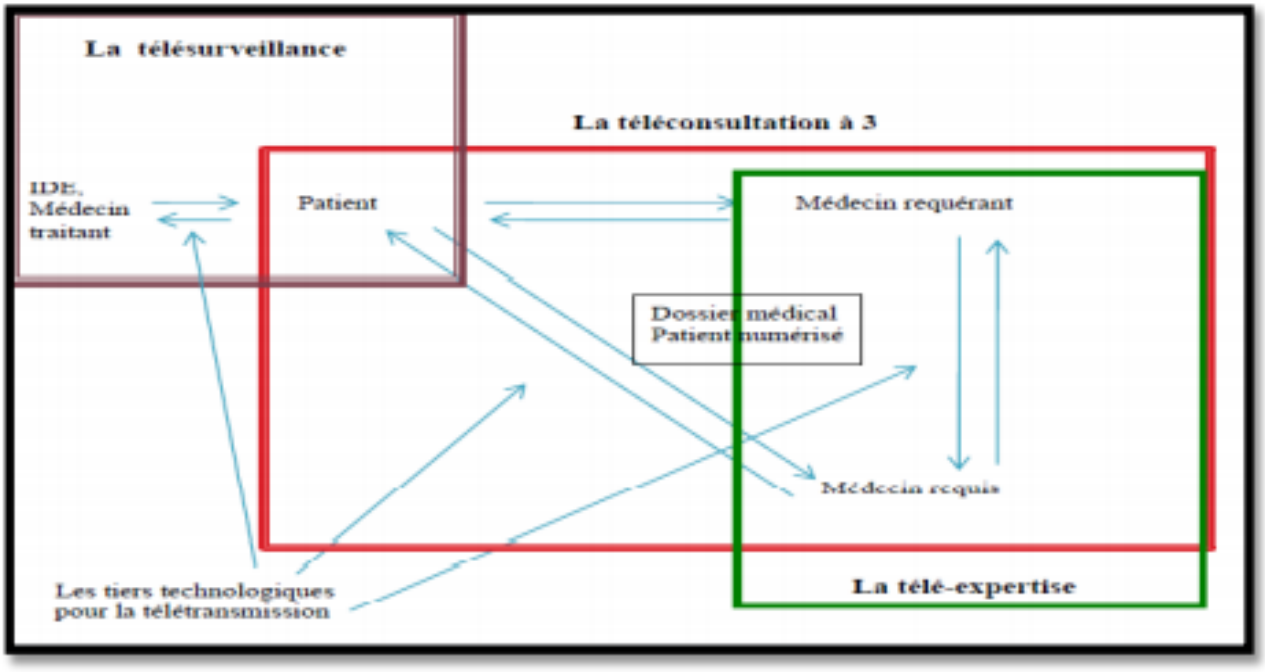


Figure I.7. Diagram of the interactions between the different actors involved in the three main telemedicine acts.

I.3 Factors of Telemedicine

The multiple needs of stakeholders (success factors) are not always met, know Taking into account regulatory, normative (standards), ethical, legal and deontological aspects [9]:

- ❖ Adequate broadband infrastructure, hardware and software equipment.
- ❖ Telehealth services adapted to needs, easy to use, with evaluated uses.
- ❖ Awareness-raising / training activities for a culture of change, of projects.
- ❖ More coordination / pooling of collective actions.
- ❖ The definition of organizational and economic models.

I.4 Principles of Telemedicine

The telephone is considered as oldest telemedicine tool that meets the defined criteria. But currently, the term is rather used to refer to more recent systems with video interaction capabilities, transmission and possible data storage allowing in particular remote monitoring. The technical support being the multimedia microcomputer.

These techniques are experiencing a permanent expansion explained by:

- ❖ The development of the information superhighways (of the "net").
- ❖ The design of tools allowing the recording, then the transmission of data and digital images on these telecommunication networks.

It should be noted that at the same time the prices of hardware, software, as well as communication times have benefited from notable reductions, which favors access to such technologies [6].

I.5 Some telemedicine web plaform

In our daily environment and in our wanderings on the Internet, we find many web platforms related to telemedicine. We will mention some of them in the following.

I.5.1 Esiha.net

Esiha, a medical platform for searching, locating and taking appointments online with health professionals, doctors, radiology and analysis centers, in Algeria. Elsiha also provides remote consultations and modified medical records for Algerians [11].

I.5.2 Virtual Doctors

It is a UK based charity (registered charity: 1129924) that helps rural health workers in Africa, where there are no doctors, to contact UK doctors and specialist physicians.

It also permit to Save lives By providing sophisticated yet easy-to-use telemedicine software and cutting-edge technology, the charity has three clear goals:

- Help reduce unnecessary mortality and morbidity by empowering health workers in rural areas to treat more patients on site.
- Reduce unnecessary referrals to remote and hard-to-reach hospitals.
- Improve the skills and knowledge of rural health workers [12].

I.5.3 MDLIVE

Is a telehealth provider focused on the digital delivery of high-quality, convenient and cost-effective medical care. The company provides consumers, health insurance plans, healthcare systems and self-insured employers with any time (24/7/365) access to licensed physicians, pediatricians and therapists through a video app, phone or secure smartphone online [13].

I.5.4 American Well

It is a private telehealth company based in Boston, Mass. That instantly connects patients to physicians via secure video. The company provides immediate and urgent web visits to patients in 46 states. The service works on computers, and in 2013, well released US mobile applications for Android and IOS operating systems. The applications allow a mobile-optimized version of the same video tours [14].

I.5.5 Medical city of Dubai

The Dubai Health Regulatory Authority (DHCR) is an independent arm of the Dubai Health Care City Authority (DHCA), the governing body of the Dubai Health Care City Free Zone (DHCC), a destination for health and of well-being.

Launched in 2002 by His Highness Sheikh Mohammed Bin Rashid Al Maktoum, Vice President and Prime Minister of the United Arab Emirates and Ruler of Dubai, the world's largest free care zone consists of two phases. The first phase is dedicated to health; however, the second phase is medical education, occupies 4.1 million square feet in Oud Metha, and phase 2, dedicated to wellness, occupies 22 million square feet in Al Jadaf, overlooking the historic Dubai Creek [15].

I.5.6 UMP Global Care

A Uniform Medical Plan (UMP) is a self-insured medical plan offered by the Public Employee Benefits Office (PEBB) program of the Washington State Health Care Authority. UMP is administered by Regence Blue Shield and Washington State Rx Services.

UMP offers three plan options: Uniform Medical Plan Classic, UMP Consumer Directed Health Plan (UMP CDHP), and UMP Plus [16].

I.5.7 Cisco Extended Care

Cisco Extended Care is more than a telehealth solution. It is a collaborative healthcare platform that:

- Unifies infrastructure components and peripherals.
- Simplifies workflows.
- Provides high quality interactive visual communications.

In the above listed process, Cisco Extended Care permits the doctors and patients to exchange experiences.

Extended Care is a solution rather than a video endpoint. It eliminates disjointed platforms and code shuffling with questionable levels of reliability, security, and scalability. In addition, it is the electronic medical record (EMR) - end point of video, and application-agnostic. Businesses can use their existing Cisco video devices or the options built into their vendor portals and applications [17].

I.6 Benefits of Telemedicine

The expected benefits of telemedicine should focus on three areas. The «Patient», The «Health Professional» axis and the « Institutional » axis:

- **Benefits for healthcare professionals:**
  - Make up for the geographical isolation of a team.
  - Optimize medical time and encourage medical exchanges.
  - Decompartmentalize activities, strengthen collaborations, initiate new forms of partnership between health professionals.
  - Attractiveness of this new organization.
- **Benefits for patients:**
  - Provide an appropriate response from the start of treatment.
  - Reduce the frequency and duration of hospitalizations and transport.
  - Improve the comfort of the patient (and those around him) who feel more secure by taking better account of their needs.
  - Promote better care (see remote imaging, remote monitoring, etc.).
- **Benefits for the health system:**
  - more efficient organization.
  - optimization of professional resources [9].

I.7 Telemedicine and ethical issues

Telemedicine makes it possible to underline the ethical principles shared by the entire medical profession with regard to this new way of practicing medicine [6].

- The telemedicine relationship between a patient and a doctor, even in the collective practice of medicine, must be personalized, that should be based on sufficient knowledge of the patient and his antecedents, his consent to this new mode exercise should be obtained.
- Professional secrecy must be guaranteed, which requires an exchange and transmission system that is perfectly secure.
- The practice of telemedicine must meet a need whose essential reasons are equal access to care, improvement of the quality of care and its safety, objectives to which everyone has a right, telemedicine having the advantage of shorten the access time and thus improve the chances of a patient when away from a care structure.
- Principle of responsibility as for any medical act.
- Security principle reference to the various data protections when they are transmited and reproducted.
- Principle of confidentiality in the doctor-patient relationship.
- Precautionary principle to avoid for example altering data transmitted by telematics; thus, can be diverted; their transmission requires special care (encryption).
- Principle of transparency because telemedicine operation must be based on information correctness given by the doctor to his patient, resulting in informed consent.
- Principle of non-maleficence because We must not tolerate experimentation allowing perform operations that have no real interest for the patient.

I.8 Medical fields of application of telemedicine

We can apply telemedicine in many different medical fields and specialties, which we mention, for example, in the following [6].

I.8.1 Cardiologist

The management of a patient suffering from an unstable heart disease appears to be quite suitable, in particular by the functions known as telemonitoring, such as the monitoring of cardiovascular constants, the recording and transmission of electrocardiographic tracings. As a result, numerous applications are envisaged, in particular with regard to diagnostic and therapeutic assistance for coronaries and heart failure (detection of arrhythmias, electric shock, early thrombolysis of infarcts). For example, a Toulouse Cardiology team is experimenting with a portable and compact (20cmX4cm) E.C.G device, fully automatic, that the patient applies to his chest, allowing automatic recording of the electrocardiographic trace which can then be transmitted. This system allows in particular the "emergency" doctor to have a rapid specialist opinion.

I.8.2 Dermatologist

Dermatology is the specialty of medicine which, according to the European definition of 1995, includes "the diagnosis, treatment (both medical and surgical) and prevention of

diseases of the skin, subcutaneous cell tissue, mucous membranes. and skin appendages (body hair, hair, nails) as well as skin manifestations of systemic diseases. It also involves the promotion of good skin health". Since many dermatological diseases are directly or indirectly linked to other conditions, dermatologists often work in close collaboration with doctors specializing in internal medicine.

I.8.3 Diabetology

The follow-up of the evolution of wounds is quite satisfactory although very dependent on the quality of the image and on the condition that a home caregiver completes the data transmitted in video with finer elements (appearance, texture, etc.), which can only be collected at home. Some authors have focused on the prevention phase of trophic skin disorders.

Thus the interest is major in the phase of rehabilitation at home of patients whose autonomy has been brutally reduced (paraplegic spinal cord injury for example). This in order to enable him to quickly detect early signs of pressure ulcers According to several authors, videophone seems to be a useful tool for the management of dermatological pathologies, which sometimes represent the majority of consultations in prison for example.

I.8.4 Maternity

Studies are already underway (remote monitoring transmission). Video telephony, in addition to teletransmission, opens up possibilities for more complete monitoring. The expectant mother whose pregnancy is not proceeding normally is often asking for advice and opinions. The accessibility of a midwife by videophone can meet this expectation. At least one trial of the use of videocommunication in this context has been carried out in France, at the Necker-Enfants Malades Hospital While this work is being written, a pregnant woman, supported by HAD for follow-up and monitoring at home of a pathological pregnancy, was included in the experiment and it will be interesting to know the results of such an application.

I.8.5 Nephrology

This application essentially relates to patients with renal insufficiency dialysis at home, in particular for the monitoring of peritoneal dialysis sessions but also for the education of patients in the preparation thereof.

I.8.6 Pediatrics

The value of these techniques has been demonstrated in the management of children in neonatal departments, in particular for the remote transmission of cardiac monitoring data. In the context of returning home, especially for premature children, the possibilities of education (nutritional for example) and help with mother-child care should be studied.

I.8.7 Pulmonology

Patients with chronic respiratory failure, whether they present an obstructive syndrome (B.P.C.O) or restrictive (post-traumatic or post-tuberculosis sequelae, certain myopathies) require close follow-up that remote assistance can help to carry out. Patients with severe unstable asthma, whose warning signs of decompensation are evidenced by the drop in peak expiratory flow.

I.8.8 Palliative care

The important role of communication between the various stakeholders and the transmission of information justifies the concern for the contribution of telemedicine in the prevention of re-hospitalization.

I.9 Obstacles to the development of Telemedicine

It can't be denied that the digital revolution of the 1990s fostered a renewed interest in telemedicine in the age of the information society. However, it should be noted that, despite this favorable context, the various applications of telemedicine have not succeeded in going beyond the experimental stage. In addition, it should be noted that various cultural, structural, organizational and legal obstacles undermine its full deployment and the fact that its benefits are not always certain, especially in a public health context remains problematic.

Many other problems raised by this new approach to medicine hinder the spread of such a practice. Among the difficulties that have been noted, there are order problems [18]:

I.9.1 Techniques

(Lack of knowledge and fears about the possibilities of networking) the reliability, compatibility, confidentiality, quality of information transmitted by new information and communication technologies can hardly be guaranteed.

I.9.2 Sociological

The questioning of an age-old way of working is changing the relationship between members of the medical profession and between them and their patients.

I.9.3 Cultural reluctance

Within this cultural reluctance, there is probably a fear for doctors that their freedom to prescribe will be called into question if they have to turn to expert doctors and, at the same time, they have to assume the responsibility of an expert prescription of which they are not the real authors. However, if they opt to send their patient to the specialist, the latter takes responsibility for the act.

I.9.4 Ethics

The image runs the risk of invalidating the text and the speech by drawing the sick man further away from the caregiver.

I.9.3 Organizational

(A lack of organization) Telemedicine does not adapt to management processes as they exist and this aspect is fundamental.

If the practice of telemedicine comes under an exclusively medical control, its success depends on an organized and joint management between the medical profession and the administrative staff.

I.9.3 Legal

Telemedicine rights are not yet very well defined. Insofar as it constitutes a very recent new practice, there is to date no case law relating to this innovation and one can only refer to the general principles of law and medical ethics. This is why the law is important to frame it.

It is often late, and it is undoubtedly in this chapter that ethics can play an important role. The law will have to define new management tools that the information society will require both to allow medicine to adapt to new fields of application, and to maintain telemedicine's humanist dimension that neither favors excessive centralization nor sectoral specialization.

I.9.3 Economical

It seems relatively obvious that the well-coordinated use of telemedicine should lead to a reduction in costs.

I.10 Conclusion

The objective of this chapter was to give a brief overview on the different notions, benefits, obstacles of development and medical fields of application of telemedicine techniques. Telediagnosis being one of the tasks of telemedicine, precisely teleconsultation which facilitates the exchange of information and the sharing of experiences between different doctors.

In the next chapter we will better detail the concept of remote diagnosis and its relationship with ICT (Information and Communication Technologies) seen in a collaborative environment.

Chapter II

Telediagnosis, medical remote monitoring and ICT

II.1 Introduction

Telediagnosis and telesurveillance are tasks of telemedicine. These two types of remote diagnosis and telesurveillance can be applied to various disciplines such as cardiology, obstetrics and pediatric emergencies, etc. telediagnosis brings together all the medical practices that allow patients to be taken care of remotely thanks to health NICTs (New Information and Communication Technologies).

ICTs have become an inescapable reality, the application of which is daily and the use steadily increasing. They have already changed the way medicine is practiced in the interest of both the public and physicians. ICTs have been considered as essential tools for the quality and the supply of remote care. They provide valuable services, in particular by promoting access to medical resources in family medicine and in specialized or ultra-specialized medicine.

In this chapter we will present the different notions of telediagnosis and telesurveillance, introduce some general notions concerning a collaborative platform and we will also approach the use of ICT, finally we will note the maintenance of medical records.

II.2 Telediagnosis

Telediagnosis means "remote diagnosis", means diagnosis carried out remotely through the transmission of parameters or signals (data from a diagnostic examination) to aid in interpretation. "

According to (Saint -Val, 2001) in his doctorate of medicine, distinguishes six types of applications namely Telediagnosis and diagnostic assistance is mainly based on the transfer of data from the clinical examination and / or data from examinations complementary imaging or laboratory. The remote diagnosis can be synchronous or not, that is to say carried out directly or not, with the simultaneous connection or not of the interveners. When the remote diagnosis takes place by cooperation of several teams involved, necessarily synchronous, we speak of co-diagnosis.

For example In Franch, telediagnosis is the most developed component of telemedicine currently according to Thierry Saint-Val, who reports, in his medical thesis, the existence of 70 telediagnosis applications in France, specifying that their number is all increasing. days [19].

II.2.2 Principle of medical telediagnosis

The patient's condition will be diagnosed remotely, in conjunction with the consultation service, surgery service or emergency service of the hospital or clinic. Technically, communication as well as the sending of images will be established between ultrasound devices via the Internet, through simple microcomputers. Thanks to this system, the doctor called the patient to interview directly with specialists, as well as surgeons in their country or abroad, in order to quickly make the right decision.

For example two hospitals A and B, hospital A does not have a radiologist on site immediately available; a clinical physician wishes to obtain an imaging test for a patient hospitalized or admitted to the emergency department; he submits his examination request to

the teleradiologist who, if necessary, in view of the clinical question and the supporting information, validates it and plans the examination protocol, which he sends to the operator.

Once the images have been produced, validated by the operator, they are available on the network of hospital A and sent to hospital B where the teleradiologist works. He interprets the images and establishes the report, transferred to Hospital A to be made available to clinicians with the images. If necessary, the teleradiologist can directly contact the clinicians, and even speak directly with the patient and / or his family. This system can be shared between several establishments and / or imaging structures [20].

II.3 Medical remote monitoring

Medical remote monitoring is a medical act that results from the transmission and interpretation by the nursing staff of a clinical, radiological or biological indicator, collected by the patient himself or by a professional. health. The interpretation can lead to the decision to intervene with the patient.

Technology allows us to move towards a consumer-centric model that is primarily concerned with improving the quality of life of individuals and controlling the total cost of health care. health. Indeed, hosting of online personal health services and devices have been and are still being developed to extend care beyond the walls of the traditional hospital and medical practice to patients' homes. These experiences allow individuals to take responsibility for managing their own health and well-being, while relieving pressure on the health system from unnecessary visits and emergencies [21].

II.3.1 Aim of medical remote monitoring

The aim of telesurveillance at home is to promote self-care through training of patients, so that they can develop the habit of monitoring themselves and they have the power to play a more active role in managing variations in their daily salaries. This will influence the role of the industry, delegates and employees of the medical equipment industry will have to be in direct contact with patients (example: implanting a personalized device to give information on the operation of the device and to repair it).

Medical remote surveillance systems are generally made up of two remote modules:

- A local unit, at the level of each habitat, for processing the signals received from the sensors, for managing a knowledge base relating to the patient, and at the origin of the transmission of messages and alarms.
- A center of such e-vigilance for the treatment of messages and alarms received from the habitats as well as a set of actors (medical person, patient and member of his family) who can access at any time, after authentication and according to their privileges, to the system data [2].

II.3.2 Benefits of medical remote monitoring

Telemedicine surveillance brings many benefits to patients and healthcare professionals. The major challenge, which will result from the implementation of such medical surveillance, will be to improve patient follow-up. This will allow the abnormalities to be treated earlier

and thus modify the treatment given in order to reduce heavy drug treatment, the need for hospitalization and unnecessary transport costs [21].

II.4 Collaborative platform

A collaborative platform is a virtual workspace that centralizes tools, applications and information related to remote diagnosis. this tool allows employees (doctors) to share working documents (images, reports, recordings, etc.) with each other.

The objective of collaborative work is to facilitate and optimize communication between individuals in the context of work or a task not related to work, the collaborative platform is also very useful for updating data, monitoring schedules.

II.4.1 Tools and Resources

Although collaborative platforms are "packaged" to meet increasingly specific needs, the basic building blocks that they make available to users are often the same:

- File sharing
- Structured knowledge base.
- Forums.
- Individual or collective blogs.
- Group spaces.
- Internal messaging.
- Live Chat.
- Task management.
- Shared calendar.
- Listing of members.
- Specific software tools.

II.4.2 Advantages of a collaborative platform

A collaborative platform has many features that give it many advantages for hospitals or clinics.

One of its main advantages is the fact of facilitating the coordination and the work between the doctors thanks to the very simple sharing of all information (document, contact, task, database etc.).

In addition, this type of platform often benefits from a collaborative application facilitating communication within the different entities (mail, chat, videoconference). Another particularity is the fact that several users can connect at the same time and update at the same time. information, tools or applications of the platform.) [22].

II.5 Use of ICT

The use of ICT by doctors therefore requires them to take all the necessary precautions to ensure, as far as possible, that professional secrecy is respected. In this regard, the law concerning the legal framework of information technologies reviews that the confidentiality of information must be protected by a means appropriate to the mode of transmission, including over communication networks [23].

II.5.1 General rules for using ICT

To use ICT technology smoothly you must follow some rules for example:

- Doctors must distinguish between their professional and private life in the use of information technologies.
- doctors must always use their judgment as to the content and quality of the information transmitted using information technology.
- Doctor is responsible for measuring the advantages and risks of exchanging information with a patient or a colleague using technological means.
- Doctor must, therefore, recognize the issues raised by the use of information technologies.
- Doctor must inform his patient of the advantages, but also of the risks related to the use of information technologies.
- Even with an agreement or consent from his patient, the doctor remains responsible for ensuring the protection of professional secrecy and the confidentiality of the information he transmits.
- Thus, even if the patient has consented to communicate by email, depending on the nature of the information to be communicated, the physician may need, on certain occasions, to adapt the mode of communication with his patient to the circumstances of the moment.
- Patient is responsible for the content of the information he transmits to his doctor.
- Doctor must use the appropriate medium depending on the mode of communication and the nature of the information he communicates to his patient.
- The doctor must agree with his patient on the modes of communication and the means of protection that he will use according to the information in question. This convention must be documented.

Doctor and the patient should always be aware that when using social media, the information transmitted is:

- public (everyone can access it).
- permanent (over time).
- universal (no geographic limit).

II.5.2 Recommendations for sending emails(messages) or texts by the doctor

Many doctors mistakenly believe that all email is private and secure. It is not the case. There are several risks associated with using email, for example: wrong recipient, interception by third parties and multiplication of copies on several devices. So we must make some Recommendations for sending emails(messages) or texts by the doctor for Example:

- Avoid acronyms and medical terms that are not well known to the public.
- Be aware that a layman may not know that common words can have a medical meaning.

- Avoid sarcastic, vulgar or biased remarks, criticisms, derogatory comments and defamatory references.
- Avoid using humor that could be misinterpreted.

II.5.3 Video conferencing applications

Videoconferencing applications allow the doctor to carry out, remotely and in real time, a consultation with his patient during which sound and an image are transmitted. This technology greatly improves medical accessibility, particularly in remote areas. It ranges from sophisticated videoconferencing systems to user-friendly applications accessible on personal computers, digital tablets and smartphones.

Regardless of the technology or application used, it is important, both on the doctor's side and on the patient's side, that it be secure and that it allows the consultation to take place in an environment where the confidentiality of exchanges will be protected. In this perspective, without being proscribed, applications or software such as Skype or FaceTime, for example, must be used with caution. In contrast, the videoconferences supported by the Integrated University Health Networks (RUIS), which use the platform (RTSS), use much more secure technology.

In all cases, it is good to remember the rules set out above on the physical premises, the presence or absence of accompanying persons and the possibility of third parties being an unwanted party to the communication. As with emails or text messages, physicians must exercise judgment and take their ethical obligations into account when using videoconferencing.

II.5.4 Social media

Among the ICTs, social media are perhaps the ones that raise the most issues for physicians, since it is practically impossible for the confidentiality of exchanges is assured. Also, few doctors use them in the context of a therapeutic relationship. Rather, they use it for educational and personal use, and even there are certain precautions to be taken.

In general, social media should not be used by physicians to offer opinions outside their area of expertise and to disseminate defamatory comments or information.



Figure II.1. Social media and video conferencing.

II.5.4.1 Linkedin or video

- Acceptable or useful for:
  - Make their professional profile known.
  - Share factual information.
  - Find a professional / consultant for his patient.
  - Advertise its services.
- Unacceptable for:
  - Disseminate defamatory comments or information.
  - Publish comparisons of results.
  - Associate with commercial sites.

II.5.4.2 Facebook

- Prerequisites:
  - Professional page separate from the personal page.
  - Adjustment of privacy settings appropriate to the desired use.
- Acceptable or useful for:
  - Make their professional profile known.
  - Share factual information.
  - Advertise its services.
  - Disseminate general health information.
- Unacceptable for:
  - Accept a request for "friendship" from a patient in his personal Facebook account (which could be seen as a commitment or a favor in a therapeutic relationship).

II.5.4.3 Twitter

- Acceptable or useful for:
  - Exchange information with colleagues.
  - Carry out continuing education.
  - Provide patients with general health information.
  - Teaching students / residents.
- Unacceptable for:
  - Exchange specific medical information about a patient.
  - Exchange specific medical information with a patient.

II.5.4.4 Websites

- Acceptable or useful for:
  - Public information:
    - Clinic hours.
    - Services offered.
    - Addresses and contact details.
    - Name of the professionals of the clinic.
    - General health information.
    - References to patient association sites or to relevant scientific sites and recognized.
    - References to scientific or general public articles.
  - Secure services (HTTPS), recommended for:
    - Making an appointment.
    - E-mail exchanges with patients.
    - Reminders for vaccination and preventive examinations.
    - Monitoring of analyzes or vital parameters.
  - Indispensable:
    - Discussion forums require an editor in order to filter comments and act as a moderator.

With the Web, the "tightness" of information transmission mechanisms is never guaranteed. Every day, violations of professional secrecy, undesirable, abusive and contrary uses for the purposes for which the information was transmitted must be observed. Physicians should always keep in mind that the Web is a commercial public space.

Without falling into exaggeration or unfounded fear, it is good to make certain reminders:

- Very often commercial use of the information.
- Malware present on the Web (viruses, hackers).
- Existence of spyware and other forms of unwanted surveillance.
- Retrieval of information and its aggregation in what is commonly referred to as "Big Data" mega data, itself for commercial and other purposes.

II.6 Keeping medical records

With the arrival of ICT, it must be recognized that the medical record is undergoing profound change, in institutions or elsewhere. We could say that the record is "exploded", the elements constituting it can be found in the archives of one or more establishments, in a private clinic, in the computer of one or more doctors and in various technological devices. intelligent, in short in a multitude of places, sometimes physical, sometimes virtual.

II.6.1 Computer support for the medical record

The evolution of medicine continues inexorably with the technological breakthroughs that continue to influence it Also certain biological parameters taken by the patient himself, at a distance and according to the conditions defined and accepted by the doctor, must be placed in the file. We talk about blood sugar, blood pressure measurement etc.

The way of practicing medicine is also changing. Thus, “the care team” is increasingly becoming an essential approach in certain treatments and follow-up of conditions such as cardiometabolic diseases, for example. Notes from the care team, which reflect observations and treatments in remote medicine, should also be included in the chart.

In short, all information and advice given to the doctor by means of information technology, whether it comes from the patient, a colleague doctor or a member of the care team must be recorded in the patient's record. This includes all emails and text messages sent or received, the original parameters recorded during an exam (a cardiac ultrasound, for example) and not just those selected by the doctor during the operation and the summary of the procedur. That for When laboratory parameters and monitoring data are provided to the physician by his patient or by third parties, the physician must document in the patient's record the technology used as well as the conditions of use defined with the patient in order to ensure the validity of these medical parameters.

II.7 Conclusion

The objective of this chapter was to give a brief overview on telediagnosis, remote monitoring and ICT, introduced some general notions concerning a collaborative platform. And we also approached the use of ICT in the remote maintenance of medical records.

In the next chapter we will try to explain WebRTC and some notions that were related to it and to remote monitoring.

Chapter III

Web RTC

III.1 Introduction

A major challenge within the web has been the inability for two web browsers to communicate and share videos, audios and data without support from software such as Flash, Java applets, Silverlight or Flex which are collectively referred to as plugins [24]. As a result, there has been a progressive effort by Internet Engineering Task Force (IETF) to specify the protocols for networking. The Worldwide Web Consortium (W3C) implemented the JavaScript API in an attempt to bring the realities of a whole new communication experience to Internet users as well as the webservers [25]. This development led to the introduction of a technology known as Web Real-time Communications (WebRTC).

It is meant to achieve Peer-to-Peer (P2P) communication within the dependable Web ecosystem. Prior to the establishment of a P2P communication, a signalling process was implemented using various technologies such as Xml HttpRequest (XHR), session initiation protocol (SIP), Extensible Messaging and Presence Protocol (XMPP) and WebSocket. Google in collaboration with IETF, W3C, Mozilla and other corporations are working on the open source project [26].

The open source project is meant to help developers to be able to design and built various applications that will allow users to communicate by establishing video conferencing, text chat in the browser in real-time [27, 28], or to be used with existing Over The Top (OTT) technologies such as Public Switch Telephone Network (PSTN) or Voice Over Internet Protocol (VOIP) [29]. WebRTC is closely similar to websocket, but websocket opens a pipe of connection with a server instead of another peer. In most cases these technologies are used together for signalling purposes. In chat applications for example, WebSocket clients first send messages to the server and the server send the messages to the recipients. WebRTC promise to provide secured direct P2P communication between users and free of plug-ins [30].

In this chapter we will present and introduce some general notions concerning the WebRTC and it’s history and devloppement of their API.

III.2 WebRTC Technologies

There are many definitions of WebRTC, among which we finding the following [31].

III.2.1 Defintion 1

WebRTC, which stands for Web Real-Time Communications, is an open source project - brought by Google, Mozilla, and others - that enables plug-in-free real-time communications via a JavaScript API. This system facilitates browser-to-browser applications for voice calls, video chat, and file sharing. VP9 is the currently supported codec for WebRTC. WebRTC uses a server called Web Conferencing Server which, together with a STUN server, is needed to provide the initial page and synchronize connections between two WebRTC endpoints.

III.2.2 Definition 2

“The WebRTC is the ability to communicate live with someone or something as if we were right next door. WebRTC addresses a critical gap in the web platform, as it allows real-time communication by opening a single web page. ” Said Justin Uberti, Technical Leader on WebRTC, Google. “WebRTC is a new front in our long war for a web without constraints,” said Brendan Eich, CTO at Mozilla.

III.2.3 Definition 3

Web Real-Time Communication (WebRTC) is a new standard that lets browsers communicate in real time using a peer-to-peer architecture. It is about secure, consent-based, audio/video (and data) peer-to-peer communication between HTML5 browsers. This is a disruptive evolution in the web applications world, since it enables, for the very first time, web developers to build real-time multimedia applications with no need for pro- prietary plug-ins.

III.3 WebRTC objectives

Most researchers describe WebRTC as “Skype-like” technology, but Skype has far existed before WebRTC and the two are completely incomparable. Despite the dominance of Skype in real-time communication industry, with over a billion subscribers, Skype still has certain drawbacks. It is proprietary and users must install supporting software or plug-ins such as Flash for it to work properly. The plug-ins used along with Skype can impose security concerns within the system. Skype also adopted the client server architecture which makes it resource intensive [32].

WebRTC also uses peer topology with less overhead. It is an openstandard / open-protocol descendant of FreeBSD media engine [33]. This means that all the real-time capabilities that existed in Flash plugin have been made available natively in WebRTC-compatible browsers so that developers can use the technology to develop various real-time solutions with ease [31].

III.3.1 Communication Technology Issues and Remedies

One challenge with Internet communication before the emergence of WebRTC is the dependence on service providers. Before WebRTC was introduced for real-time video communications, vendors such as public switch telephone networks (PSTN) had used more intricate communication processes. Their clients must participate as members of a separate PSTN IP based community. This membership is maintained by a service provider who delivers basic rudimentary necessities. There must also be an assurance that each telephone number is unique for each physical location i.e. a mobile device must be associated with a unique user or service. These types of communication may also require participants to subscribe or buy a product, while others in addition may require the participants to download plugin before multimedia contents are delivered appropriately. For example, WebEX and skype. These cases required third party applications, thereby limiting the scalability and diversity of communication. With WebRTC each website is essentially its own "service provider", without the need for any relationship with a party outside of itself and the user establishing the communication.

The issue of lack of trust during Installation of third party software or plugins is a big concern. This is because these technologies can surreptitiously introduce malicious software and malware. This may pose technical problems with the application. WebRTC is a technology that can be used to overcome the problems associated with plugins installation. Another problem is the lack of a standardised real-time media engine which can be access freely through a simple secured hypertext transfer protocol (HTTPS). In addition, security flaws or potential vulnerabilities in most browsers are programmed to be automatically

updated when discovered and sometimes fixed in newer versions. Similarly, a WebRTC browser implementation can easily be fixed rapidly as compared to traditional applications such as Voice over Internet Protocol (VoIP) application. The complex VoIP addresses similar problems posed by malicious software by developing patches to address the security flaws. This often take much time. The importance placed on browsers are generally huge due to their ubiquitous nature and speed of information accessed [34].

Skype uses a domain name server (DNS), and this may cause the decryption keys of media contents conveyed through their service to be intercepted. WebRTC ensures encryption and authentication of voice, video and data by default. This is achieved through Datagram Transport Layer Security (DTLS) and secure real-time protocol (SRTP). It is used to prevent eavesdropping and recording of the voice and video data in WiFi networks.

WebRTC does not hinder support for other communication and collaboration protocols. This is also a major consideration for a reliable session establishment using Network Address Translators (NAT). This is important because it avoids delays of responses from servers and drastically reduces factors such as server load, latency and intensifies quality. This feature is good because it helps in the development of customized applications that allow others vendors to initiate communications session with WebRTC applications. This unique achievement realized with WebRTC is not the same with skype. Application developed using WebRTC allows participants to join the interactions from any site without having to undergo separate registrations or bear cost as a result of joining the interactions like it is experienced with linkedln or google for federation.

III.4 History and birth of WebRTC

In May 2010, Google bought Global IP Solutions or GIPS, a VoIP and videoconferencing software company that had developed many components required for RTC, such as codecs and echo cancellation techniques. Google open-sourced the GIPS technology and engaged with relevant standards bodies at the IETF and W3C to ensure industry consensus. In May 2011, Google released an open-source project for browser-based real-time communication known as WebRTC. This has been followed by ongoing work to standardize the relevant protocols in the IETF [33] and browser APIs in the W3C.

In January 2011, Ericsson Labs built the first implementation of WebRTC using a modified WebKit library. In October 2011, the W3C published its first draft for the spec. WebRTC milestones include the first cross-browser video call (February 2013), first cross-browser data transfers (February 2014), and as of July 2014 Google Hangouts was "kind of" using WebRTC.

The W3C draft API was based on preliminary work done in the WHATWG. It was referred to as the ConnectionPeer API, and a pre-standards concept implementation was created at Ericsson Labs. The WebRTC Working Group expects this specification to evolve significantly based on:

- Outcomes of ongoing exchanges in the companion RTCWEB group at IETF to define the set of protocols that, together with this document, define real-time communications in web browsers. While no one signaling protocol is mandated, SIP over WebSockets is often used partially due to the applicability of SIP to most of the envisaged

communication scenarios as well as the availability of open-source software such as JsSIP.

- ❖ Privacy issues that arise when exposing local capabilities and local streams.
- ❖ Technical discussions within the group, on implementing data channels in particular.
- ❖ Experience gained through early experimentation.
- ❖ Feedback from other groups and individuals.

In November 2017, the WebRTC 1.0 specification transitioned from Working Draft to Candidate Recommendation. In January 2021, the WebRTC 1.0 specification transitioned from Candidate Recommendation to Recommendation [35].

III.5. Web is supported by many software

WebRTC is one of the most revolutionary additions to web communications and technologies. It is still a young technology but its potential is already apparent and cannot be ignored. The ability to just use your browser - a tool you use every day - to conduct a fully successful web conference, without the need for multiple steps, or installation, is definitely something to consider.



Figure III.1. Browsers that supports WebRTC.

WebRTC is currently supported by Google Chrome, Mozilla Firefox, Safari, Opera, Edge and other Chromium-based browsers, both in their desktop and Android versions and ios.

Support for these browsers is now built in, an ideal solution that does not require a third party component or plugin. The beauty of WebRTC is that when you are invited to a web meeting, no further action is required other than clicking on a link you have been provided and accepting the necessary permissions. Installing yet another plugin might be considered “asking too much” for many users.

WebRTC is growing in popularity and as browsers are now integrated into smart TVs and other IoT devices, it will be interesting to see who will adopt this protocol next.

III.6 WebRTC Architecture

WebRTC extends the client-server semantics by introducing a peer-to-peer communi-cation paradigm between browsers. The most general WebRTC architectural model (see Figure III.2) draws its inspiration from the so-called SIP (Session Initiation Protocol) Trapezoid [14].

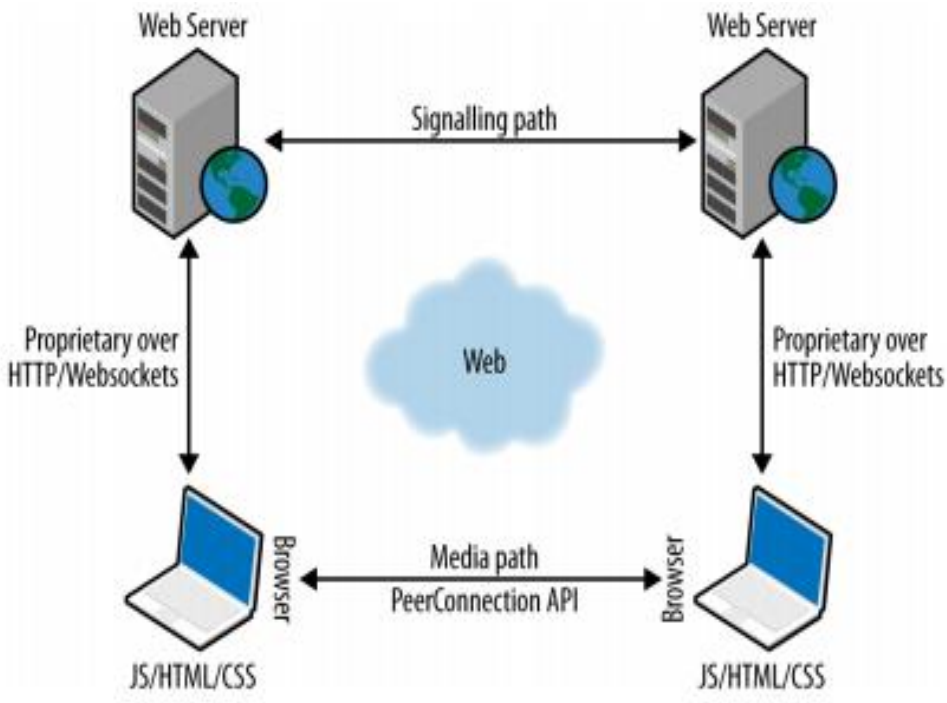


Figure III.2. WebRTC Trapezoid.

In the WebRTC Trapezoid model, both browsers are running a web application, which is downloaded from a different web server. Signaling messages are used to set up and terminate communications. They are transported by the HTTP or WebSocket protocol via web servers that can modify, translate, or manage them as needed. It is worth noting that the signaling between browser and server is not standardized in WebRTC, as it is considered to be part of the application (see “Signaling” on page). As to the data path, a PeerConnection allows media to flow directly between browsers without any inter- vening servers. The two web servers can communicate using a standard signaling pro- tocol such as SIP or Jingle (XEP-0166). Otherwise, they can use a proprietary signaling protocol. The most common WebRTC scenario is likely to be the one where both browsers are running the same web application, downloaded from the same web page. In this case the Trapezoid becomes a Triangle (see Figure III.3).

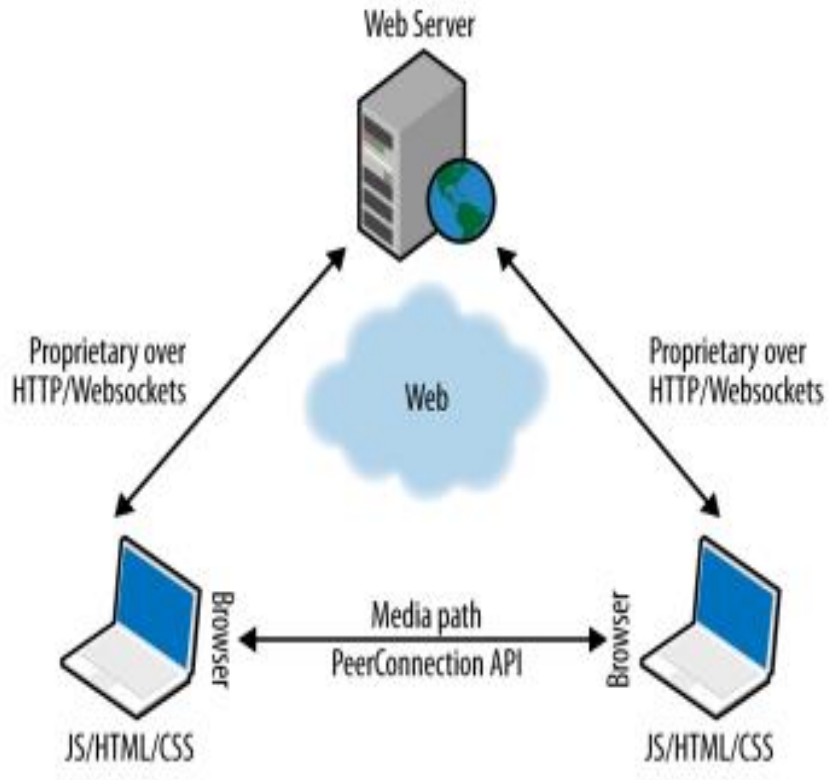


Figure III.3. WebRTC Triangle.

III.7 WebRTC in the browser

A WebRTC Web Application (typically written as a mix of HTML and JavaScript) inter- acts with web browsers through the standardized WebRTC API, allowing it to properly exploit and control the real-time browser function (see Figure III.3). The WebRTC Web Application also interacts with the browser, using both WebRTC and other standardized APIs, both proactively (e.g., to query browser capabilities) and reactively (e.g., to receive browser-generated notifications). WebRTC API must therefore provide a wide set of functions, like connection management (in a peer-to-peer fashion), encoding/decoding capabilities negotiation, selection and control, media control, firewall and NAT element traversal, etc.

III.8 Network Address Translator (NAT)

The Network Address Translator (NAT) has been standardized to alleviate the scarcity and depletion of IPv4 addresses. A NAT device at the edge of a private local network is responsible for maintaining a table mapping of private local IP and port tuples to one or more globally unique public IP and port tuples. This allows the local IP addresses behind a NAT to be reused among many different networks, thus tackling the IPv4 address depletion issue.

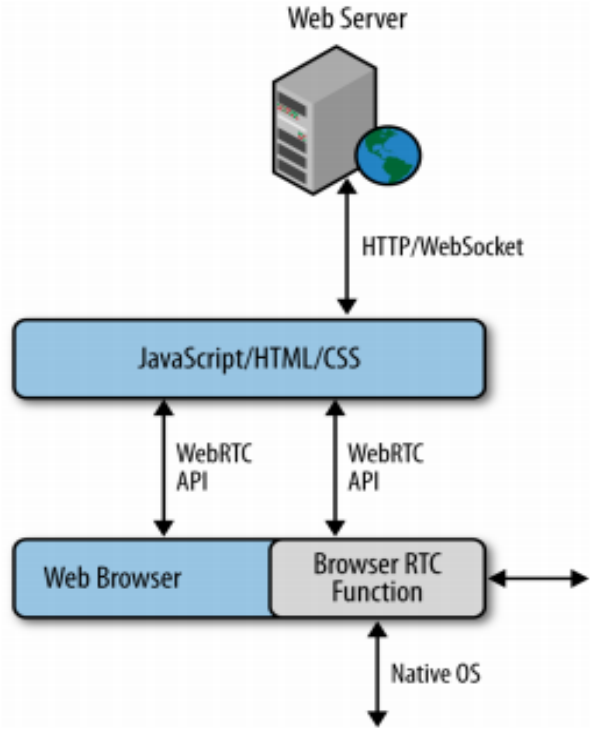


Figure III.4. Real-time communication in the browser.

The design of WebRTC API does represent a challenging issue. It envisages that a continuous, real-time flow of data is streamed across the network in order to allow direct communication between two browsers, with no further intermediaries along the path. This clearly represents a revolutionary approach to web-based communication.

Let us imagine a real-time audio and video call between two browsers. Communication, in such a scenario, might involve direct media streams between the two browsers, with the media path negotiated and instantiated through a complex sequence of interactions involving the following entities [31]:

- ❖ The caller browser and the caller JavaScript application (e.g., through the mentioned JavaScript API).
- ❖ The caller JavaScript application and the application provider (typically, a web server).
- ❖ The application provider and the caller JavaScript application.
- ❖ The caller JavaScript application and the caller browser (again through the application-browser JavaScript API).

III.9 Signaling

The general idea behind the design of WebRTC has been to fully specify how to control the media plane, while leaving the signaling plane as much as possible to the application layer. The rationale is that different applications may prefer to use different standardized signaling protocols (e.g., SIP or eXtensible Messaging and Presence Protocol [XMPP]) or even something custom.

Session description represents the most important information that needs to be exchanged. It specifies the transport (and Interactive Connectivity Establishment [ICE])

information, as well as the media type, format, and all associated media configuration parameters needed to establish the media path.

Since the original idea to exchange session description information in the form of Session Description Protocol (SDP) "blobs" presented several shortcomings, some of which turned out to be really hard to address, the IETF is now standardizing the JavaScript Session Establishment Protocol (JSEP). JSEP provides the interface needed by an application to deal with the negotiated local and remote session descriptions (with the negotiation carried out through whatever signaling mechanism might be desired), together with a standardized way of interacting with the ICE state machine.

The JSEP approach delegates entirely to the application the responsibility for driving the signaling state machine: the application must call the right APIs at the right times, and convert the session descriptions and related ICE information into the defined messages of its chosen signaling protocol, instead of simply forwarding to the remote side the messages emitted from the browser [31].

III.10 WebRTC API

The W3C WebRTC 1.0 API allows a JavaScript application to take advantage of the novel browser's real-time capabilities. The real-time browser function (see Figure III.3) implemented in the browser core provides the functionality needed to establish the necessary audio, video, and data channels. All media and data streams are encrypted using DTLS.[1]

III.10.1 Datagram Transprt Layer Security (DTLS)

The DTLS (Datagram Transport Layer Security) protocol is designed to prevent eavesdropping, tampering, or message forgery to the datragram transport offered by the User Datagram Protocol (UDP). The DTLS protocol is based on the stream oriented Transport Layer Security (TLS) protocol and is intended to provide similar security guarantees.

The DTLS handshake performed between two WebRTC clients relies on self signed certificates. As a result, the certificates themselves cannot be used to authenticate the peer, as there is no explicit chain of trust to verify.

To ensure a baseline level of interoperability between different realltime browser function implementations, the IETF is working on selecting a minimum set of mandatory to support audio and video codecs. Opus and G.711 have been selected as the mandatory to implement audio codecs. However, at the time of this writing, IETF has not yet reached a consensus on the mandatory to implement video codecs. The API is being designed around three main concepts: MediaStream, PeerConnec tion, and DataChannel [31].

III.10.2 MediaStream

A MediaStream is an abstract representation of an actual stream of data of audio and/or video. It serves as a handle for managing actions on the media stream, such as displaying the stream's content, recording it, or sending it to a remote peer. A Media Stream may be extended to represent a stream that either comes from (remote stream) or is sent to (local stream) a remote node. A LocalMediaStream represents a media stream from a local media-

[1] DTLS is actually used for key derivation, while SRTP is used on the wire. So, the packets on the wire are not DTLS (except for the initial handshake).

capture device (e.g., webcam, microphone, etc.). To create and use a local stream, the web application must request access from the user through the getUserMedia() function. The application specifies the type of media audio or video to which it requires access. The devices selector in the browser interface serves as the mechanism for granting or denying access. Once the application is done, it may revoke its own access by calling the stop() function on the LocalMediaStream.

Media-plane signaling is carried out of band between the peers; the Secure Real-time Transport Protocol (SRTP) is used to carry the media data together with the RTP Control Protocol (RTCP) information used to monitor transmission statistics associated with data streams. DTLS is used for SRTP key and association management. As Figure III.5 shows, in a multimedia communication each medium is typically carried in a separate RTP session with its own RTCP packets. However, to overcome the issue of opening a new NAT hole for each stream used, the IETF is currently working on the possibility of reducing the number of transport layer ports consumed by RTP-based real-time applications. The idea is to combine (i.e., multiplex) multimedia traffic in a single RTP session [31].

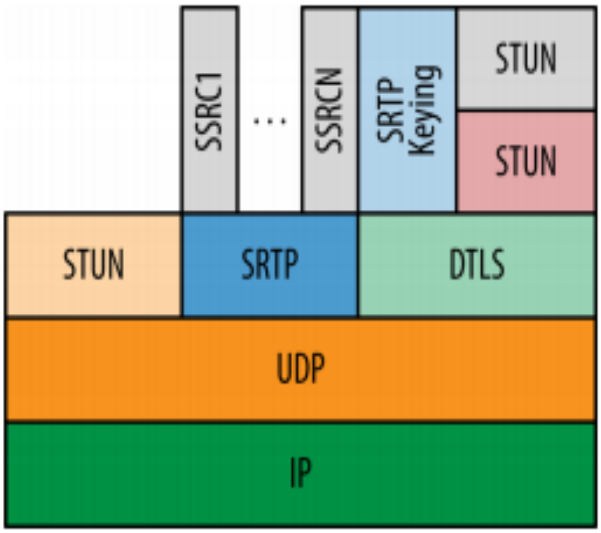


Figure III.5. WebRTC protocol stack.

III.10.3 PeerConnection

A PeerConnection allows two users to communicate directly, browser to browser. It then represents an association with a remote peer, which is usually another instance of the same JavaScript application running at the remote end. Communications are coordinated via a signaling channel provided by scripting code in the page via the web server, e.g., using XMLHttpRequest or WebSocket. Once a peer connection is established, media streams (locally associated with ad hoc defined MediaStream objects) can be sent directly to the remote browser.

III.10.4 STUN and TURN

The Session Traversal Utilities for NAT (STUN) protocol allows a host application to discover the presence of a network address translator on the network, and in such a case to

obtain the allocated public IP and port tuple for the current connection. To do so, the protocol requires assistance from a configured, third-party STUN server that must reside on the public network.

The Traversal Using Relays around NAT (TURN) protocol allows a host behind a NAT to obtain a public IP address and port from a relay server residing on the public Internet. Thanks to the relayed transport address, the host can then receive media from any peer that can send packets to the public Internet.

The PeerConnection mechanism uses the ICE protocol together with the STUN and TURN servers to let UDP-based media streams traverse NAT boxes and firewalls. ICE allows the browsers to discover enough information about the topology of the network where they are deployed to find the best exploitable communication path. Using ICE also provides a security measure, as it prevents untrusted web pages and applications from sending data to hosts that are not expecting to receive them. Each signaling message is fed into the receiving PeerConnection upon arrival. The APIs send signaling messages that most applications will treat as opaque blobs, but which must be transferred securely and efficiently to the other peer by the web application via the web server [31].

III.10.5 DataChannel

The DataChannel API is designed to provide a generic transport service allowing web browsers to exchange generic data in a bidirectional peer-to-peer fashion. The standardization work within the IETF has reached a general consensus on the usage of the Stream Control Transmission Protocol (SCTP) encapsulated in DTLS to handle non media data types (see Figure III.5).

The encapsulation of SCTP over DTLS over UDP together with ICE provides a NAT traversal solution, as well as confidentiality, source authentication, and integrity protected transfers. Moreover, this solution allows the data transport to interwork smoothly with the parallel media transports, and both can potentially also share a single transport layer port number. SCTP has been chosen since it natively supports multiple streams with either reliable or partially reliable delivery modes. It provides the possibility of opening several independent streams within an SCTP association towards a peering SCTP endpoint. Each stream actually represents a unidirectional logical channel providing the notion of insequence delivery. A message sequence can be sent either ordered or unordered. The message delivery order is preserved only for all ordered messages sent on the same stream. However, the DataChannel API has been designed to be bidirectional, which means that each DataChannel is composed as a bundle of an incoming and an outgoing SCTP stream.

The DataChannel setup is carried out (i.e., the SCTP association is created) when the CreateDataChannel() function is called for the first time on an instantiated PeerConnection object. Each subsequent call to the CreateDataChannel() function just creates a new DataChannel within the existing SCTP association [31].

III.11 Famous Application using WebRTC

The huge capabilities provided by the WebRTC, which facilitates real-time communication, made many companies race to use these technologies to create various applications and different platforms for remote communication.

III.11.1 Google Meet and Google Hangouts

Google Meet (or more accurately, Hangouts) is most probably one of the main reasons we have WebRTC.

Google had their own video conferencing service, working from Gmail, but it needed a plugin. Real time video just wasn't there in the browser, which is where and why WebRTC started. And it started with a contribution by Google which we now know as webrtc.org.

To date, Google Meet (or Hangouts), is a massive application that makes use of WebRTC.

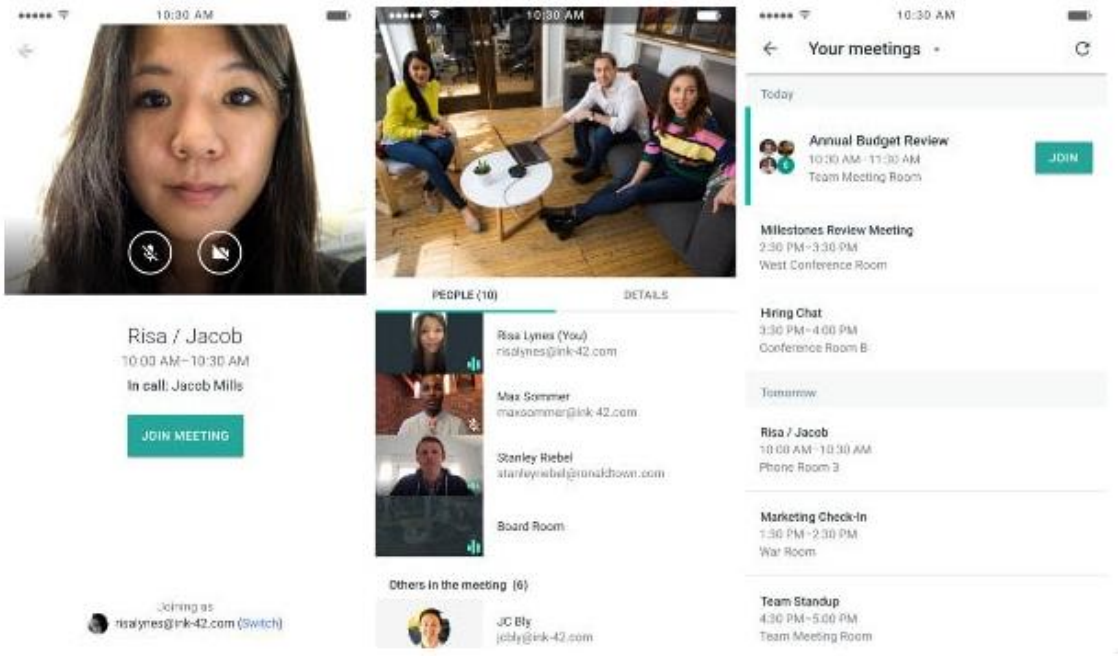


Figure III.6. Google meet.

III.11.2 Facebook messenger

Facebook Messenger is an instant messaging system created by the Facebook company, and incorporated into the social networks Facebook and Instagram.

The application, available for Windows and various mobile operating systems, allows members of the social network to interact with their contacts without necessarily being connected to the website.

In June 2014, David Marcus was hired by Facebook and became vice president of messaging Messenger2. In May 2018, he left the vice-presidency to devote himself to projects related to blockchain3.

Since July 2015, Facebook's mobile applications have systematically redirected messaging to the Facebook Messenger application. The application has also become accessible to users who do not have a Facebook account but register with their phone number.



Figure III.7. Facebook massenger.

III.11.3 Discord

Discord, a popular group-chatting app, was originally made to give gamers a place to build communities and talk. But since its launch in 2015, it has branched out to include communities from all over the internet, ranging from writers to artists to K-Pop stans. It has boomed in popularity during the pandemic of covid 19, as more people have worked, played games, and socialized online, and the platform now has more than 140 million active monthly users.

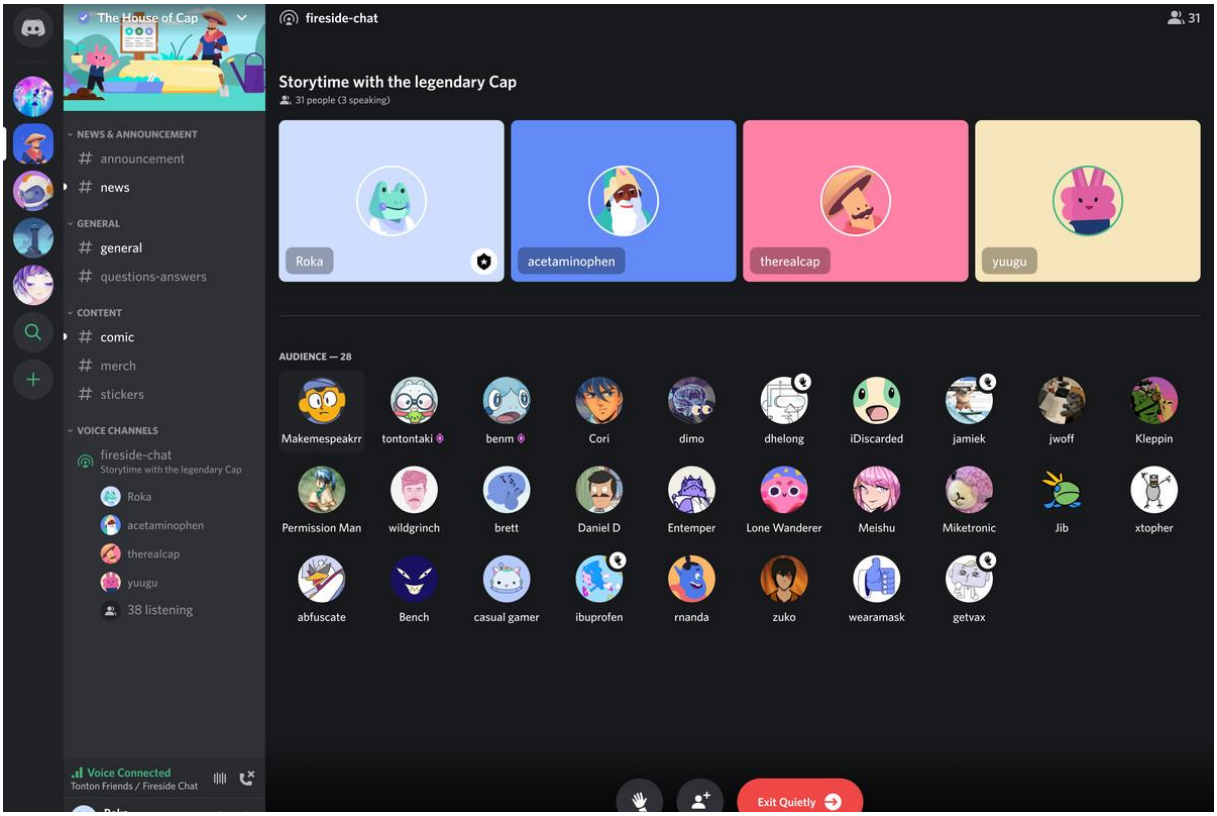


Figure III.8. Discord.

III.11.4 Amazon chime

Amazon Chime is a communications service that allows you to meet and chat with your employees, as well as make business calls within and outside your organization, all from a single app. Developers can use the same communications infrastructure and services that power Amazon Chime. They can also add audio calling, video calling and screen sharing functions directly to their applications using the Amazon Chime SDK.

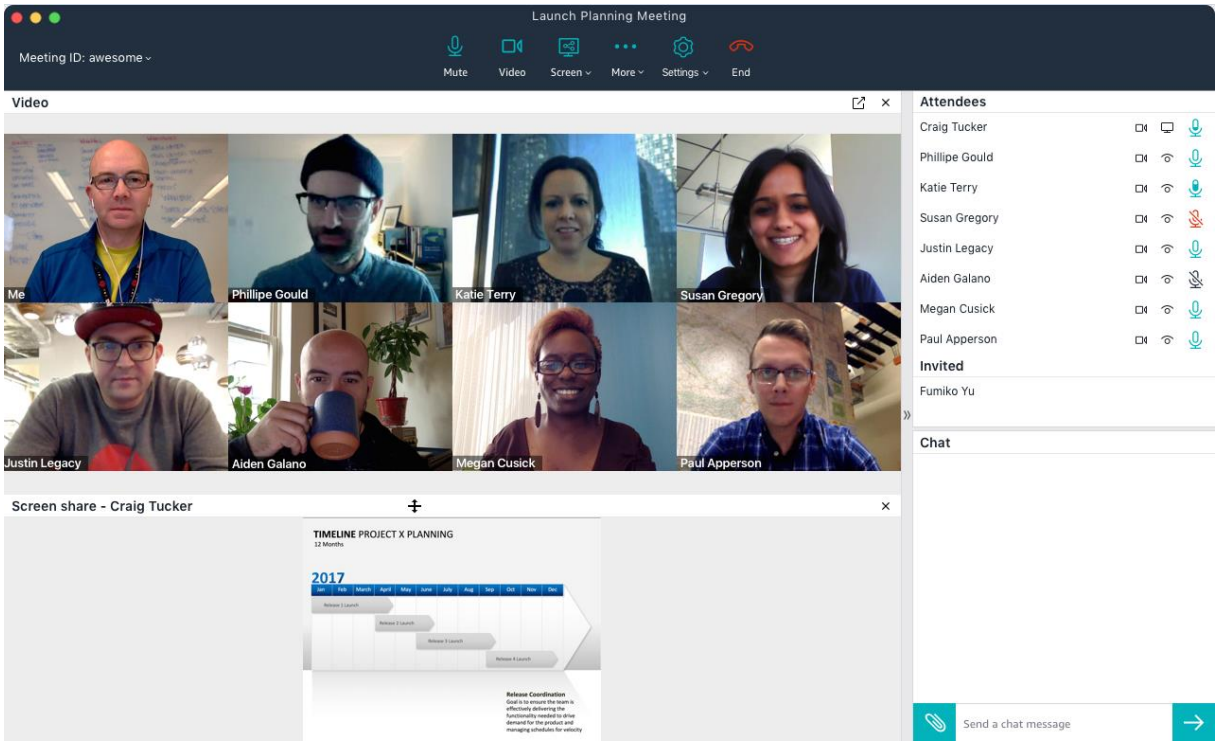


Figure III.9. Amazon chime.

III.12 Conclusion

In this chapter, we have given a little overview on WebRTC and its different concept. Next, we have presented the webRTC APIs and their operating principle. These terms related to WebRTC will be used in the next chapter which will present the design of our system and the relationship of the previous chapters with the intended objectives of our theme.

Chapter IV

Conception

IV.1 Introduction

The design of any solution must be dealt within a precise and detailed manner, preceded by a deep and well-considered analysis, because it is the reflection of the future system before even its realization. In this chapter, we will first explain the main causes and the stated objectives of the realization of this remote monitoring application. Then, a global IT solution is presented in order to see the technical approach followed which will be detailed by an information system design method, namely the UML language allowing to represent well the functional and static aspect of this solution.

IV.2 Architecture of the proposed solution

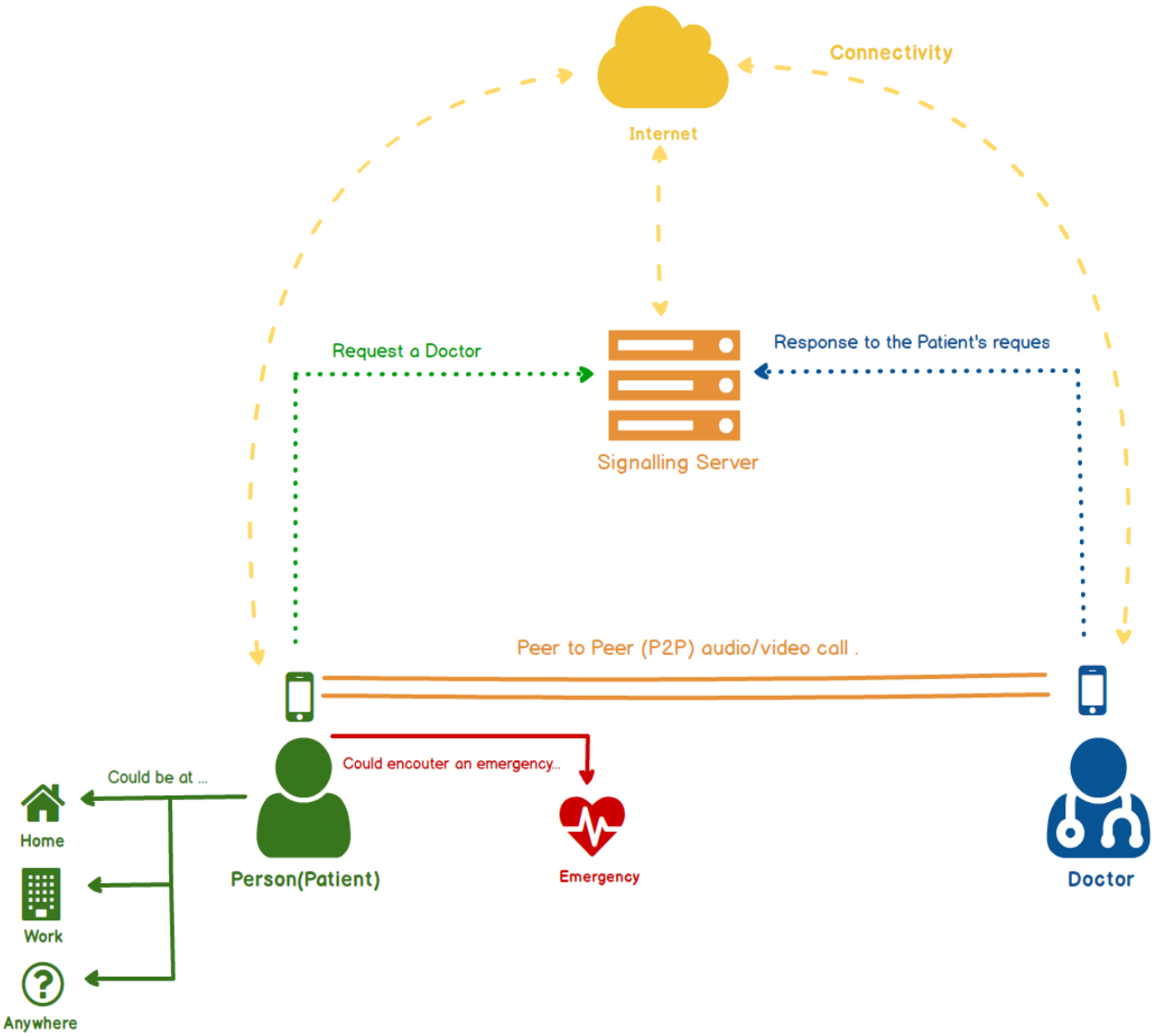


Figure IV.1. Global schema of solution.

IV.3 Modelization

The unified modeling language (UML), is an object-oriented modeling language, i.e. all modeled entities are objects or related objects. Object has a data structure (with this which are called "attributes") and behaviours (with what are called “Operations”). This language was born from the fusion of several previously existing methods and has become now the benchmark in terms of object

modeling adopted by Object Management Group (OMG), it has thus become the industry standard. This is a visual form based on diagrams for the visualization of the system design. UML is used to specify, view, modify and build documents necessary for the proper development of object-oriented software, but also for systems non-IT.

IV.4 Functional aspect

In this part we presented the UML diagrams that we used including: use case diagram, sequence diagram, class diagram.

IV.4.1 Use case diagram

The use case diagram represents the structure of the major features required by system users. This is the first diagram of the UML model, the one where ensures the relationship between the user and the objects that the system implements.

A use case diagram captures the behaviour of a system, subsystem, or component as seen by an outside user. It splits the functionality of the system in coherent units, the use cases, meaningful to actors. Use cases are used to express the needs of users of a system, they are therefore a user-oriented vision of users need, unlike a computer vision.

Elements of use case diagrams [36]:

- Actor: is the idealization of a role played by an external person (represented by a small man with his name).
- Use case is represented by an ellipse containing the name of the case.
- Continuous line linking the actor to a use case.
- Relationship between one use case to another.
- System boundary is represented by a frame.

IV.4.1.1 Global use case

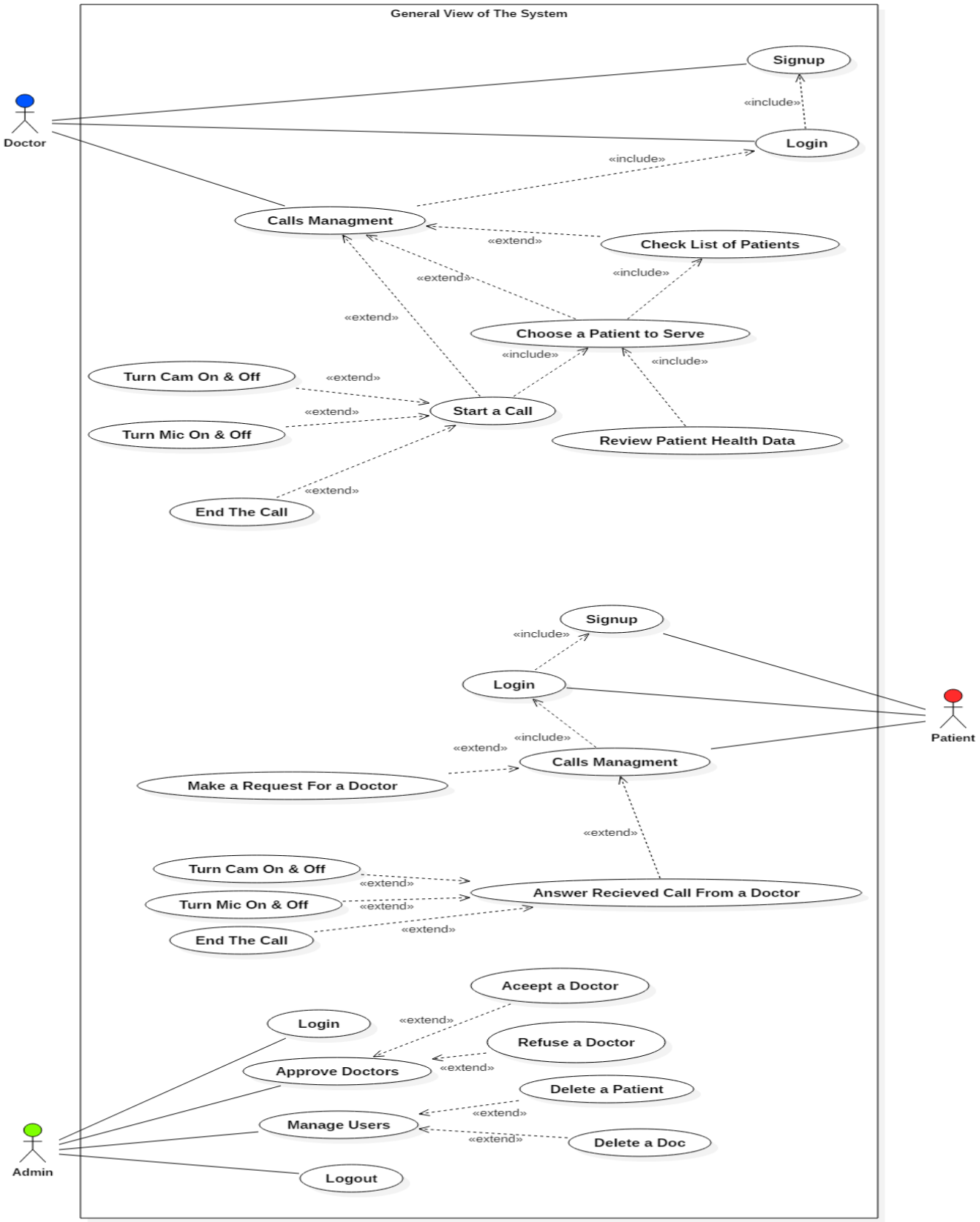


Figure IV.2. Global use case.

In order to guarantee maximum data security, no action is permitted without Authentication access limits, are based on the type of user.

In the global use case diagram figures we have provided a global view of the system represented by general use cases.

IV.4.1.1.1 Text description of use case

USE CASE	Description
Actor	Admin
Nominal scenario	Login, Approve doctors(accept or refuse doctors), manage users(delete doctors or patient),logout
Actor	Doctor
Nominal scenario	Signup, login, calls management: check list of patient, chose a patient to serve, start a call (turn camera on/off, turn microphone on/off, end the call), Review patient health data.
Actor	Patient
Nominal scenario	Signup, login , calls management(make a request for a doctor, answer received calls from doctors(turn camera on/off, turn microphone on/off, , end the call))

Table IV.1. Description of use cases.

IV.4.2 Sequence diagram

The sequence diagram represents the chronological succession of operations performed by an actor. It indicates the objects that the actor will manipulate and the operations that make move from one object to another.

The main information contained are the messages exchanged between the lines of life and the both constructing a sequence diagram, presented in chronological order [37].

IV.6.2.1 Patient login (Authentication)

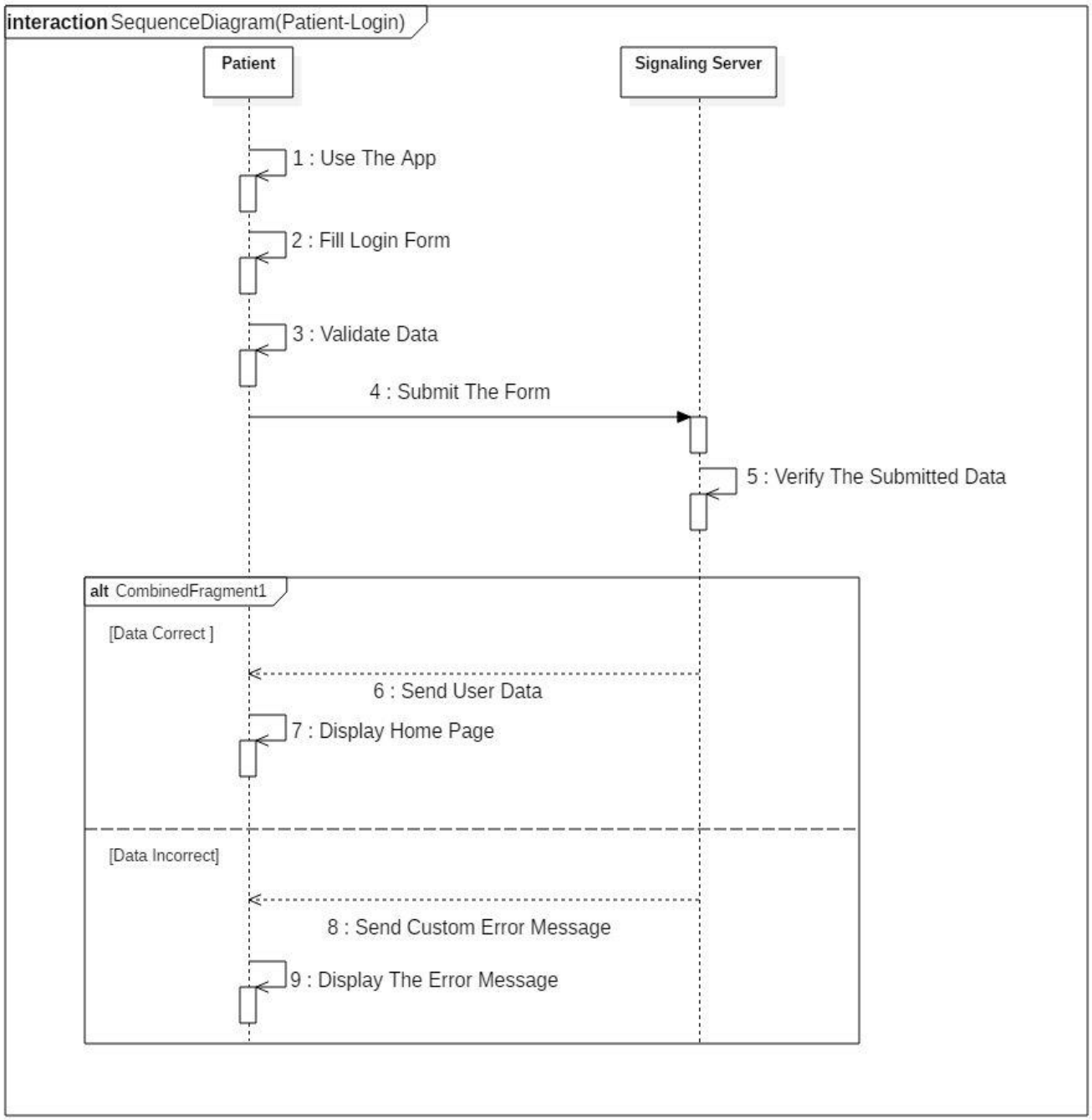


Figure IV.3. Sequence diagram of patient login.

This diagram, shows the login operation for the patient, it is done by sending a query to the server, containing the login credentials, those credentials, gets validated locally first (in the app before sending the request to the server), if they are correct the server receives the query and verify the given data in the database, if the credentials matches with the data stored in the database, a full object containing the patient's data, will be sent back to the patient , and the Application will display the home page. and if they are not correct, the server will send a proper error message to the patient, where the Application will eventually display it.

IV.4.2.2 Patient request a doctor

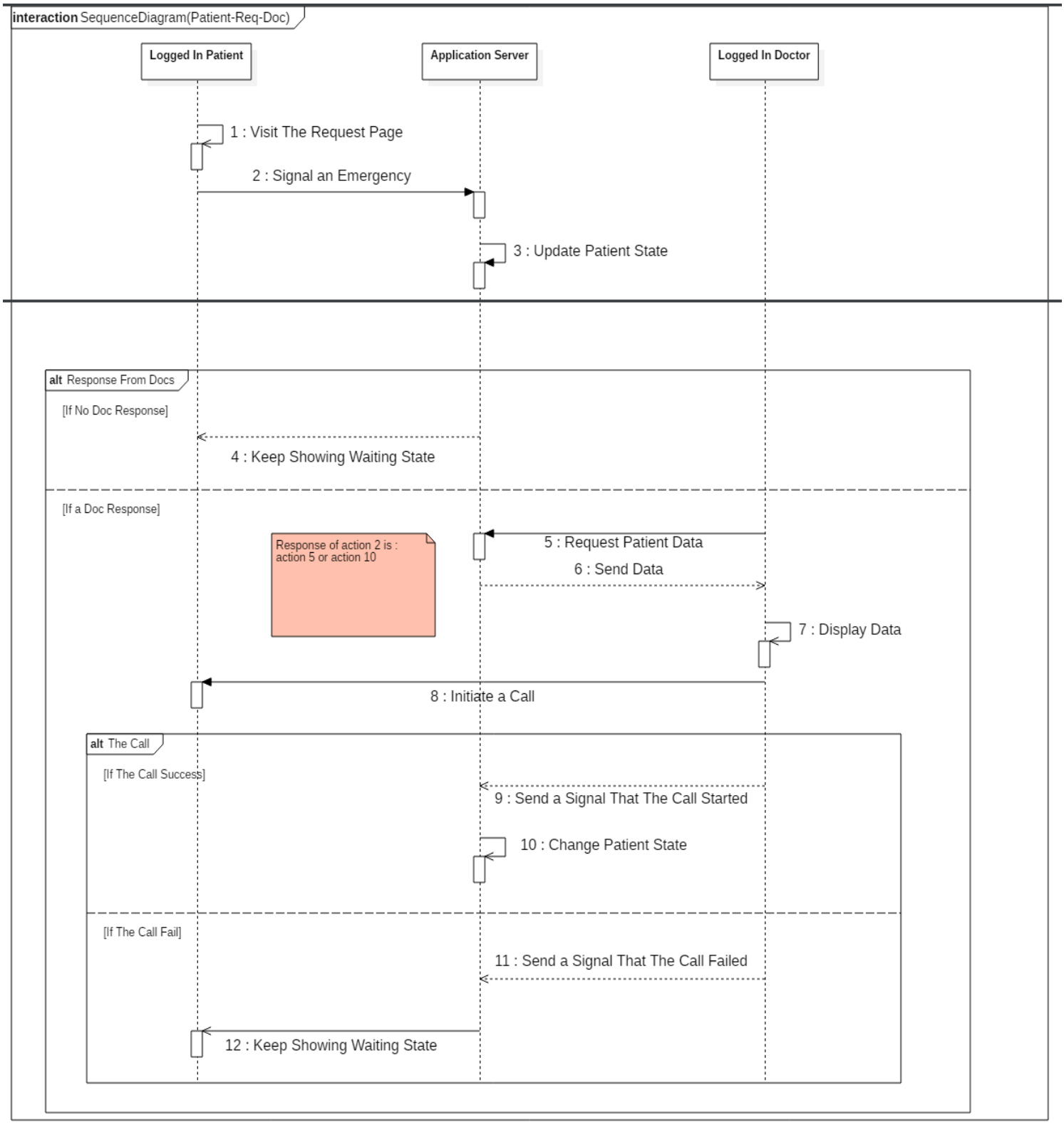


Figure IV.4. Sequence diagram of patient request a doctor.

The sequence diagram for the operation: Patient request a doctor, illustrate that the operation is triggered by the patient sending an emergency signal to the server, the server update the state of the patient, so that he will appear for the doctors searching patients who needs to be served. In case no doctor response to the request of the patient, a waiting status will be shown to the patient, and in case a doctor responses, a call will be initiated as the rest of the steps described in the diagram.

IV.6.2.3 A doctor request the list of the available patients.

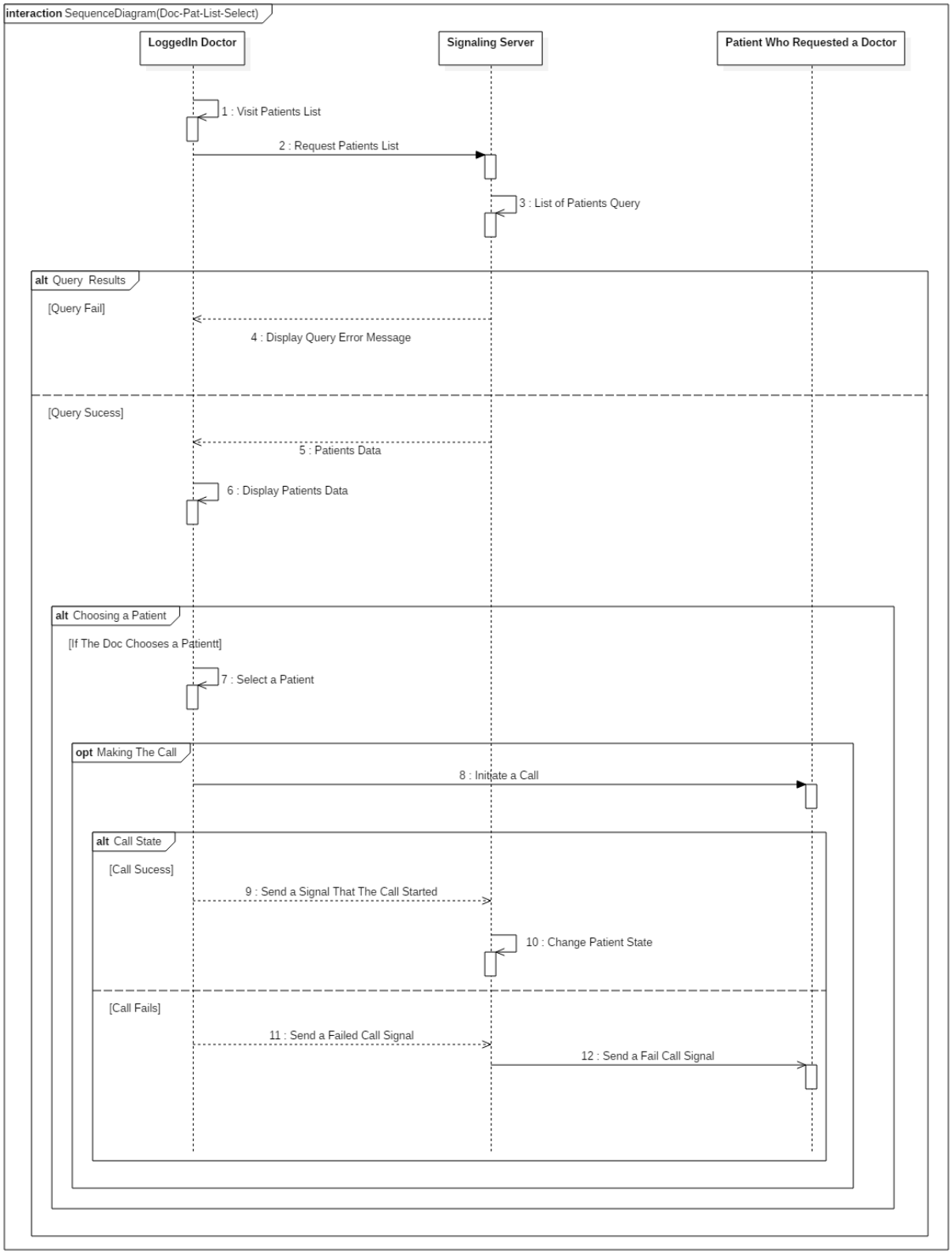


Figure IV.5. Sequence diagram of A doctor request the list of the available patients to serve along with selecting one of them to call.

This sequence diagram, shows the operation concerning requesting the list of the available patients to serve along with selecting one of them to call.

First, the doctor requests the data of the available patients from the server, an error message will be sent to the doctor in case the operation is not succeed, else, the patients data will be sent to the doctor as a result, the Application display the received data of the patients.

In case the doctor wants to select a patient to call, a call would be initiated with the selected patient, where we can encounter two possible cases.

The first where the call success, and that causes the state of the patient to be changed (meaning that the patient has been served by a doctor), and the second in case the call fails, where both the doctor and the patient will be informed of the failure of establishing a call.

IV.4.3 Class diagram

The class diagram is generally considered to be the most important in object-oriented development. It represents the conceptual architecture of the system; It also describes the classes that the system uses, as well as their links, this classes represent a conceptual interlocking (inheritance) or an organic relation (aggregation).

The main elements of this static view are the classes and their relationships including: association, generalization, and several types of dependencies such as realization and use [38].

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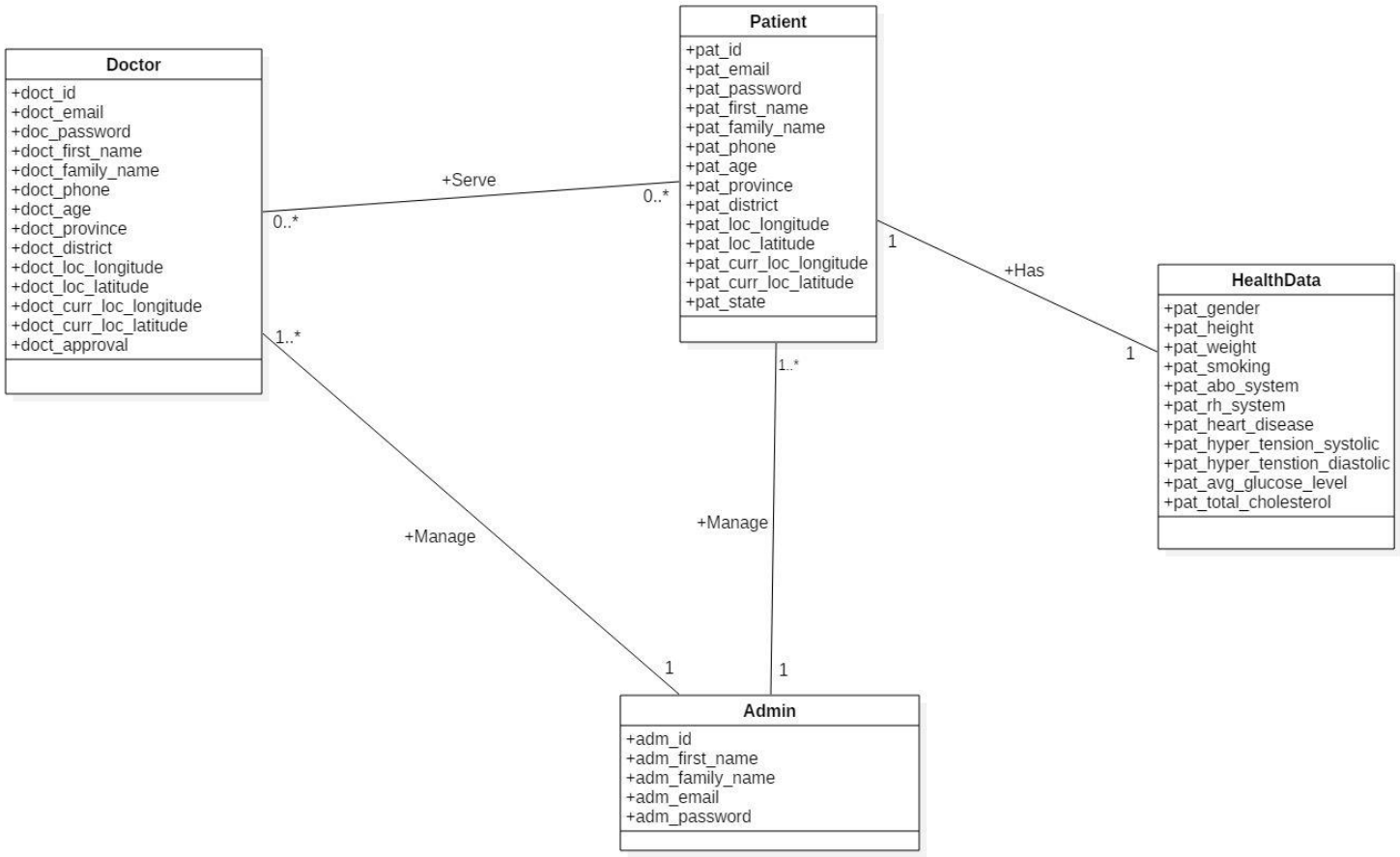


Figure IV.6. Class diagram.

IV.4.3.1 Class diagram description

- **Class "doctor"**

Attribute	Description	Type
doct_id	Identifier of doctor	String
doct_email	Email of doctor	String
doct_password	Password of doctor	String
doct_first_name	First name of doctor	String
doct_family_name	Family name of the doctor	String
doct_phone	Phone number of the doctor	String
doct_age	Age of the doctor	Number
doct_province	Province of doctor	String
doct_district	District of doctor	String
doct_loc_longitude	Doctor location longitude	String
doct_loc_latitude	Doctor location latitude	String
doct_curr_loc_longitude	The currently location longitude of doctor	String
doct_curr_loc_latitude	The currently location latitude of doctor	String
doct_approval	Indicator of the doctor confirmation by the administrators of the system	Binary

Table IV.2. Description of class Doctor.

- **Class "patient"**

Attribute	Description	Type
pat_id	Identifier of patient	String
pat_email	Email of patient	String
pat_password	Password of patient	String
pat_first_name	First name of patient	String
pat_family_name	Family name of patient	String
pat_phone	Phone number of the patient	String
pat_age	Age of patient	Number
pat_province	Province of patient	String
pat_district	District of patient	String
pat_loc_longitude	Patient location longitude	String
pat_loc_latitude	Patient location latitude	String
pat_curr_loc_longitude	Currently location longitude of patient	String
pat_curr_loc_latitude	Currently location latitude of patient	String

pat_state	Indicate whether the patient is in an emergency or not	Binary

Table IV.3. Description of class patient.

- **Class "Admin"**

Attribute	**Description**	**Type**
adm_id	Identifier of admin	String
adm_first_name	First name of admin	String
adm_family_name	Family name of admin	String
adm_email	Email of admin	String
adm_password	Password of admin	String

Table IV.4. Description of class Admin.

- **Class "HealthData"**

Attribute	**Description**	**Type**
pat_gender	Gender of patient	String
pat_height	Height of patient	Number
pat_weight	Weight of patient	Number
pat_smoking	Indicate whether the patient smoke or not	Boolean
pat_abo_system	The ABO blood group of the patient	String
pat_rh_system		String
pat_heart_disease		Boolean
pat_hyper_tension_systolic	This for hyper tension systolic of patient unit: Blood pressure is measured in units of millimeters of mercury (mmHg). The readings are always given in pairs with the upper (systolic) value first, followed by the lower (diastolic) value. -Normal blood pressure. below :120/80 mm Hg -Elevated blood pressure: systolic pressure ranging from 120 to 129 mm Hg and a diastolic pressure below (not above) 80 mm Hg. -Stage 1 hypertension: systolic pressure ranging from 130 to 139 mm Hg or a diastolic pressure ranging	Number

	from 80 to 89 mm Hg -Stage 2 hypertension: systolic pressure of 140 mm Hg or higher or a diastolic pressure of 90 mm Hg or higher. -Hypertensive crisis: Hypertensive crisis. A blood pressure measurement higher than 180/120 mm Hg is an emergency situation that requires urgent medical care	
pat_hyper_tension_dialostic	For hyper tension dialostic of patient unit: Blood pressure is measured in units of millimeters of mercury (mmHg). The readings are always given in pairs with the upper (systolic) value first, followed by the lower (diastolic) value. -Normal blood pressure. below :120/80 mm Hg -Elevated blood pressure: systolic pressure ranging from 120 to 129 mm Hg and a diastolic pressure below (not above) 80 mm Hg. -Stage 1 hypertension: systolic pressure ranging from 130 to 139 mm Hg or a diastolic pressure ranging from 80 to 89 mm Hg -Stage 2 hypertension: systolic pressure of 140 mm Hg or higher or a diastolic pressure of 90 mm Hg or higher. -Hypertensive crisis: Hypertensive crisis. A blood pressure measurement higher than 180/120 mm Hg is an emergency situation that requires urgent medical care	Number
pat_avg_glucose_level	unit: milligrams (mg) per decilitre (dL). -Normal: 170-200 -Impaired Glucose: 190-230 -Diabetic: 220-300 -Need Medical Care : above 300	Number
pat_total_cholesterol	unit: milligrams (mg) per decilitre (dL). Total cholesterol. The combined amount of low-	Number

	density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol in your blood. -Desirable: < 200 -Bordeline High: 200- 239 -High : above 240	

Table IV.5. Description of class Health Data.

IV.5 Relational data model

By applying the passage rules for our class diagram, we end up with the following relational table:

Patient (**pat_id**,pat_email, pat_password, pat_first_name, pat_family_name,pat_phone, pat_age, pat_province, pat_district, pat_loc_longitude,pat_loc_latitude,pat_curr_loc_longitude, pat_curr_loc_latitude , pat_state,).

Doctor (**doct_id**, doct_email, doct_password, doct_first_name, pat_family_name, doct_phone, doct_age, doct_province, doct_district, doct_loc_longitude, doct_loc_latitude, doct_curr_loc_longitude, doct_curr_loc_latitude,).

Admin (**adm_id**, adm_first_name, adm_family_name, adm_email, adm_password).

HealthData (**id_health_data**, pat_gender, pat_height,pat_weight, pat_smoking, pat_abo_system, pat_rh_system, pat_heart_disease, pat_hyper_tension_systolic, pat_hyper_tension_diastolic, pat_avg_glucose_level, pat_total_cholesterol).

IV.6 Conclusion

In this chapter we have presented our design vision, with the presentation of the objectives of our proposed solution. Thus we have described the two functional and static aspects of our solution through the development of use case diagram, sequence and class diagram.

In the next chapter we will talk about the implementation of our idea by presenting the tools used in the realization of the application as well as the main user graphical interfaces.

Chapter V

Implementation, Test and Results

V.1 Introduction

The main objective of this chapter is to present the realization of our application which uses specific technologies. This chapter is made up of two parts: the first part presents the development technologies used to build our application, while the second part concerns the main graphical interfaces.

V.2 Development environment

To develop an application, the development environment as well as the technologies used are many and varied depending on the type of application we are agrees to achieve. Below we present, among many others, the few technologies used for the case of our work.

To realize our application, we used the programming language (Dart + sdk), which we used it in a development environment called Flutter.

V.3 Development technologies

We have used multiple technologies to implement this work , including:

- **MongoDB**



MongoDB is a source-available cross-platform document-oriented database program. Classified as a NoSQL database program, MongoDB uses JSON-like documents with optional schemas. MongoDB is developed by MongoDB Inc. and licensed under the Server Side Public License (SSPL) [39].

- **Node.js**



Node.js is an open-source, cross-platform, back-end JavaScript runtime environment that runs on the V8 engine and executes JavaScript code outside a web browser. Node.js lets developers use JavaScript to write command line tools and for server-side scripting—running scripts server-side to produce dynamic web page content before the page is sent to the user's web browser. Consequently, Node.js represents a "JavaScript everywhere" paradigm, unifying web-application development around a single programming language, rather than different languages for server-side and client-side scripts.

Though (.js) is the standard filename extension for JavaScript code, the name "Node.js" doesn't refer to a particular file in this context and is merely the name of the product. Node.js has an event-driven architecture capable of asynchronous I/O. These design choices aim to optimize throughput and scalability in web applications with many input/output operations, as well as for real-time Web applications (e.g., real-time communication programs and browser games).

The Node.js distributed development project was previously governed by the Node.js Foundation, and has now merged with the JS Foundation to form the Open JS Foundation, which is facilitated by the Linux Foundation's Collaborative Projects program [40].

- **Express.js**

Express.js, or simply **Express**, is a back end web application framework for Node.js, released as free and open-source software under the MIT License. It is designed for building web applications and APIs.It has been called the de facto standard server framework for Node.js.

The original author, TJ Holowaychuk, described it as a Sinatra-inspired server, meaning that it is relatively minimal with many features available as plugins. Express is the back-end component of popular development stacks like the MEAN, MERN or MEVN stack, together with the MongoDB database software and a JavaScript front-end framework or library [41].

- **Socket.io**

Socket.IO is a JavaScript library for real-time web applications. It enables real-time, bi-directional communication between web clients and servers. It has two parts: a client-side library that runs in the browser, and a server-side library for Node.js. Both components have a nearly identical API. Like Node.js, it is event-driven.

Socket.IO primarily uses the Web Socket protocol with polling as a fullback option, while providing the same interface. Although it can be used as simply a wrapper for WebSocket, it provides many more features, including broadcasting to multiple sockets, storing data associated with each client, and asynchronous I/O.

It can be installed with the npm tool [42].

- **Flutter**

Flutter is an open-source UI software development kit created by Google. It is used to develop cross platform applications for Android, iOS, Linux, Mac, Windows, Google Fuchsia,and the web from a single codebase.

The first version of Flutter was known as codename "Sky" and ran on the Android operating system. It was unveiled at the 2015 Dart developer summit with the stated intent of being able to render consistently at 120 frames per second.During the keynote of Google Developer Days in Shanghai, Google announced Flutter Release Preview 2, which is the last

big release before Flutter 1.0. On December 4, 2018, Flutter 1.0 was released at the Flutter Live event, denoting the first "stable" version of the Framework. On December 11, 2019, Flutter 1.12 was released at the Flutter Interactive event.

On May 6, 2020, the Dart software development kit (SDK) in version 2.8 and the Flutter in version 1.17.0 were released, where support was added to the Metal API, improving performance on iOS devices (approximately 50%), new Material widgets, and new network tracking.

On March 3, 2021, Google released Flutter 2 during an online Flutter Engage event. This major update brought official support for web-based applications with new CanvasKit renderer and web specific widgets, early-access desktop application support for Windows, MacOS, and Linux and improved Add-to-App APIs [43].

- **Dart**



Dart is a client-optimized language for developing fast apps on any platform. Its goal is to offer the most productive programming language for multi-platform development, paired with a flexible execution runtime platform for app frameworks.

Languages are defined by their *technical envelope* — the choices made during development that shape the capabilities and strengths of a language. Dart is designed for a technical envelope that is particularly suited to client development, prioritizing both development (sub-second statefull hot reload) and high-quality production experiences across a wide variety of compilation targets (web, mobile, and desktop).

Dart also forms the foundation of Flutter. Dart provides the language and runtimes that power Flutter apps, but Dart also supports many core developer tasks like formatting, analysing, and testing code [44].

- **WebRTC**



WebRTC (Web Real-Time Communication) is a free, open-source project providing web browsers and mobile applications with real-time communication (RTC) via simple application programming interfaces (APIs). It allows audio and video communication to work inside web pages by allowing direct peer-to-peer communication, eliminating the need to install plugins or download native apps. Supported by Apple, Google, Microsoft, Mozilla, and Opera, WebRTC specifications have been published by the World Wide Web Consortium (W3C) and the Internet Engineering Task Force (IETF).

According to the webrtc.org website, the purpose of the project is to "enable rich, high-quality RTC applications to be developed for the browser, mobile platforms, and IoT devices, and allow them all to communicate via a common set of protocols" [31].

V.4 Test and results

We present in this part the results of our works and some interfaces of application.

V.4.1 Application Server

The application server, represents the back-end link between the different actors of the system (Doctor, Patient) and their respective data, stored in a database, it provides several operations including retrieving, updating and storing data for its clients, throughout fetching HTTP requests and getting responses in a form of JSON objects.

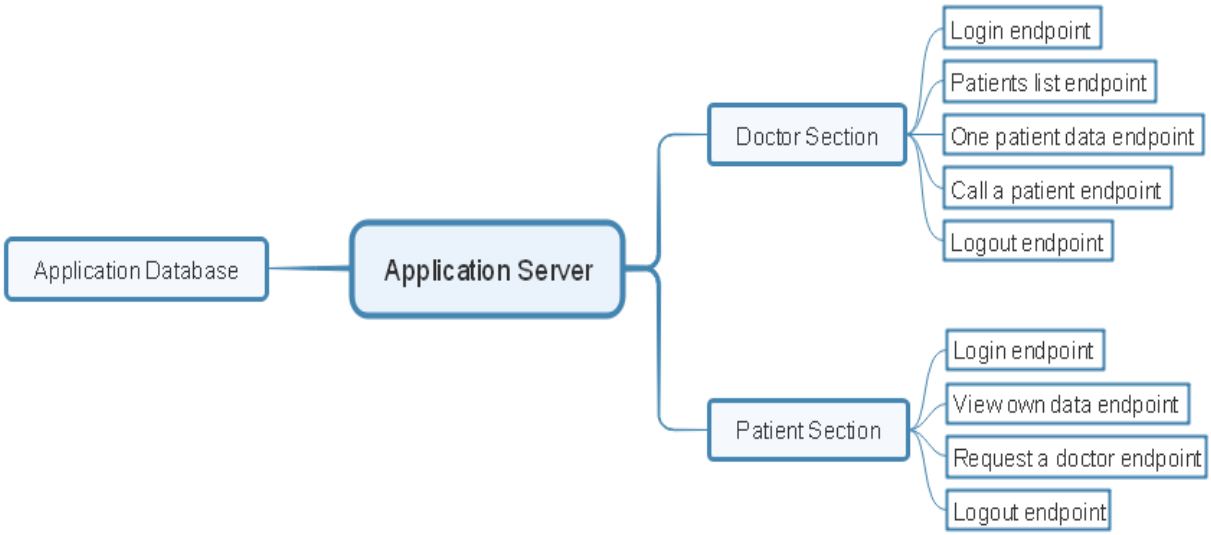


Figure V.1. Application server schema.

V.4.1.1 Implementation

The application server was implemented using Node.js along with Express.js and the Mongoose ODM for database interaction. By targeting the different endpoints that the server provides, the client can get plenty of necessary data and functionalities in return that ensure the functionality of his application (mobile application) and benefits from its features.

When targeting an endpoint, the client must include the necessary data for that endpoint to be executed successfully via the HTTP request body.

Example:

- The endpoint : **http://localhost:3000/doctor/login**
- The HTTP request: must contain in its body the client (doctor) credentials.
- The response: a JSON object containing the doctor full data.

V.4.1.2 Results

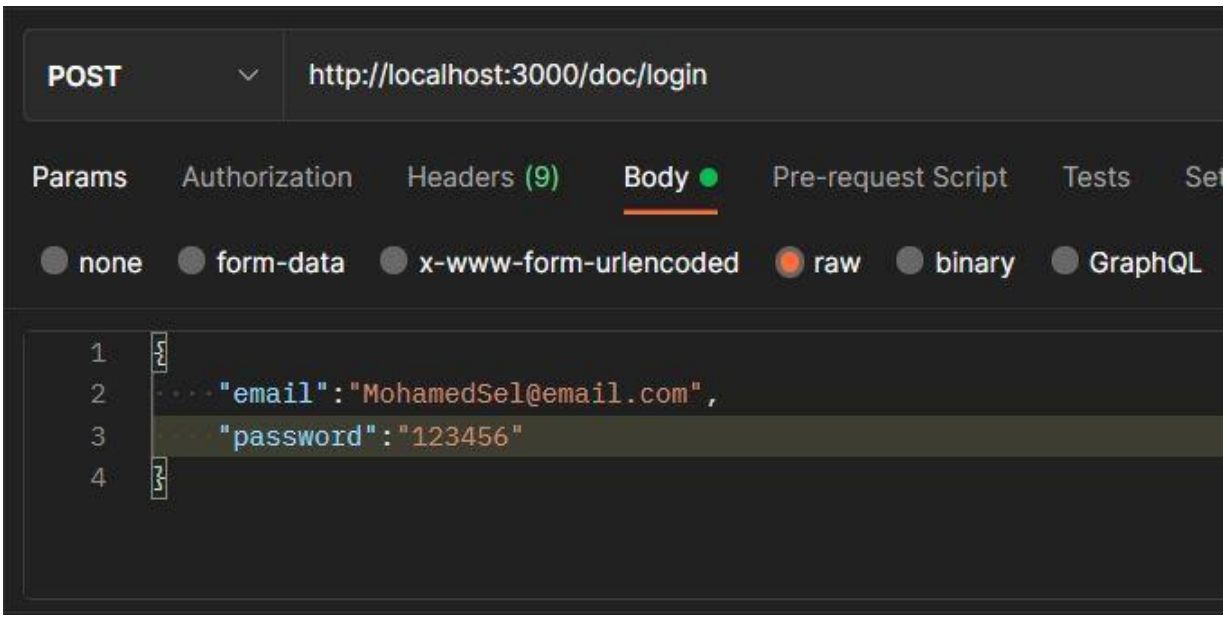


Figure V.2. Server endpoint and request body example.



Figure V.3. Part of the endpoint response.

V.4.2 Admin Server

The administrator server is the interface that allows the administrators of the system to take control of it, and make sure that they are provided with information about its users (patients, doctors) and their state. This server supply the administrators with various functionalities, such as login, checking system statistics, deleting users, accepting new doctors, etc.

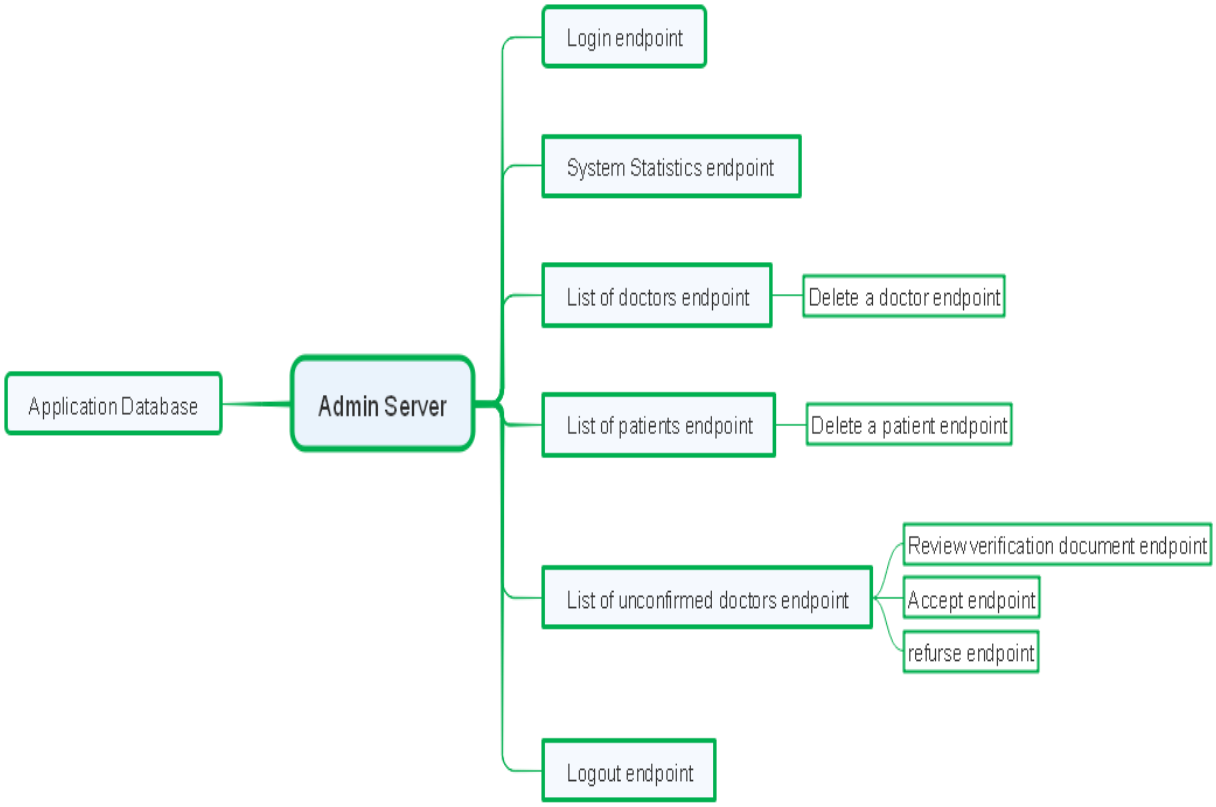


Figure V.4. Admin server schema.

V.4.2.1 Implementation

Its implementation was inspired by the Model-view-controller (MVC) design pattern, using Node.js with Express.js along with the MongoDB driver. The admin must have knowledge about the main entry of this server, once the admin reach the main entry, the server will start responding in a form of HTML pages, populated with data (using EJS templating engine), fetched from the database if needed.

V.4.2.2 Results



Figure V.5. Administrator login page.

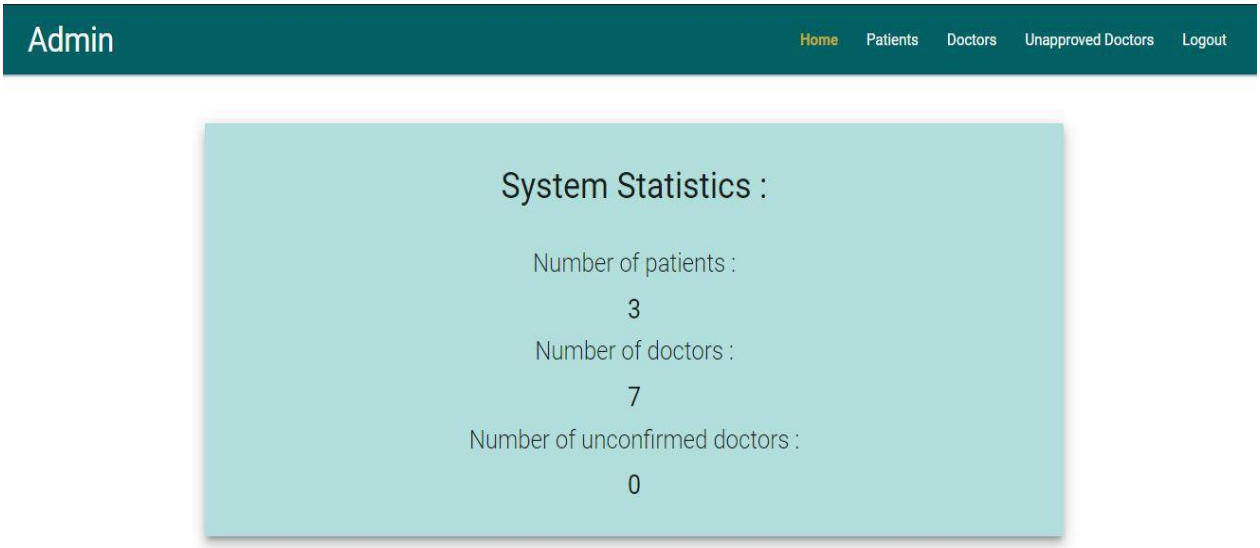


Figure V.6. Administrator home page.

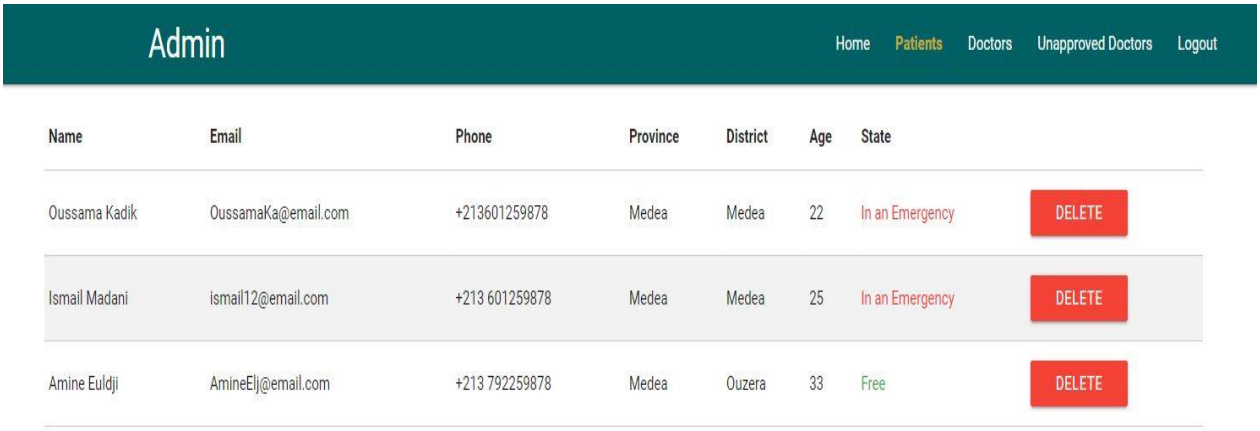


Figure V.7. Patients list page.

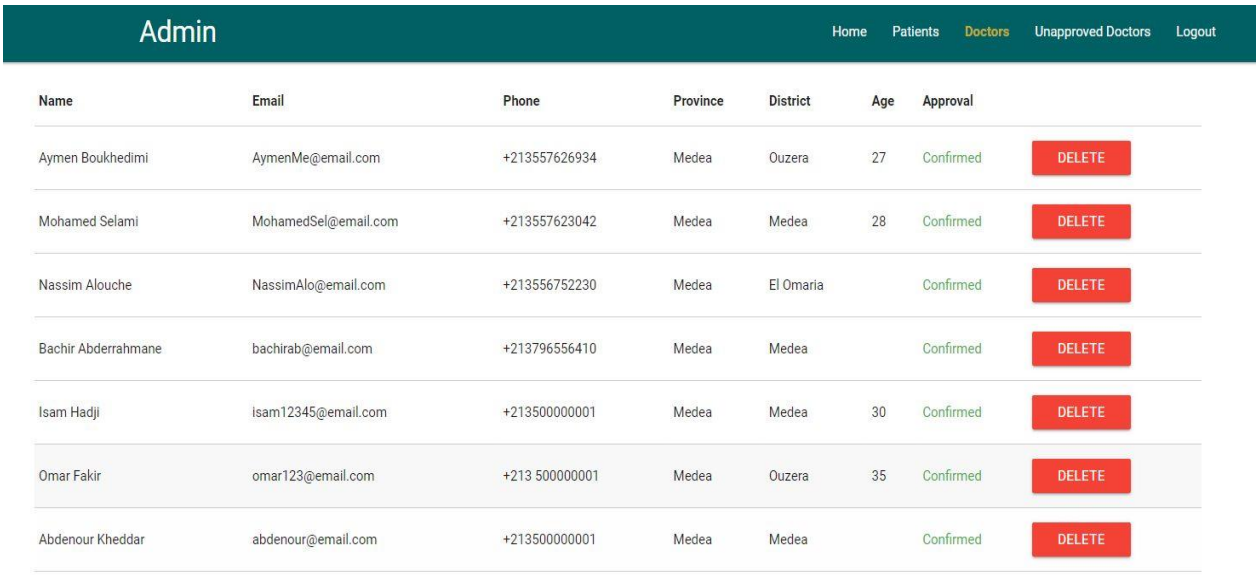


Figure V.8. Doctors list page.

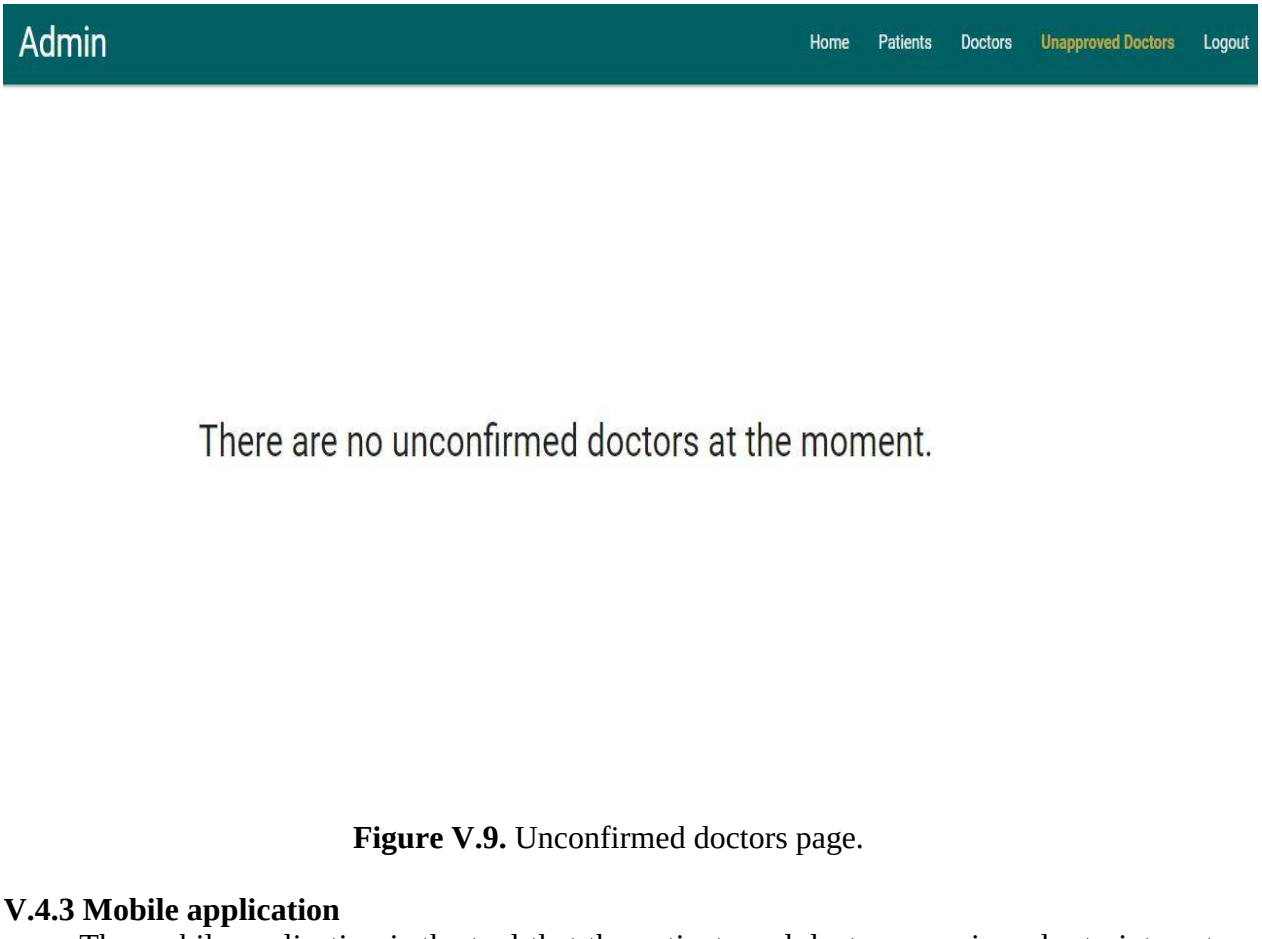


Figure V.9. Unconfirmed doctors page.

V.4.3 Mobile application

The mobile application is the tool that the patients and doctors uses in order to interact with the system and benefits from its features, it provides distinct UI (user interface) for both actors , allowing each , to run the different provided functionalities , as shown in figure 10, with data being served from the application server when needed , through making requests (targeting server endpoints) by forming HTTP requests , and receiving the required data in return, and eventually fetch it on the user screen.

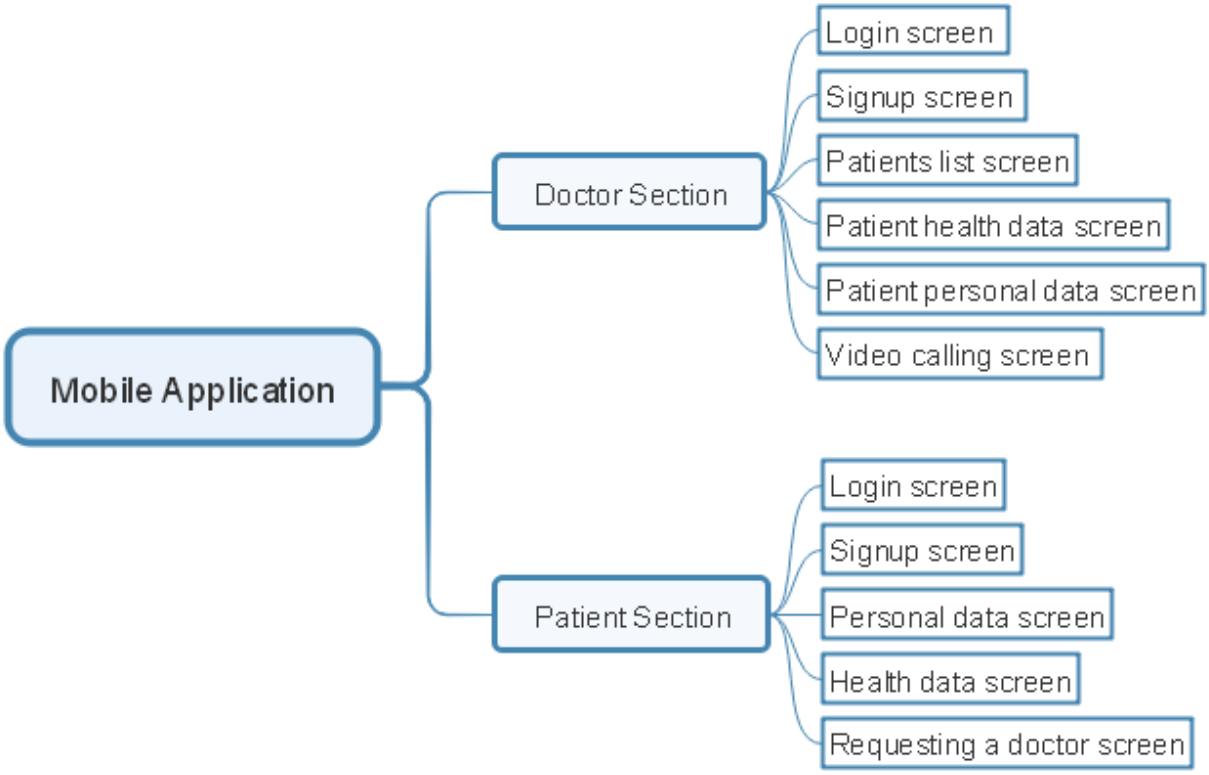


Figure V.10. Mobile application schema.

V.4.3.1 Implementation

The mobile application was built using the open-source UI software development kit Flutter, that uses the Dart programming language in its core. Both the doctor and patient uses the same mobile application, with the possibility to switch to the desired login screen, after performing the login operation successfully, each actor can have access to his selected screens.

V.4.3.2 Results

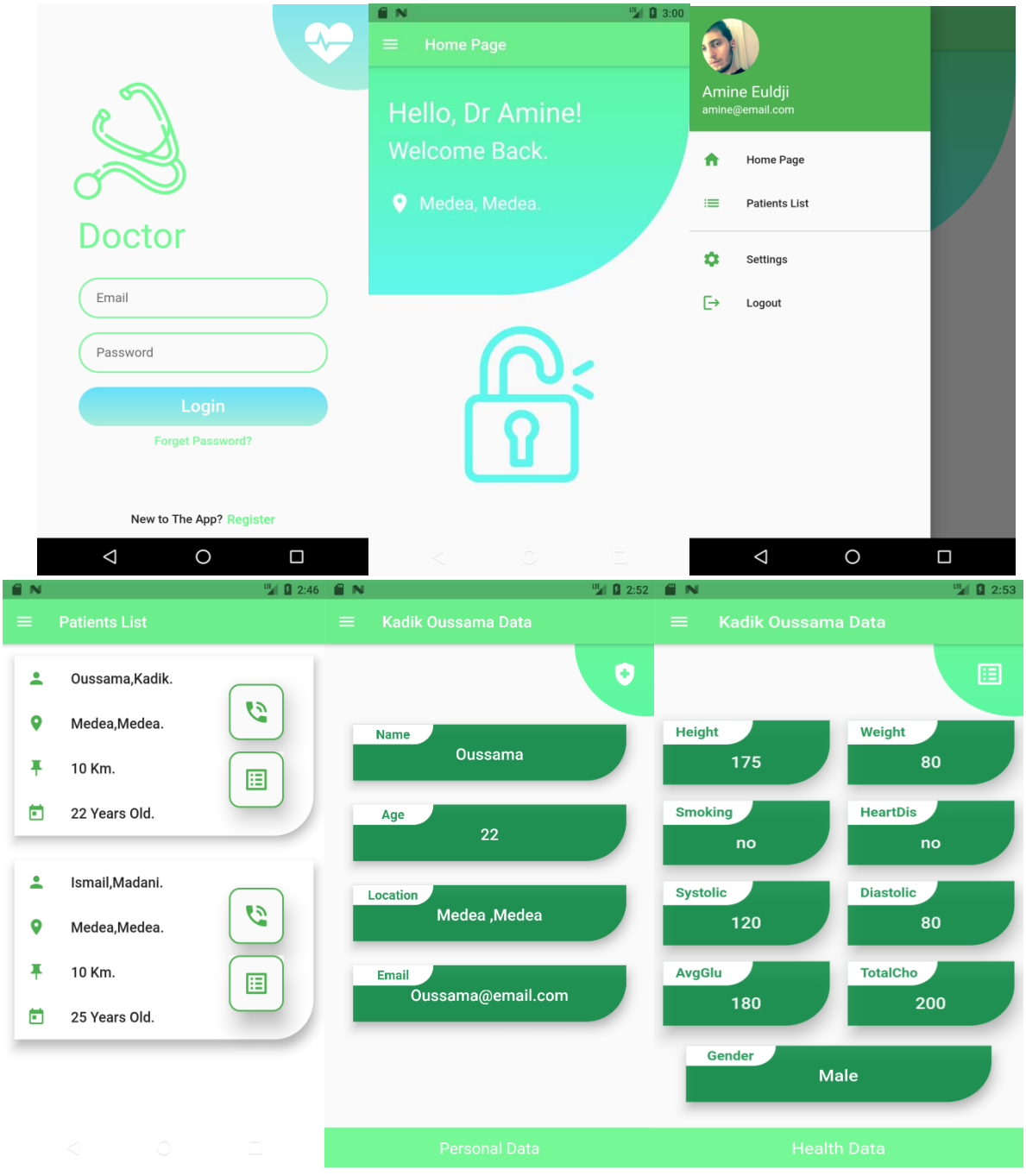


Figure V.11. Doctor screens.

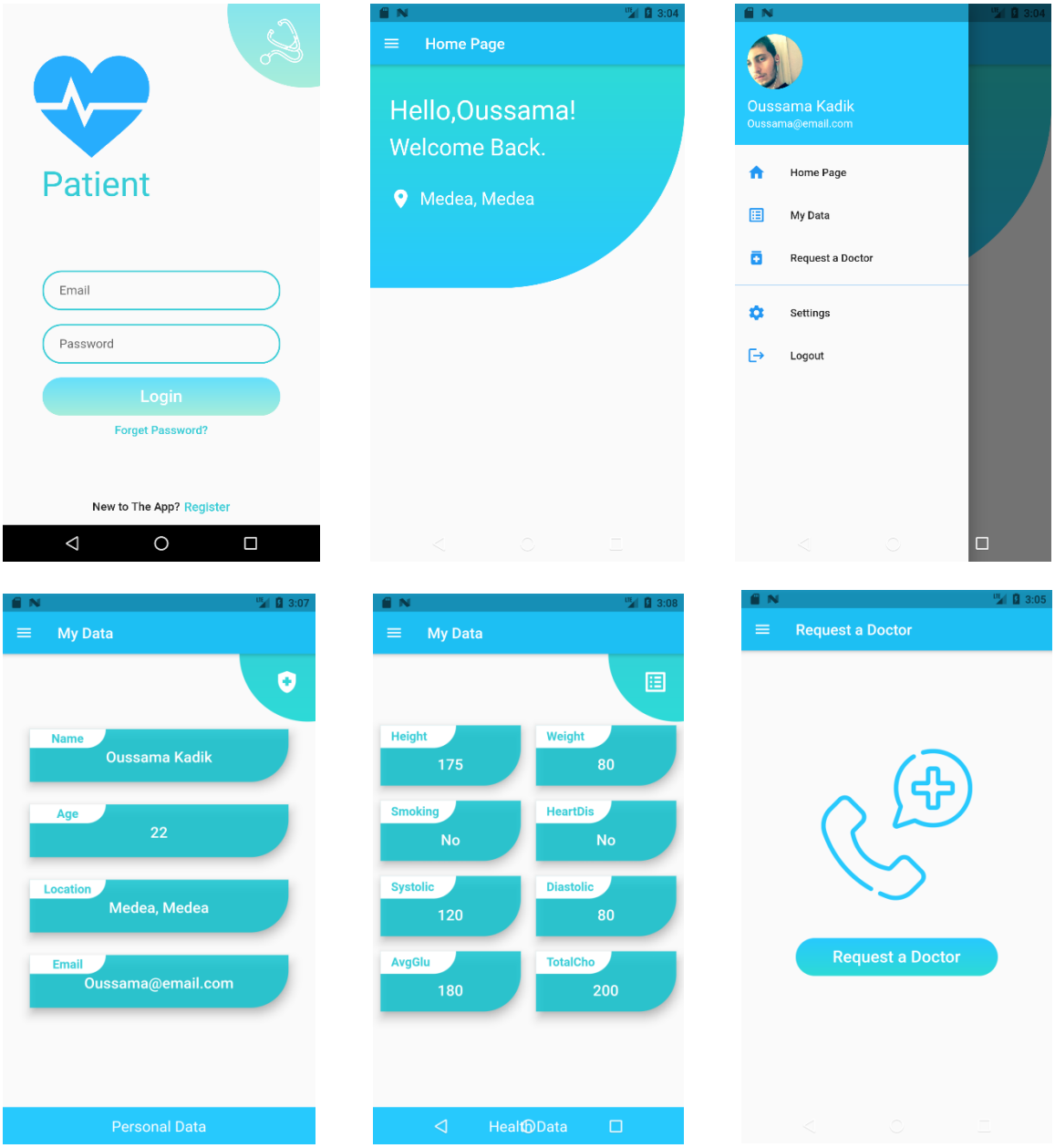


Figure V.12. Patient screens.

V.4.4 Data updating server

The Data updating server plays a very important role in the system, which is simulating a health monitoring device, that update the health data of each patient regularly in a unit of time.

V.4.4.1 Implementation

The data updating server was implement using Node.js, depending heavily on its scheduling system to perform different actions in different unit of times, and Mongoose ODM to interact with the database and altering it, the server has different updating methods for each health measurement we have in the system, taking the Glucose level in the human body as an example:

- Unit: milligrams (mg) per decilitre (dl).

- Normal: 170-200.
- Impaired Glucose: 190-230.
- Diabetic: 220-300.
- Need Medical Care: above 300.
- A method called update Glucose, sets the Glucose indicator to a value in the range 170 – 350, each 30 minutes (unit of time).

V.4.5 Agora platform

Agora.io provides an SDK that enables the developers to add interactive real-time functionalities to their projects, it uses WebRTC in the background to achieve that, and gives the developer plenty of tools to embed the real-time engagement functionalities.

V.4.5.1 Implementation

Agora has a Flutter SDK that was used in this project in order to achieve the peer to peer (P2P) video/audio calling between a doctor and a patient, using the RtcEngine class that provides the main methods that can be invoked by the application, theRtcEngineEventHandler class that enables callbacks to the application , alongside with the RtcChannel that provides methods that enable real-time communication in a specified channel , and last but not least the RtcChannelEventHandler that provides callbacks that report events and statistics of a specified channel.

V.4.5.2 Results

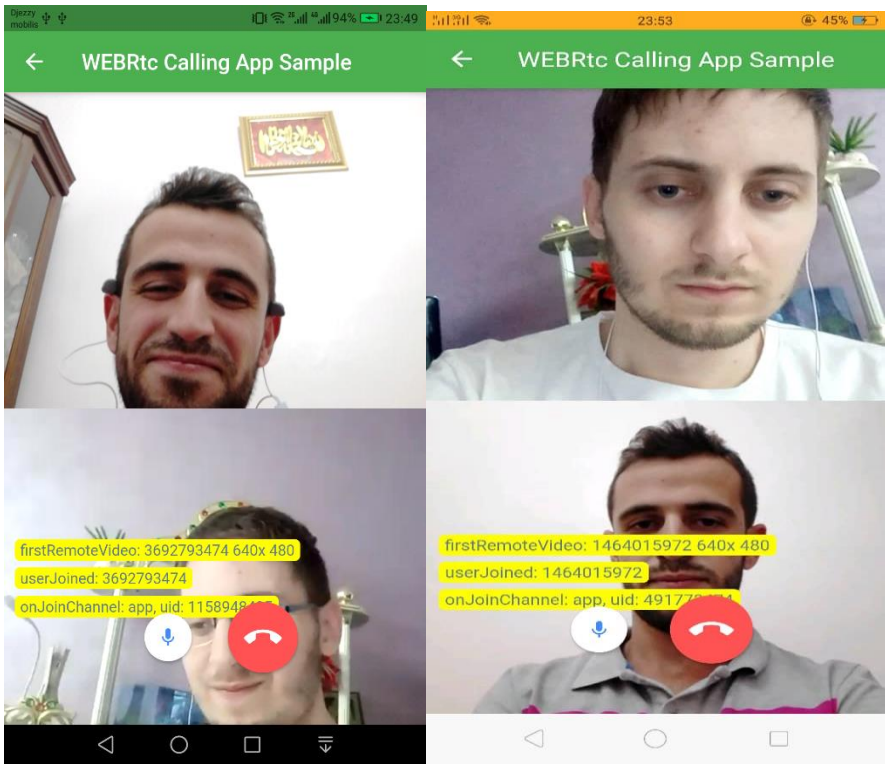


Figure V.13. WebRTC vedeo call simple.

V.5 Conclusion

In the course of this chapter we have presented the different aspects and functionality of our application carried out, starting first by exposing the tools and technologies used in the implementation of the application, then we presented some user interfaces graphical of implemented system.

General conclusion

The work carried out in this thesis is in the field of decision support in the health sector. Our main objective is that, in the relatively near future, a doctor, whatever his geographical position (doctor's office, outpatient, in any health structure), whatever his specialty and his experience, can have a help on its medical diagnoses of patients. This help can be done through a mobile application allowing a remote dialogue between doctor and patient and detecting emergencies.

This project was the subject of a very interesting and enriching experience, as it allowed us to familiarize ourselves with new concepts on the one hand, and to improve our knowledge and skills in the field of programming.

Being sure that our project will be of definite use in the medical field, both for doctors and especially for patients. We note that it can meet the fixed needs and will contribute to the easy life of the human being, knowing that it opens up other possibilities and prospects for improvement

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