الجـــــــــــــــمـهـوريـــة الجـــــــــزائـريـة الديمـــــقـراطيـة الشـــــــعـبيـة

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

وزارة التـــــــــــــــــــــــــعـليـم العـــــالي و البـــــــــحث العـــلـمـــي

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

جـــــــــــــامعة أبي بكـــر بـلـقـايد – تـلمســـــــــــــان –

Aboubakr Belkaïd University – Tlemcen –

Faculty of TECHNOLOGY

THESIS

Thesis for obtaining a master degree

In: *Biomedical Engineering*

Speciality: *Biomedical and Hospital Informatics*

Presented by: **Wadjih Mohammed DJEFAFLIA**

Subject

Radiology Information System Software (RIS)

Supervised by: **Pr.Benamar KADRI**

Jury members:

- Dr. BENALI Radhwane (President)
- Mr.TALEB Tariq (Examiner)

2023/2024

Abstract:

The Radiology Information System (RIS) software presented in this thesis aims to enhance the efficiency and effectiveness of radiology departments within medical institutions. Designed to address common challenges in the field, the RIS software offers comprehensive functionalities, including patient registration, scheduling, tracking, order management, billing, and reporting. By streamlining these processes, the software significantly improves operational workflows, reduces administrative burdens, and enhances patient care.

Despite the numerous advantages, traditional RIS software also faces several challenges, such as outdated user interfaces, portability limitations, and communication gaps between clinic staff members. This thesis provides a detailed analysis of these issues and discusses solutions to overcome them.

Overall, this thesis demonstrates the vital role of RIS software in modernising radiology departments and underscores its potential to significantly contribute to the medical field. This work provides a comprehensive overview of the software's capabilities and its impact on healthcare delivery.

Key words

Radiology Information System (RIS), Patient Registration, Appointment Management, Scheduling, Patient Tracking, Order Management, Billing, Reporting, Patient Care, User Interfaces, Portability Limitations, Communication Gaps, Digital Imaging and Communications in Medicine (DICOM), Health Level Seven (HL7), Picture Archiving and Communication System (PACS), Web-based RIS, Java, Oracle Database 21c Express Edition, HTML, CSS, JavaScript, Figma, GitHub, Visual Studio Code, Apache Tomcat Server, IntelliJ IDEA, Patient Details, Clinic Revenue, Doctors’ Revenue, Clinic Tasks Management, Chat Services, Report Generation.

Résumé

Le logiciel de Système d'Information Radiologique (RIS) présenté dans cette thèse vise à améliorer l'efficacité et l'efficience des départements de radiologie au sein des institutions médicales. Conçu pour répondre aux défis courants du domaine, le logiciel RIS offre des fonctionnalités complètes, y compris l'enregistrement des patients, la planification, le suivi, la gestion des commandes, la facturation et les rapports. En rationalisant ces processus, le logiciel améliore considérablement les flux de travail opérationnels, réduit les charges administratives et améliore les soins aux patients.

Malgré les nombreux avantages, les logiciels RIS traditionnels rencontrent également plusieurs défis, tels que des interfaces utilisateur obsolètes, des limitations de portabilité et des lacunes de communication entre les membres de la Clinic. Cette thèse fournit une analyse détaillée de ces problèmes et discute des solutions pour les surmonter.

Dans l'ensemble, cette thèse démontre le rôle vital du logiciel RIS dans la modernisation des départements de radiologie et souligne son potentiel à contribuer de manière significative au domaine médical. Ce travail offre une vue d'ensemble complète des capacités du logiciel et de son impact sur la prestation des soins de santé.

Mots clés

Système d'information radiologique (RIS), Enregistrement des patients, Gestion des rendez-vous, Planification, Suivi des patients, Gestion des ordres, Facturation, Rapport, Soins aux patients, Interfaces utilisateur, Limites de portabilité, Lacunes de communication, Imagerie numérique et communication en médecine (DICOM), Health Level Seven (HL7), Système d'archivage et de communication d'images (PACS), RIS basé sur le Web, Java, Oracle Database 21c Express Edition, HTML, CSS, JavaScript, Figma, GitHub, Visual Studio Code, Serveur Apache Tomcat, IntelliJ IDEA, Détails des patients, Revenus de la clinique, Revenus des médecins, Gestion des tâches de la clinique, Services de chat, Génération de rapports.

الملخص

يهدف برنامج نظام المعلومات الإشعاعية (RIS) المقدم في هذه الأطروحة إلى تعزيز كفاءة وفعالية أقسام الأشعة في المؤسسات الطبية. تم تصميم البرنامج لمعالجة التحديات الشائعة في هذا المجال، ويوفر وظائف شاملة تشمل تسجيل المرضى، جدولة المواعيد، تتبع المرضى، إدارة الطلبات، الفوترة، والتقارير. من خلال تبسيط هذه العمليات، يُحسِّن البرنامج بشكل كبير سير العمل التشغيلي، ويقلل من الأعباء الإدارية، ويعزز رعاية المرضى.

رغم الفوائد العديدة، تواجه برامج RIS التقليدية أيضاً عدة تحديات، مثل واجهات المستخدم القديمة، قيود النقل، وفجوات التواصل بين العمال. تقدم هذه الأطروحة تحليلاً مفصلاً لهذه القضايا وتناقش الحلول لتجاوزها.

بشكل عام، تُظهر هذه الأطروحة الدور الحيوي لبرنامج RIS في تحديث أقسام الأشعة وتبرز قدرته على الإسهام بشكل كبير في المجال الطبي. يقدم هذا العمل نظرة شاملة على قدرات البرنامج وتأثيره على تقديم الرعاية الصحية.

كلمات رئيسية

نظام معلومات الأشعة(RIS) ، تسجيل المرضى، إدارة المواعيد، الجدولة، تتبع المرضى، إدارة الأوامر، الفوترة، التقارير، رعاية المرضى، واجهات المستخدم، قيود النقل، فجوات الاتصال، التصوير الرقمي والاتصالات في الطب(DICOM) ، Health Level Seven (HL7)، نظام أرشفة وتواصل الصور(PACS) ، نظام RIS المستند إلى الويب، جافا، قاعدة بيانات Oracle 21c Express Edition، HTML، CSS، Javascript، Figma، GitHub، Visual Studio Code ، Serveur Apache Tomcat ، IntelliJ IDEA، تفاصيل المرضى، عائدات العيادة، عائدات الأطباء، إدارة مهام العيادة، خدمات الدردشة، كتابة التقارير.

Abreviations list

RIS - Radiology Information System

HL7 - Health Level Seven

PACS - Picture Archiving and Communication System

DICOM - Digital Imaging and Communications in Medicine

HTML - HyperText Markup Language

CSS - Cascading Style Sheets

JS - JavaScript

DB - Database

IDE - Integrated Development Environment

UML - Unified Modelling Language

HTTP - HyperText Transfer Protocol

AJAX - Asynchronous JavaScript and XML

API - Application Programming Interface

RAM - Random Access Memory

CPU - Central Processing Unit

JSON - JavaScript Object Notation

Gratitude

Before starting, I want to thank Allah for all the help that I know about it and for the ones that I did not know about it. Due to him, I was getting help from people without even asking or looking, he was the main reason for being in this position right now.

Also, thanks to my mother, then my mother, then my mother, because she was the number one supporter after Allah, and with her by my side, I was never alone. Also, thanks to my father for looking after me, and to my merciful little sister, I hope you surpass me one day.

Special thanks go to my uncles, aunts, and grandmother for their continuous support in helping cover my college expenses.

I express my gratitude to my supervisor; he has been very cooperative, understanding, and helpful. Thank you for accepting me. You were my number one choice when I proposed my idea, given your expertise in this field and other factors.

Also, a big thanks to the jury members for agreeing to evaluate my work; it is truly an honour for me.

In conclusion, I hope you like the software and the thesis.

Thank you again, everyone.

Table of Contents

Introduction

The development of health care has become essential these days so humans can have a better life, and this development has touched on different aspects of the medical field, like medication, treatment procedures, and devices used, all of which led to better treatment quality. But another problem showed up after the development of the last aspect mentioned, which is the waiting time that patients have to wait to get their reports and all their papers ready, which has become so long due to all the paper needed and to human limitations when it comes to sorting and storing patient data quickly. That is what led to the development of a software called RIS, or radiology information system software.

Radiology information systems software (RIS) stand at the forefront of this evolution. They offer an indispensable tool to medical professionals for managing patient data. They serve as software solutions developed to facilitate the storage and analysis of radiological patient information.

A. Problems:

Although RIS is a critical component of modern healthcare infrastructure and health IT, it has some very bad problems that will impact the desire to use this software, and maybe it will lead to aversion by the clinic worker after years of using it.

One of the primary problems is that this software is most of the time, desktop-based and tied to local servers. This presents a big limitation in terms of portability that will lead to spending hours facing your desktop writing reports, and I personally saw some workers during my visit to one of the clinics in my region using pillows to support their backs and reduce back pain.

Another problem that must be mentioned is the user interface. Most of the user interfaces used, especially in my country, are exhausting and uncomfortable; they were designed without any care for the agronomic aspects of the software. Since doctors do not notice this aspect, even if they do, they do not complain about it because they are not familiar with the software development field. They can pay more than 10,000 USD for software that has frustrating interfaces that decrease the productivity of the clinic.

B. Objective:

The primary objective of this thesis is to highlight the disadvantages of outdated RIS software by presenting a new web-based RIS that focuses on streamlining the management of radiological data and making the workflow and routine of the worker a lot more friendly and faster with new interfaces.

Also, I seek to introduce innovative features such as portability of the software, real-time communication (Chat), and more features that we will explore later.

C. Thesis structure:

In this thesis, we will focus on three chapters, and every chapter will help us achieve our objective:

- **First chapter:** We will have an overview of the radiology information software, including its features, the problems he solved, and the problems he caused or did not solve yet.
- **Second chapter:** We will have a look at the architecture and structure of my radiology information system software to get a clear understanding on how it works.
- **Third chapter:** At the end, we will see all the tools that have been used to develop this web-based RIS, and we will also explore all the software interfaces.

Chapter 01

Overview of the Radiology Information System (RIS)

Introduction:

Radiology information system software is the backbone of modern radiology departments. This tool centralizes the data generated from the radiology department. More than that, it is mainly used to streamline daily operations and remove papers from the clinic by storing, managing, and sharing patient records in a numeric form. [1]

Figure 1.1: Some RIS software interfaces obtained from: https://www.softlinkinternational.com/ris-radiology-information-system-software-workflow/

The structure of the software changes from developer to developer, but the main functionality the RIS must possess is, in most cases are the same. The radiology software will contain modules covering the following processes:

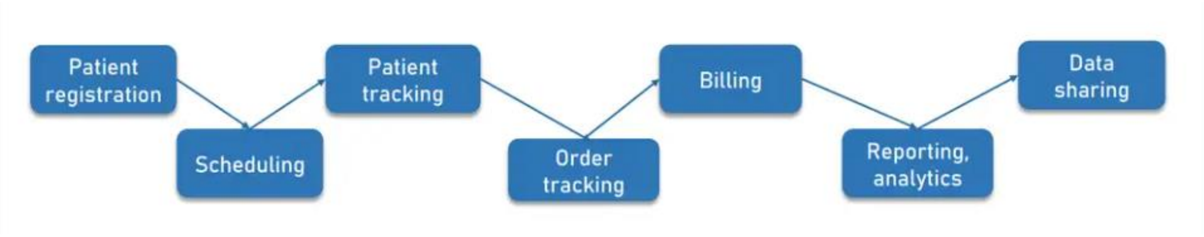


Figure 1.2:The main functionalities of a radiology information system software obtained from https://www.altexsoft.com/blog/radiology-information-system/

1.1 Problems solved by RIS software functionalities:

All RIS functionalities are designed to be a solution for problems that the radiology department suffered from back in the day, and in this section, we will explore all of these problems and how RIS solved them. All this is just to highlight their important role in enhancing patient care and to gain valuable insight into the transformative impact of this system on radiology practice.

1.1.1 Patient registration:

Patient registration is considered one of the initial steps that must be done to start getting treatment, and due to the sensitive nature of this step, it must be error-free because the doctor will use all the information that was given to provide you with a personalized treatment. This step was usually manual, time-consuming, slow, and frustrating, and it caused a loss of productivity. Here is in detail what they were facing before RIS:

- **Handwriting registration:** During the absence of the RIS software, clinic staff members used to register patient information by hand by transcribing paper given by the patient into clinic paper that can be used and understood by the doctors, and this process is frustrating given the errors that can happen, like typing mistakes, which can be hard to modify later, and missing information mistakes. All this can slow the treatment or even stop it in some cases if the information is found to be wrong.

  More to that, entering patient data manually was time-consuming and will make employees focus more on paper work than giving treatment to patients.
- **Slow search:** Doctors use patient previous files to review patient progress, track patient improvement, or even update some records and results, but due to the abundance of search tools, this will increase the wait time for patients, decrease the efficiency of treatment, and kill productivity.
- **Duplication of Effort:** When patients visit the clinic again, it is a good idea to use the last obtained data from the last visit to reduce the effort of re-registering the patient but in a paper-based environment checking patient exciting in the clinic archive each time he visits the clinic is bottlenecks for the staff.

This is why the clinic staff prefers to re-register the patient again rather than going and searching for him in the archives, but this duplicate effort is not only time-consuming but also increases the risk of having a contradiction in the information obtained from the previous visit with the current visit.

After the integration of the RIS in the health care system, patient records were digitalized, which opened the door to a searching and sorting algorithm to provide the doctors and all the staff with quick access to patient records, which reduced the wait time and, as a consequence, increased the efficiency of the treatment.

Also, digitalizing the records helped in error rectifying and stopped the duplication effort since it became easy to find patient last records and prevented the staff from going through all those archives. And for the handwriting registration problem, RIS provided the staff with electronic forms that were easier to fill out rather than writing all the information by hand.

1.1.2 Patient Scheduling:

Patient scheduling is an important module in the radiology department, and it needs to be done efficiently since any problem can crash the workflow. Here are some challenges that the radiology department faced before RIS:

- **Double Bookings:** due to the absence of a centralized system that checks for conflict, appointments were handled by books and calendars, and that caused a double-booking problem, which is when two patients were registered in the same time slot. This problem accrues specifically in a busy health care environment where miscommunication and misreading of the calendar can happen. Double booking can cause confusion and delay, and in some cases, it can cause conflict between patients.
- **Missed Appointments:** due to the communication gaps between staff and patients and the inefficiencies in appointment reminders. Patients may forget about their appointment or fail to receive reminders and come late for the examination. All this can cause confusion and more conflict in the radiology department and can shift the

effort of the clinic staff members from focusing on providing patient care to focusing more on solving those conflicts.

All these problems were solved by the implementation of RIS software; now scheduling is done automatically with algorithms that were designed to accept rules from doctors and nurses to help them schedule patient appointments based on these rules, for example:

Rule 01: Schedule patients only on those days [Sunday from 8 am to 1 pm, Monday from 2:00 pm to 4:00 pm, etc]

You can also go deeper, like this:

Rule 02: Schedule any [CT scan abdominal procedure] only on Sunday.

Also, RIS has helped in managing conflict because it is a lot easier and faster for computers to check available time slots. More to that, if you accidentally or forcibly try to register two patients in the same time slot, RIS will notify you immediately.

RIS also reminds patients of their appointments by sending automatic emails and SMS messages to them when the appointment date approaches.

All these features have helped reduce conflict, confusion, and patient waiting time. They have also made clinic staff members focus more on providing better health care for patients than handling all these problems.

1.1.3 Patient tracking:

Knowing your patient's position and location in the radiology department is a good thing, and in some cases, it can accelerate the treatment, but without that information, some problems may occur. Some of those problems are:

- **limited visibility on patient statuses and locations:** Back in the day, clinic staff used to use handwritten notes and papers just to register and track patient status [patient register, patient check-in, patient exam in progress - exam completed etc] and that was causing a short and limited visibility on patient status in the clinic and also increased wait time. Doctors do not know where the patient is unless they receive a paper or a note from another staff member that dealt with the patient.

- **Unnecessary searching:** Often staff members go and search for the patient in all the radiology department services just to know their treatment progress, which is an unnecessary effort.

The implementation of centralized software like RIS that can be accessed from anywhere to track patient status has made the "**limited visibility on patient statuses and locations**" problem not a big deal anymore since changing the status from any radiology department service using the RIS tracking feature will make the patient status visible to all RIS users, and that will prevent the "**unnecessary searching**" problem as well.

1.1.4 Order tracking:

Tracking procedures and treatments that your patient has done is called order tracking, this process is very important because it will let you check whether the patient received the appropriate treatment or not and if the patient received good care or not. But in a paper-based environment, this will decrease productivity and result in treating only a few patients because checking patient treatment from papers will be time-consuming and frustrating.

RIS provided a solution for this type of problem since RIS already stores patient files in a numeric form. It is easy to display those files on a computer, sorted by time, and also to facilitate the navigation of these files. As a result, this solution will decrease the treatment time and increase productivity, which means treating more patients.

1.1.5 Billing:

This process is sensitive since we are dealing with department money, and mistakes could cause delayed reimbursements and financial losses. Back in the day, before having a RIS, this module was prone to errors and a lot of problems. Here are some:

- **Manual billing process:** Manually entering and calculating bills is very risky since this procedure forces you to deal with a lot of big numbers. Also, since it is a paper-based environment, misreading mistakes are common but are also very dangerous, especially when dealing with money, so you must focus when doing this process, which means it will be time-consuming.
- **Difficulty in Identifying Billing Errors:** Identifying billing errors was done manually back in the day, which made detecting and finding errors even more difficult, time-consuming, and effort-consuming than calculating bills manually. All that was due to the absence of automated error detection mechanisms.

Without a doubt, the RIS contribution to this module was noticeable. RIS has automated this process by using functions designed to detect errors and give better results with more accuracy, less errors, and less manual effort.

Now clinics won't have to worry about detailing their bills, which will lead to maximizing clinic revenue.

1.1.6 Reporting and analytics:

Reports that were created by doctors in the radiology department represented a detailed conclusions and observations for patient medical images. Before the advent of Radiology Information Systems (RIS), writing and analysing those reports was challenging. Here is why:

- **Manual Report Generation:** Reports were written by hand back in the day, and that was time-consuming and prone to typing mistakes and misinformation mistakes. Also, correcting those reports is so frustrating. All these problems affect the productivity and the waiting time, causing a delay in treatment and a decrease in the number of patients treated.
- **Paper-based reporting systems:** Using paper-based reports has stopped the clinic from automating trend analysis, performance tracking, and identifying areas for improvement, all due to the nature of the data. The only way to do those analyses was manually, which required a lot of effort.

Those problems were targeted by the RIS software. He provided doctors with text editors to facilitate writing reports and error-rectifying them. RIS also provided automated report templates, which are standard premade reports; doctors will just need to personalise them for each patient. Also, RIS comes with dictation tools, allowing radiologists to write reports quickly and accurately.

In addition to that, RIS provided clinic staff members with statistics and analysis tools that helped streamline the radiology department workflow, improve patient care outcomes, and give you a better understanding of what aspects you need to develop more to enhance department performance.

1.1.7 Data sharing:

Radiologists often share data between them, or in some cases, departments share data with another department, but in the absence of a RIS, this process had some challenges back in the day. Here are some:

- **Physically transfer data:** In the absence of RIS, the common approach to sending data is to physically print and copy them if you are planning to share those data hand-to-hand, but another approach is to manually fax them. Both of these approaches are time-consuming and also effort-consuming.

- **Security:** Those transfer methods are vulnerable to interception without encryption mechanisms; data will be at risk of losing confidentiality and privacy, and they can be accessed by any unauthorised third party, which is a very big problem, especially in health care.

The RIS solution to these problems was using encryption algorithms to solve the **security** problem, but about the **"physical transfer of data"** problem, RIS developed to be able to communicate with other health care systems easily by using a standard protocol to communicate with them called HL7 (**Appendix 6**), so that sending data to any department safely won't be a problem, and that improved collaboration between departments and reduced the treatment time.

1.2 Challenges Faced and Unresolved by RIS Software:

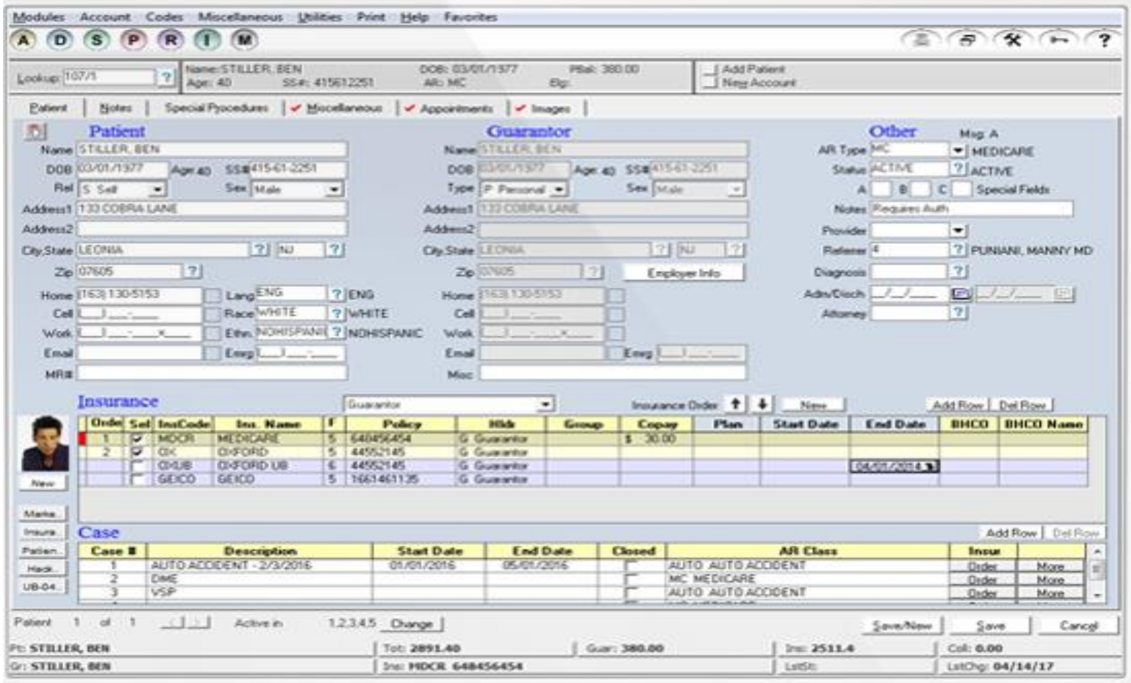
RIS also like any software have some bad sides and this is what i think that must be highlighted in this thesis because by addressing those bad sides RIS can be re-designed again to solve those issue and improve patient care, in this section we are going to explore some along with real-life examples:

1.2.1 Outdate User Interfaces:

Some RIS software developers tend to neglect designing a good user interface that will satisfy clinic staff members. That seems unimportant to some developers, but it is highly important because it will cause usability challenges. Clinic staff members will lose their productivity due to the terrible and unorganised interfaces, which could potentially increase error rates.

The clinic owner may pay thousands of dollars to increase the productivity of the clinic and solve all the traditional issues by implementing a RIS solution, but at the end, due to the bad interfaces, members will lose their productivity after some years of using the software.

More to that, because most of the clinic owners do not know about the field of software development and good user interfaces, they accept any RIS software that has a low price, and after some years, they start seeing fewer patients being treated due to the loss of productivity. The big problem is that they will not easily know the cause of this problem. Here are some examples to demonstrate more:



Lookup: 107/1

Name: STILLER, BEN DOB: 03/01/1977 PBal: 380.00
Age: 40 SS#: 415612251 AR: MC Elg:

Patient

Name STILLER, BEN
DOB 03/01/1977 Age 40 SS# 415-61-2251
Rel S Self Sex Male
Address1 133 COBRA LANE
Address2
City,State LEONIA NJ
Zip 07605
Home (163) 130-5153 Lang ENG ENG
Cell (___) ___-____ Race WHITE WHITE
Work (___) ___-____x____ Ethn. NOHISPANIC NOHISPANIC
Email Emrg (___) ___-____
MR#

Guarantor

Name STILLER, BEN
DOB 03/01/1977 Age 40 SS# 415-61-2251
Type P Personal Sex Male
Address1 133 COBRA LANE
Address2
City,State LEONIA NJ
Zip 07605
Home (163) 130-5153
Cell (___) ___-____
Work (___) ___-____x____
Email Emrg (___) ___-____
Misc

Other Msg: A

AR Type MC MEDICARE
Status ACTIVE ACTIVE
A □ B □ C □ Special Fields
Notes Requires Auth
Provider
Referrer 4 PUNIANI, MANNY MD
Diagnosis
Adm/Disch __/__/____ __/__/____
Attorney

Insurance Guarantor

Order	Sel	InsCode	Ins. Name	F	Policy	Hldr	Group	Copay	Plan	Start Date	End Date	BHCO	BHCO Name
1	☑	MDCR	MEDICARE	5	640456454	G Guarantor		$ 30.00					
2	☑	OX	OXFORD	5	44552145	G Guarantor							
	□	OXUB	OXFORD UB	6	44552145	G Guarantor					04/01/2014		
	□	GEICO	GEICO	5	1661461135	G Guarantor							

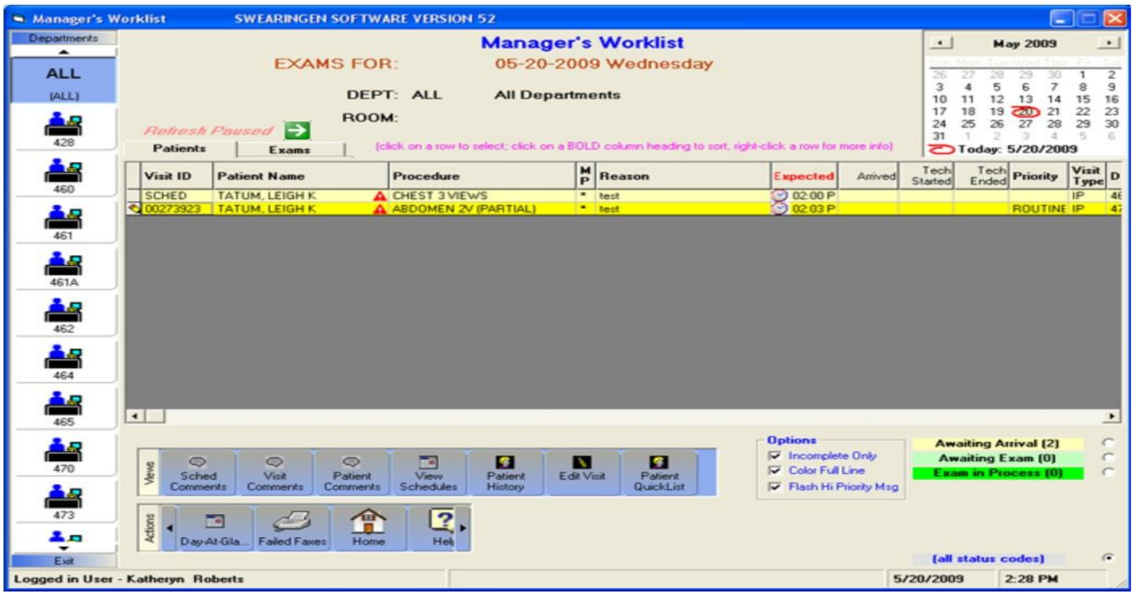
Case

Case #	Description	Start Date	End Date	Closed	AR Class	Insur	
1	AUTO ACCIDENT - 2/3/2016	01/01/2016	05/01/2016	□	AUTO AUTO ACCIDENT	Order	More
2	DME			□	MC MEDICARE	Order	More
3	VSP			□	AUTO AUTO ACCIDENT	Order	More

Patient 1 of 1 Active in 1,2,3,4,5

Pt: STILLER, BEN | Tot: 2891.40 | Guar: 380.00 | Ins: 2511.4 | Coll: 0.00
Gr: STILLER, BEN | Ins: MDCR 648456454 | LstSt: | LstChg: 04/14/17

Figure 1.3:Patient registration interface from ADS MedicsPremier RIS on https://www.adsc.com/practice-management-software



Manager's Worklist

EXAMS FOR: 05-20-2009 Wednesday

DEPT: ALL All Departments

ROOM:

(click on a row to select; click on a BOLD column heading to sort, right-click a row for more info)

May 2009

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

Today: 5/20/2009

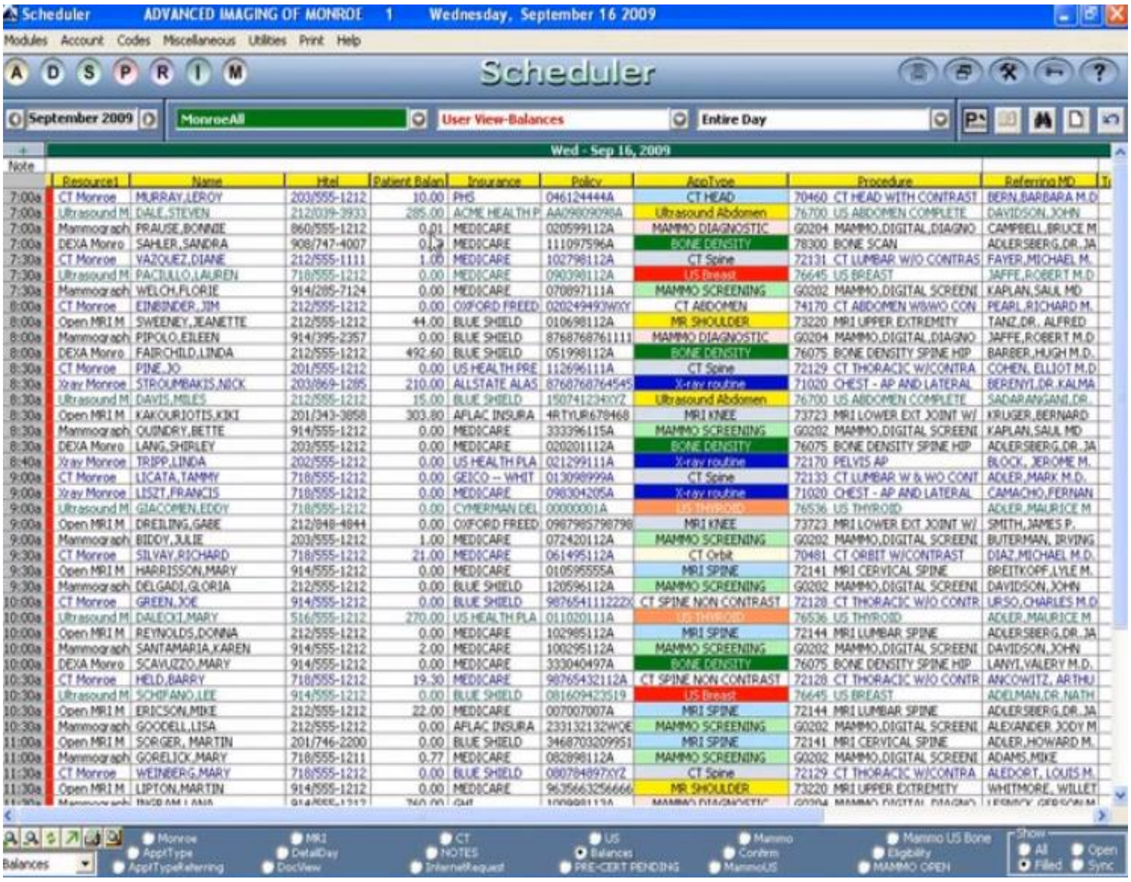
Visit ID	Patient Name	Procedure	MP	Reason	Expected	Arrived	Tech Started	Tech Ended	Priority	Visit Type	D
SCHED	TATUM, LEIGH K	CHEST 3 VIEWS	*	test	02:00 P					IP	46
00273923	TATUM, LEIGH K	ABDOMEN 2V (PARTIAL)	*	test	02:03 P				ROUTINE	IP	47

Options
☑ Incomplete Only
☑ Color Full Line
☑ Flash Hi Priority Msg

○ Awaiting Arrival (2)
○ Awaiting Exam (0)
○ Exam in Process (0)
● (all status codes)

Logged in User - Katheryn Roberts | 5/20/2009 | 2:28 PM

Figure 1.4:Exam page interface From RISynergy software on https://www.softwareadvice.com/medical/swearingen-risynergy-profile/



Scheduler ADVANCED IMAGING OF MONROE 1 Wednesday, September 16 2009
Modules Account Codes Miscellaneous Utilities Print Help
A D S P R I M
Scheduler

September 2009 | MonroeAll | User View-Balances | Entire Day

Wed - Sep 16, 2009

Note

	Resource1	Name	Htel	Patient Balan	Insurance	Policy	AppType	Procedure	Referring MD
7:00a	CT Monroe	MURRAY,LEROY	203/555-1212	10.00	PHS	046124444A	CT HEAD	70460 CT HEAD WITH CONTRAST	BERN,BARBARA M.D
7:00a	Ultrasound M	DALE,STEVEN	212/039-3933	285.00	ACME HEALTH P	AA098090908A	Ultrasound Abdomen	76700 US ABDOMEN COMPLETE	DAVIDSON,JOHN
7:00a	Mammograph	PRAUSE,BONNIE	860/555-1212	0.01	MEDICARE	020599112A	MAMMO DIAGNOSTIC	G0204 MAMMO,DIGITAL,DIAGNO	CAMPBELL,BRUCE M
7:00a	DEXA Monro	SAHLER,SANDRA	908/747-4007	0.[illegible]	MEDICARE	111097596A	BONE DENSITY	78300 BONE SCAN	ADLERSBERG,DR.JA
7:30a	CT Monroe	VAZQUEZ,DIANE	212/555-1111	1.00	MEDICARE	102798112A	CT Spine	72131 CT LUMBAR W/O CONTRAS	FAYER,MICHAEL M.
7:30a	Ultrasound M	PACIULLO,LAUREN	718/555-1212	0.00	MEDICARE	090398112A	US Breast	76645 US BREAST	JAFFE,ROBERT M.D
7:30a	Mammograph	WELCH,FLORIE	914/285-7124	0.00	MEDICARE	070897111A	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	KAPLAN,SAUL MD
8:00a	CT Monroe	EINBINDER,JIM	212/555-1212	0.00	OXFORD FREED	020249493WXY	CT ABDOMEN	74170 CT ABDOMEN WB/WO CON	PEARL,RICHARD M.
8:00a	Open MRI M	SWEENEY,JEANETTE	212/555-1212	44.00	BLUE SHIELD	010698112A	MR SHOULDER	73220 MRI UPPER EXTREMITY	TANZ,DR., ALFRED
8:00a	Mammograph	PIPOLO,EILEEN	914/395-2357	0.00	BLUE SHIELD	876876876111	MAMMO DIAGNOSTIC	G0204 MAMMO,DIGITAL,DIAGNO	JAFFE,ROBERT M.D
8:00a	DEXA Monro	FAIRCHILD,LINDA	212/555-1212	492.60	BLUE SHIELD	051998112A	BONE DENSITY	76075 BONE DENSITY SPINE HIP	BARBER,HUGH M.D.
8:30a	CT Monroe	PINE,JO	201/555-1212	0.00	US HEALTH PRE	112696111A	CT Spine	72129 CT THORACIC W/CONTRA	COHEN, ELLIOT M.D
8:30a	Xray Monroe	STROUMBAKIS,NICK	203/869-1285	210.00	ALLSTATE ALAS	876876876454545	X-ray routine	71020 CHEST - AP AND LATERAL	BERENYI,DR.KALMA
8:30a	Ultrasound M	DAVIS,MILES	212/555-1212	15.00	BLUE SHIELD	150741234XYZ	Ultrasound Abdomen	76700 US ABDOMEN COMPLETE	SADARANGANI,DR.
8:30a	Open MRI M	KAKOURIOTIS,KIKI	201/343-3858	303.80	AFLAC INSURA	4RTYUR678468	MRI KNEE	73723 MRI LOWER EXT JOINT W/	KRUGER,BERNARD
8:30a	Mammograph	QUINDRY,BETTE	914/555-1212	0.00	MEDICARE	333396115A	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	KAPLAN,SAUL MD
8:30a	DEXA Monro	LANG,SHIRLEY	203/555-1212	0.00	MEDICARE	020201112A	BONE DENSITY	76075 BONE DENSITY SPINE HIP	ADLERSBERG,DR.JA
8:40a	Xray Monroe	TRIPP,LINDA	202/555-1212	0.00	US HEALTH PLA	021299111A	X-ray routine	72170 PELVIS AP	BLOCK, JEROME M.
9:00a	CT Monroe	LICATA,TAMMY	718/555-1212	0.00	GEICO -- WHIT	013098999A	CT Spine	72133 CT LUMBAR W & WO CONT	ADLER,MARK M.D.
9:00a	Xray Monroe	LISZT,FRANCIS	718/555-1212	0.00	MEDICARE	098304205A	X-ray routine	71020 CHEST - AP AND LATERAL	CAMACHO,FERNAN
9:00a	Ultrasound M	GIACOMEN,EDDY	718/555-1212	0.00	CYMERMAN DEL	00000001A	US THYROID	76536 US THYROID	ADLER,MAURICE M
9:00a	Open MRI M	DREILING,GABE	212/848-4844	0.00	OXFORD FREED	0987985798798	MRI KNEE	73723 MRI LOWER EXT JOINT W/	SMITH,JAMES P.
9:00a	Mammograph	BIDDY,JULIE	203/555-1212	1.00	MEDICARE	072420112A	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	BUTERMAN, IRVING
9:30a	CT Monroe	SILVAY,RICHARD	718/555-1212	21.00	MEDICARE	061495112A	CT Orbit	70481 CT ORBIT W/CONTRAST	DIAZ,MICHAEL M.D.
9:30a	Open MRI M	HARRISSON,MARY	914/555-1212	0.00	MEDICARE	010595555A	MRI SPINE	72141 MRI CERVICAL SPINE	BREITKOPF,LYLE M.
9:30a	Mammograph	DELGADI,GLORIA	212/555-1212	0.00	BLUE SHIELD	120596112A	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	DAVIDSON,JOHN
10:00a	CT Monroe	GREEN,JOE	914/555-1212	0.00	BLUE SHIELD	9876541112222X	CT SPINE NON CONTRAST	72128 CT THORACIC W/O CONTR	URSO,CHARLES M.D
10:00a	Ultrasound M	DALECKI,MARY	516/555-1212	270.00	US HEALTH PLA	011020111A	US THYROID	76536 US THYROID	ADLER,MAURICE M
10:00a	Open MRI M	REYNOLDS,DONNA	212/555-1212	0.00	MEDICARE	102985112A	MRI SPINE	72144 MRI LUMBAR SPINE	ADLERSBERG,DR.JA
10:00a	Mammograph	SANTAMARIA,KAREN	914/555-1212	2.00	MEDICARE	100295112A	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	DAVIDSON,JOHN
10:00a	DEXA Monro	SCAVUZZO,MARY	914/555-1212	0.00	MEDICARE	333040497A	BONE DENSITY	76075 BONE DENSITY SPINE HIP	LANYI,VALERY M.D.
10:30a	CT Monroe	HELD,BARRY	718/555-1212	19.30	MEDICARE	98765432112A	CT SPINE NON CONTRAST	72128 CT THORACIC W/O CONTR	ANCOWITZ, ARTHU
10:30a	Ultrasound M	SCHIFANO,LEE	914/555-1212	0.00	BLUE SHIELD	081609423519	US Breast	76645 US BREAST	ADELMAN,DR.NATH
10:30a	Open MRI M	ERICSON,MIKE	212/555-1212	22.00	MEDICARE	007007007A	MRI SPINE	72144 MRI LUMBAR SPINE	ADLERSBERG,DR.JA
10:30a	Mammograph	GOODELL,LISA	212/555-1212	0.00	AFLAC INSURA	233132132WQE	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	ALEXANDER JODY M
11:00a	Open MRI M	SORGER, MARTIN	201/746-2200	0.00	BLUE SHIELD	3468703209951	MRI SPINE	72141 MRI CERVICAL SPINE	ADLER,HOWARD M.
11:00a	Mammograph	GORELICK,MARY	718/555-1211	0.77	MEDICARE	082898112A	MAMMO SCREENING	G0202 MAMMO,DIGITAL SCREENI	ADAMS,MIKE
11:30a	CT Monroe	WEINBERG,MARY	718/555-1212	0.00	BLUE SHIELD	080784897XYZ	CT Spine	72129 CT THORACIC W/CONTRA	ALEDORT, LOUIS M.
11:30a	Open MRI M	LIPTON,MARTIN	914/555-1212	0.00	MEDICARE	963566325666	MR SHOULDER	73220 MRI UPPER EXTREMITY	WHITMORE, WILLET
11:30a	Mammograph	INGRAM,LANA	914/555-1212	760.00	GHI	100998112A	MAMMO DIAGNOSTIC	G0204 MAMMO,DIGITAL,DIAGNO	LESNICK,GERSON M

Balances

○ Monroe ○ AppType ○ ApptTypeReferring ○ MRI ○ DetailDay ○ DocView ○ CT ○ NOTES ○ InternetRequest ○ US ● Balances ○ PRE-CERT PENDING ○ Mammo ○ Confirm ○ MammoUS ○ Mammo US Bone ○ Eligibility ○ MAMMO OPEN

Show: ○ All ● Filled ○ Open ○ Sync

Figure 1.5:Scheduling page from ADS MedicsPremie RIS software on https://www.adsc.com/practice-management-software

1.2.2 Portability Limitation:

The use of desktop-based RIS in clinics has resulted in a lack of portability within Radiology Information Systems (RIS). From my observations, clinic workers often resort to using pillows to relieve back pain because they spend long hours next to the computer writing reports using frustrating interfaces.

This discomfort will impact the productivity of the worker and, in some cases, will lead to errors. Also, workers were often unable to complete reports within a single day, leading to a cycle of unfinished tasks carrying over to the next day.

All this can be solved by using web-based RIS, which can offer flexibility in writing reports. You can even write reports on your phone when you are in a bus or even in your house.

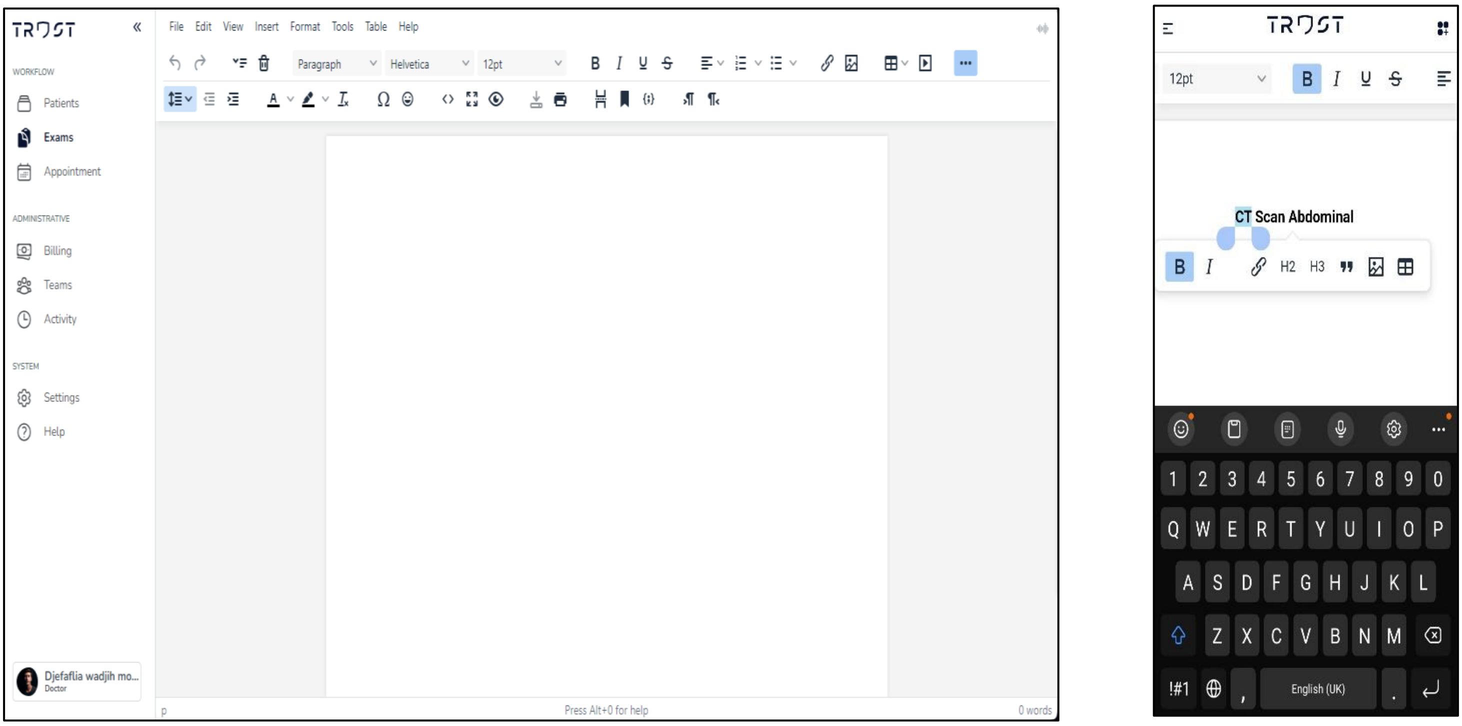


Figure 1.6:Report page from my RIS Software that support portabilty

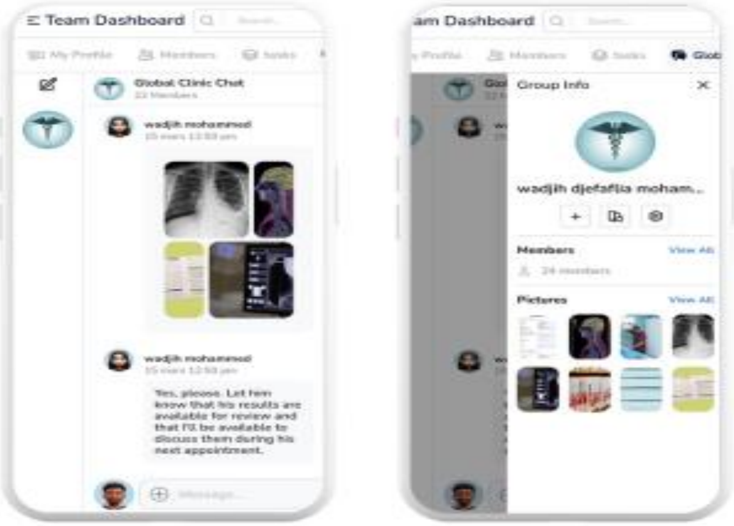
1.2.3 Lack of communication:

Communication between health staff is important to provide better and faster patient treatment, but without a built-in messaging tool that can link clinic staff together, staff will rely on other tools like phone calls, SMS messages, and emails, and this can be annoying to some members.

For example, doctors don't like phone calls during exams, but with a built-in chat service, texting all the clinic members becomes easy, faster, and more flexible.

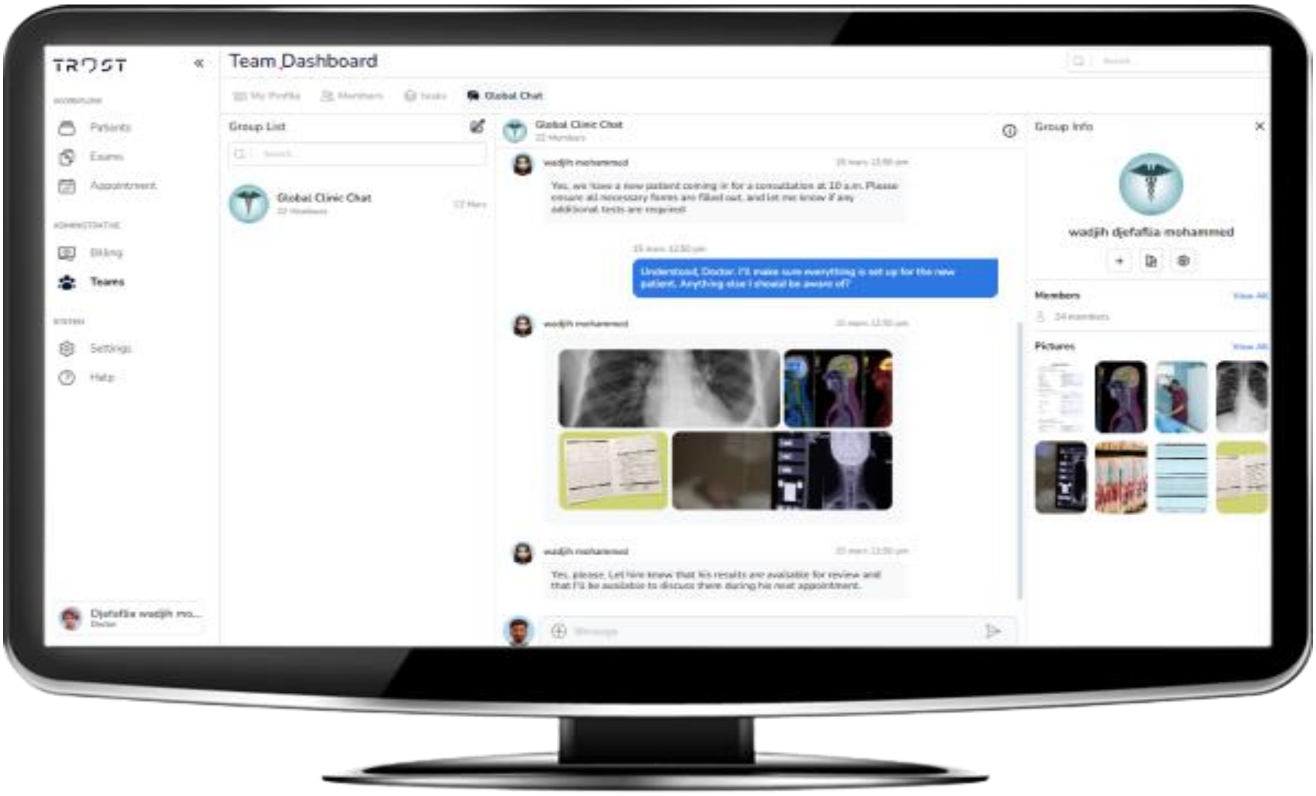
Doctors or any members do not need to manually text each worker in the clinic to dispatch a message to the team because RIS will allow you to create a conversation between a group of members that you choose, and that conversation will be your bond. For example, a doctor will open a conversation between him and a group of technicians that he usually works with, and that conversation will be used only to share a message that concerns the members of the conversation.

This will result in better communication and better coordination between staff members without unnecessary noises like yelling inside the clinic so your message can be heard by all the team or any other annoying sounds like phone ringing. This will also result in a calm environment for patients and, especially, for the worker. here is an example:



Yes, please. Let him know that his results are available for review and that I'll be available to discuss them during his next appointment.

Figure 1.7:mobile chat page from my RIS software



wadjih mohammed

Yes, we have a new patient coming in for a consultation at 10 a.m. Please ensure all necessary forms are filled out, and let me know if any additional tests are required.

Understood, Doctor. I'll make sure everything is set up for the new patient. Anything else I should be aware of?

wadjih mohammed

wadjih mohammed

Yes, please. Let him know that his results are available for review and that I'll be available to discuss them during his next appointment.

Figure 1.8:desktop chat page from my RIS software

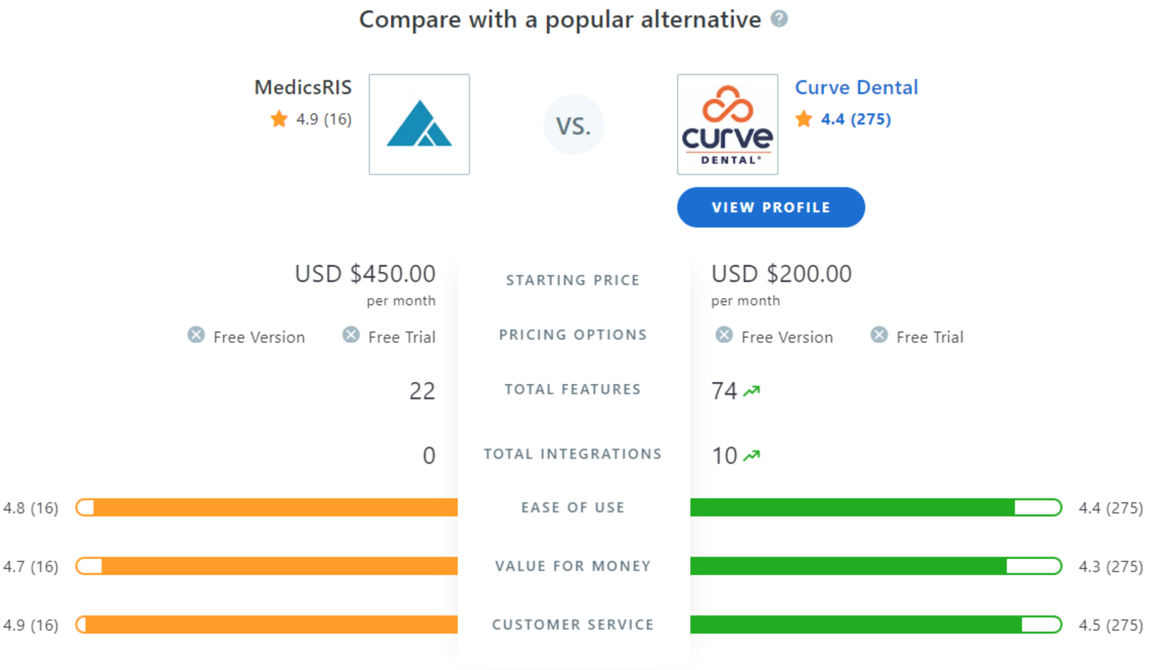
1.3 Market Overview:

A lot of RIS software is available on the market, and the difference between them is in the performance and the ergonometric of the interface, or what features it contains and how much resource it will take. Also, the most important thing is what it can be integrated with.

Some developers use cloud-based RIS, where data gets stored on a remote server, while others try to integrate the HL7 protocol (**Appendix 6)**, which is just a protocol that people in health care like to use to send data in a common format that can be understood by any health machine or software that supports this protocol. This protocol will structure your patient data in a common structure that can be read by anything that supports the HL7 protocol (**Appendix 6)**.

Also, some people like to integrate PACS (**Appendix 2)** software with the RIS to store patient DICOM (**Appendix 1)** images. These images have a big size that can reach to 2 GB for every exam, and RIS by itself cannot deal with this large data, so he collaborates with this PACS **(Appendix 2)** software to manage patient data and all his DICOM **(Appendix 1)** exam images.

The more you have extra features, more integrations, better ergonometric interfaces, and good performance, the more expensive the RIS becomes. [1]. After doing my personal research, I found out that the prices in my country go from USD $2,250 to USD $15,000, but globally, most of the cases you pay monthly for your RIS software in the average of USD $300 each month. Here are some RIS for which I was able to find their prices on the internet:



Compare with a popular alternative

MedicsRIS ★ 4.9 (16)	VS.	Curve Dental ★ 4.4 (275) VIEW PROFILE
USD $450.00 per month	STARTING PRICE	USD $200.00 per month
⊗ Free Version ⊗ Free Trial	PRICING OPTIONS	⊗ Free Version ⊗ Free Trial
22	TOTAL FEATURES	74 ↗
0	TOTAL INTEGRATIONS	10 ↗
4.8 (16)	EASE OF USE	4.4 (275)
4.7 (16)	VALUE FOR MONEY	4.3 (275)
4.9 (16)	CUSTOMER SERVICE	4.5 (275)

Figure 1.9:Example of RIS price found on https://www.capterra.com/p/121634/MedicsRIS/

1.4 Conclusion:

In this chapter, we have introduced the RIS technology, how important it is in health care, and its impact on improving productivity and treatment time by highlighting the problems that clinic staff members were facing before RIS and how it addresses these challenges, such as patient registration, scheduling, patient tracking, order tracking, billing, reporting and analytics, and data sharing.

Then we shed the light on the problems that are still unresolved or caused by the RIS software, like outdated interfaces, portability limitations, and the lack of communication tools and how they will help the health care if they get solved, and we gave some real examples of those problems.

At the end of the chapter, we mentioned the criteria that raise the price of this software and how much it costs in our country.

In the next chapter, we will explore the design and architecture of our RIS project **TRUST**, like the class diagram, use cases, and sequence diagram, as well as all the tools that have been used to give you a better understanding of our software structure.

Chapter 02

System Architecture and Design

Introduction:

In this chapter, we will explore the system architecture and design of our radiology information system (Trust) using some Unified Modelling Language (UML) diagrams, which are, in this case, the use case diagram, sequence diagram, and class diagram for the RIS. Each of these diagrams will help understand a different aspect of the software and clarify its structure and architecture.

UML diagrams are universal tools that can help anyone understand the system with a standardised modelling language that provides a set of conventions for drawing diagrams that describe the structure and behaviour of a system, and in this case, they will be used to help break down a complex system like RIS.

By employing these UML diagrams, we will not just enhance the readability of the software but also help developers from all over the world collaborate and work on the same project by using UML as a communication language.

In our case, because the project was done by one developer, UML will also help me organise my thoughts and have a clear and wide view on my software, which will help me identify some potential problems.

2.1 Use Case diagram:

The use case diagram provides a visual representation of the interactions between users (actors) and the Radiology Information System (RIS). It can also be used as documentation for our system since he highlights all the system's capabilities. The use case diagram can help you list all the system functionality and understand the workflow clearly, which is why it is chosen. Also, when dealing with customers, this diagram will help show that all client requirements are met. [14]

2.1.1 Actors:

In our RIS software, we have identified 4 actors, and each of these actors has a specific use case. We are going to explore each actor separately. Those actors are:

- **Doctor**
- **Nurse**
- **Accountant**
- **Admin**

Since the admin actor encompasses the roles of all three other actors, creating a use case diagram for the admin would effectively mean creating a use case for the entire radiology information system software on a single page. This approach would result in an unreadable diagram due to the system's complexity, as the admin has access to all features.

Therefore, the use case diagram was split into three use case diagrams where each actor has his own use case diagram.

2.1.2 Use Case Diagram explanation:

In the next Use Case Diagrams, we will mention all the use cases involving the nurse and doctor and accountant as the actors. To enhance readability, here is some instructions to clarify the use case diagrams:

- **Blue use cases:** represent direct use cases. These are the first actions that the actor performs directly within the system.
- **Red use cases:** represent indirect use cases. These are the actions that happen only when the direct use cases are performed and can be categorized based on their relationship with the direct use cases:
    - **Include relationship:** Some red use cases are necessary components of the blue use cases. This means that whenever a blue use case is executed, the associated red use case must also be executed.

    - **Extend relationship:** Some red use cases are optional they can occur only when the blue use cases are executed, but they are not mandatory.
- **Green use cases:** represent also indirect use cases. These are the actions that can happen only when red use cases are performed. Also, those use cases are always optional, meaning they are completely subject to the will of the user or to system behaviour example: the system may intervene to do certain procedure if any issue has been detected.
- **Orange use cases:** represent indirect use cases. These are the alert messages that must be executed after the execution of any use cases that require an alert.

2.1.3 Nurse Use Case Diagram:

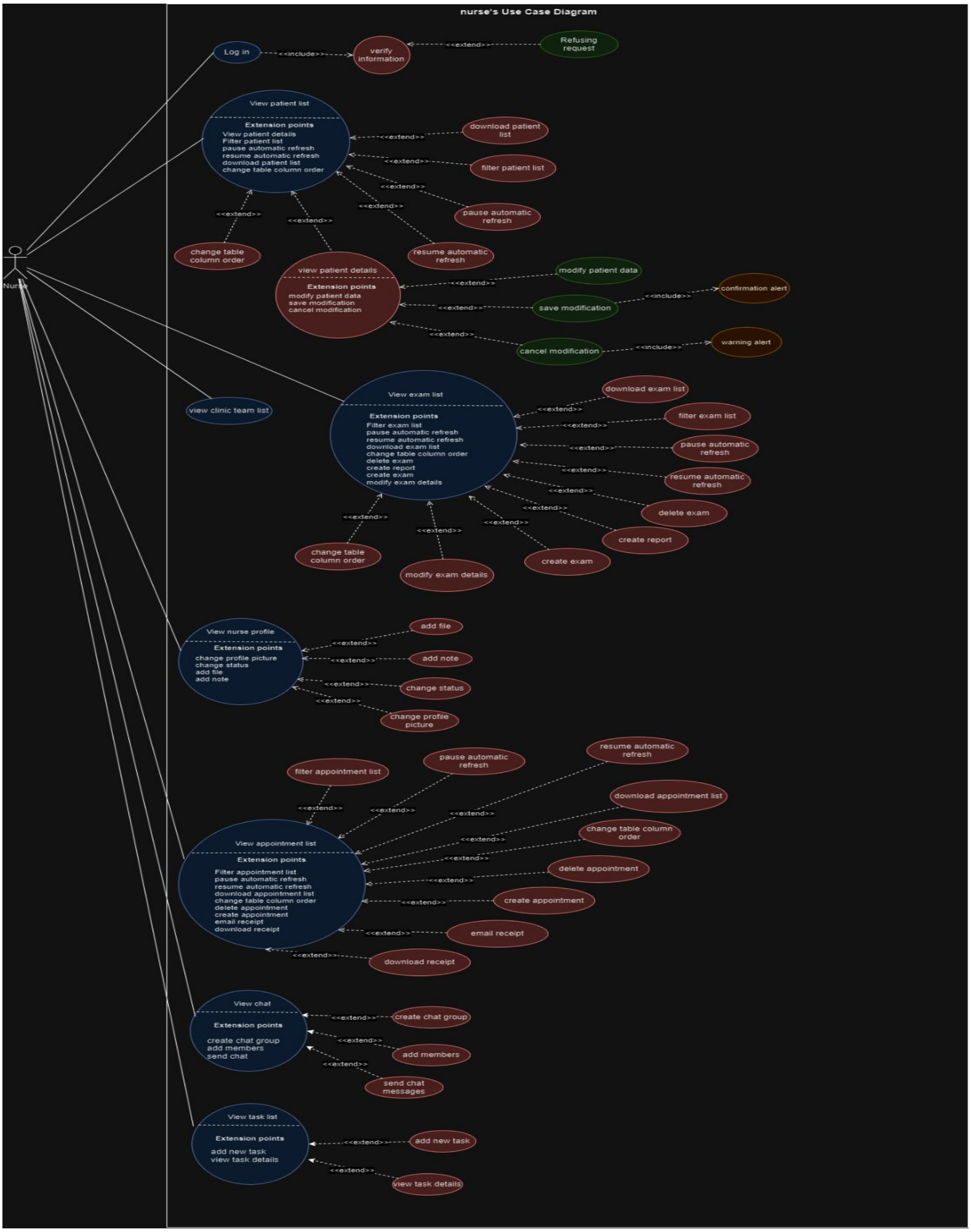


Figure 2.1: Use case Diagram for Nurse Actor

Examples:

- **Blue use case:** "View patient list" is one of the first interactions that the nurse can execute. This use case will allow the nurse to see the patient list available in the database and will also open the door for them to do other optional use cases like downloading patient lists.
- **Red use cases:**
  - **With include relationship:"** verify information**"** This is an indirect use case because it can only happen when the login direct use case happens. Also, due to the include relationship with the login, this use case must happen whenever there is a log-in.
  - **With extend relationship:"** Filter patient lists." This is an indirect use case because it can only happen when the direct use case "view patient list" is performed. Also, due to the extend relationship with the blue use cases, this means that this use case can only happen with the will of the nurse, which means it is optional.
- **Green use case:"** save modification**"** This use case is an indirect use case, which means it can only happen when the red use case 'view patient details" is performed. Also, due to the extend relationship with the red use case, this use case is optional and will be executed by the will of the nurse.
- **Orange use case:"** confirmation alert**"** This use case will be executed to alert the nurse that the saving of the modification is successful.

2.1.4 Doctor Use Case Diagram:

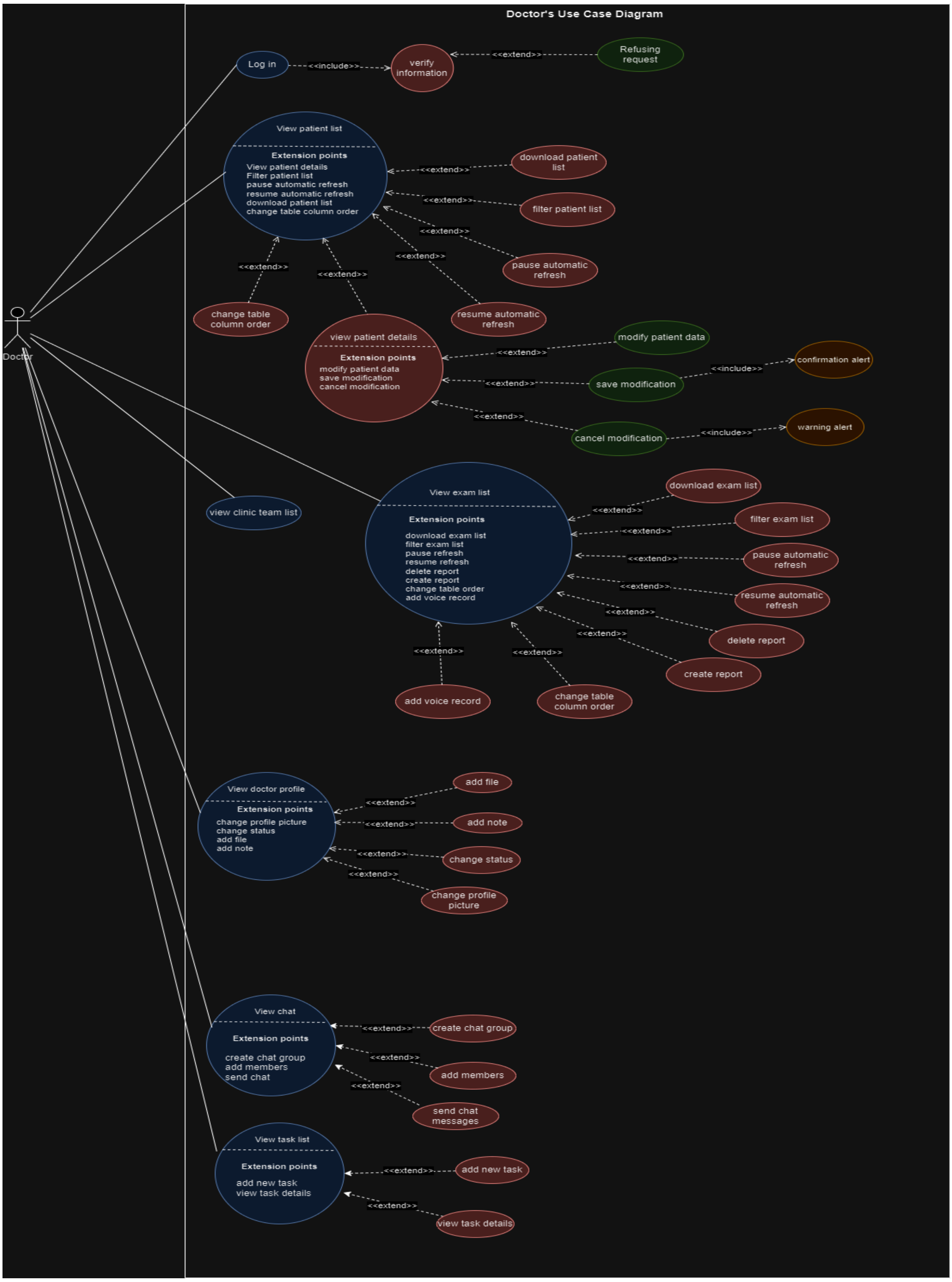


Figure 2.2: use case diagram for doctor actor

Examples:

- **Blue use case:** "View exam list" is one of the first interactions that the doctors can execute. This use case will allow the doctors to see the exam list available in the database and will also open the door for them to do other optional use cases like writing reports.
- **Red use cases:**
    - **With include relationship:"** verify information**"** This indirect use case is shared with all actors, and it is the only one available that has an include relationship with the blue use cases.
    - **With extend relationship:"** change table column order." This is an indirect use case because it can only happen when the direct use case "view exam list" is performed. This use case allows doctors to manage the column visibility of the exam table and the order in which they want the columns to appear with.
- **Green use case:"** cancel modification**"** This use case is an indirect use case, which means it can only happen when the red use case 'view patient details" is performed. This use case allows doctors to cancel the modification that they have made to the patient's details.
- **Orange use case:"** warning alert**"** This use case will be executed to alert the doctor that the modifications have been discarded.

2.1.5 Accountant Use Case Diagram:

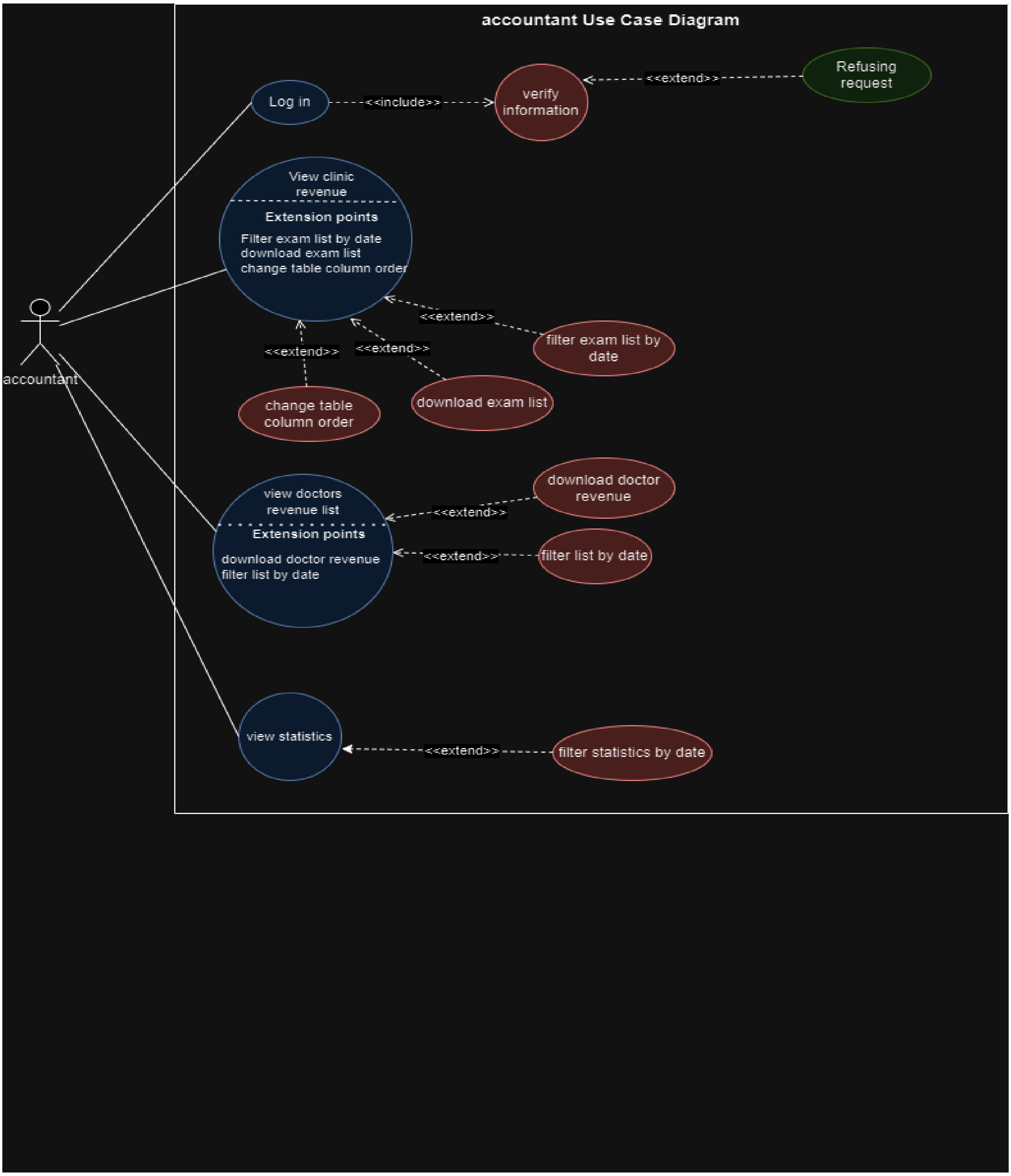


Figure 2.3: Use case Diagram for accountant

Examples:

- **Blue use case:** “View clinic revenue” is one of the first interactions that the accountant can execute. This use case will allow the accountant to check all the clinic revenue in a specific date range. it also has extension points where you can perform other use cases, like downloading the exam list, etc.
- **Red use cases:**
  - **With include relationship:”** verify information**”** This indirect use case is shared with all actors, and it is the only one available that has an include relationship with the blue use cases. This use case is done automatically by the software whenever you try to login.
  - **With extend relationship:”** filter statistics by date**”** This is an indirect use case because it can only happen when the direct use case “view statistic” is performed. This use case allows accountant to update the statistic that are shown on the page by changing their date range.
- **Green use case:”** refusing request**”** This use case is an indirect use case, which means it can only happen when the red use case ‘verify information” is performed. This use case represents a procedure that will be taken by the software when the verification identifies that the actor is not a user.

2.2 Sequence diagram:

A sequence diagram is one of the Unified Modelling Language (UML) diagrams that shows how objects interact with each other to accomplish a certain functionality. It is essential, specifically for developers, to understand the order of the operation and how data flows in the software over time. In our case, where the software is RIS software, this sequence diagram will show various entities like doctors, nurses, and accountants, as well as the web interfaces, the web server, and the database server. The diagram will also ensure that all the software use cases are optimised for readability and efficiency. [15]

Due to the complexity of the software, it is hard to represent every functionality in a separate diagram. That is why, in this section, I am going to put multiple use cases in one sequence diagram.

Each sequence diagram will represent a web page on my web site, and every sequence diagram will mention only the **important** use cases on the page, all this to enhance readability.

Since this approach does not violate the norms and rules of using a sequence diagram, I found it better to represent most of the system use cases.

2.2.1 patient page sequence diagram:

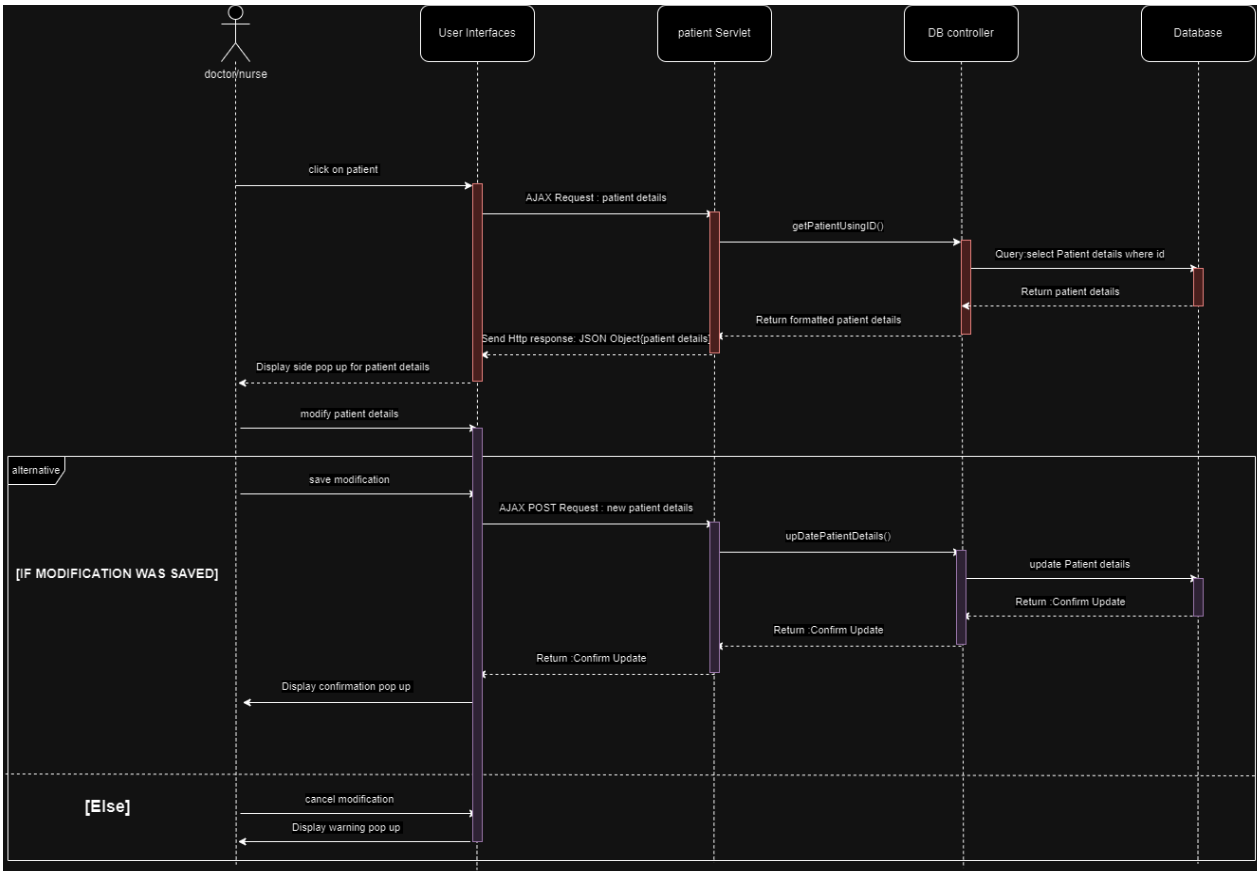


Figure 2.4: sequence Diagram for patient page

Explanation:

Actors:

- **Doctor:** will use this page most of the time to see patient history.
- **Nurse:** will use this page most of the time to change patient details.

Object:

- **User interface:** patient interface.
- **Patient servlet** (Appendix 5)**:** Java programme that will handle web-based requests and generate dynamic content for patient interface.

- **DB controller:** Java class that handle SQL transaction and executing queries like selecting patient reports, exams, payments.
- **Database Server:** Used to store, access, and manage patient page data like patient history.

Interaction (important one only):

- **Click on patient:** This feature allows you to display patient information like identification, contact details, medical condition, previous exam, and reports in a side pop-up by sending an AJAX request (**Appendix 4**) to the web server requesting those data.
- **Modify patient details:** The side pop-up mentioned above will also give you the right to modify patient information and send the modification back to the server.

2.2.2 Exam page sequence diagram:

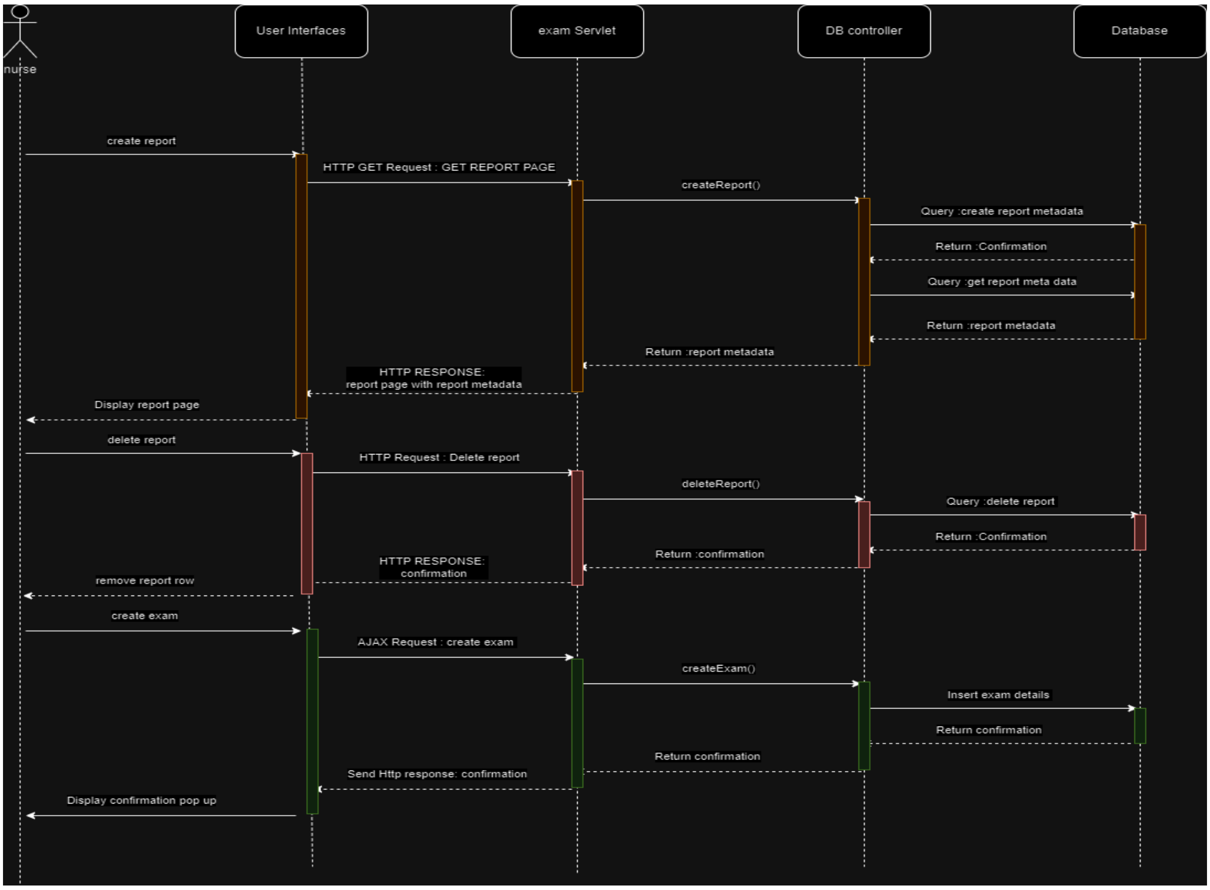


Figure 2.5: Sequence Diagram for exam page

Explanation:

Actors:

- **Doctor:** will use this page most of the time to create reports.
- **Nurse:** will use this page most of the time to create exams.

Object:

- **User interface:** exam interface.
- **Exam servlet** (Appendix 5)**:** Java programme that will handle web-based requests and generate dynamic content for exam interface.

Interaction (important only):

- **Create exam:** In this interaction, data will be sent to the exam servlet (**Appendix 5)** as an AJAX POST request (**Appendix 4)**. The servlet will need to get the exam information from the request using the getParameter () function, and then using the connection that the DB controller has, data will be inserted into the database.
- **Create report:** In this interaction, the interface will send a HTTP GET request (**Appendix 3)** to the exam servlet requesting the report editor page. The servlet will have to create a report record in the database containing metadata about the report editor, like the date of the creation and the ID, etc., and then send the page back to the employee.

2.2.3 Appointment page sequence diagram:

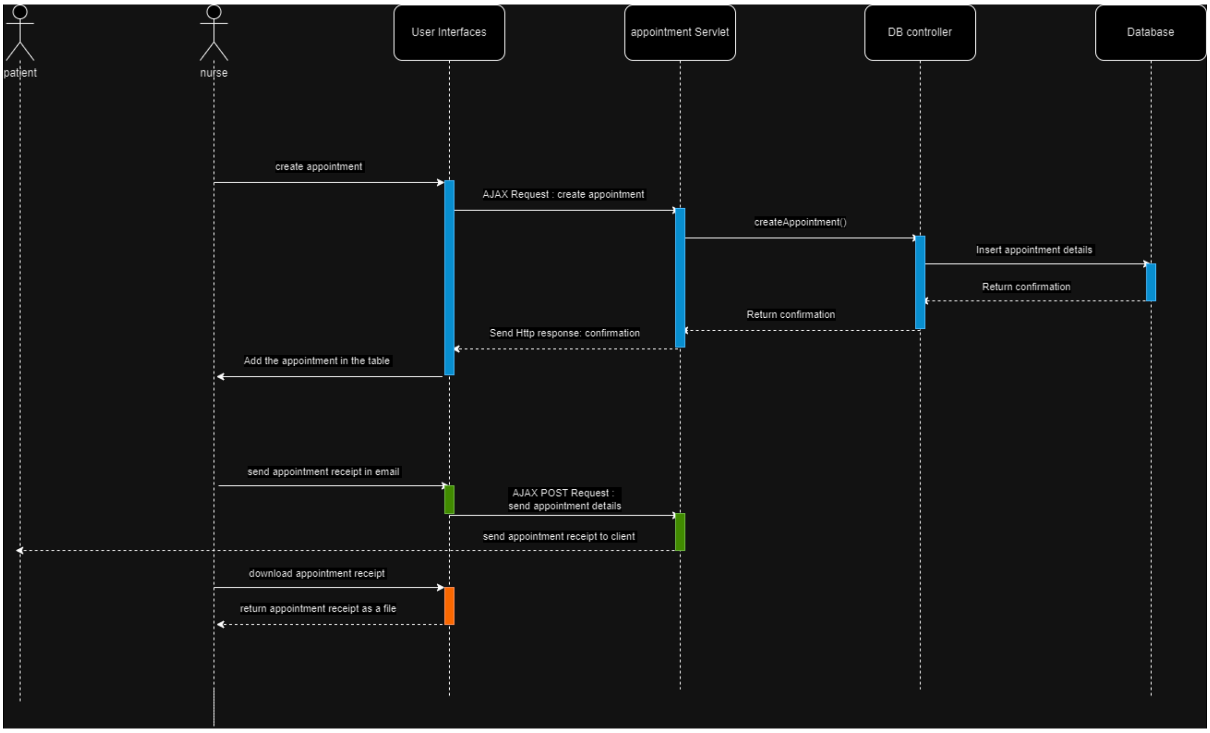

patient
nurse
User Interfaces
appointment Servlet
DB controller
Database
create appointment
AJAX Request : create appointment
createAppointment()
Insert appointment details
Return confirmation
Return confirmation
Send Http response: confirmation
Add the appointment in the table
send appointment receipt in email
AJAX POST Request :
send appointment details
send appointment receipt to client
download appointment receipt
return appointment receipt as a file

Figure 2.6: sequence Diagram for appointment page

Explanation:

Actors:

- **Nurse:** will be the only one to use this page to register appointments.
- **Patient:** He will have one role in this sequence diagram, which is accepting the email coming from the nurse.

Object:

- **User interface:** appointment interface.
- **Appointment servlet:** Java programme that will handle web-based requests and generate dynamic content for the appointment interface.

Interaction (important only):

- **Create an appointment:** The appointment page will allow nurses to register appointments. The interface will send an AJAX request (Appendix 4) to the appointment servlet. The servlet extracts the data from the request and calls the createAppointment() function in the DB controller to save the appointment in the database.
- **Send an appointment receipt via email:** For this interaction, an AJAX POST request with the patient's email will be sent to the appointment servlet. The servlet uses the **JavaMail API** to compose an email with details like the appointment date and procedure name, and then sends it to the patient.

2.2.4 Billing page sequence diagram:

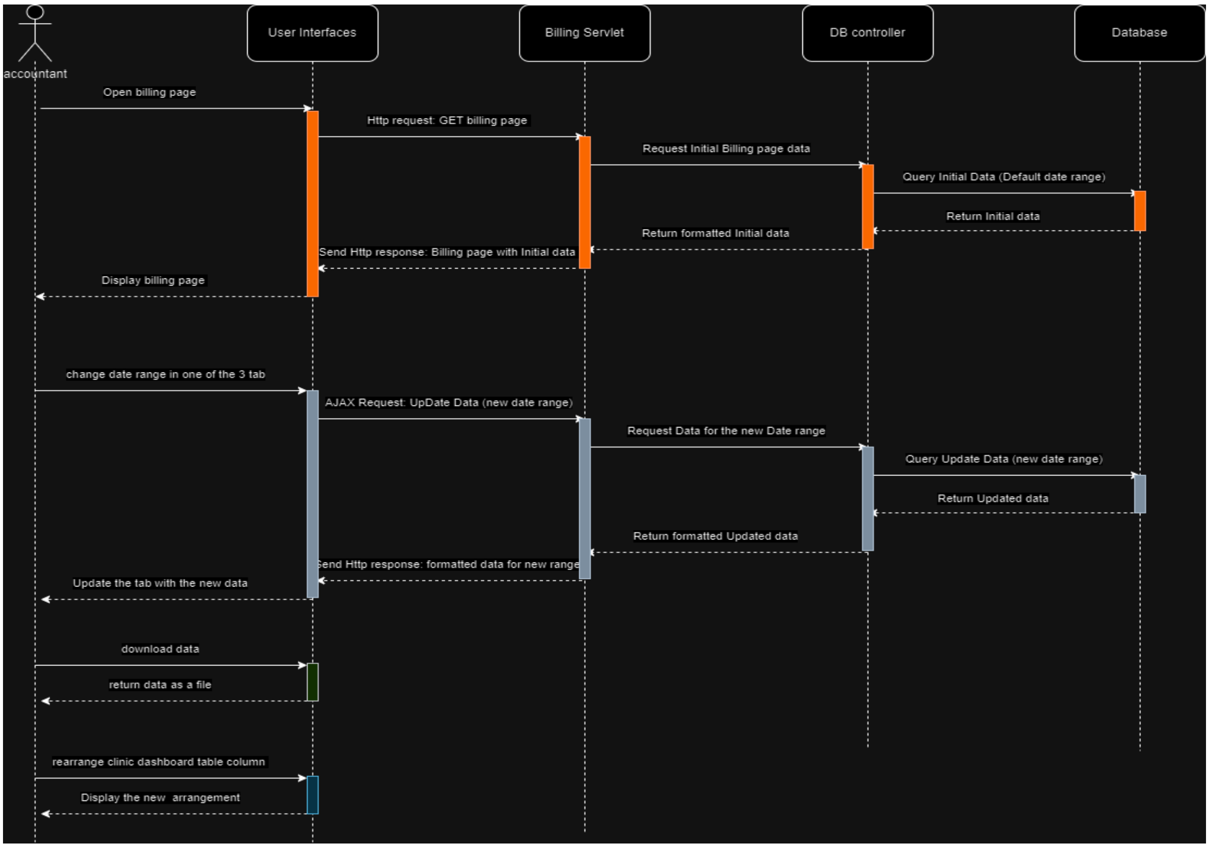

accountant
User Interfaces
Billing Servlet
DB controller
Database
Open billing page
Http request: GET billing page
Request Initial Billing page data
Query Initial Data (Default date range)
Return Initial data
Return formatted Initial data
Send Http response: Billing page with Initial data
Display billing page
change date range in one of the 3 tab
AJAX Request: UpDate Data (new date range)
Request Data for the new Date range
Query Update Data (new date range)
Return Updated data
Return formatted Updated data
Send Http response: formatted data for new range
Update the tab with the new data
download data
return data as a file
rearrange clinic dashboard table column
Display the new arrangement

Figure 2.7: sequence diagram for billing page

Explanation:

Actors:

- **Accountant:** will use this page to check clinic revenue and doctor revenue in a specific date range. He will also use the page to know the progress of the clinic during a specific date range.

Object:

- **User interface:** billing interface.
- **Billing servlet:** Java programme that will handle web-based requests and generate dynamic content for the billing interface.

Interaction (important only):

- **Change date range in tab:** This interaction happens when the user tries to see the statistics and revenue of a specific date, so when he changes the date, an AJAX request will be sent to the billing server. The server determines whether the request is for doctor revenue, clinic revenue, or clinic statistics and calls the appropriate DB controller method.

  The data obtained will be formatted to JSON using the GSON API and then sent back to the interface to update the page content.

2.2.5 teams page sequence diagram:

Due to the complexity of the page, it will have three diagrams for each tab.

Profile tab:

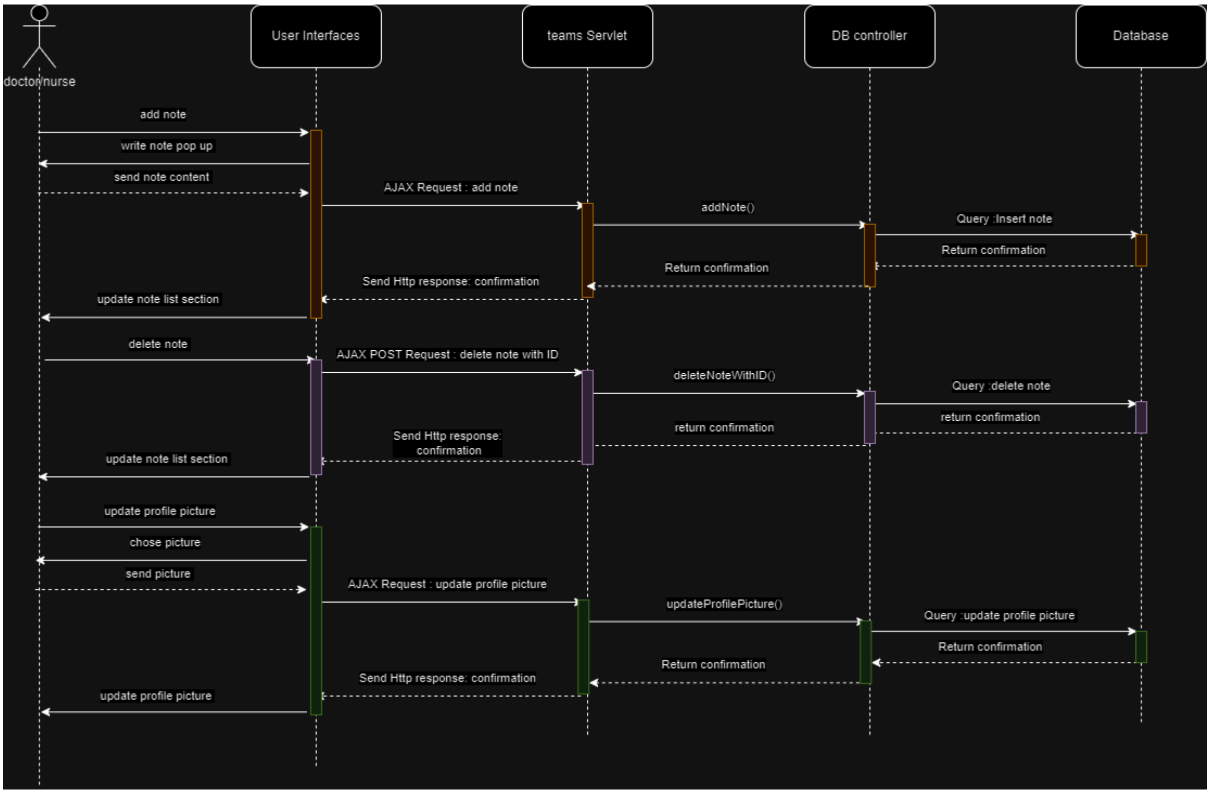


Figure 2.8: Sequence Diagram for teams profile

Explanation:

Actors:

- **doctor**
- **Nurse**

Object:

- **User interface:** teams, profile tab interface.

- **Teams servlet:** Java programme that will handle web-based requests and generate dynamic content for the teams interface.

Interaction (important only):

- **Add file:** This interaction starts from the interface, which will display a file chooser. once the employee selects a file. It will be sent to the team servlet using an AJAX request. The servlet passes the file data to the addFile() method in the DB controller, which will insert it into the database.
  A confirmation message is sent back through the servlet to the interface, which then updates the document section to indicate successful file addition.

Tasks tab:

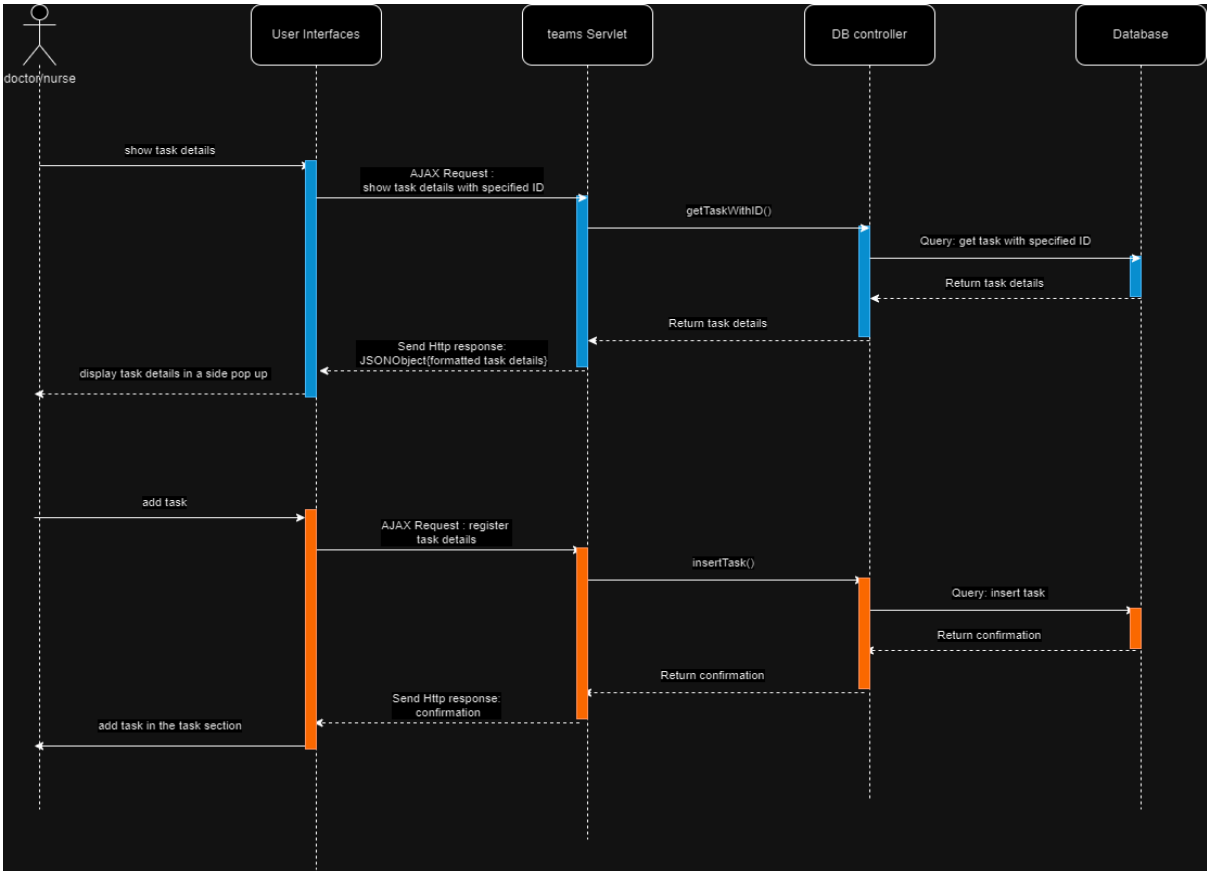

doctor/nurse
User Interfaces
teams Servlet
DB controller
Database
show task details
AJAX Request : show task details with specified ID
getTaskWithID()
Query: get task with specified ID
Return task details
Return task details
Send Http response: JSONObject(formatted task details)
display task details in a side pop up
add task
AJAX Request : register task details
insertTask()
Query: insert task
Return confirmation
Return confirmation
Send Http response: confirmation
add task in the task section

Figure 2.9: sequence Diagram for teams task tab

Explanation:

Interaction (important only):

- **Add task:** An AJAX request with task details is sent to the team servlet. The servlet calls the insertTask() method, passing the task details. This method in the DB controller uses the open connection there to insert the task into the database.

Teams tab:

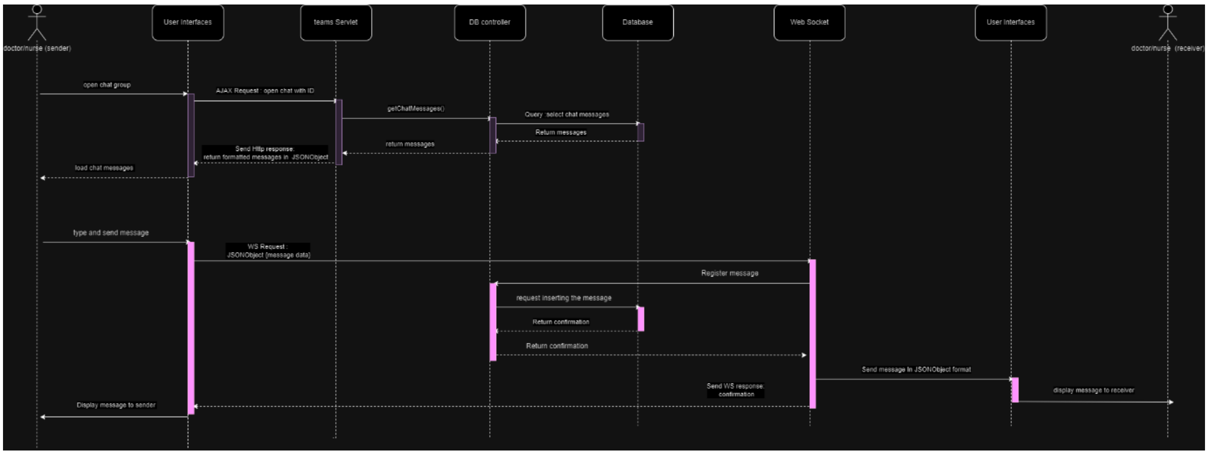


Figure 2.10: sequence Diagram for chat tab

Explanation:

Actors:

- **Sender**
- **Receiver**

Object:

- **User interface:** teams, chat tab interface.
- **Teams servlet:** Java programme that will handle web-based requests and generate dynamic content for the teams interface.

- **Web socket:** is a Java program that manages communication between a client and a server by providing real time data exchange**.**

Interaction (important only):

- **Type and send message:** This interaction begins with the interface establishing a WebSocket connection (channel) with the server for real-time data exchange. This channel will be used to send messages formatted in JSON objects with details like content, receiver ID, and IP address to the server.
  The WebSocket class on the server passes the message details to the DB controller to register them in the database. Once confirmed, the WebSocket dispatches the message to the receiver and sends a response to the sender's interface to display the message in the chat.

2.3 Class diagram:

A class diagram is one of the Unified Modelling Language (UML) diagrams that shows the system entities and how they are related to each other. It offers a wide view for developers because it shows the entire system architecture. A class diagram is one of the fundamental diagrams that must be done if you are trying to illustrate your system structure. In the context of our Radiology Information System (RIS) software, the class diagram will show various entities such as patients, employees, appointments, and reports, along with their attributes and associations, all of which will ensure the clarity of the software. [13]

Due to the complexity of the software and the large database, this section will only show an abstraction of various modules.

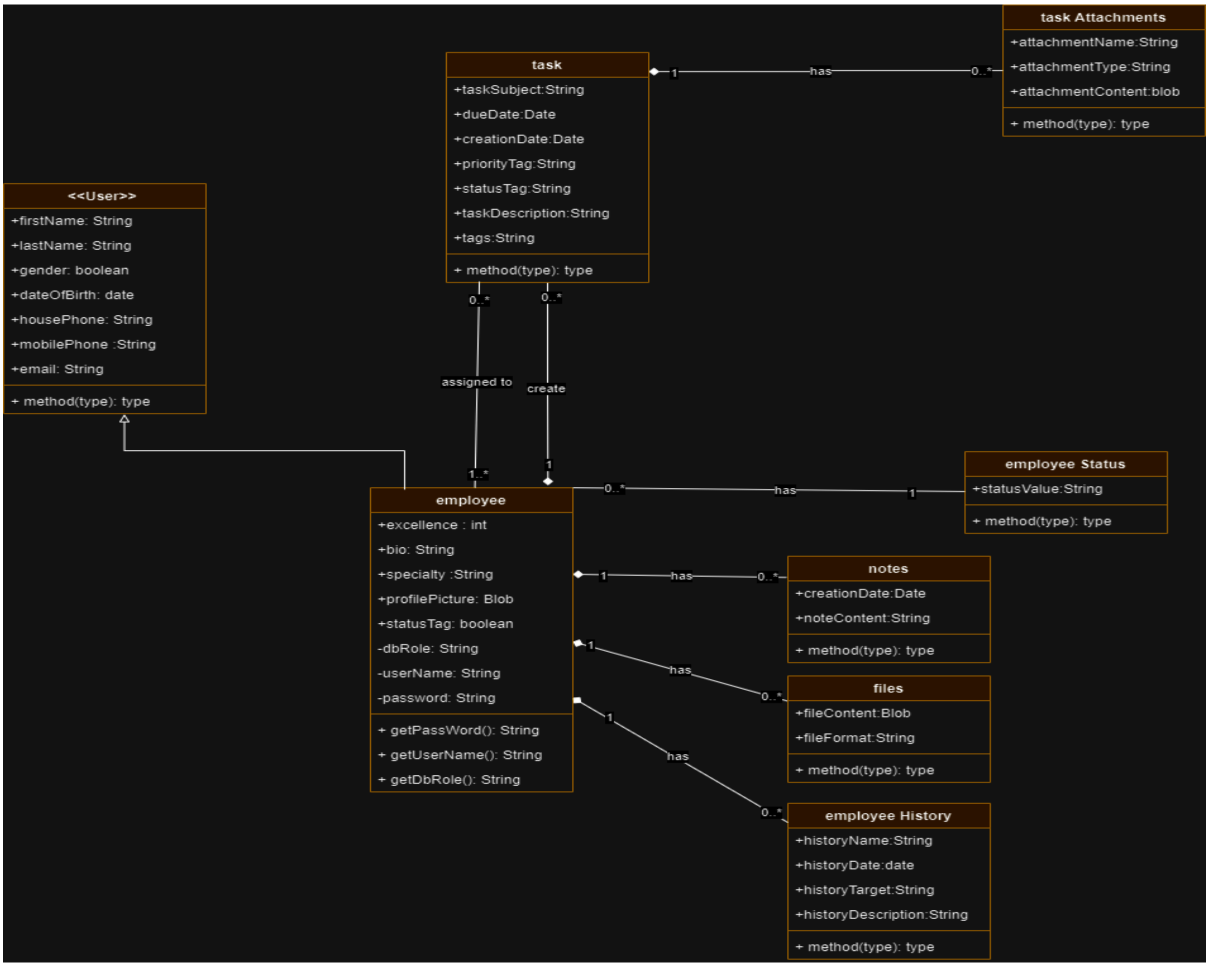


Figure 2.11: Employee profile class Diagram for TRUST RIS

Employee Profile Class Diagram: This diagram represents the employee's profile, including:

- **Personal Information**: Basic details about the employee.
- **Notes**: Created by the employee.
- **Files**: Uploaded by the employee for personal storage.
- **Employee History**: A table logging actions such as creating reports, logging in, and signing in.
- **Tasks**: A table storing all tasks created by the employee, along with any attached files.

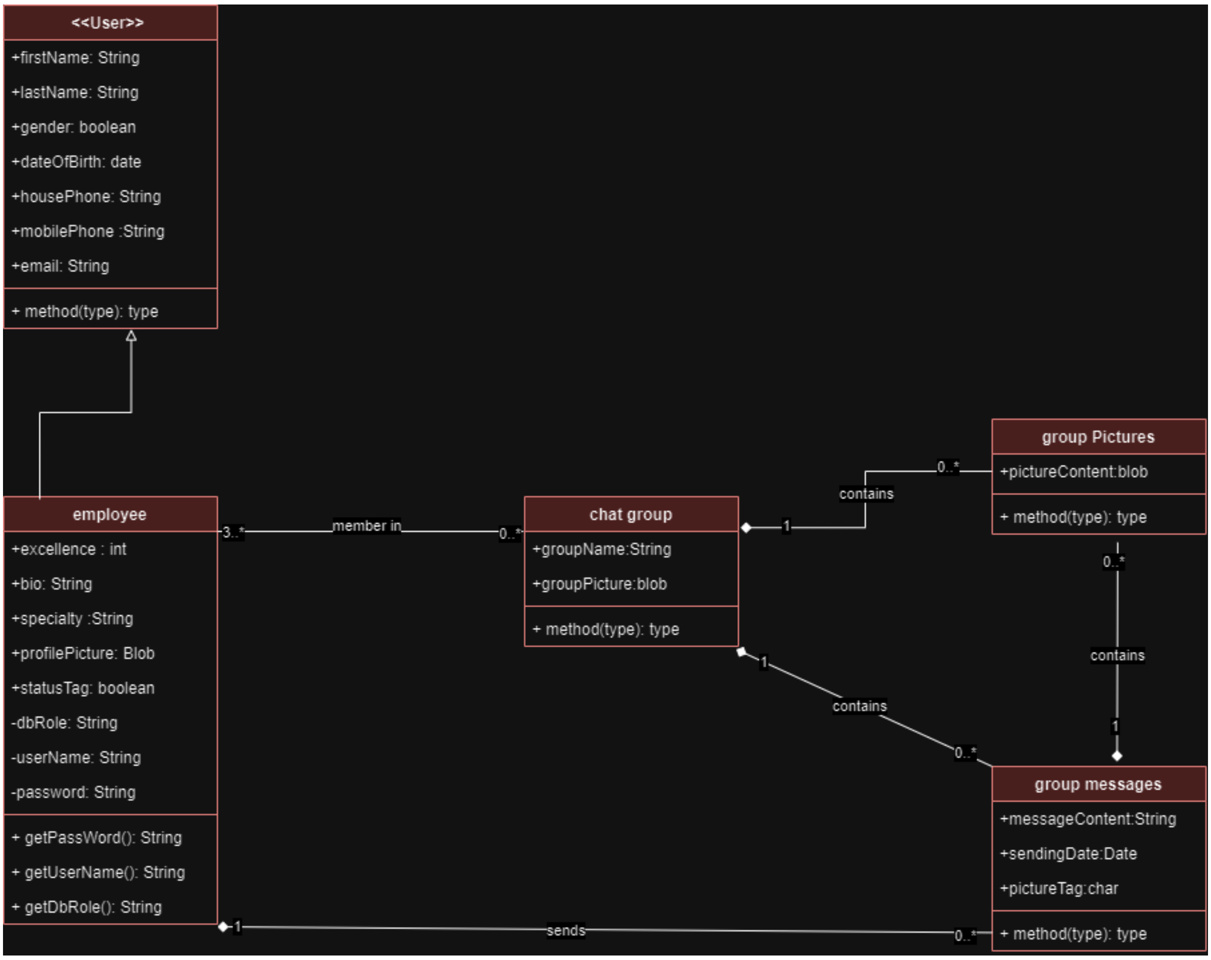


Figure 2.12: Employee chat class Diagram for TRUST RIS

Employee Chat Class Diagram: This diagram illustrates how an employee interacts with the chat section:

- **Chat Group Table**: Records all chat groups the employee is a member of.
- **Group Messages**: Linked to the chat groups, storing messages sent within each group.
- **Group Pictures**: Linked to group messages, storing the message pictures.

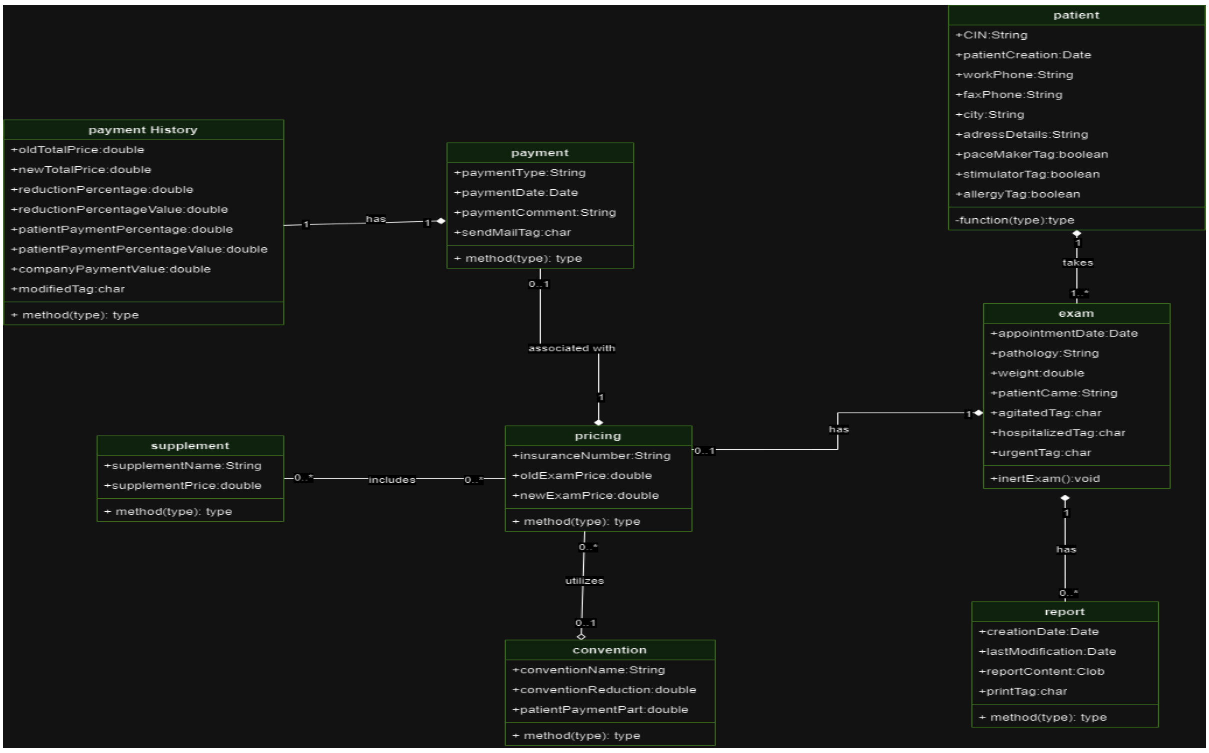


Figure 2.13: Employee Payment class Diagram for TRUST RIS

Payment System Class Diagram: This diagram outlines the payment system structure:

- **Patient Table**: Stores patient personal information.
- **Exam Table**: Records all exams of the patient:
- **Pricing Table**: Contains the total exam price, including supplements.
- **Supplement Table**: Lists clinic supplements and their prices.
- **Convention Table**: Stores clinic conventions and reduction percentages.
- **Payment Table**: Records payment details such as date, type, and other specifics.
- **Payment History Table**: Provides detailed payment information.

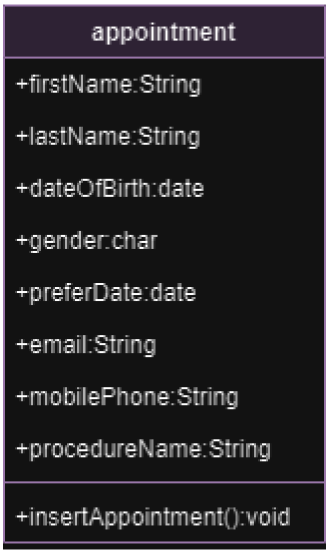


Figure 2.14: Appointment class Diagram for TRUST RIS

Appointment Class Diagram: The appointment section comprises a single table:

- **Appointment Table**: Stores all appointment details, including date, time, patient information, and any additional relevant data.

2.4 conclusion:

In conclusion, this chapter has provided an overview of the essential diagrams utilised during the development of the software. Each diagram was chosen to highlight an aspect of the software. The use case diagrams have shed light on the capabilities of the software, and then we jumped into the sequence diagrams, which offered an overview of how the system accomplished the use cases that were mentioned.

Finally, we finished with the class diagram, which offered a wide view of the system's internal structure and architecture.

In the upcoming chapter, we will delve into the implementation details and tools utilized in building the RIS software.

Chapter 03

Radiology information system software: Implementation and tools used

Introduction:

Knowing the tools that have been used is definitely important, especially if you are developing RIS software with a group of developers. This knowledge enhances collaboration; team members can quickly and easily share code and thoughts since they are working with the same tools. Also, declaring the tools that you used will let developers focus more on developing their skills in the tools that were mentioned; this will accelerate the finishing of the software and lead to better effort management.

This is why in this chapter we will start by presenting the tools that have been used, and then we will jump to the software implementation.

3.1 Tools:

3.1.1 HTML: HyperText Markup Language:

HTML, short for Hypertext Mark-up Language is the backbone of the web. It defines the structure of web content. And it can be used with other technologies like CSS and JS, which will add style and dynamic behaviour to the web content.

The term "HyperText" is used due to the HTML ability to incorporate links within pages to help connect your webpage with other pages.

The term "markup" is used because HTML uses tags to label the content, like **<p>**Here is a paragraph**</p>**. The tags help the web browser know how to treat content.[3]

Figure 3.1:HTML logo
from: https://en.wikipedia.org/wiki/File:HTML5_logo_and_wordmark.svg

3.1.2 CSS: Cascading Style Sheets:

CSS, or Cascading Style Sheets, is a stylesheet language used to define the presentation of HTML or XML documents. Other definition of CSS is a set of style rules that define how HTML elements must be displayed on the computer screen, mobile screen, and even on paper when you try to print the page. [4]

All web browsers can understand CSS due to a specific component called the CSS engine, which is responsible for reading and processing those rules and rendering them.

Figure 3.2:CSS logo

from: https://en.m.wikipedia.org/wiki/File:CSS3_logo_and_wordmark.svg

3.1.3 Js: JavaScript:

JavaScript (JS) is a lightweight programming language commonly used for web development. It is used to add dynamic behaviour to the content and to do all the client-side processes.

JavaScript is very flexible due to the runtime object construction feature, where objects can be constructed or reconstructed while the programme is running, rather than only declaring them in the beginning. [5]

Browsers can read javascript due to the javascript engine, a web browser component responsible for interpreting the javascript file.

.

Figure 3.3: Javascript logo
From : https://logos-world.net/javascript-logo/

3.1.4 Oracle database 21c express edition:

Oracle Database 21c Express Edition (XE) is a relational database developed by Oracle Corporation that is completely free to use. It allows you to store, manipulate, and access data. but it has some limitations, like:

- It can only store 12GB of user data, even if you have more storage.
- It can only use 2GB of RAM, regardless of the available system memory.
- It can only use two CPU threads, even if you have more threads available. [6]

Figure 3.4: oracle database 21c XE logo from : www.oracle.com

3.1.5 Java:

Java is a widely used object-oriented programming language. Created by James Gosling at Sun Microsystems in 1991, this language is based on the C and C++ languages. The main advantage of this language is that it can run anywhere on any device, including notebooks and mobile computer devices, without the need to write code for each device. This is what is called the "write once, run anywhere" principle. [7]

Figure 3.5: Java logo
from: https://fr.wikipedia.org/wiki/Fichier:Java_Logo.svg

3.1.6 Apache Tomcat Server:

Tomcat is a web server, a container, and a host for Java web applications. It is famous for its lightweight and efficient nature, making it a good choice for developers. Tomcat was developed by the Apache Software Foundation to be an open-source web server that can work with different operating systems. [8]

Figure 3.6: apache Tomcat server logo from: https://tomcat.apache.org

3.1.7 IntelliJ:

IntelliJ IDEA is an integrated development environment (IDE) for Java and Kotlin, offering free use for students. It can work on multiple platforms, including Windows, macOS, and Linux. It supports a lot of languages but is primarily used in Java and Kotlin. It also contains a lot of features that can help developers be more productive. [9]

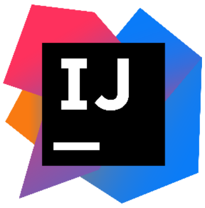


Figure 3.7: IntelliJ IDE logo
from: https://en.wikipedia.org/wiki/File:IntelliJ_IDEA_Icon.svg

3.1.8 Figma:

Is a collaborative web application designed for user interface (UI) and user experience (UX) design, founded by Dylan Field and Evan Wallace. It supports real-time collaboration where multiple users work on the same design at the same time, but is mainly used by designers to create interactive prototypes.

This tool was a lifesaver during my development of the RIS software; it allowed me to create web page designs, and due to the large community, I was able to put my hands on expensive materials like icons and pictures and already made designs for free. [10]

Figure 3.8: Figma logo from: https://fr.wikipedia.org/wiki/Figma

3.1.9 GitHub:

Is a developer platform that allows developers to create, store, manage, and share their code. It is used by over 100 million developers as of January 2023 and contains over 420 million projects, with 28 million public projects. The reason for this big community is due to the version control feature, which means it allows you to store your code versions, so if any problems happen with your current version, you will have a backup of your last version that you pushed there. This platform has other features like collaboration, bug tracking, etc. [11]

In the context of developing RIS software, this tool has really stopped some serious problems. It was my first time using it, and now I cannot imagine developing any application without it.

Figure 3.9: GitHub logo from: https://github.com/logos

3.1.10 Visual studio code:

Visual Studio Code is a lightweight but powerful source code editor that runs on your desktop and is available for Windows, macOS, and Linux. It comes with built-in support for some languages, but you can also add other languages using the extensions that he provides. [12]

Some famous extensions are LiveServer, which will help you host your HTML interfaces, allowing you to see your code results simultaneously while coding and also allowing you to access your interfaces from mobile devices.

Visual Studio Code was one of the fundamental tools that helped me build the interfaces.

Figure 3.10: Visual studio code logo from: https://code.visualstudio.com/docs

3.2 Implementation:

In this section, we will describe some interfaces for our radiology information system software, and some interfaces will have a description for clarification:

3.2.1 Patient page:

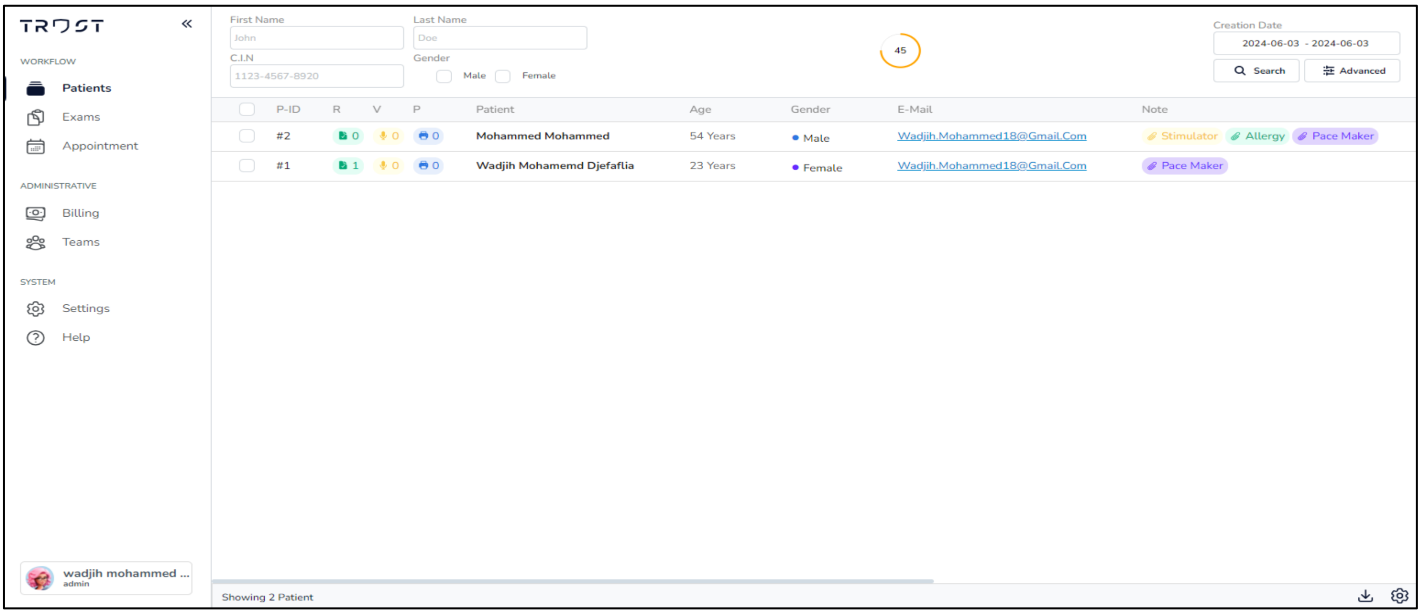
This page is used to display all the patients in the clinic. This page can be used by doctors and nurses to access patient histories.

Also, this page contains a filter bar to minimise the searching time. Nurses and doctors can use the patient's first name, last name, date of birth, gender, or even the time the patient was registered to find the patient.

After finding the patient, this page allows you to see all the patient records, like personal information (identification information, contact details, and medical condition). Also, you can see all the information about the exam that he has taken and all the staff members who were responsible for his treatment.

You can also check on all the supplements that he has taken and have a look at the payment details. Also, you can see all the previous reports of the patient.

The page is also mobile-responsive to support the probability when accessing patient history, doctors and nurses no longer need to be attached to their desks to access patient details.



First Name: John

Last Name: Doe

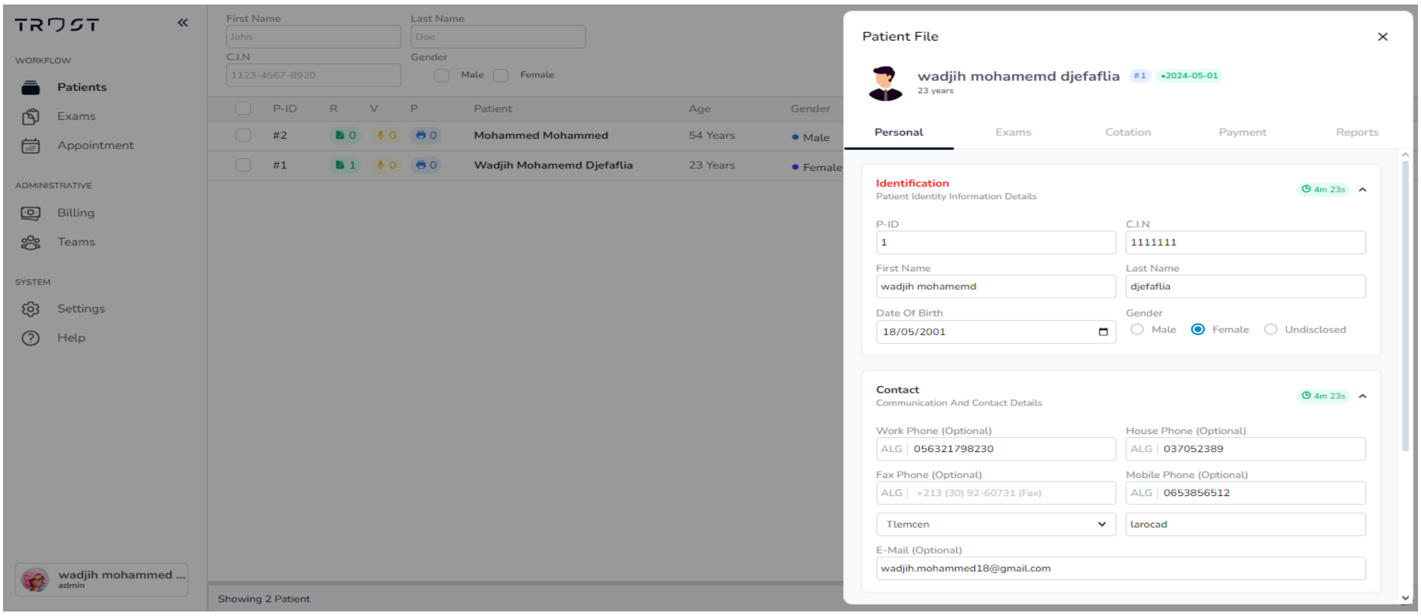
C.I.N: 1123-4567-8920

Gender: □ Male □ Female

Creation Date: 2024-06-03 - 2024-06-03

□	P-ID	R	V	P	Patient	Age	Gender	E-Mail	Note
□	#2	0	0	0	Mohammed Mohammed	54 Years	● Male	Wadjih.Mohammed18@Gmail.Com	Stimulator Allergy Pace Maker
□	#1	1	0	0	Wadjih Mohamemd Djefaflia	23 Years	● Female	Wadjih.Mohammed18@Gmail.Com	Pace Maker

Showing 2 Patient



Patient File

wadjih mohamemd djefaflia #1 •2024-05-01
23 years

Personal | Exams | Cotation | Payment | Reports

Identification
Patient Identity Information Details

P-ID: 1

C.I.N: 1111111

First Name: wadjih mohamemd

Last Name: djefaflia

Date Of Birth: 18/05/2001

Gender: ○ Male ● Female ○ Undisclosed

Contact
Communication And Contact Details

Work Phone (Optional): ALG 056321798230

House Phone (Optional): ALG 037052389

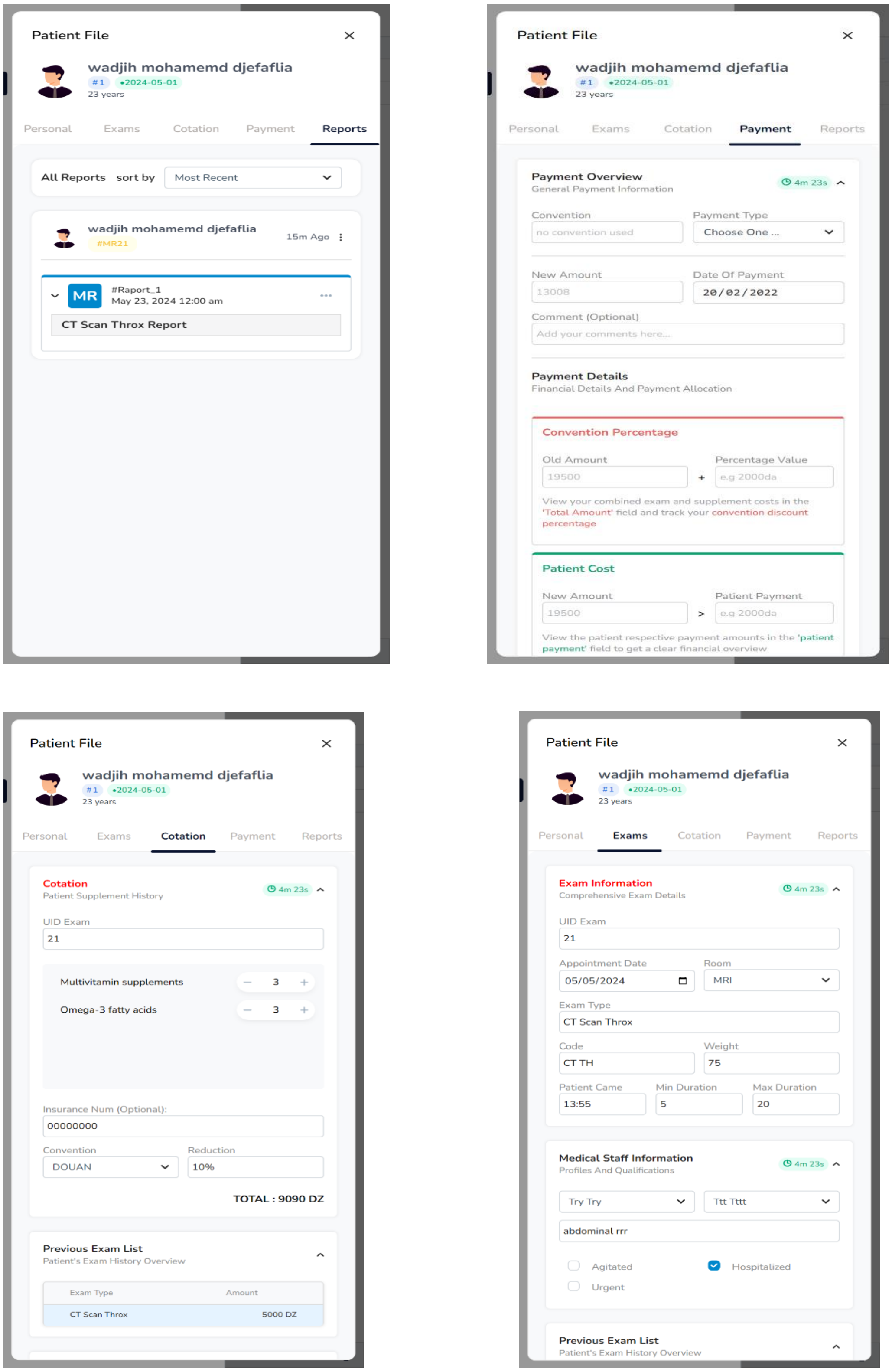
Fax Phone (Optional): ALG +213 (30) 92-60731 (Fax)

Mobile Phone (Optional): ALG 0653856512

Tlemcen

larocad

E-Mail (Optional): wadjih.mohammed18@gmail.com



Patient File

wadjih mohamemd djefaflia
#1 •2024-05-01
23 years

All Reports sort by Most Recent

wadjih mohamemd djefaflia
#MR21
15m Ago

MR #Raport_1
May 23, 2024 12:00 am

CT Scan Throx Report

Patient File

wadjih mohamemd djefaflia
#1 •2024-05-01
23 years

Payment Overview
General Payment Information
4m 23s

Convention: no convention used
Payment Type: Choose One ...

New Amount: 13008
Date Of Payment: 20/02/2022

Comment (Optional): Add your comments here...

Payment Details
Financial Details And Payment Allocation

Convention Percentage

Old Amount: 19500 + Percentage Value: e.g 2000da

View your combined exam and supplement costs in the 'Total Amount' field and track your convention discount percentage

Patient Cost

New Amount: 19500 > Patient Payment: e.g 2000da

View the patient respective payment amounts in the 'patient payment' field to get a clear financial overview

Patient File

wadjih mohamemd djefaflia
#1 •2024-05-01
23 years

Cotation
Patient Supplement History
4m 23s

UID Exam: 21

Multivitamin supplements − 3 +
Omega-3 fatty acids − 3 +

Insurance Num (Optional): 00000000

Convention: DOUAN
Reduction: 10%

TOTAL : 9090 DZ

Previous Exam List
Patient's Exam History Overview

Exam Type	Amount
CT Scan Throx	5000 DZ

Patient File

wadjih mohamemd djefaflia
#1 •2024-05-01
23 years

Exam Information
Comprehensive Exam Details
4m 23s

UID Exam: 21

Appointment Date: 05/05/2024
Room: MRI

Exam Type: CT Scan Throx

Code: CT TH
Weight: 75

Patient Came: 13:55
Min Duration: 5
Max Duration: 20

Medical Staff Information
Profiles And Qualifications
4m 23s

Try Try
Ttt Tttt

abdominal rrr

□ Agitated ☑ Hospitalized
□ Urgent

Previous Exam List
Patient's Exam History Overview

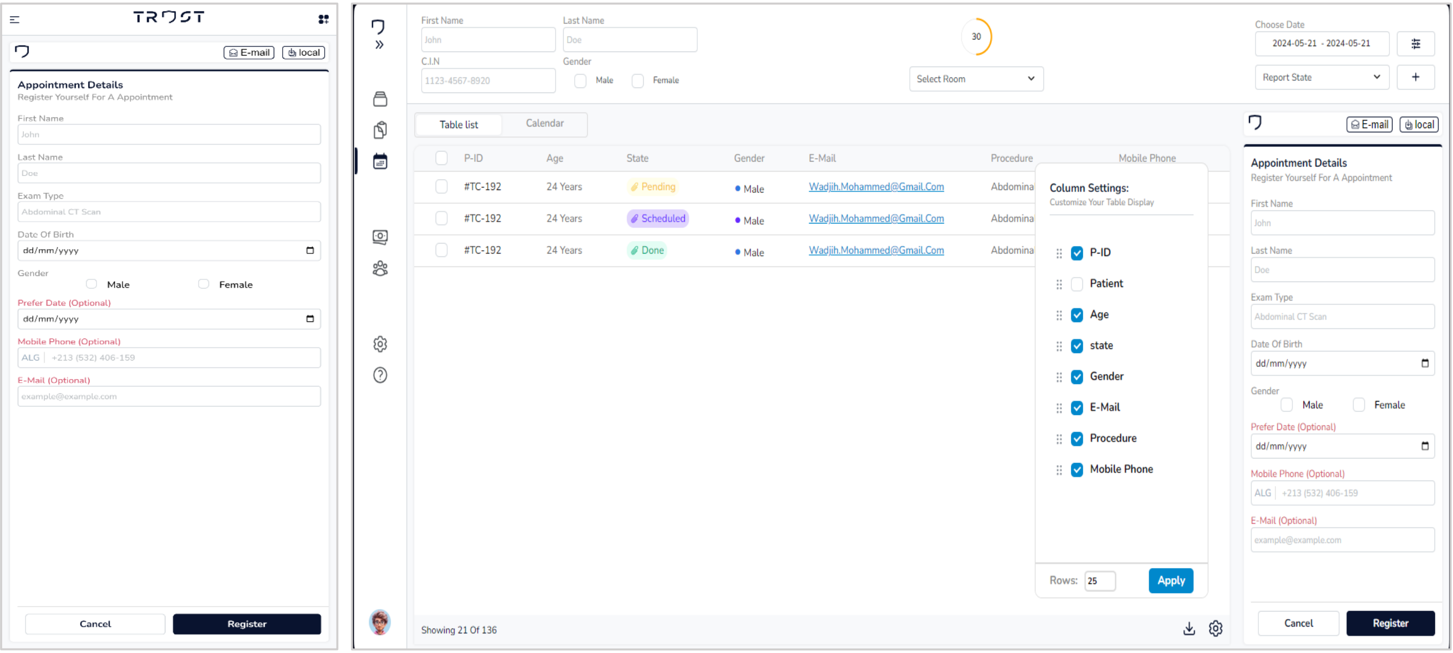
Figure 3.11: Patient page

3.2.2 Appointement page :

This page is used to register and display appointments, and it is only used by nurses. This page contains a table to display all the appointments that are finished and those that are still waiting.

The page also contains a form that allows nurses to add appointments; they can choose a date and an exam to do. This form also contains two buttons. The first button will allow you to download a receipt for the patient. The receipt will contain a QR code containing all the patient information in it, and for the second button, he allows nurses to send the receipt to the patient's email directly.

Also, this page contains a filter bar that helps filter appointments by date of the appointment, state of appointment, name of the patient, gender, and date of birth. Also, this page is mobile responsive, which will allow nurses to register appointments for patients even when they are riding a bus.



Appointment Details
Register Yourself For A Appointment

First Name: John
Last Name: Doe
Exam Type: Abdominal CT Scan
Date Of Birth: dd/mm/yyyy
Gender: □ Male □ Female
Prefer Date (Optional): dd/mm/yyyy
Mobile Phone (Optional): ALG | +213 (532) 406-159
E-Mail (Optional): example@example.com

First Name: John
Last Name: Doe
C.I.N: 1123-4567-8920
Gender: □ Male □ Female
Choose Date: 2024-05-21 - 2024-05-21

□	P-ID	Age	State	Gender	E-Mail	Procedure	Mobile Phone
□	#TC-192	24 Years	Pending	● Male	Wadjih.Mohammed@Gmail.Com	Abdomina	
□	#TC-192	24 Years	Scheduled	● Male	Wadjih.Mohammed@Gmail.Com	Abdomina	
□	#TC-192	24 Years	Done	● Male	Wadjih.Mohammed@Gmail.Com	Abdomina	

Column Settings:
Customize Your Table Display

☑ P-ID
□ Patient
☑ Age
☑ state
☑ Gender
☑ E-Mail
☑ Procedure
☑ Mobile Phone

Rows: 25

Showing 21 Of 136

Figure 3.12: Appointment Page

3.2.3 Statistics page:

This page is used by the accountants, the owner of the clinic, or anyone responsible for billing. This page contains a chart to show all the clinic revenue in a date range that you choose from the date picker.

The user will have to choose a date range from the date picker on top of the chart, and then the server will update the chart. The chart can also be printed or downloaded as PNG, CSV, or SVG.

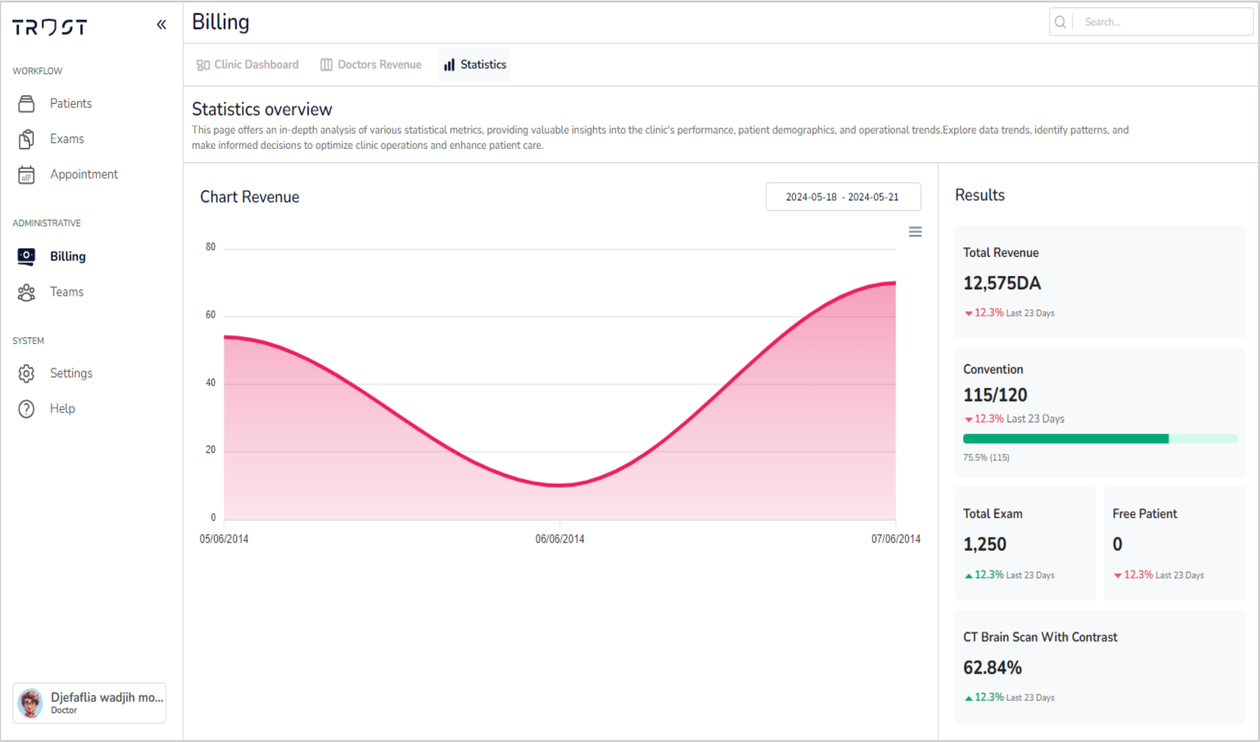
At the left of the chart, you will find a section that will show you other information about clinic revenue that can help you understand your clinic or that you can use to develop your clinic. For example, it displays the total revenue over a selected date range, such as 7 days, along with progress indicators. For example:

"1200.00 DA, -10% in the last 7 days."

This indicates a total revenue of 1200.00 DA over 7 days, which is a 10% decrease compared to the previous 7 days.

It will also show how much exam you have done and how much free patient you have done in for example 7 days, and it will also compare these results with the previous 7 days to show you if your revenue is decreasing or increasing.

This page is also responsive and can be displayed on mobile devices.



Billing

Statistics overview

This page offers an in-depth analysis of various statistical metrics, providing valuable insights into the clinic's performance, patient demographics, and operational trends.Explore data trends, identify patterns, and make informed decisions to optimize clinic operations and enhance patient care.

Chart Revenue

2024-05-18 - 2024-05-21

Results

Total Revenue
12,575DA
▼12.3% Last 23 Days

Convention
115/120
▼12.3% Last 23 Days
75.5% (115)

Total Exam
1,250
▲12.3% Last 23 Days

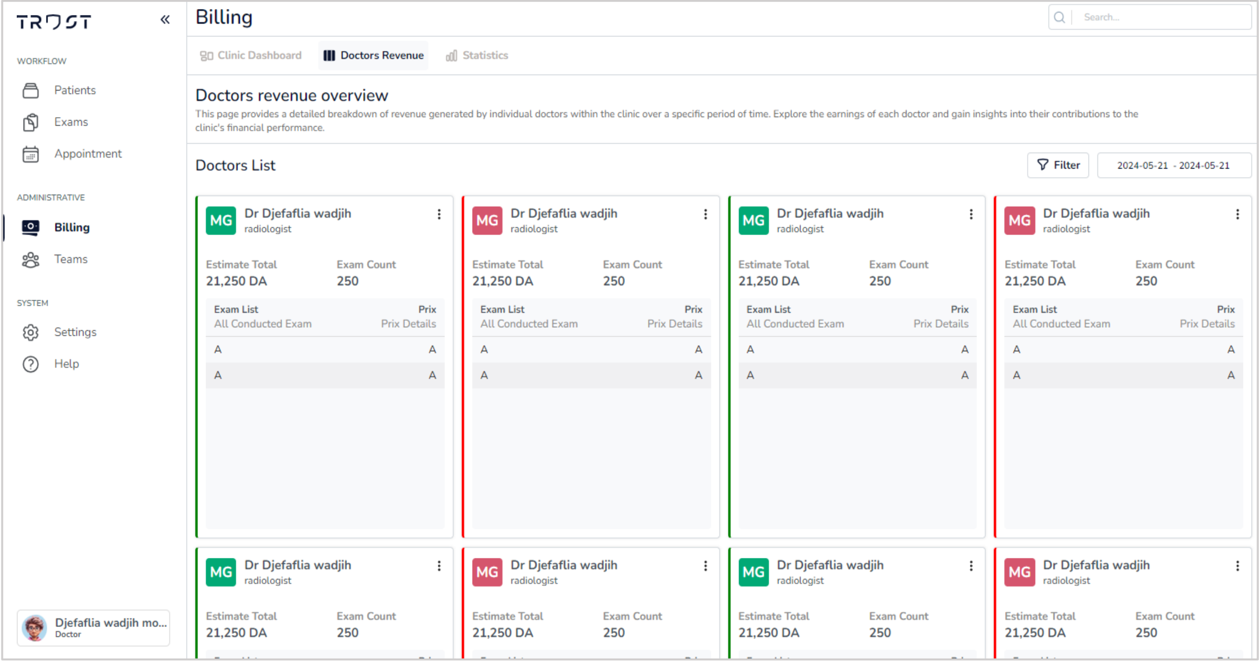
Free Patient
0
▼12.3% Last 23 Days

CT Brain Scan With Contrast
62.84%
▲12.3% Last 23 Days

Figure 3.13: statistics page

3.2.4 Doctors’ revenue page :

This page is used by accountants, the clinic owner, or anyone responsible for billing. It allows users to view the revenue generated by doctors over a selected date range. By selecting a date range, the accountant can see all exams performed by each doctor and get an estimated total of their revenue within that period.



Doctors revenue overview

This page provides a detailed breakdown of revenue generated by individual doctors within the clinic over a specific period of time. Explore the earnings of each doctor and gain insights into their contributions to the clinic's financial performance.

Doctors List

2024-05-21 - 2024-05-21

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

Exam List All Conducted Exam	Prix Prix Details
A	A
A	A

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

Exam List All Conducted Exam	Prix Prix Details
A	A
A	A

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

Exam List All Conducted Exam	Prix Prix Details
A	A
A	A

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

Exam List All Conducted Exam	Prix Prix Details
A	A
A	A

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

MG Dr Djefaflia wadjih
radiologist

Estimate Total	Exam Count
21,250 DA	250

Figure 3.14: doctors’ revenue page

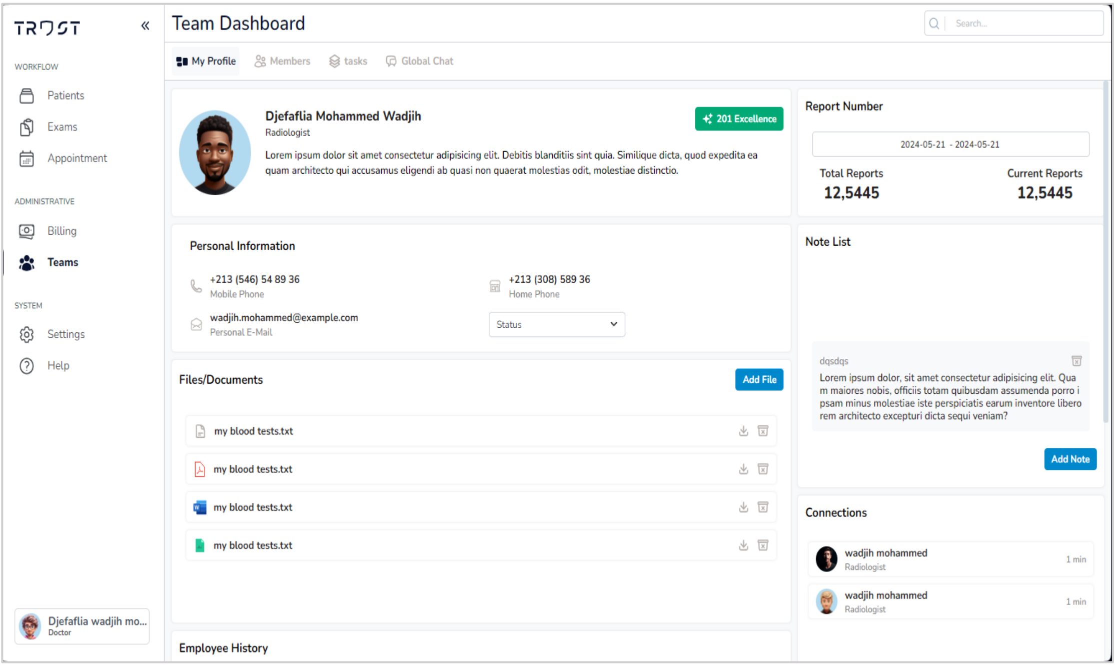
3.2.5 Profile page :

This page is used to see the activity logs and charts by providing a date range picker at the top of the page, so the employees can then select a date range to see all the reports that they have written in that period in a chart. They can also see all their activity in that period (like what time they logged in and signed in and what they modified, created, and deleted in that period).

Also, this page provides a section for the employee to store notes, just to help minimise paper usage inside the clinic. Also, the page provides a section for employees to store their personal files, which can be in any format (PNG, JPG, DOCX, PDF, etc.).

Also, this page allows employees to choose a profile picture from their files, or they can also choose a picture from the avatar list that comes with the page. Just in case the employee does not like adding his personal picture.

This page is also mobile-responsive, so employees can present their profiles to anyone and anywhere.



Djefaflia Mohammed Wadjih
Radiologist
Lorem ipsum dolor sit amet consectetur adipisicing elit. Debitis blanditiis sint quia. Similique dicta, quod expedita ea quam architecto qui accusamus eligendi ab quasi non quaerat molestias odit, molestiae distinctio.

Personal Information

+213 (546) 54 89 36
Mobile Phone

+213 (308) 589 36
Home Phone

wadjih.mohammed@example.com
Personal E-Mail

Status

Files/Documents

my blood tests.txt
my blood tests.txt
my blood tests.txt
my blood tests.txt

Employee History

Report Number

2024-05-21 - 2024-05-21

Total Reports 12,5445
Current Reports 12,5445

Note List

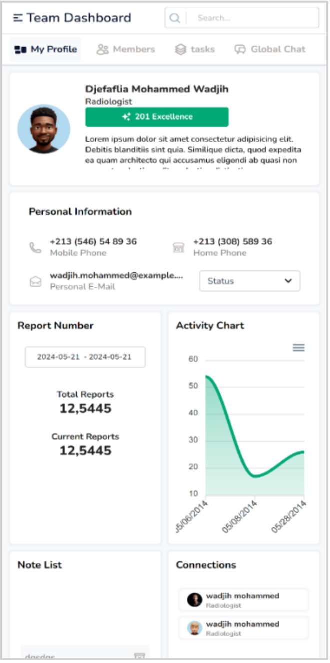
dqsdqs
Lorem ipsum dolor, sit amet consectetur adipisicing elit. Quam maiores nobis, officiis totam quibusdam assumenda porro ipsam minus molestiae iste perspiciatis earum inventore libero rem architecto excepturi dicta sequi veniam?

Connections

wadjih mohammed
Radiologist
1 min

wadjih mohammed
Radiologist
1 min

Djefaflia wadjih mo...
Doctor



Djefaflia Mohammed Wadjih
Radiologist
Lorem ipsum dolor sit amet consectetur adipisicing elit. Debitis blanditiis sint quia. Similique dicta, quod expedita ea quam architecto qui accusamus eligendi ab quasi non

Personal Information

+213 (546) 54 89 36
Mobile Phone

+213 (308) 589 36
Home Phone

wadjih.mohammed@example....
Personal E-Mail

Status

Report Number

2024-05-21 - 2024-05-21

Total Reports
12,5445

Current Reports
12,5445

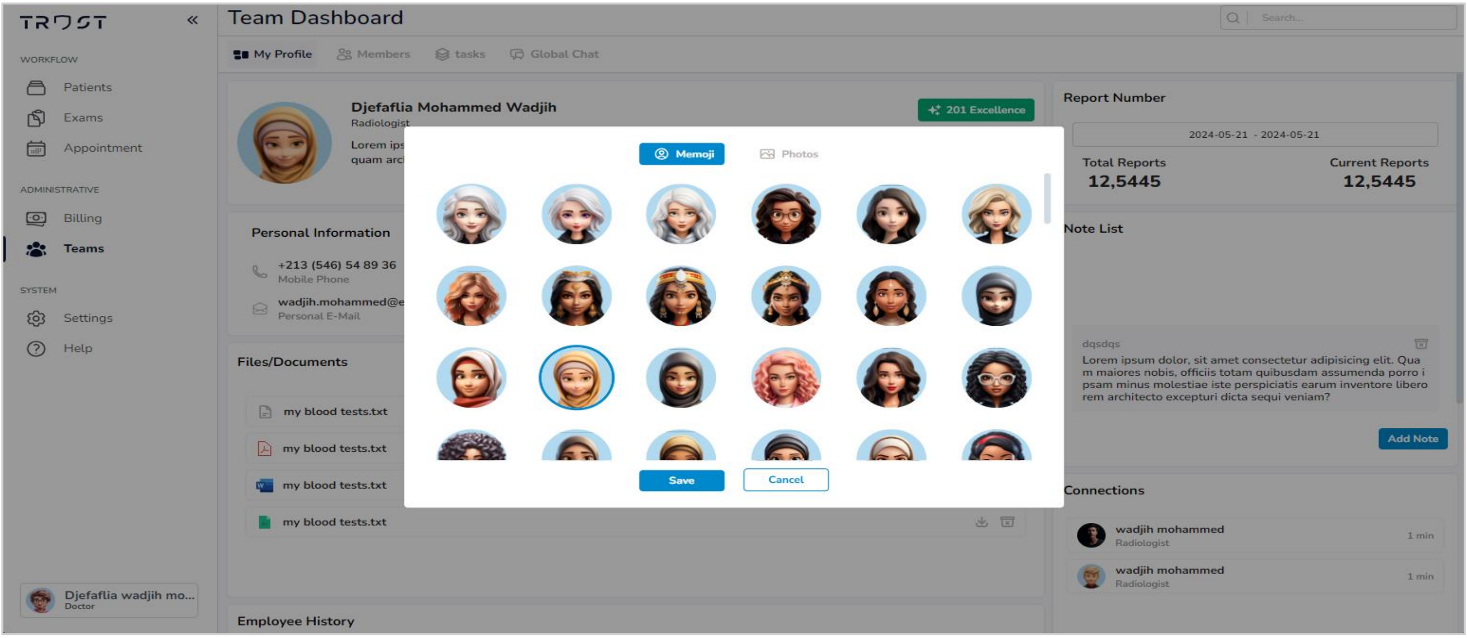
Note List

dqsdqs

Connections

wadjih mohammed
Radiologist

wadjih mohammed
Radiologist



Djefaflia Mohammed Wadjih
Radiologist
Lorem ips quam arc

Personal Information

+213 (546) 54 89 36
Mobile Phone

wadjih.mohammed@e
Personal E-Mail

Files/Documents

- my blood tests.txt
- my blood tests.txt
- my blood tests.txt
- my blood tests.txt

Employee History

Report Number

2024-05-21 - 2024-05-21

Total Reports	Current Reports
12,5445	12,5445

Note List

dqsdqs
Lorem ipsum dolor, sit amet consectetur adipisicing elit. Quam maiores nobis, officiis totam quibusdam assumenda porro ipsam minus molestiae iste perspiciatis earum inventore libero rem architecto excepturi dicta sequi veniam?

Connections

wadjih mohammed Radiologist	1 min
wadjih mohammed Radiologist	1 min

Djefaflia wadjih mo...
Doctor

Figure 3.15: profile page

3.2.6 Tasks page :

This page is used by all clinic staff members. This page allows employees to create tasks and assign them to anyone. Example:

Task subject: Modify the report of the patient with ID #1235.

and then the creator of this task can assign it to a group of members, and this task will show up to all those members. Also, every task has a priority and status, for example:

priority: **URGENT**.

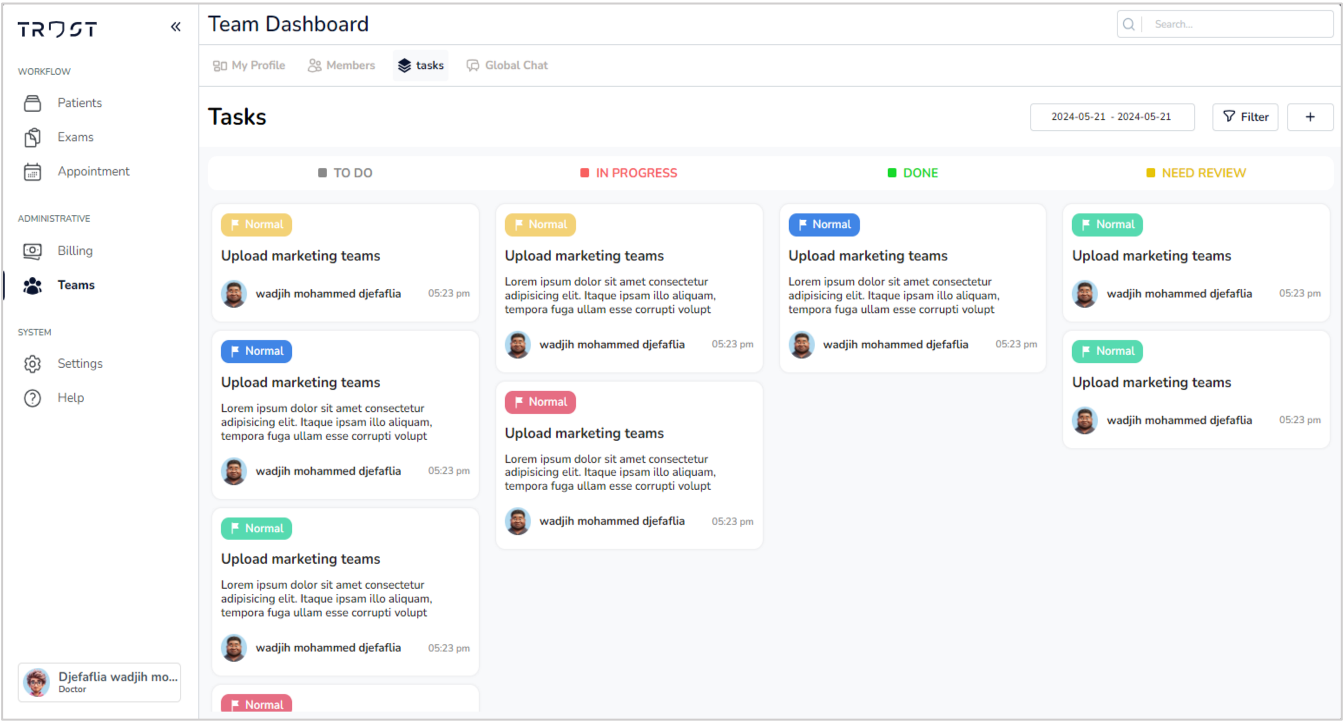
status: **IN progress**.

This will help employees identify their tasks and also the priority and status of the tasks, which will lead to better time management.

Also, the page has a date picker, which will allow you to see all the tasks within a specified period.

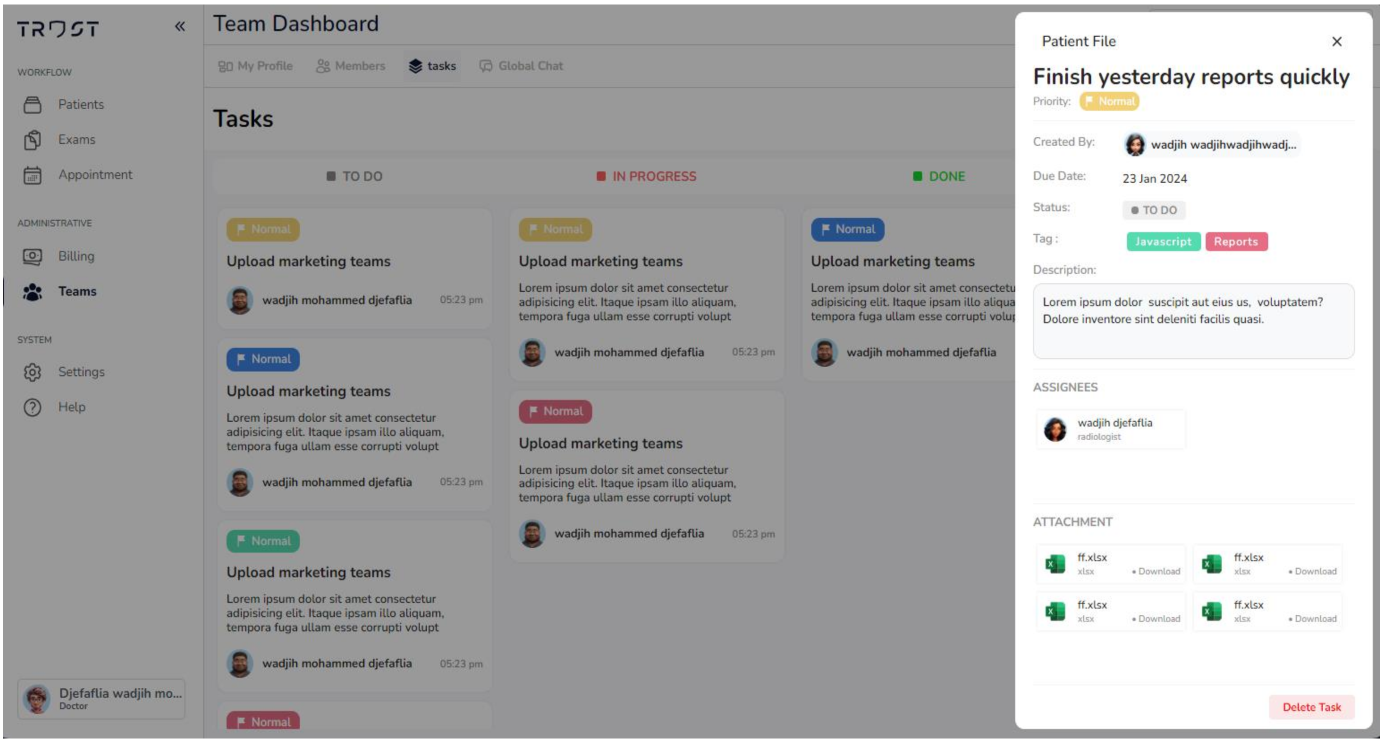
Every task has some details, like the deadline for the task, the attachment files that come with it, or the description of the task, and all these details will be displayed in a side pop-up when you click on the task.

This page is mobile-responsive, so the employee will notice the task from anywhere.



Normal
Upload marketing teams
wadjih mohammed djefaflia 05:23 pm

Normal
Upload marketing teams
Lorem ipsum dolor sit amet consectetur adipisicing elit. Itaque ipsam illo aliquam, tempora fuga ullam esse corrupti volupt
wadjih mohammed djefaflia 05:23 pm



Finish yesterday reports quickly

Priority: Normal

Created By: wadjih wadjihwadjihwadj...

Due Date: 23 Jan 2024

Status: TO DO

Tag : Javascript Reports

Description:

Lorem ipsum dolor suscipit aut eius us, voluptatem? Dolore inventore sint deleniti facilis quasi.

wadjih djefaflia
radiologist

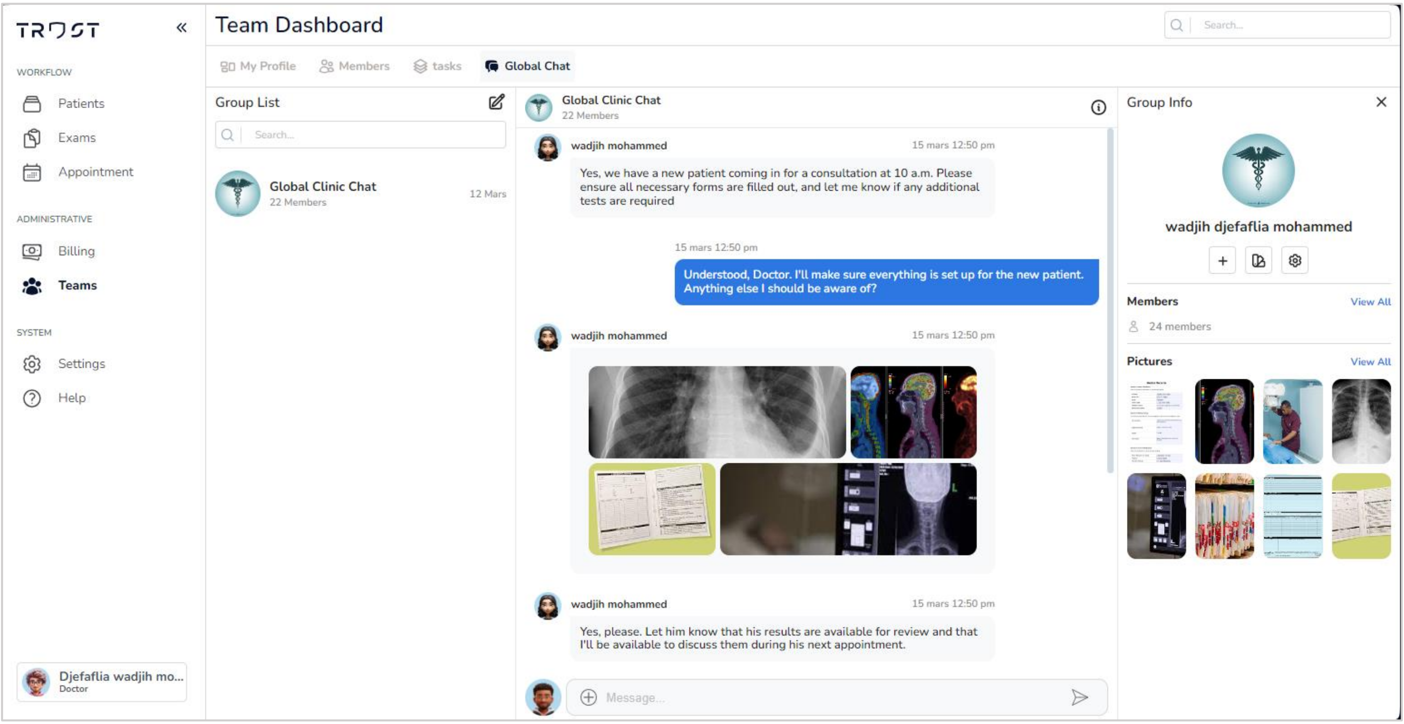
Figure 3.16: tasks page

3.2.7 Chat page :

This page is used to solve the communication problem. It provides small chat services between clinic staff members. Now any doctor and nurse can create groups and text each other. For example, all the doctors and nurses that work in the CT Scan service can create a group and name it **"CT Scan Group,"** which they will use to share information related to their service.

This will increase communication between staff; members will not have to text all their co-workers one by one to dispatch a message. It also reduces noise in the clinic, as staff no longer need to shout to convey messages, leading to a quieter and more patient-friendly environment.

This page is also mobile-responsive to help staff communicate from anywhere.



wadjih mohammed 15 mars 12:50 pm

Yes, we have a new patient coming in for a consultation at 10 a.m. Please ensure all necessary forms are filled out, and let me know if any additional tests are required

15 mars 12:50 pm

Understood, Doctor. I'll make sure everything is set up for the new patient. Anything else I should be aware of?

wadjih mohammed 15 mars 12:50 pm

wadjih mohammed 15 mars 12:50 pm

Yes, please. Let him know that his results are available for review and that I'll be available to discuss them during his next appointment.

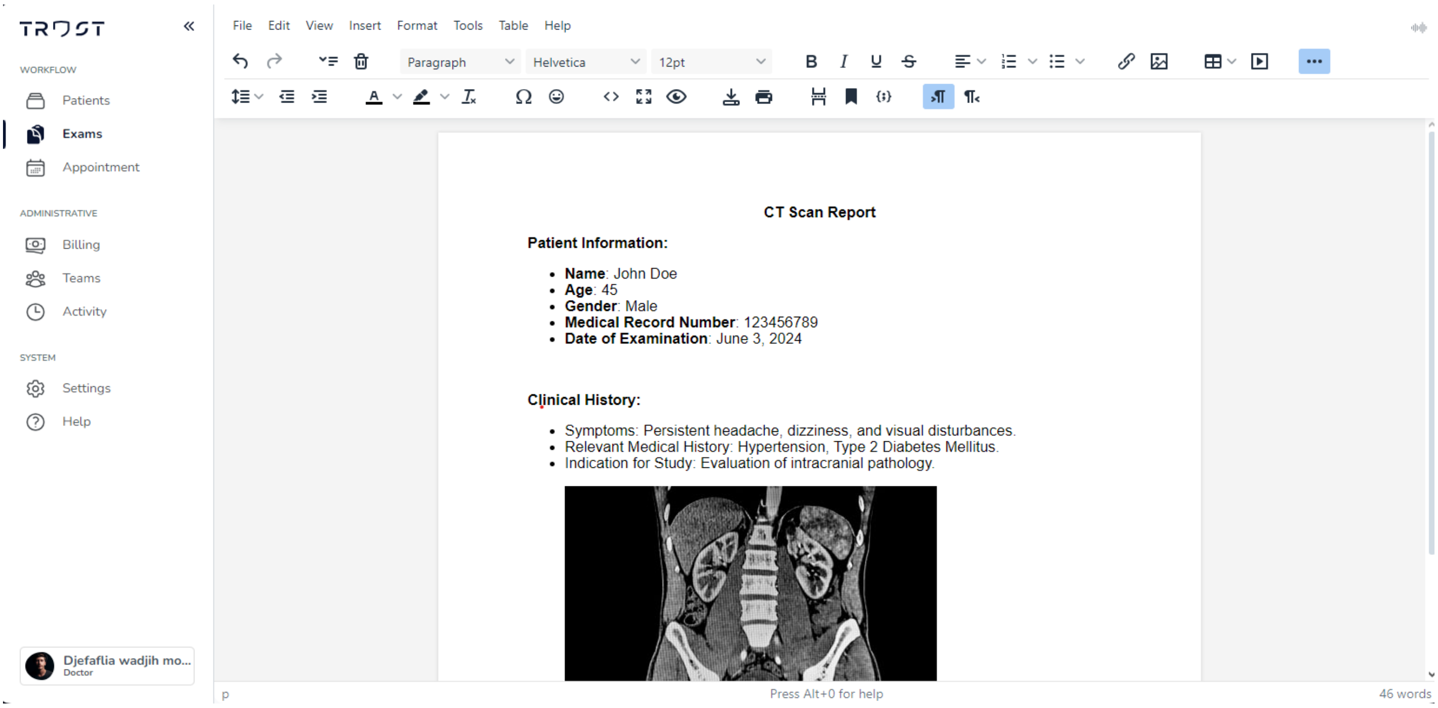
Figure 3.17: chat page

3.2.8 Report page :

This page is simply used to write reports, and it has all the necessary tools to do so. This page is based on a library that offers a text editor for free named Tiny MCE. This library supports images and tables, and it also offers a print service for employees to print reports. It also has a pre-made help section for employees to help them understand how to use this editor.

This page is simple, and it is mobile responsive, which means nurses are no longer attached to their offices, and they can also write reports from their homes. This breaks the cycle of unfinished tasks that get carried over to the next day.

This page has been proposed to a nurse who suffers from back pain from sitting next to the computer for 8 hours writing reports, and I was able to notice a big desire to obtain such a feature.



CT Scan Report

Patient Information:

- **Name**: John Doe
- **Age**: 45
- **Gender**: Male
- **Medical Record Number**: 123456789
- **Date of Examination**: June 3, 2024

Clinical History:

- Symptoms: Persistent headache, dizziness, and visual disturbances.
- Relevant Medical History: Hypertension, Type 2 Diabetes Mellitus.
- Indication for Study: Evaluation of intracranial pathology.

Figure 3.18: report page

3.3 Conclusion:

In this last chapter, we explored the environment in which we developed our web application **TRUST**, detailing what tools we have used, what languages have been used, and software that has helped me. And also, we took an overview of the software interfaces.

General conclusion

Conclusion:

This thesis presents the development and implementation of a web-based radiology information system. It commenced with the challenges in health care before having radiology information system software, such as manual report generation and scheduling problems. Then it sheds light on the problems that are still exciting after having RIS software, focusing on the portability constraints, the absence of ergonomic design principles in RIS interfaces, and communication gaps among staff members. all of which have forced the development of a web-based RIS (TRUST).

In the next chapter, "System Architecture and Design," we have dived into understanding our RIS structure and architecture by presenting three essential diagrams. Use a case diagram, sequence diagram, and class diagram. All three diagrams have provided a comprehensive overview of how the RIS operates.

After that, in the third chapter, "Implementation and Tools Used," it shifted the focus towards the technologies used during the creation of the web-based RIS. Also, we took a look at the RIS interfaces.

At the end, we have proved that there is a solution for portability problems and the need to stay on-site so you can write reports, which caused only pain and less productivity, all by transferring from a traditional desktop-based RIS to a web-based RIS accessible from any location with internet connectivity.

Also, we have designed interfaces that are more comfortable for the user and more organised, providing a solution to the ergonomic design problems.

Additionally, the implementation of a clinic chat feature has facilitated seamless communication and information exchange among staff members, providing a solution for the lack of communication problems.

After finding solutions for our problems, I can say that there is more that can be done to this web-based RIS software, especially in terms of security since the web-based RIS software will need to send a lot of data over the internet. Also, since we are in the artificial intelligence era, I think we can integrate it into the RIS software to write fast reports.

For future researchers, the thesis serves as a foundation for future studies that aim to advance the capabilities of the Radiology Information System software.

References:

[1] Radiology information system. (n.d.). Retrieved from scopicsoftware: https://scopicsoftware.com/blog/radiology-information-system/

[2] *Current Edition*. (n.d.). Retrieved from dicomstandard: https://www.dicomstandard.org/current

[3] GABRIEL, MICHAEL. (n.d.). 1.1 What is HTML? In M. GABRIEL, *Beginner's guid to HTML.*

[4] *CSS*. (n.d.). Retrieved from MDN web docs: https://developer.mozilla.org/en-US/docs/Web/CSS

[5] Crockford, D. (2008). JavaScript: The Good Parts. In D. Crockford, *JavaScript: The Good Parts* (p. 172). O'Reilly Media, Inc.

[6] *Oracle Database XE*. (n.d.). Retrieved from Oracle: https://www.oracle.com/database/technologies/appdev/xe.html

[7] By Ken Arnold, J. G. (2005). Overview. In J. G. By Ken Arnold, *The Java Programming Language, Fourth Edition* (p. 928). Addison Wesley Professional.

[8] *What is Tomcat?* (n.d.). Retrieved from simplilearn: https://www.simplilearn.com/what-is-tomcat-article

[9] *IntelliJ IDEA overview*. (n.d.). Retrieved from jetBrains: https://www.jetbrains.com/help/idea/discover-intellij-idea.html

[10] *Figma*. (n.d.). Retrieved from wikipedia: https://en.wikipedia.org/wiki/Figma

[11] *GitHub*. (n.d.). Retrieved from wikipedia: https://en.wikipedia.org/wiki/GitHub

[12] *Docs*. (n.d.). Retrieved from Visual Studio Code: https://code.visualstudio.com/docs

[13] Schmitt, P. H. (2002/2003). UML Class diagrams. In P. H. Schmitt, *UML and its Meaning* (p. 255).

[14] Hensgen, P. (n.d.). Use Case Diagram. In P. Hensgen, *Umbrello UML Modeller Handbook* (p. 49).

[15] Hensgen, P. (n.d.). Sequence Diagrams. In P. Hensgen, *Umbrello UML Modeller Handbook* (p. 49).

Appendices:

Appendix 1: DICOM

(Digital Imaging and Communications in Medicine) is the global standard for medical images and associated information. It is used by various radiotherapy devices (X-ray, CT, MRI, ultrasound, etc.) to ensure the compatibility of medical image exchanges. Regardless of what radiotherapy device you are using and what type of radiology images you want to send, by implementing DICOM, those images will be structured in a way that can be understood by most of the medical devices. [2]

Appendix 2: PACS

PACS, which stands for Picture Archiving and Communication System, it is software that has the ability to store DICOM (Appendix 1) images and patient reports. Widely used in health care, it offers an archive service for patient records in the clinic.

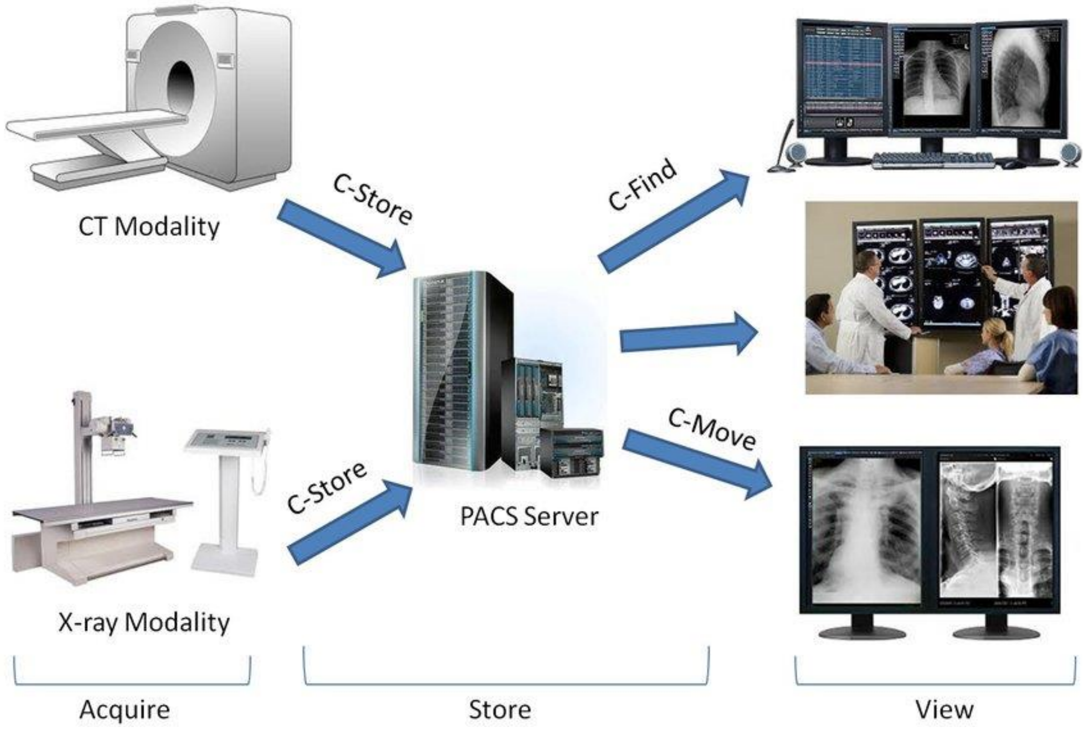


Figure 1: PACS Integration with Clinic Devices from: https://www.researchgate.net/figure/Major-PACS-components-and-sample-DICOM-messages_fig1_268195635

Appendix 3: HTTP request

An HTTP request is a message sent by your browser (client) to a website (server) to get information (like a webpage), send information, or execute a process on a web server. This message will contain details like the web server URL and the action you are trying to do, like the GET LOGIN PAGE, and other details.

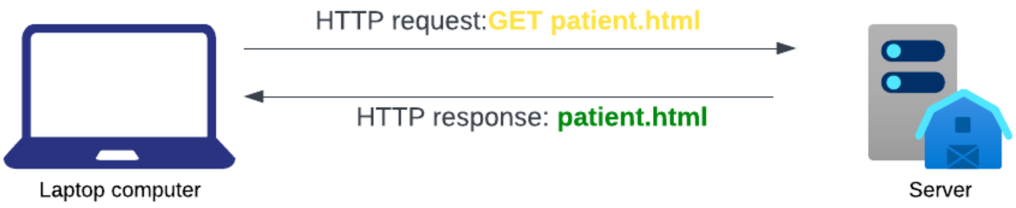


Figure 2: Analogy for an HTTP Request

Appendix 4: AJAX request

AJAX, short for Asynchronous JavaScript and XML, is a technique that utilises asynchronous HTTP requests, and the term asynchronous is used due to the nature of this HTTP request (**Appendix 3**), meaning that the web page doesn't have to wait for the server response to continue processing. In other words, this AJAX request will not stop the execution of the website while waiting for a response from the server. Also, the response that you get from these requests will not force the web browser to refresh the page, which will give our website more dynamic behaviour.

Appendix 5: Servlet

A servlet is a Java programming language class that runs on the server side. It has a URL and can be accessed using an HTTP request. Servlets have two essential methods. ‘doGet ()’ method this will treat any GET request send by the browser these requests are usually send to ask for information, also a ‘doPost ()’ method this will treat any post requests coming from the browser usually these types of requests are not asking for information instead they give information for the server.

Appendix 6: HL7

Health Level 7 is used to transfer patient data like reports and personal information between different healthcare software applications because it provides a common structure for patient data that can be understood by most health care devices. [1]