Technical University of Moldova
Faculty of Computers, Informatics and Microelectronics
Department of Software Engineering and Automatics
Software Engineering Study Programme

INTERNSHIP REPORT

Medtrack - Smart Health Records

Team no. 10

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ABSTRACT

The project titled ”MedTrack” was developed by students Anastasia Tiganescu, Andi Blindu, Catalin Darzu, Daniela Cojocari, Janeta Grigoras, and Mihai Caraman from the Technical University of Moldova. This paper includes two main chapters: Domain Analysis and System Design, followed by Conclusions and Bibliography.

The problem addressed is the limitations and weaknesses of traditional paper-based medical records, which often lead to data loss, inaccessibility, and inefficiency of healthcare services. As a solution to this, MedTrack is presented as a secure web-based application that will store patients' medical history electronically and provide role-based access to patients, doctors, and administrators.

The system offers access to information like appointments, prescriptions, vaccinations, and allergies to the respective users. Its implementation uses robust security measures such as encryption, multi-factor authentication, and input validation to ensure data security. MedTrack is a modern, simplified, and patient-oriented application with the potential to increase transparency, reduce errors, and allow better healthcare management.

Keywords: healthcare, patients, security, medical, records

Content

INTRODUCTION

Nowadays, digitalization of healthcare is a pressing necessity in increasing accessibility, efficiency, and safety for patients. Traditional systems, such as paper-based medical records, remain prevalent, especially in Moldova, but are increasingly inadequate. Such systems are accompanied with dangers of incomplete documentation, limited accessibility in emergencies, and compromised reliability over long-term care.

The reason for the project is the need to modernize medical record-keeping by offering an orderly, secure, and transparent solution. MedTrack enhances communication between health professionals and enables patients to become more engaged in their own health through accurate storage and fast retrieval of patient data.

Its usefulness extends beyond the patient: for doctors, it reduces the possibility of human error and enables good decision-making, while for administrators, it makes management and monitoring of the system simpler. On a broader level, the implementation of electronic solutions such as MedTrack serves to modernize healthcare systems.

This report is structured into two main chapters. The first chapter provides the domain analysis, examining the background, existing problems, solution concept, and relevant case studies. The second chapter addresses system design, including technical requirements, behavioral modeling, and structural modeling. Together, these sections establish both the theoretical foundation and the practical implementation of MedTrack as a patient-centered digital health solution.

1. DOMAIN ANALYSIS

1.1. Problem Overview

1.1.1. Problem Description

For decades, the medical system in Moldova has relied on physical medical booklets where doctors record a patient's history, treatments, and prescriptions. These booklets are central to care, ensuring that important medical information is written down and available during visits. In the past, this format was practical: it provided a simple way to keep track of vaccines, illnesses, and treatments in one place. However, in the context of modern healthcare, the paper format has become a significant limitation.

Firstly, their physical format is, by itself, a limitation. In emergencies, or while traveling, patients don't usually carry their medical booklets with them. In such cases, doctors have to rely on incomplete details or patient memory, which are inherently faulty, and never equal the accuracy of a detailed medical log. This is not only inconvenient, but also dangerous. A study on medication errors found that up to 67% of patients admitted to hospitals had at least one error in their medication history, with over 40% of these errors carrying clinical significance and nearly a quarter posing actual harm [1]. This shows clearly "that there is potential for significant harm to patients" when medical history is incomplete or inaccurate.

Digital solutions have already proven their advantage. A 2019 study comparing emergency departments using electronic medical records (EMR) with those using handwritten ones showed that EMRs reported lower levels of medication errors and "contributed to a continuous improvement in patients' safety" [2]. In other words, storing information digitally directly saves lives.

The problem is not limited to emergencies. Over the course of their lives, patients see on average 18.7 different doctors, according to a survey conducted by GfK Roper for Practice Fusion [3]. For older patients, this number rises to over 28. Each new doctor has to either consult the paper booklet (if available) or rely on the patient's memory. This is time-consuming, error-prone, and frankly absurd in today's world. Traditional paper-based records, instead of supporting care, can easily put patients at risk.

Secondly, traditional booklets also block patient engagement. They are mostly written for doctors, not patients, and rarely provide clear explanations or instructions. As a result, patients are left with poor understanding of their own health. Modern approaches, such as Personal Health Records (PHRs), change this dynamic. A study on contemporary PHRs found that users are more informed about their conditions and more able to participate in their care [4]. This leads to better communication between patients and providers and encourages patients to take responsibility for their health.

PHRs are not just about storing information. As another study highlights, they are also tools for health literacy and citizen empowerment [5]. By allowing patients to monitor daily activities, share experiences with caregivers, and collaborate with doctors, PHRs improve engagement, personalization of care,

and overall outcomes.

All in all, the limitations of paper-based medical records are too significant to ignore. They are often unavailable in emergencies, they slow down care, contribute to medical errors and fail to engage patients – all prove they are potentially harmful and must be replaced. Therefore, it becomes clear that continuing to rely on outdated methods is not sustainable. The only way forward is to address the inconvenience and dangers posed by the traditional physical medical booklets in modern healthcare.

1.1.2. Domain Analysis

Electronic Health Records (EHRs) are digital versions of the so-called traditional paper medical booklets. Unlike paper booklets, which can be lost, damaged, or even incomplete, EHRs centralize information such as diagnoses, treatments, test results, etc. Because of these advantages, replacing paper records with EHRs is becoming essential.

To begin with, electronic medical records reduce medical errors and improve patient safety. A study conducted in Israel showed that after the introduction of EHR systems, medication errors decreased by approximately 30% compared to paper-based methods [6]. Similarly, Trout et al. (2022) [7] reported that hospitals with fully implemented EHRs experienced significant decreases in adverse events, including a 291% reduction in deaths, 242% decline in postoperative metabolic issues, and a 193% decrease in wound-related complications. Supporting this evidence, a Nature study [8] showed that moving from paper to digital reduced reported medication incidents by 38%, procedural errors from 32.1% to 1.3%, and dosing errors from 32.3% to 14%. Collectively, these findings highlight how EHRs directly contribute to safer and more reliable healthcare delivery.

In contrast, paper-based systems often prove unreliable. Traditional paper records are often incomplete, disorganized, or lost, making it difficult for doctors to get a full picture of a patient's history, often leading to delays in treatment. For instance, a study conducted in two hospitals by Daniel Hahn, Pepela Wanjala & Michael Marx [9] found that only 71.7% and 77.8% of patient records could be retrieved from paper registers, even after extensive research. Moreover, researcher Liezel Ennion found that in a rural South African community, fewer than 40% of requested records were found [10]. These gaps delay care and create inefficiencies. In contrast, EHRs store information centrally and securely, ensuring records are complete and accessible whenever needed.

In summary, electronic health records provide a reliable and efficient alternative to traditional paper-based medical booklets. By centralizing patient information and making it easily accessible, EHRs reduce errors, improve patient safety, and streamline healthcare processes.

1.1.3. Problem Statement

The inconvenience and dangers posed by the traditional physical medical booklets in modern healthcare.

1.2. Target Audience

1.2.1. Stakeholders

The patients will benefit from the system by having easy and secure access to their complete medical history anytime, which allows them to better understand their health. They can quickly share records with new doctors, reducing the need for repeated tests, and they gain increased transparency and trust in the healthcare process.

The doctors and medical staff will benefit from quick access to patient histories, enabling more accurate diagnoses and treatment plans. The system reduces time spent on paperwork, provides standardized forms for recording visits, and minimizes errors, such as drug interactions or allergy conflicts, improving overall patient care.

Hospital and clinic administrators will benefit from centralized management of patient records, making reporting, auditing, and compliance easier. The platform reduces costs associated with storing and handling physical records and increases operational efficiency by streamlining staff workflows and patient management.

Health institutions, including hospitals, clinics, and laboratories, will benefit from digital transformation, improving collaboration between departments and increasing overall service efficiency. Modernized services enhance patient satisfaction and strengthen the institution's reputation.

Government and health authorities will benefit from access to accurate, real-time data that can support public health monitoring, such as vaccination rates or disease outbreaks. The system simplifies enforcement of healthcare laws and regulations while reducing bureaucratic procedures in medical reporting and statistical collection.

1.2.2. Target Groups

To improve healthcare management and patient care, it is essential to consider the key groups who will benefit from the solution. All these groups face different issues while trying to access, exchange, and manage medical data. Healthcare professionals, for example, work with many patient files day in and day out and require a user-friendly system that is not only time-saving but also minimizes errors with quick access to correct information. Patients themselves, however, have issues keeping their own records, especially when paper-based systems are employed. They require an easy and secure platform where they can look at test results, track vaccinations, check visit history, and be confident their information is up to date and accurate. Hospital administrators are tasked with the organization of the control of the firm and the storage of the medical records, which typically entail significant information and complex access rules. To all of them, there must be an electronic solution in one place to streamline administrative tasks, regulate access the proper way, and ensure the records are always well-arranged and readily retrievable. By addressing the needs of these groups, the system enables streamlined workflows, enhanced communication

between health care providers, and improved quality of care to patients in general.

1.3. Solution Concept

In response to the limitations and risks posed by the traditional paper-based medical booklets, MedTrack is introduced as a web application designed to securely store patients' medical history and make it accessible to both patients and doctors whenever needed. One of the key features of MedTrack is role-based access. The platform supports three main user categories:

- Patients, who can securely log in with their unique IDNP and view their entire medical history. This includes records of past and current visits, treatments, prescriptions, vaccinations, allergies, and chronic conditions. Patients can also see real-time updates after each medical consultation and are notified when their record is accessed or updated, ensuring transparency.
- Doctors, who can create and update patient records during or after consultations. They can add diagnoses, prescriptions, treatment plans, vaccination updates, and notes, as well as track the progress of patients over time. The system also highlights when a record is being accessed, promoting accountability and trust.
- Administrators, who manage user accounts, oversee platform functionality, and ensure the consistency and integrity of the medical database.

In addition to access management, MedTrack ensures structured health records, which organize data into categories such as visits, treatments, prescriptions, vaccinations, allergies, and chronic conditions. This structured format minimizes errors, ensures quick retrieval of essential data in emergencies, and provides a reliable alternative to patient memory.

Security is a core foundation of the system, ensuring that sensitive medical information is fully protected while remaining accessible only to authorized users. Authentication is implemented through JSON Web Tokens (JWT), providing secure and stateless session management. Combined with role-based access control (RBAC), the platform enforces strict separation between patients, doctors, and administrators, making sure that each user can only access information appropriate to their role. To further enhance protection, multi-factor authentication (MFA) adds an additional layer of verification during login, safeguarding accounts even in cases where credentials are compromised. In addition, the platform applies rigorous input validation and data formatting checks, reducing vulnerabilities and ensuring that all stored and processed data complies with security standards.

Beyond security, the system also integrates a notification module designed to keep users consistently informed and engaged. Patients automatically receive reminders about upcoming appointments and vaccination schedules, helping them stay on track with their healthcare plans. Doctors are likewise notified of new appointment requests or updates to patient information, which supports better coordination and timely responses. Notifications are delivered via email for maximum accessibility and reliability, ensuring that im-

portant updates reach users regardless of the device they are using. Together, these security and notification mechanisms create a platform that is not only safe and resilient but also user-friendly and responsive to the needs of both patients and healthcare providers.

Looking forward, MedTrack can be expanded with features such as exporting options, allowing patients to download summaries of their history in secure formats, and analytics dashboards, helping doctors and administrators monitor trends, optimize treatments, and gain valuable insights into population health.

In short, MedTrack provides a secure, modern, and patient-centered solution that eliminates the inconvenience and dangers of traditional paper-based medical booklets while setting the stage for a more efficient and engaging healthcare experience.

1.4. Market Research

1.4.1. User Personas

Dr. Samuel Thompson, 42, depicted in **Figure 1.1**, represents the target group of medical professionals. He is a General Practitioner at Riverside Community Clinic and manages hundreds of patient files each week. He needs an intuitive solution that saves time, reduces errors, and keeps patient data organized.

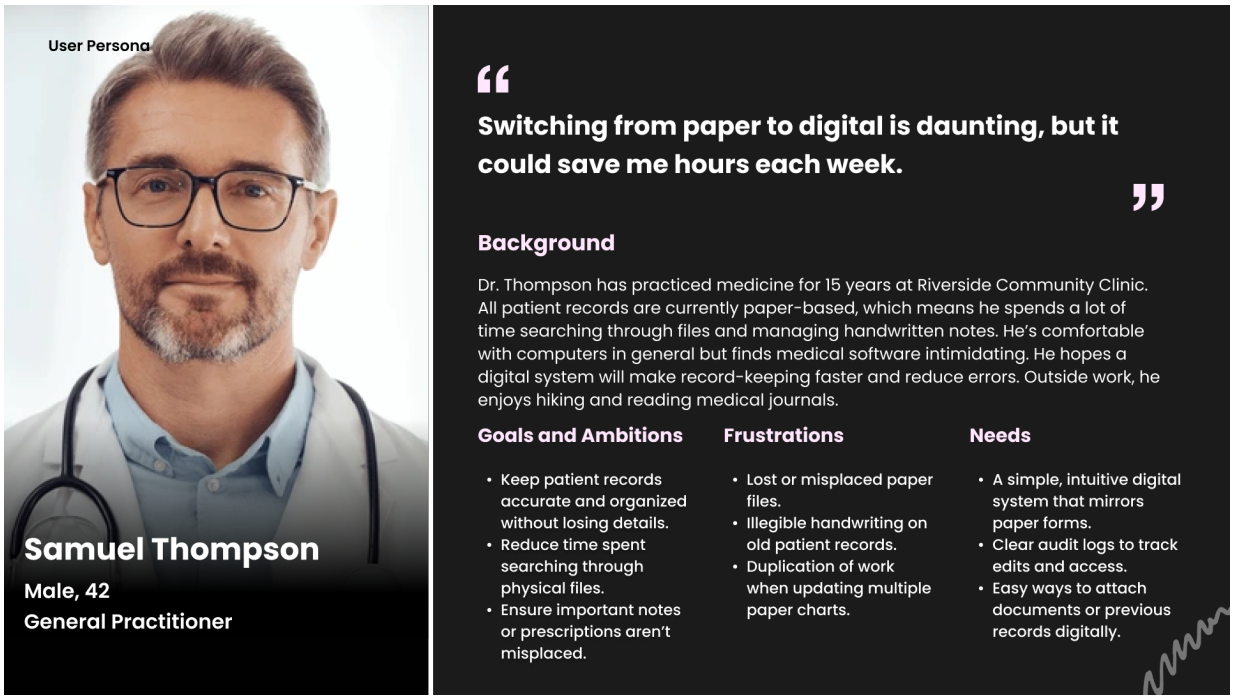

Figure 1.1: User Persona - Samuel Thompson

Aisha Malik, 29, illustrated in **Figure 1.2** represents the target group of patients who currently rely on paper medical records. She is a Marketing Specialist at BrightWave Marketing Agency and often has to call or visit clinics to verify her health information. She needs a secure, easy-to-access system to track vaccinations, allergies, and visit history.

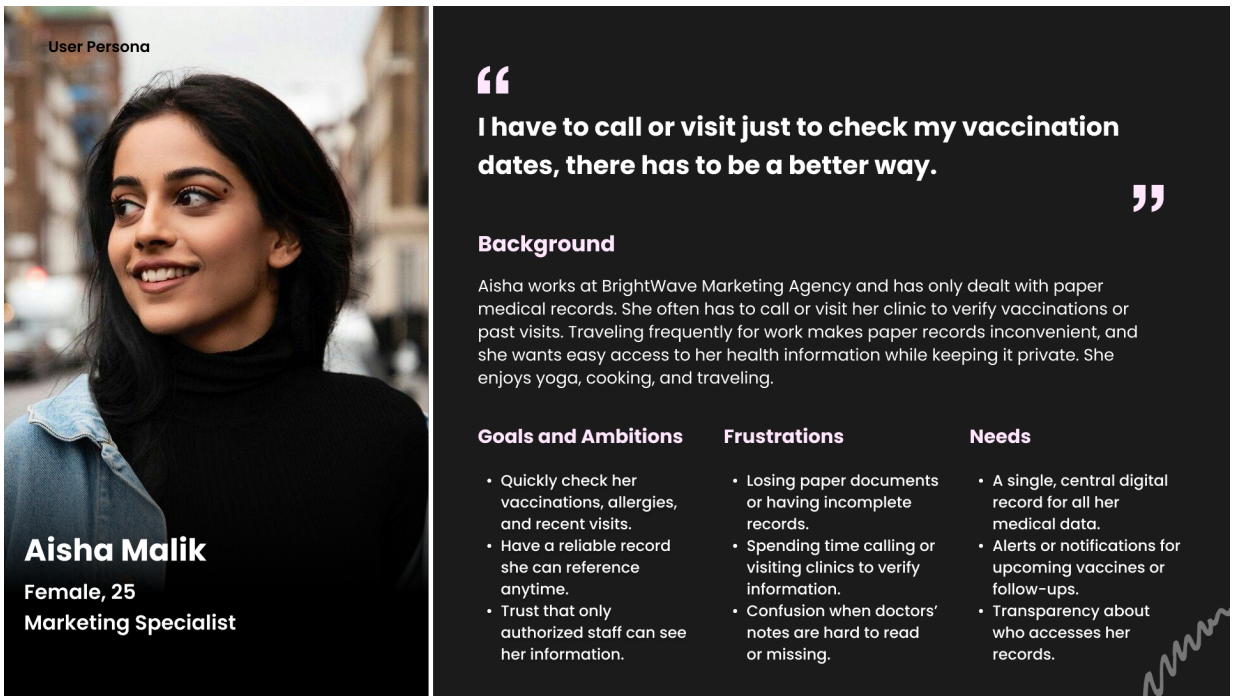

Figure 1.2 User Persona - Aisha Malik

Carlos Rivera, 35, pictured in **Figure 1.3** represents the target group of hospital administrators responsible for managing large volumes of paper records. He works as a Hospital IT & Administration Officer at Greenfield Regional Hospital. He needs a simple, secure digital system to improve organization, minimize errors, and maintain proper access control.

Figure 1.3: User Persona - Carlos Rivera

1.4.2. User story

Aisha Malik often struggles to keep track of her health records, which are still stored in paper booklets at different clinics. One morning, she decides to use MedTrack to manage her medical information digitally. She navigates to the MedTrack website and logs in securely using her unique IDNP and a one-time authentication code sent to her phone.

Once logged in, Aisha sees a clear dashboard summarizing her medical history, including past visits, prescriptions, vaccinations, allergies, and chronic conditions. She notices a notification indicating that her doctor has updated her latest consultation. Clicking the notification, she reviews the notes, prescriptions, and follow-up recommendations, feeling reassured that her records are complete and up to date. Next, Aisha wants to check her vaccination schedule. She navigates to the "Vaccinations" section, where she sees which vaccines are current and receives reminders for upcoming doses. She also explores her "Visit History" to review previous consultations and track her ongoing treatments.

Curious about sharing her information with another clinic, Aisha uses the export feature to download a secure PDF summary of her medical history. The system confirms that the export is encrypted and safe to share. Throughout the process, Aisha notices small indicators whenever her record is accessed or updated, giving her confidence that her information is secure and that any activity is transparent.

By the end of her session, Aisha feels empowered. She has easy access to her complete medical history, reminders for upcoming care, and the assurance that her sensitive data is protected. MedTrack has eliminated the stress and confusion she used to experience with paper booklets, allowing her to manage her health efficiently and securely.

1.5. Comparative Analysis

Effective medical platforms aim to improve patient–doctor interaction, streamline appointment scheduling, and secure medical data. Compared to traditional paper-based records, which are often difficult to access, prone to loss, and slow to update, an online medical system ensures information is centralized, easily retrievable, and consistently maintained across different users and environments. This shift not only reduces administrative burden and repeated tests but also increases transparency for patients and efficiency for doctors. While established platforms like Doctolib, Zocdoc, and Athenahealth already provide proven services in this area, the project introduces features tailored to both usability and data security, offering a balanced alternative.

The project sets itself apart through its ability to integrate both medical records and appointment scheduling within a secure, role-based environment. Patients and doctors benefit from clear dashboards, secure authentication, and multi-factor login protection that ensures sensitive data remains safe. In addition, the platform includes a doctor review system, allowing patients to view reviews of their doctors and

provide their own feedback, enhancing transparency and trust in the healthcare experience. This contrasts with platforms such as Doctolib, which is well known in Europe for simplifying appointment booking and enabling teleconsultations but does not focus deeply on comprehensive medical record management or patient-generated doctor feedback. Similarly, Zocdoc, widely used in the United States, serves primarily as a discovery and booking tool that allows patients to find doctors based on insurance coverage, specialty, or location, but it offers limited functionality when it comes to storing and managing detailed clinical data. Athenahealth, on the other hand, represents a complete enterprise-level solution with extensive electronic health record integration, billing, insurance management, and advanced analytics, making it far more complex and resource-intensive than what smaller clinics or practices may require.

In terms of user management, the system emphasizes role-based access control with clearly defined permissions for patients, doctors, and administrators, supported by JSON Web Tokens and multi-factor authentication. This level of fine-grained security and validation is not as prominent in platforms like Doctolib or Zocdoc, where the primary distinction lies only between patients and doctors. Athenahealth, however, provides advanced role hierarchies and clinical workflows but often with the trade-off of complexity and higher barriers to entry for smaller institutions.

Medical record handling is another key differentiator. The platform enables doctors to create detailed visit reports, vaccination records, and allergy documentation, while patients retain full visibility of their health history. Doctolib and Zocdoc largely omit this functionality, focusing instead on appointments and scheduling, leaving medical record management to other systems. Athenahealth again provides full clinical record support but is designed primarily for large-scale healthcare providers.

Security measures further highlight the difference. The system ensures protection through JWT-based authentication, RBAC, and MFA, alongside strict data validation. Doctolib and Zocdoc comply with GDPR or HIPAA depending on jurisdiction, but authentication mechanisms are generally less robust, often limited to standard login credentials. Athenahealth naturally adheres to enterprise-grade security and compliance, but it is often deployed in large healthcare organizations rather than in smaller clinics where the system would provide a more accessible solution.

Dashboards and reporting in the system are tailored to user roles, giving patients an overview of their medical history and doctors an overview of their patients and activities. By comparison, Doctolib provides a scheduling-focused dashboard, Zocdoc emphasizes booking history and patient reviews, while Athenahealth delivers extensive dashboards that integrate financial, clinical, and population health analytics, going far beyond the everyday needs of smaller practices.

Ultimately, Doctolib and Zocdoc excel in connecting patients with doctors and simplifying booking but lack strong support for comprehensive medical record management. Athenahealth delivers a full-fledged enterprise solution that includes billing, insurance, and analytics but is often too complex and costly for

smaller providers. The project stands in between these extremes, providing a solution that is more than a booking app yet lighter and more accessible than enterprise EHRs. With its strong security foundation, role-based design, integrated records, and the doctor review system, it offers a modern and balanced platform for patient–doctor interaction and data management.

FEATURES	MEDTRACK	DOCTOLIB	ZOCDOC	ATHENAHEALTH
Appointment Scheduling	YES	YES	YES	YES
Medical Record Management	COMPREHENSIVE RECORDS	LIMITED, MOSTLY APPOINTMENT INFO	LIMITED, MOSTLY APPOINTMENT INFO	FULL EHR SUPPORT
Multi-Factor Authentication (MFA)	YES	NO	NO	YES
Doctor Review System	YES	NO	YES	NO
Security	JWT AUTHENTICATION, RBAC, MFA, STRICT VALIDATION	GDPR/HIPAA COMPLIANT, BASIC LOGIN	HIPAA COMPLIANT, BASIC LOGIN	ENTERPRISE-GRADE SECURITY & HIPAA COMPLIANCE
Communication / Notifications	YES	YES	YES	YES

Table 1.1: Comparative Analysis Table

2. SYSTEM DESIGN

2.1. Technical Requirements

The system is designed to provide patients and doctors with a secure and user-friendly platform for managing medical records, scheduling appointments, and accessing essential health-related information. Its functionality is structured around user management, role-based access control, medical records handling, dashboards, notifications, and auditing, ensuring that each user interacts with the platform according to their specific needs.

2.1.1. Functional Requirements

From a functional perspective, the platform allows patients, doctors, and administrators to access the system with distinct roles and responsibilities. Users can log in securely, update their profiles, and manage personal information as needed, with authentication mechanisms ensuring data protection.

Role-based access control (RBAC) ensures clear separation of responsibilities. Patients can view their medical history, vaccination records, allergies, prescriptions, and details of their assigned doctors. They are also able to schedule appointments and receive confirmation through email notifications. Doctors manage the records of their assigned patients by creating, updating, and deleting visit records, vaccination details, and allergy information. They also review and respond to appointment requests, which supports efficient scheduling. Administrators oversee the platform as a whole, monitoring its operation and managing user activity when necessary.

Medical record management represents the core of the system. Doctors can create detailed visit records that include symptoms, diagnoses, and treatments, while patients maintain full visibility of their own medical history. Vaccination and allergy records are managed consistently, enabling accurate tracking of critical health information by both doctors and patients.

Dashboards provide a tailored experience for each role. Patients receive a clear overview of their recent medical activity, including visits and vaccination updates, while doctors access dashboards that highlight their patient lists and ongoing cases. Notifications strengthen this functionality by ensuring that patients are reminded of upcoming appointments and vaccination schedules, while doctors are promptly alerted to new or updated appointment requests. Email notifications complement these features by keeping both parties informed in real time. In addition, auditing and logging mechanisms track all critical actions, ensuring accountability, supporting system maintenance, and enabling error resolution.

2.1.2. Non-functional Requirements

From a non-functional perspective, the system is designed to meet high standards of security, performance, usability, reliability, and scalability. Security is central, with encryption applied both in transit and at rest, JWT-based authentication, MFA, and RBAC guaranteeing protection of sensitive data. The system

also integrates advanced validation mechanisms and protection against common security threats such as SQL injection, CSRF, and XSS.

Performance requirements ensure that the platform responds quickly and smoothly, with dashboards and medical records loading within seconds under normal operating conditions. It is built to handle multiple concurrent requests efficiently, allowing scalability as the user base expands. Usability plays an equally important role, with the frontend designed to be intuitive, responsive, and accessible across desktop, tablet, and mobile devices. The interface follows accessibility standards to ensure inclusivity for users with special needs.

Reliability is reinforced through robust backup and recovery mechanisms, minimizing downtime and ensuring that no medical data is lost in case of technical failures. Availability is prioritized so that the system remains accessible at all times, supporting both patients and doctors when they need it most. Finally, maintainability and scalability are supported by a modular, well-documented architecture that simplifies the integration of new features and updates.

2.2. Behavioral Modeling

Behavioral Modeling examines the dynamic behavior of the system, focusing on the interactions between users and the platform. The modeling is represented through use case diagrams, which capture the functional capabilities available to each role, and sequence diagrams, which describe the step-by-step flow of actions and system responses. Together, these models creat a view of how the system operates in practice.

2.2.1. Use Case Diagrams

The Patient Use Case Diagram, shown in **Figure 2.1**, illustrates the key functions available to a patient within the portal. After logging in or registering through the Authentication module, patients can manage appointments by booking, canceling, or viewing them. They can also access medical information such as medical records, vaccines, uploaded documents, and contact their doctor. In the Profile Management section, patients can view and edit their personal information. Patients can also view, book and even cancel their appointments.

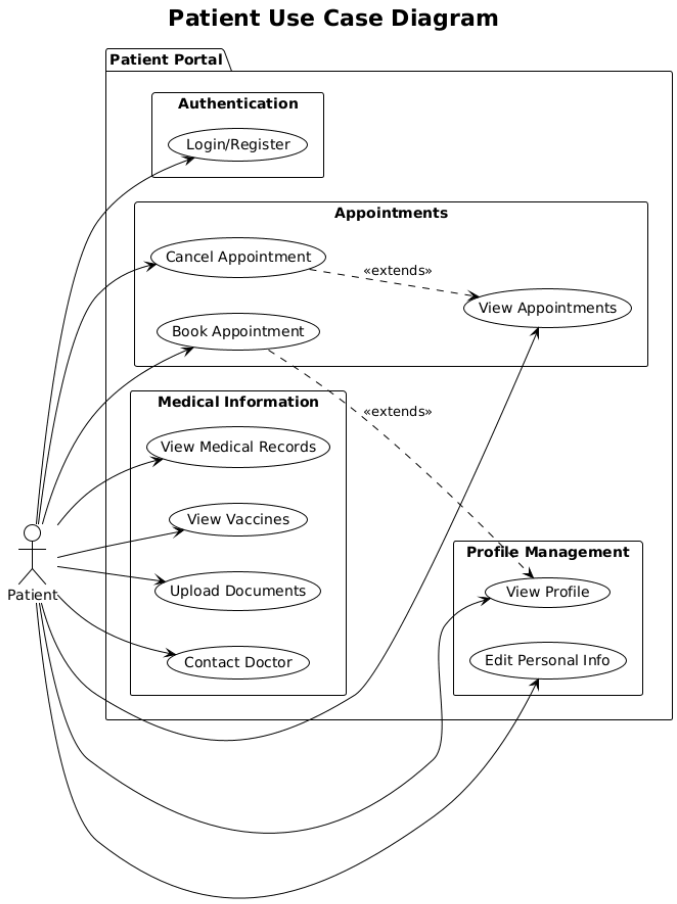

Figure 2.1: Patient Use Case Diagram

The Doctor Use Case Diagram, presented in **Figure 2.2**, illustrates the primary functionalities available to a doctor within the portal. After authentication through the login process, doctors can access their dashboard and manage their profile. In the Medical Records & Reports section, they are able to generate reports, update patient medical records, manage vaccines, and upload documents, with uploading documents extending from updating medical records. Doctors can also manage appointments by scheduling and viewing them. Within Patient Management, doctors can search for patients, view patient lists, and access detailed patient information, where viewing patient details includes the patient list and searching patients extends from this process. Overall, the diagram highlights how the system supports efficient patient care, record management, and appointment handling in a structured and integrated manner.

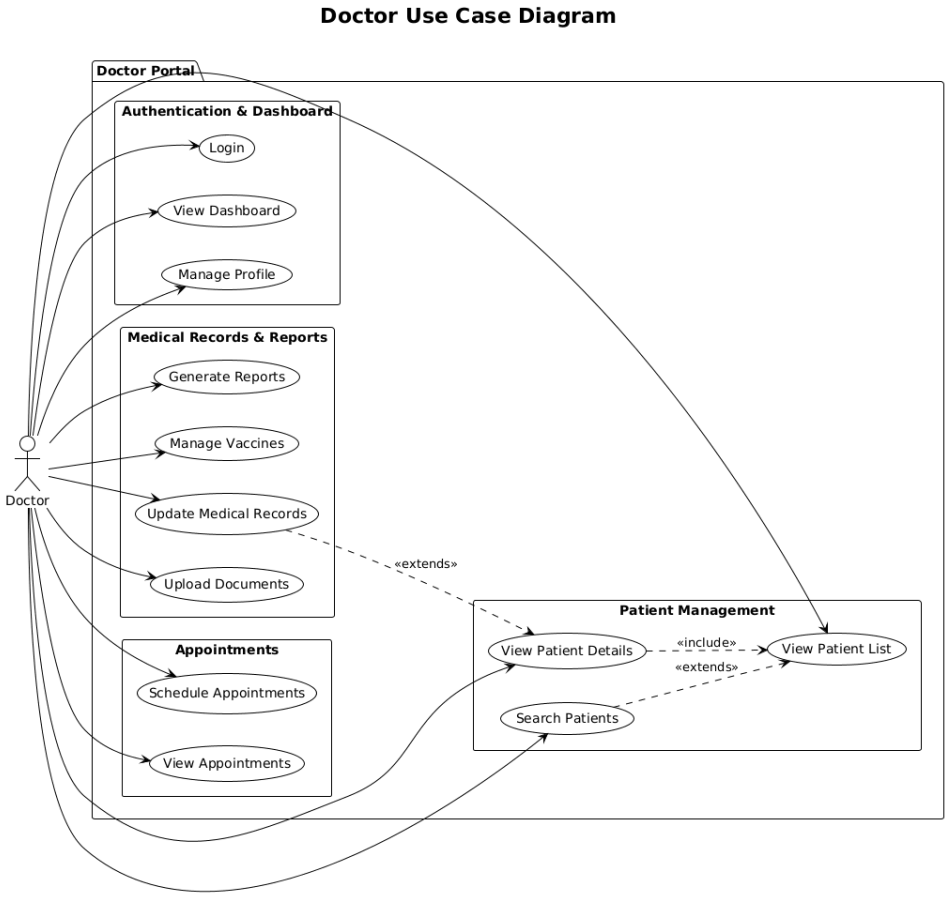

Figure 2.2: Doctor Use Case Diagram

The Admin Use Case Diagram, shown in **Figure 2.3**, illustrates the key functions available to an administrator within the portal. Through the Authentication & Dashboard module, admins can log in and access the system dashboard. In the User Management section, admins can create accounts, deactivate users, and manage permissions, all of which extend from the central action of managing users. The System Administration module enables admins to configure the system, manage clinics, monitor overall activity, and back up critical data. Additionally, the Reporting & Logs section allows admins to view system logs and generate reports for oversight and auditing. Overall, the diagram emphasizes how the admin role ensures smooth operation, security, and governance of the system.

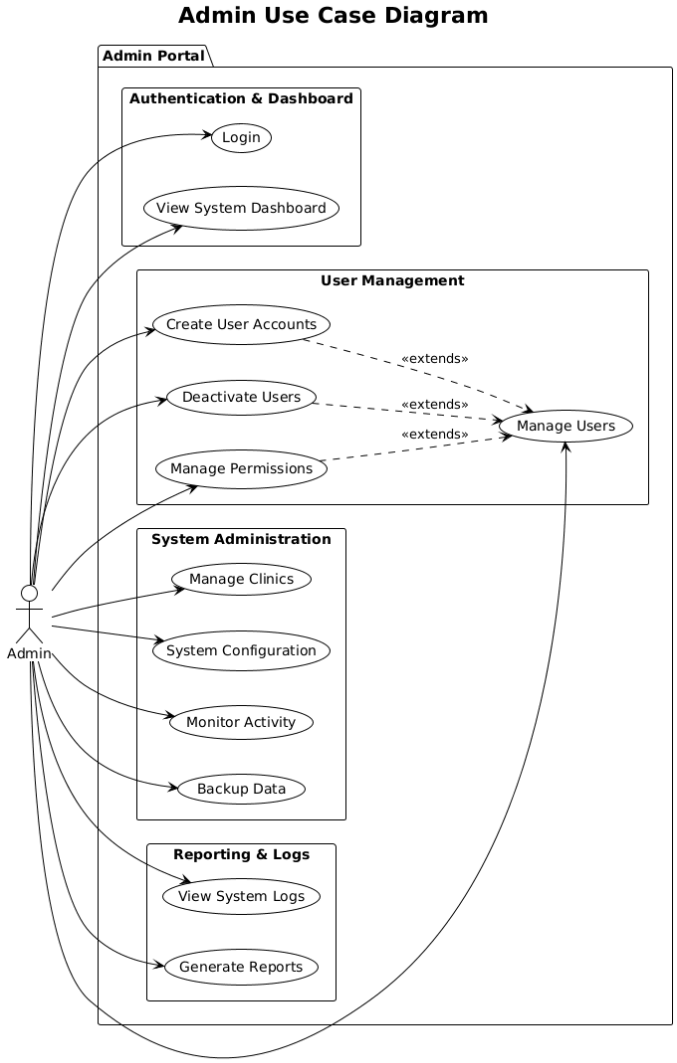

Figure 2.3: Admin Use Case Diagram

2.2.2. Sequence Diagrams

The login process, pictured in **Figure 2.4**, ensures that only authorized users gain access to the platform. The process starts with the user entering their credentials on the login page. These credentials are then sent to the authentication service, which then forwards them to the backend API through a login request.

If the backend API validates the credentials, it returns user data and an authentication token. The authentication service saves this information and updates the Redux store with the new state. A success response is then sent back to the login page, redirecting the user to the dashboard.

In case the login attempt fails, the authentication service triggers an error response instead. The login page receives this error, and the user gets displayed an appropriate error message.

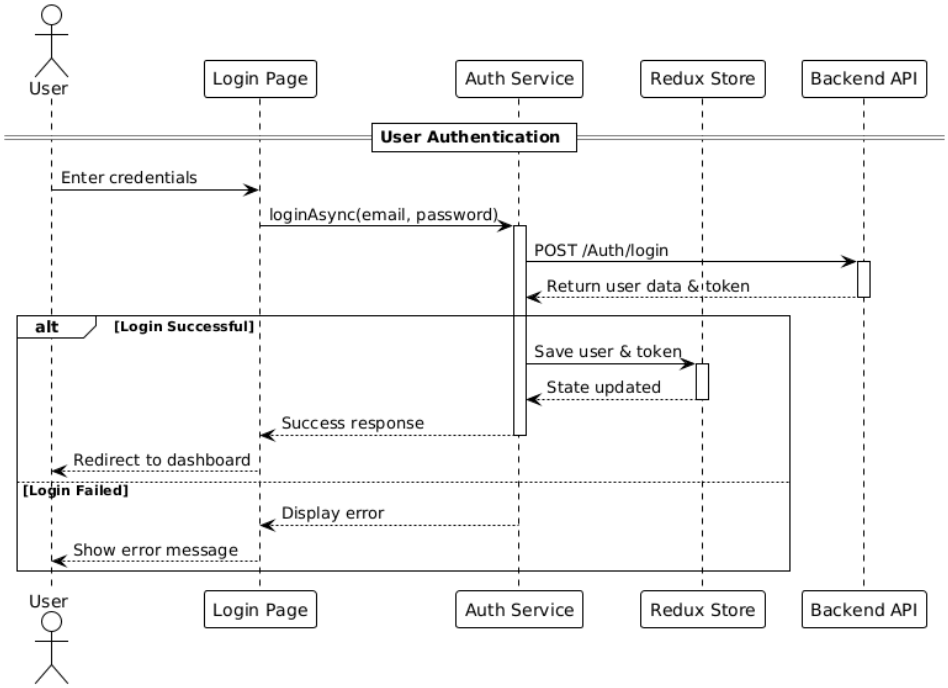

Figure 2.4: Login Sequence Diagram

The authentication check, illustrated in **Figure 2.5**, ensures that only authenticated users can access the dashboard. The process begins when the user attempts to access the /dashboard route. The Auth Guard verifies the authentication state by consulting the Redux store. If the user is authenticated, the system retrieves both the user and their role.

Based on the role (admin, doctor, or patient), the dashboard application requests role-specific data from the API service. The API service responds with the appropriate information, and the dashboard application displays the corresponding dashboard to the user.

If the user is not authenticated, the Auth Guard prevents access to the dashboard and redirects the user to the login page (/auth/login).

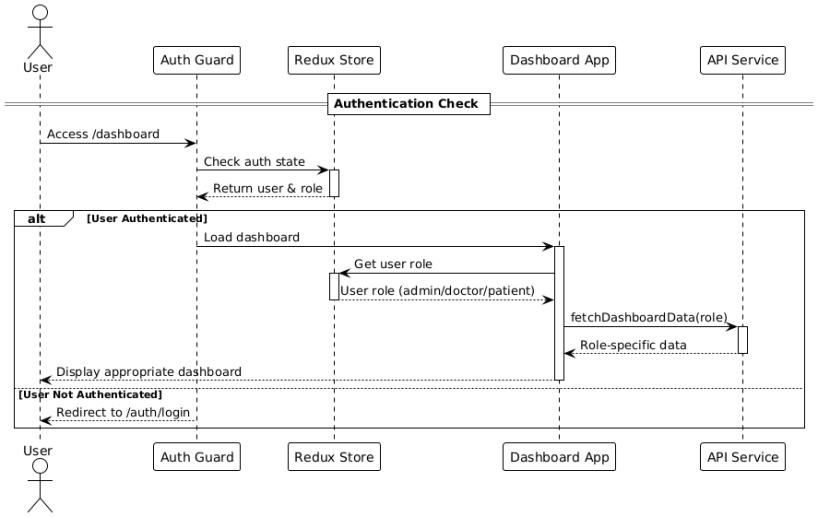

Figure 2.5: Authentication Sequence Diagram

The user management process, captured in **Figure 2.6**, allows administrators to view existing users and create new ones. The process begins when the admin accesses the user management section in the dashboard. The system triggers a request to fetch all users, which is handled by the User API. The API queries the database and returns the list of users. The dashboard then displays this list in a user table.

When the admin clicks “Add User”, the system displays a user creation form. After filling in the required details and submitting, the dashboard sends a createUser(userData) request to the User API. The API inserts the new user into the database.

If the creation is successful, the API returns a success response, and the dashboard shows a confirmation message while refreshing the user list. If the creation fails, the API responds with an error, and the dashboard displays the appropriate error messages to the admin.

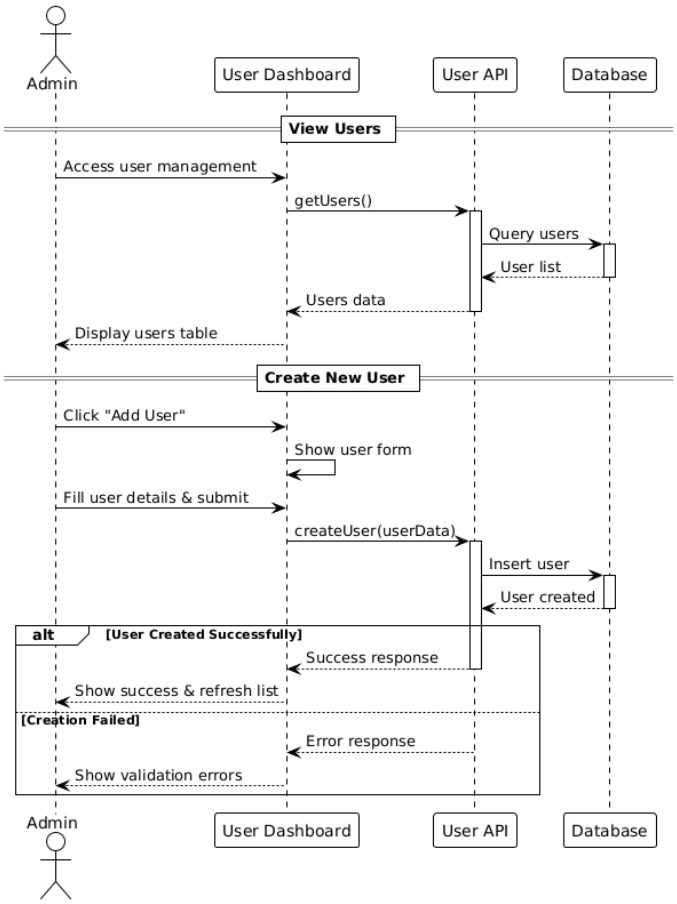

Figure 2.6: User Management Sequence Diagram

The patient management process, shown in **Figure 2.7**, allows doctors to securely view and update patient information through the dashboard. The process starts when the doctor selects a patient in the system. The dashboard sends a request to the Medical API using the patient’s ID. The API queries the database, retrieves the patient’s records, and returns the information, including medical history, vaccines, and allergies. The dashboard then displays this information to the doctor.

When the doctor adds a new medical record, the dashboard sends the record data to the Medical API. The API stores the new record in the database and returns a confirmation. The dashboard then notifies the doctor that the record has been created successfully.

For updates to vaccines or allergies, the doctor modifies the information in the dashboard, which sends the updated data to the Medical API. The API updates the corresponding records in the database and confirms the operation. The dashboard receives this confirmation and shows the doctor that the update was successful.

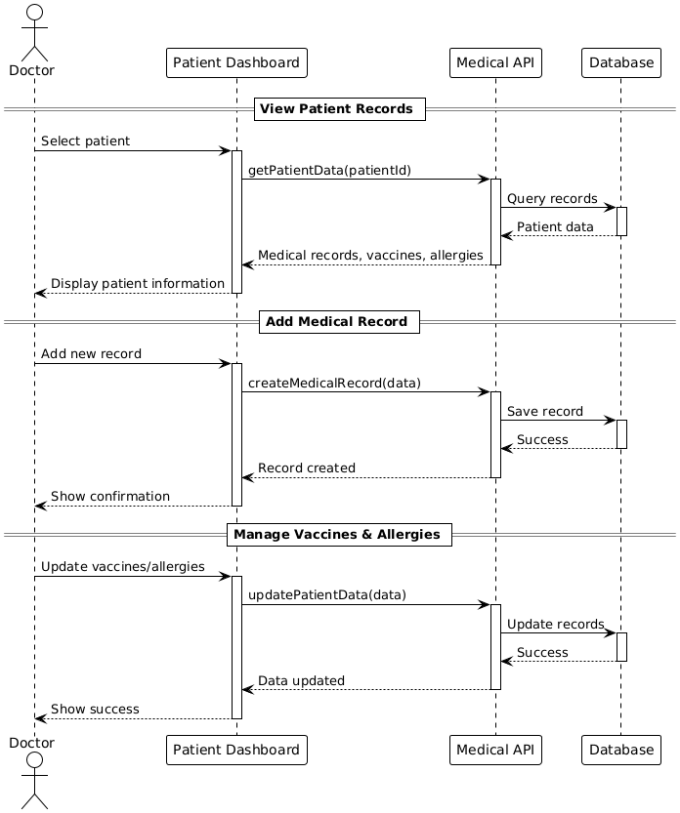

Figure 2.7: Patient Management Sequence Diagram

The appointment booking process, pictured in **Figure 2.8**, enables patients to check doctor availability and reserve time slots. The process begins when the patient accesses the calendar. The calendar app sends a request to the Appointment API, which queries the database for available slots based on the chosen date and doctor. The available times are returned and displayed to the patient in the calendar.

When the patient selects a time slot and fills in the appointment details, the calendar app sends this information to the Appointment API. The API reserves the slot in the database and confirms that the appointment has been created. If the booking is successful, the API also triggers the Notification Service, which sends notifications to the patient and doctor. The calendar app then displays a confirmation message to the patient.

If the booking fails due to conflicts or system errors, the Appointment API returns an error response

instead. The calendar app receives this error and displays an appropriate error message to the patient.

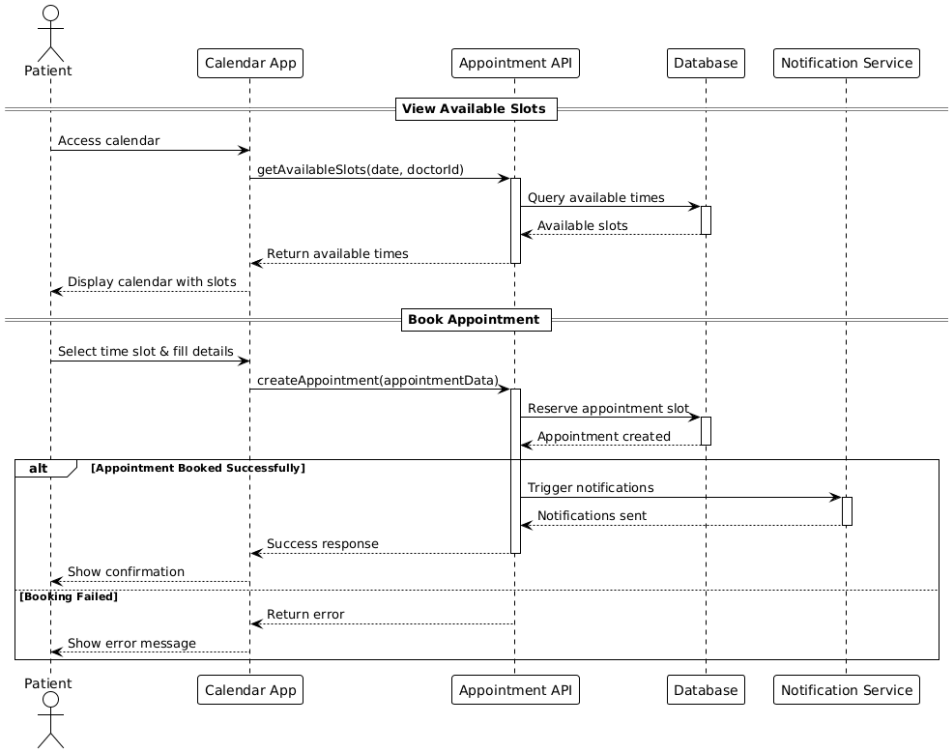

Figure 2.8: Appointment Booking Sequence Diagram

The notification flow, displayed in **Figure 2.9**, ensures that users receive timely updates and can interact with them efficiently. The process begins when a backend event triggers the notification service. This service broadcasts the notification to the WebSocket server, which sends the notification in real time to the frontend app using WebSockets.

Once received, the frontend app updates the notification state and stores the new data in the Redux store. A visual indicator, such as a notification badge, is shown to alert the user.

When the user clicks the notification badge, the frontend fetches the list of notifications from the Redux store and displays them. If the user marks a notification as read, a request is sent back to the notification service to update its status. Upon successful update, the frontend UI reflects the change, ensuring the user interface remains consistent with the server state.

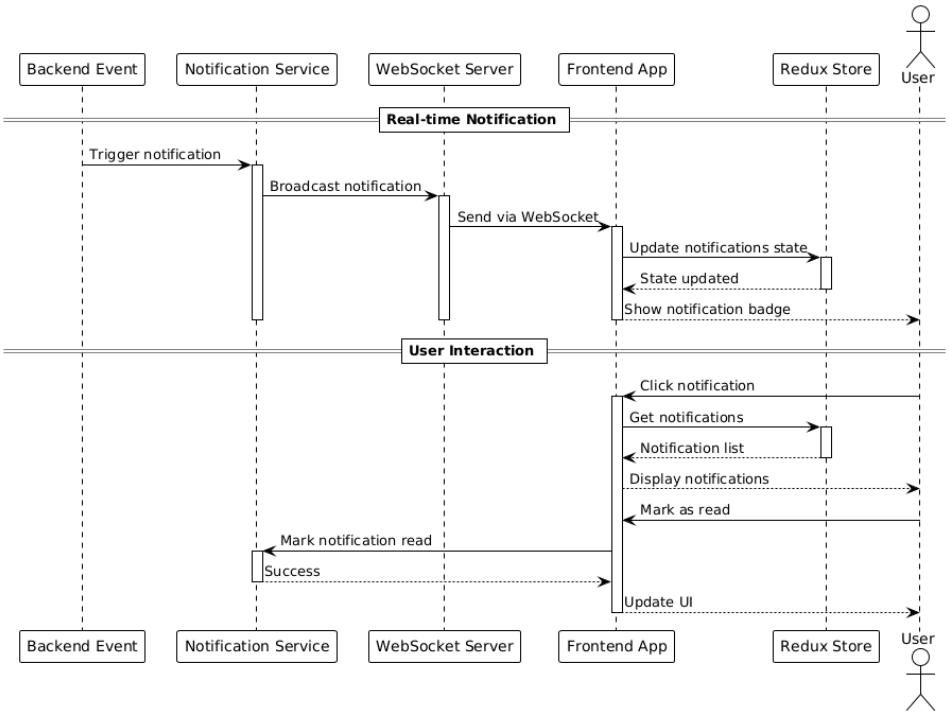

Figure 2.9: Notification Flow Sequence Diagram

The session management process, depicted in **Figure 2.10**, ensures that only authenticated users can access the application and that their session remains valid throughout usage. When a user accesses the application, the app checks with the Auth Service to verify the current session. The Auth Service then communicates with the Session Manager to validate the session. If the session is valid, the user is authenticated and granted access to the application content.

To maintain continuous access, the system includes an auto session refresh mechanism. At regular intervals, the application checks the token's expiration status. If the token is nearing expiration, the application requests a new token from the Auth Service, which refreshes it via the Session Manager and returns an updated token, thereby extending the session without interrupting the user experience.

When a user chooses to log out, the application initiates the logout process by notifying the Auth Service, which instructs the Session Manager to clear the session. Once the session is cleared, the user is logged out and redirected to the login page.

If a user attempts to access the application with an invalid or expired session, the authentication fails, and the system redirects the user to the login page to initiate a new session.

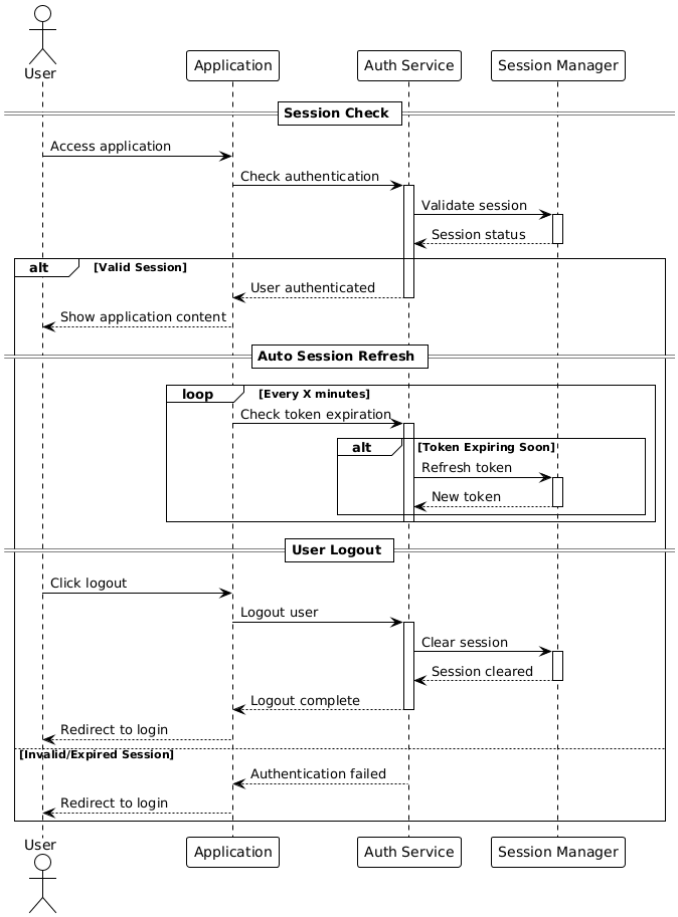

Figure 2.10: Session Management Sequence Diagram

2.3. Structural Modeling

The MedTrack Class Diagram, depicted in **Figure 2.11**, represents the structural design of the system, showing how different classes interact to support healthcare management. The User class contains essential information such as identification, contact details, and account activity, and is divided into three roles: Doctor, Patient, and Admin. Doctors manage their patients through viewing and updating their medical records and handling schedules. On the other hand, patients can book appointments, access medical history, and rate doctors. Admins hold higher-level responsibilities such as managing users, viewing statistics, and configuring the system.

The Appointment Management component links doctors and patients through the Appointment class, which holds appointment details including status, reason, and notes. It also provides actions like rescheduling, cancellation, or completion. Appointment status is standardized using the AppointmentStatus enumeration.

The Medical Records module enables doctors to create and update MedicalRecord entries that store diagnoses, treatments, and symptoms for patients. Patients can also give Ratings, which are associated with doctors and include comments and timestamps, supporting feedback and quality monitoring.

Supporting classes make medical data management easier. For example, Specialty defines medical

expertise areas for doctors, while BloodType and Allergy capture important patient-specific medical information. Nonetheless, Vaccine records administered vaccines along with their dates. These supporting classes strengthen the accuracy of medical histories and ensure personalized treatment.

Overall, the diagram highlights how the system integrates user roles, appointments, medical records, and supporting medical data, ensuring MedTrack is a cohesive and scalable application.

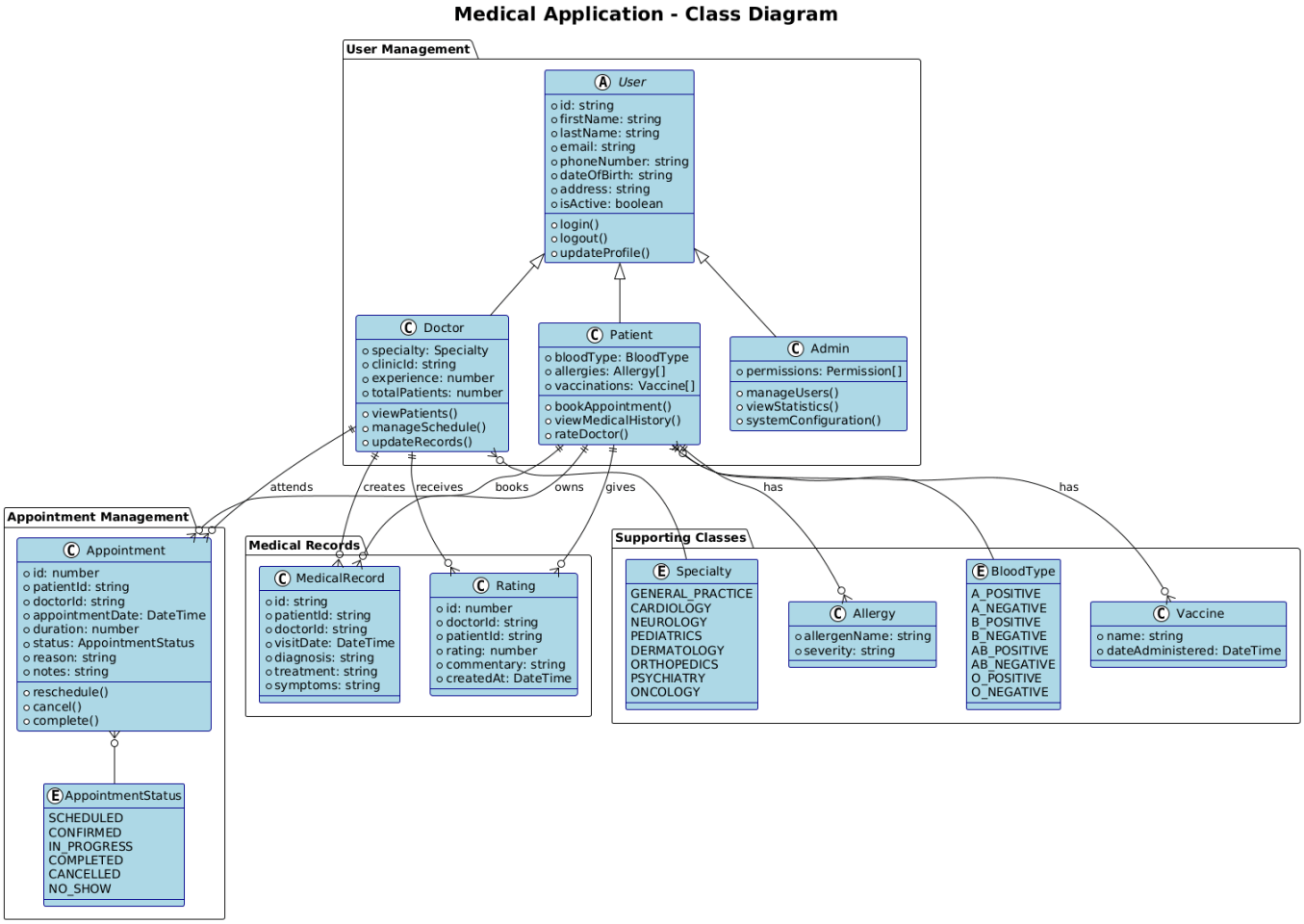

Figure 2.11: MedTrack Class Diagram

CONCLUSIONS

This project successfully demonstrates the development of a modern and secure medical platform designed to improve the way patients and doctors interact with healthcare information. By replacing traditional paper-based records with a digital system, the platform ensures greater accessibility, reliability, and protection of sensitive medical data. The combination of a React.js frontend with an ASP.NET Core backend creates a scalable and maintainable architecture.

Through features such as role-based access control, comprehensive medical records handling, appointment scheduling, notifications, and dashboards tailored to each user, the system streamlines workflows and fosters better communication between patients and doctors. Security has been a central priority, with JWT authentication, MFA, RBAC, and strong validation ensuring data confidentiality and integrity at all times. Non-functional requirements, including performance, usability, reliability, and scalability, further support the system's ability to serve a growing user base efficiently and consistently.

Overall, the project not only addresses the limitations of physical medical records but also delivers a reliable digital solution that enhances patient care, simplifies doctors' administrative tasks, and creates a trustworthy environment for managing healthcare data. It provides a strong foundation for future development, with the potential to expand into more advanced features and broader healthcare integration.

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