FACULTY OF INFORMATION TECHNLOGY AND COMMUNICATIONS

BITP - DISTRIBUTED APPLICATION

2 BITS (S1G1)

GROUP PROJECT

DR. HARIZ

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INTRODUCTION

The Clinic Management System (CMS) is developed to address the operational challenges faced by small to medium-sized clinics. Traditionally, clinics rely on manual processes for patient registration, appointment booking, medical recordkeeping, and billing. This often results in inefficiencies, human errors, and increased workload on clinic staff.

The CMS automates and streamlines these processes by providing a centralized digital platform. It improves data accuracy, reduces paperwork, enhances patient service, and allows easier data access for authorized personnel. The system is designed with scalability and user-friendliness in mind, ensuring it can adapt to the growing needs of healthcare facilities.

The Clinic Management System (CMS) is an end-to-end digital healthcare platform designed to modernize medical practice operations. Built with Java Swing for the frontend and a RESTful Java backend with MySQL/JSON data persistence, this system solves critical inefficiencies in traditional clinic workflows.

PROBLEM STATEMENTS

1. **Manual Appointment Scheduling**

   Traditional paper-based appointment booking systems create numerous operational challenges for medical clinics. Using physical appointment books or basic computer spreadsheets often leads to scheduling conflicts when multiple staff members try to book patients simultaneously. Without a centralized system, double bookings frequently occur where two patients are accidentally scheduled for the same time slot. This creates frustration for both patients and staff when appointment times need to be adjusted at the last minute.

   Paper systems also make it difficult to track appointment attendance. Clinics have no effective way to follow up with patients who miss their appointments, as there's no automated reminder system. Staff must manually call each patient beforehand, which consumes considerable administrative time. Rescheduling appointments becomes a tedious process of erasing and rewriting entries in the appointment book, often leading to messy, hard-to-read schedules.

2. **Fragmented Patient Records**

   Physical paper records create significant inefficiencies in clinical workflows. When a patient arrives for an appointment, staff must locate their paper chart from storage, which may be filed among thousands of other records. During busy periods, this chart retrieval process can cause delays in seeing patients. Important health information is often scattered across different forms, sticky notes, and test result attachments within the paper file, making it difficult for providers to quickly find critical information.

   Paper records are vulnerable to damage from spills, tears, or normal wear-and-tear. They also present security risks, as paper files can be lost, stolen, or viewed by unauthorized personnel. When patients see multiple providers within a practice, their information may be recorded differently in separate charts, leading to inconsistent medical histories.

3. **Inefficient Clinic Workflows**

   Traditional clinic operations require excessive manual coordination between different staff members and departments. Front desk personnel spend considerable time physically routing paper charts to the appropriate providers and treatment rooms. Nurses and medical assistants waste time searching for available equipment or preparing paperwork between patient visits.

   The prescription process is particularly cumbersome, requiring providers to hand-write medication orders that front desk staff must then call or fax to pharmacies. Generating reports for practice analysis or patient referrals involves manually compiling data from multiple sources, often resulting in incomplete or inconsistent information.

OBJECTIVES

1. **To develop a real-time digital scheduling system with automated conflict detection and multi-channel patient notifications.** If a patient tries to book a slot that's already taken, the system immediately suggests the next available time. Once confirmed, the system sends automated reminders through SMS, email, or app notifications.

2. **To establish secure electronic health records with encrypted data storage and role-based access controls.** A doctor can view full medical histories and see appointment-related information.

3. **To create structured clinical documentation tools with temporal visualization of treatment histories.** A visual timeline showing all the patient's visits, treatments administered, and lab results over months, aiding better clinical decision-making.

4. **To create a secure and safe to use medical platform.** All users will need proper authentication to access the application.

COMMERCIAL VALUE & THIRD-PARTY INTEGRATION

1. Market Potential

Target :

Private Clinics: Small-to-medium practices seeking affordable digital transformation.

Multi-Specialty Hospitals: Large facilities needing centralized patient management.

Telehealth Providers: Platforms requiring appointment scheduling and EHR integration.

2. Third-party integration

1) Database System: MySQL (Relational Database)

Justification:

ACID Compliance: MySQL ensures Atomicity, Consistency, Isolation, and Durability, which are essential when dealing with medical data (e.g., patient records, appointments, prescriptions) to prevent data corruption or loss.

Implementation:

DBConnection.java

This Java class is responsible for establishing a connection to the MySQL database.
It likely includes methods for:

- **Connecting to the DB using JDBC**
- **Executing SQL queries (SELECT, INSERT, UPDATE, DELETE)**
- **Managing prepared statements and result sets**
- **Ensures reusability and separation of concerns by centralizing DB access logic in one place**

2) JSON Data Sync: org.json Library

Justification:

JSON (JavaScript Object Notation) is a lightweight format that is easy to parse and generate.

It is useful for offline storage, data exchange, or syncing settings/configurations.

Great for mobile apps or browser-based apps that need to sync with server data.

Implementation:

JSONHandler.java

- **Manages reading from and writing to JSON files.**
- **Handles two-way synchronization, such as:**
- **Exporting DB data into a JSON file (backup or sync to client)**
- **Importing JSON data into the database (restore or sync from client)**
- **Useful in distributed systems, remote backups, or interoperability with non-Java systems.**

3) HTTP Server: com.sun.net.httpserver

Justification:

A native Java HTTP server (no need for external web server like Apache or Tomcat).

Ideal for lightweight RESTful APIs, internal tools, or simple services.

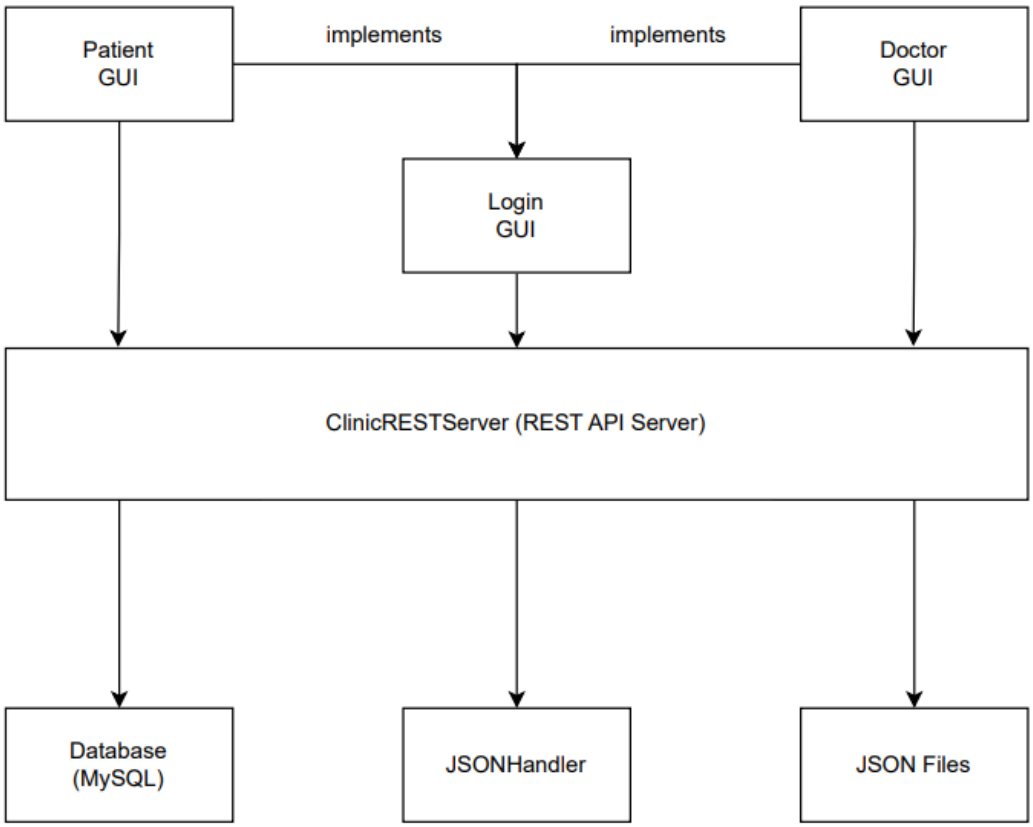
Implementation:

ClinicRestServer.java

- **Defines the REST API endpoints such as:**
- **GET /patients → fetch all patients**
- **POST /appointments → add an appointment**
- **PUT /prescriptions/{id} → update prescription**
- **Handles routing and response formatting (JSON responses).**
- **Useful for client-server communication (a front-end app or mobile app consuming this API).**

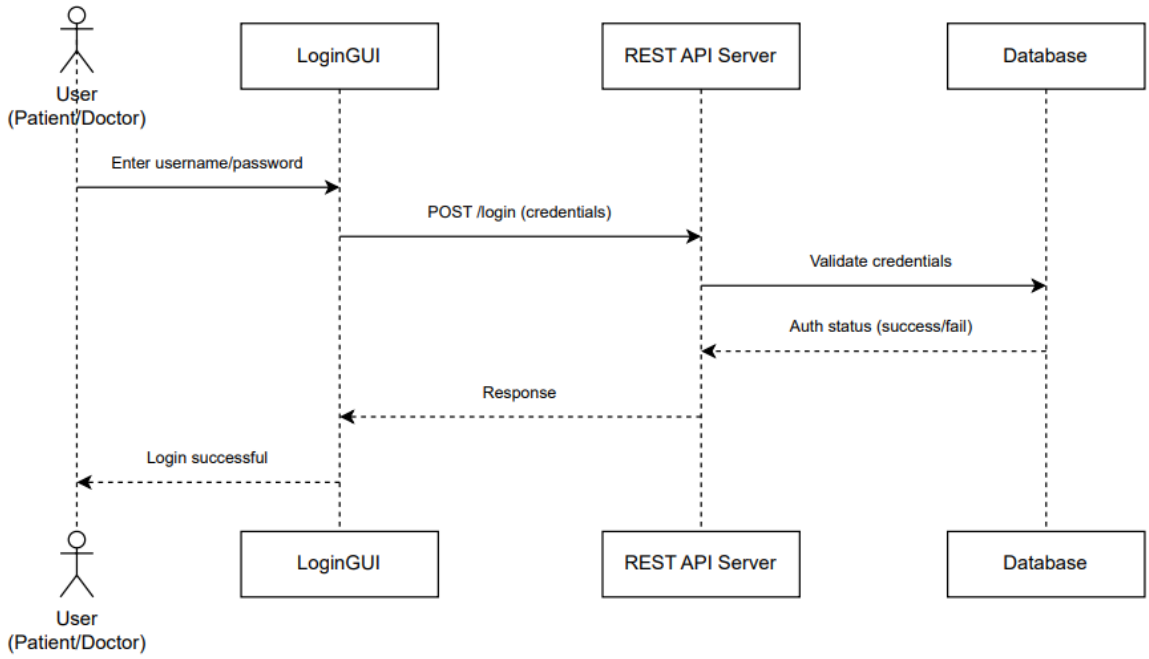
SYSTEM ARCHITECTURE

High level design

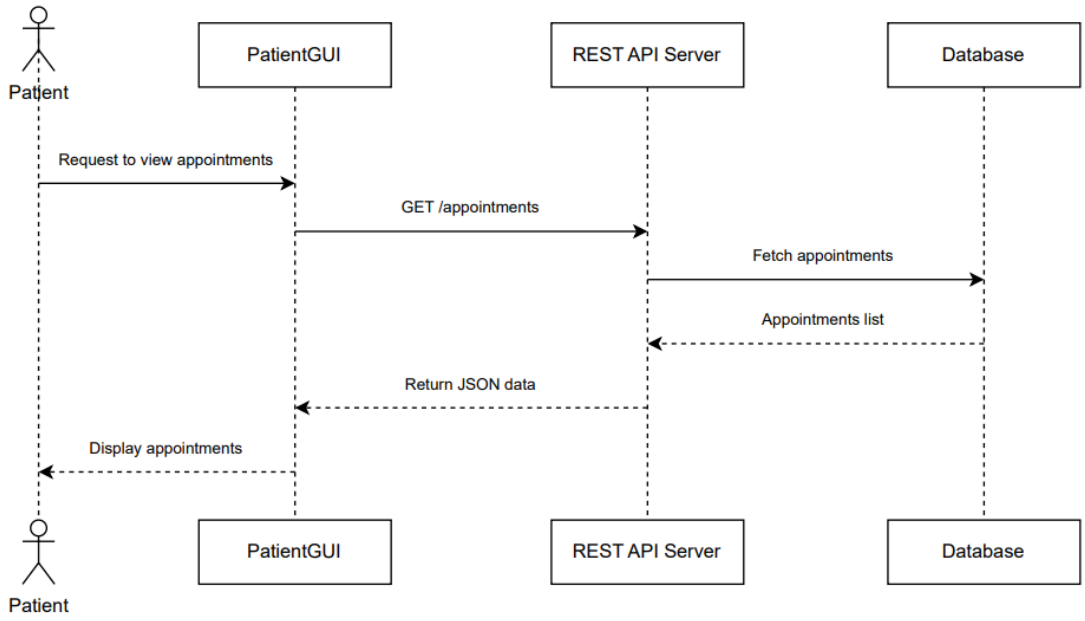


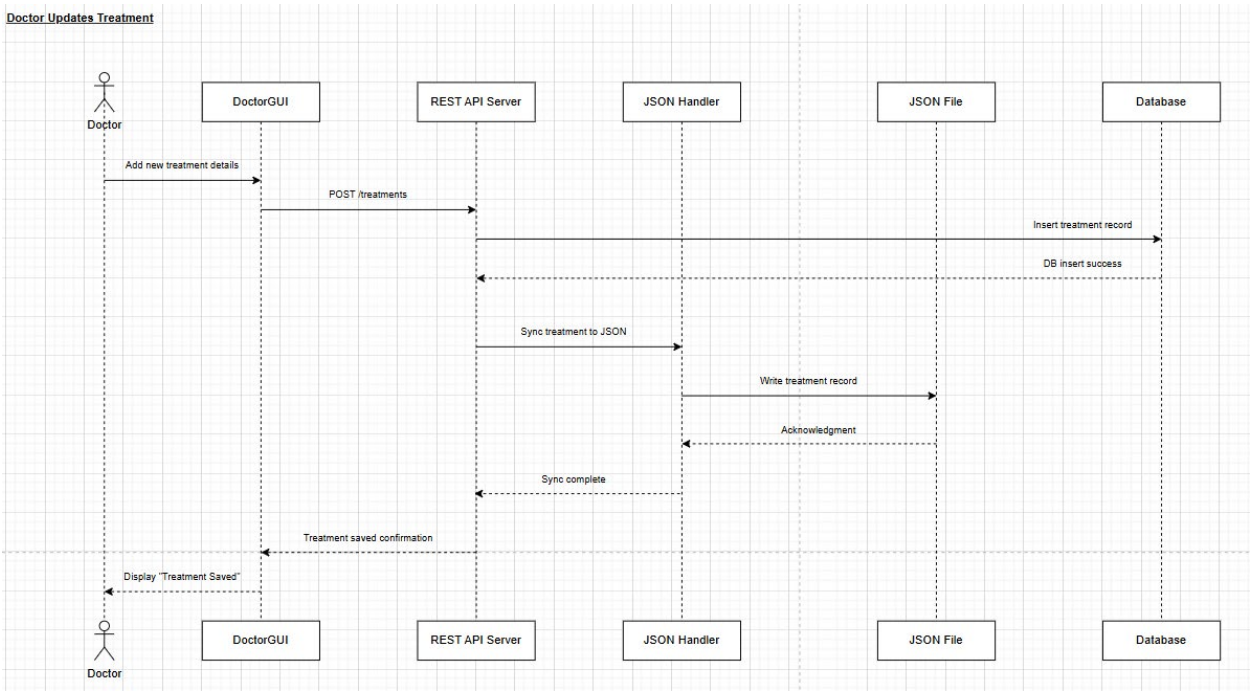
Sequence diagram

User Login



Patient View Appointment




Doctor Updates Treatment
Doctor
DoctorGUI
REST API Server
JSON Handler
JSON File
Database
Add new treatment details
POST /treatments
Insert treatment record
DB insert success
Sync treatment to JSON
Write treatment record
Acknowledgment
Sync complete
Treatment saved confirmation
Display "Treatment Saved"
Doctor
DoctorGUI
REST API Server
JSON Handler
JSON File
Database

BACKEND APPLICATION

Technology stack

Component	Technology	Version	Justification
Programming language	Java	11+	Java offers strong static typing, which reduces runtime errors and ensures greater reliability,critical for handling sensitive medical data. Its mature ecosystem, widespread community support, and built-in security features make it well-suited for developing healthcare applications where data integrity and safety are paramount. Java 11+ also provides performance improvements, long-term support (LTS), and modern APIs that aid in building scalable, maintainable systems.
HTTP Server	com.sun.net.httpserver	JDK-native	This built-in lightweight HTTP server eliminates the need for external frameworks, reducing system complexity and improving portability. It is efficient for RESTful service development and is ideal for applications with moderate traffic, such as a university health center. Using a JDK-native component

			also minimizes deployment overhead and simplifies system updates and maintenance.
JSON Processing	org.json	20231013	The `org.json` library provides a simple and effective way to parse and generate JSON, a widely adopted data interchange format. It supports data structures compatible with FHIR (Fast Healthcare Interoperability Resources), enabling easier integration with future medical systems or third-party APIs. Its lightweight footprint makes it an optimal choice for data serialization in resource-constrained environments.
Database	MySQL	8.0+	MySQL 8.0+ supports full ACID (Atomicity, Consistency, Isolation, Durability) compliance, which is essential for maintaining the integrity and reliability of clinical data. Its support for indexing, foreign keys, and advanced query optimizations ensures fast and secure data access. Additionally, MySQL's widespread adoption and robust

			documentation make it a stable choice for backend data storage in healthcare systems.
Concurrency	java.util.concurrent	JDK-native	The `java.util.concurrent` package provides high-level concurrency utilities such as thread pools, locks, and atomic variables, which are essential for managing concurrent user interactions like scheduling appointments. It ensures thread safety and responsiveness in a multi-user environment, allowing the system to handle simultaneous operations without race conditions or data corruption. Being JDK-native, it integrates seamlessly with the rest of the Java application.

API documentation

(1) A list of all API endpoints

(2) The HTTP method for each endpoint

(3) Required request parameters, headers, and body formats .

(4) Example success and error responses.

(5) Security: Detail the security measures implemented.

Appointment management

Endpoint	Method	Parameter	Header	Body	Success Response	Error Responses
GET /api/appointments	GET	?doctorId=int ?patientId=int ?date=YYYY-MM-DD	Authorization: Bearer <token>	None	200: List of appointments	401: Unauthorized 500: Server error

POST /api/appointments	POST	None	Content-Type: application/json	json
				{
				 "patientId": int,
				 "doctorId": int,
				 "date": "YYYY-MM-DD",
				 "time": "HH:MM:SS"
				}
					201: Created appointment	400: Invalid data 409: Conflict

PUT /api/appointments/{id}/status	PUT	id=int	Content-Type: application/json	json
				{
				 "status": "confirmed|completed|cancelled"
				}
					200 : Status updated	404: Not found 422: Invalid status

PUT /api/appointments/{id}/reschedule	PUT	id=int	Content-Type: application/json	json
				{
				 "newDate": "YYYY-MM-DD",
				 "newTime": "HH:MM:SS"
				}
					200: Rescheduled	400: Invalid datetime 409: Slot occupied

Treatment management

Endpoint	Method	Parameter	Header	Body	Success Response	Error Responses

POST /api/treatments	POST	None	Content-Type: application/json	json
				{
				 "appointmentId": int,
				 "diagnosis": string,
				 "treatmentType": string,
				 "medication": string,
				 "notes": string
				 }
					201: Treatment created Location: /api/treatments/{id}	400: Missing data 404: Appointment not found

GET /api/treatments/{appointmentId}	GET	appointmentId=int	Authorization: Bearer <token>	None	200: Treatment details	403: Forbidden 404: Not found

Patient data

Endpoint	Method	Parameter	Header	Body	Success Response	Error Responses
GET /api/patient/{id}	GET	id=int	Authorization: Bearer <token>	None	200: Patient profile	401: Unauthorized 404: Not found
GET /api/patients/{id}/records	GET	id=int ?limit=int	Authorization: Bearer <token>	None	200: Medical history	403: Access denied
GET /api/patients/search	GET	?name=string ?birthDate=YYYY-MM-DD	Authorization: Bearer <token>	None	200: Patient list	400: Invalid query

System operation

Endpoint	Method	Parameter	Header	Body	Success Response	Error Responses

GET /api/health	GET	None	None	None	200: json
					{
					"status": "ok",
					"dbConnected": boolean
					}
						503: Service unavailable

POST /api/sync	POST	None	X-Admin-Token: string	None	202: Sync initiated	401: Unauthorized 423: Sync in progress

Json examples

1) **Appointment management:**
   GET /api/appointments

   Request:

   GET /api/appointments?doctorId=5&date=2025-07-20
   Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...

   Success Response (200):


```
{
  "data": [
    {
      "id": 1023,
      "patientId": 101,
      "patientName": "John Doe",
      "doctorId": 5,
      "date": "2025-07-20",
      "time": "09:30:00",
      "status": "confirmed",
      "notes": "Annual checkup"
    }
  ]
}
```


   Error Response (401):


```
{
  "error": "Unauthorized",
  "message": "Invalid or expired token",
  "timestamp": "2025-07-20T08:15:00Z"
```

}

POST /api/appointments

Request:

POST /api/appointments

Content-Type: application/json

Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...

{
  "patientId": 101,
  "doctorId": 5,
  "date": "2025-07-21",
  "time": "14:00:00",
  "notes": "Follow-up visit"
}

Success Response (201):

{
  "id": 1024,
  "status": "confirmed",
  "location": "/api/appointments/1024",
  "confirmationNumber": "CLINIC-2025-1024"
}

Error Response (409):


```
{
  "error": "Conflict",
  "message": "Doctor not available at requested time",
  "nextAvailable": "2025-07-21T14:30:00"
}
```


2) **Treatment management**
   POST /api/treatments

Request:

```
POST /api/treatments
Content-Type: application/json
Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...
```


```
{
  "appointmentId": 1024,
  "diagnosis": "Hypertension (I10)",
  "treatmentType": "Medication",
  "medication": "Lisinopril 10mg",
  "dosage": "Once daily",
  "notes": "Monitor blood pressure weekly"
}
```


Success Response (201):


```
{
  "id": 789,
  "appointmentId": 1024,
  "diagnosisCode": "I10",
  "medications": [
    {
      "name": "Lisinopril",
      "strength": "10mg",
      "refills": 3,
      "instructions": "Take once daily in the morning"
```

```
    }
  ],
  "followUpDate": "2025-08-21"
}
```


Error Response (404):


```
{
  "error": "Not Found",
  "message": "Appointment 1024 not found",
  "suggestedAppointments": [1023, 1025]
}
```


3) **Patient data**

GET /api/patients/101/records

Request:

```
GET /api/patients/101/records?limit=5
Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...
```

Success Response (200):


```
{
  "patientId": 101,
  "name": "John Doe",
  "records": [
    {
      "date": "2025-07-20",
      "doctor": "Dr. Smith",
      "diagnosis": "Hypertension",
      "treatment": "Prescribed Lisinopril"
    },
    {
      "date": "2025-06-15",
      "doctor": "Dr. Johnson",
      "diagnosis": "Annual physical",
      "treatment": "Lab tests ordered"
    }
  ]
}
```

Error Response (403):

```
{
  "error": "Forbidden",
  "message": "You don't have permission to access these records"
}
```

4) **System operation**
   GET /api/health

   Request:

   GET /api/health

   Success Response (200):

```
{
  "status": "healthy",
  "components": {
    "database": {
      "status": "connected",
      "latency": "12ms"
    },
    "memory": {
      "used": "45%",
      "total": "16GB"
    }
  },
  "uptime": "5d 7h 22m"
}
```

   Error Response (503):

```
{
  "status": "unhealthy",
  "errors": [
    {
      "component": "database",
      "error": "Connection timeout",
```

```
    "timestamp": "2025-07-20T09:45:00Z"
   }
  ],
  "maintenanceWindow": "00:00-02:00 UTC"
 }
```


Security implementation

1. Authentication

Method: Direct database credential validation
Location: LoginGUI.java

```
// Plaintext credential verification
String sql = "SELECT id FROM patients WHERE email = ? AND password = ?";
try (PreparedStatement stmt = conn.prepareStatement(sql)) {
    stmt.setString(1, email);
    stmt.setString(2, password);  // Stored and compared in plaintext
    ResultSet rs = stmt.executeQuery();
    return rs.next() ? rs.getInt("id") : -1;
}
```

2. Database Security

Location: DBConnection.java

```
// SSL-enabled connection
String url = "jdbc:mysql://localhost:3306/clinicdb?useSSL=true";
```

Protections:

- **Forces TLS for MySQL connections**
- **Uses parameterized queries to prevent SQL injection**

3. Input Sanitization

Location: Various handlers

```
// Basic string cleaning
String cleanInput = input.replaceAll("[^a-zA-Z0-9]", "");
```

4. API Protection

Location: ClinicRestServer.java

```
// CORS headers
exchange.getResponseHeaders().add("Access-Control-Allow-Origin", "*");
```

5. JSON Data Security

Location: JSONHandler.java

```
// No encryption for JSON files
Files.write(Paths.get("patients.json"), jsonArray.toString().getBytes());
```

FRONTEND APPLICATION

Basically, there are three GUI in the project, which is LoginGUI, DocterGUI and PatientGUI.

1. Doctor GUI

Purpose: Designed for medical professionals to manage clinical operations.

Key functions:

- Viewing/filtering appointments by status (confirmed, pending, completed).
- Recording diagnoses, treatments, and medications.
- Updating appointment statuses.
- Accessing/exporting patient medical records.

Target User:
Medical professionals (doctors) in a clinic.

Technology Stack:

Category	Technologies & Libraries
Core Framework	Java Swing (GUI)
HTTP Client	Java 11+ HttpClient
JSON Handling	org.json library
UI Components	Java AWT (graphics), Swing components (tables, comboboxes)
Utilities	JDBC (authentication), Java NIO (file export)

API Integration:
Communicates with backend REST API at http://localhost:8000:

1) Data Retrieval

GET /api/appointments?doctorId={id}: Loads doctor's appointments

GET /api/all-records?search={term}: Searches patient records

2) Data Submission

POST /api/treatments: Submits diagnosis/treatment details

PUT /api/appointments/{id}/status: Updates appointment status

3) Data Format

Requests: JSON payloads

Responses: JSON arrays (appointments) or objects (patient details)

4) Authentication

Uses doctorId from login session in all API requests

2. Patient GUI

Purpose: Enables patients to manage personal healthcare interactions.

Key functions:

- Booking/rescheduling/canceling appointments
- Viewing medical records and appointment history
- Exporting health data
- Locating pharmacies via Google Maps

Target User:
Patients registered with the clinic.

Technology Stack:

Category	Technologies & Libraries
Core Framework	Java Swing (GUI)
HTTP Client	Java 11+ HttpClient
JSON Handling	org.json library
Maps Integration	java.awt.Desktop (Google Maps links)
UI Components	Java AWT layouts, Swing tables/dialogs

API Integration:
Communicates with backend REST API at http://localhost:8000:

1) Appointment Management

POST /api/appointments: Books new appointments

PUT /api/appointments/{id}/reschedule: Changes appointment time

DELETE /api/appointments/{id}: Cancels appointments

2) Data Access

GET /api/records?patientId={id}: Retrieves medical records

GET /api/patients?id={id}: Fetches patient profile

3) Profile Updates

PUT /api/patients/{id}/profile: Saves profile changes

4) Authentication

Uses patientId from login session in all requests

3. Login GUI

Purpose: Central authentication gateway for both patients and doctors.

Features:

- Role-based login (Patient/Doctor)
- Secure password field with visibility toggle
- Input validation (email format)
- Redirect to appropriate portal

Target User:
Patients and medical staff.

Technology Stack:

Category	Technologies & Libraries
Core Framework	Java Swing (GUI)
Authentication	JDBC (SQL queries)
UI Components	Java AWT graphics, Swing text fields/buttons
Validation	Regex (email format)

API Integration:
Direct database access :

1) Authentication Flow

Runs SQL queries against patients/doctors tables:

SELECT id FROM patients WHERE email=? AND password=?

SELECT id FROM doctors WHERE email=? AND password=?

2) Session Initialization

Launches PatientGUI or DoctorGUI with user ID on success

3) Security

Uses parameterized SQL queries to prevent injection

Key Architectural Notes

1) Shared Backend
Both portals consume the same REST API (http://localhost:8000) but access role-specific endpoints.

2) Stateless Design
User IDs (doctorId/patientId) are passed in all API requests instead of sessions.

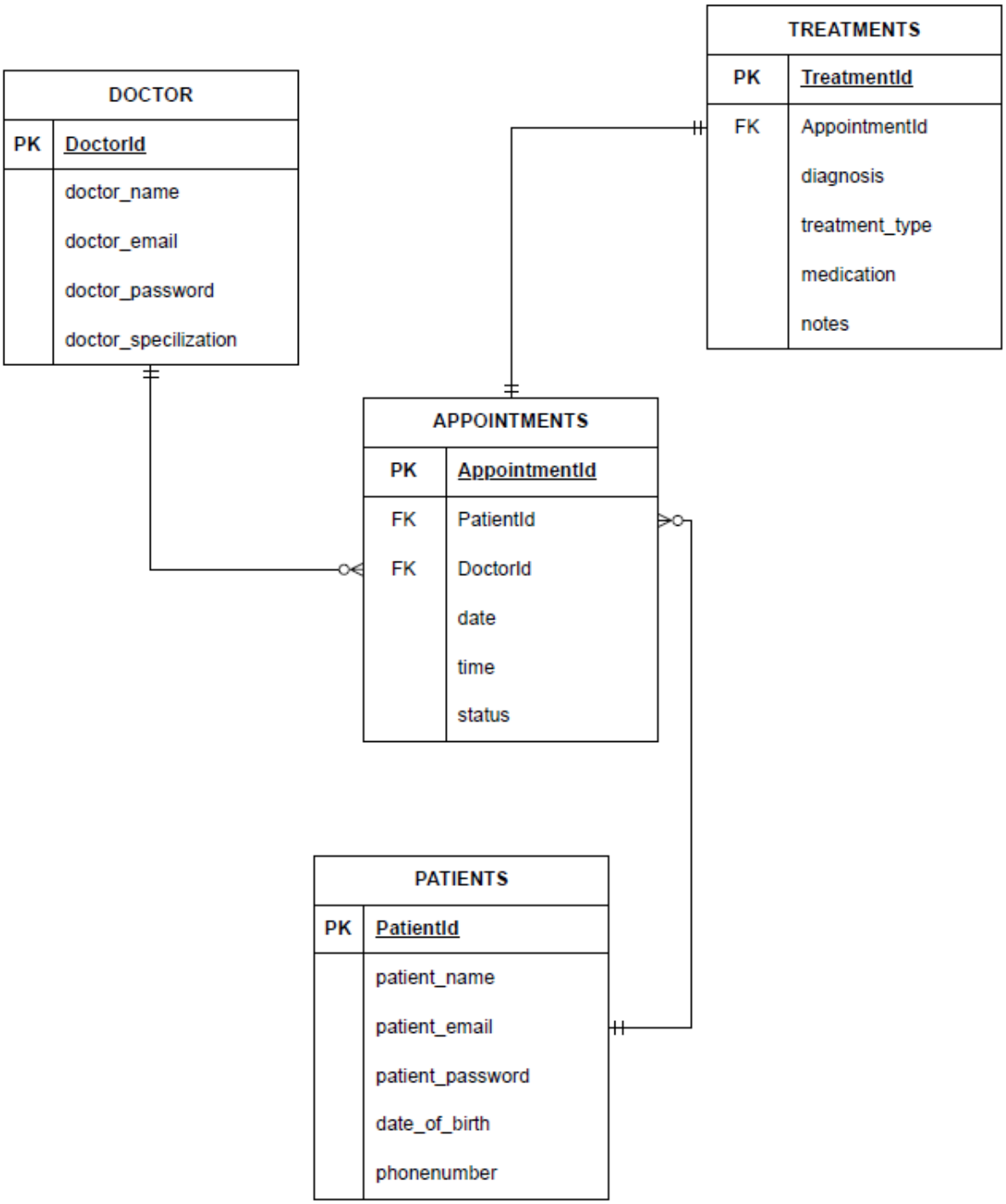
3) Error Handling

API errors shown in Swing JOptionPane dialogs

HTTP status codes (200, 201, 400) drive UI feedback

DATABASE DESIGN

ENTITY RELATIONSHIP DIAGRAM (ERD)



Schema Justification

Normalization:

- The database schema is designed with a degree of normalization to reduce data redundancy and improve data integrity. Each entity (Doctors, Patients, Appointments, Treatments) has its own table.

Primary Keys:

- Each table has a unique id column serving as its primary key, ensuring that each record can be uniquely identified.

Foreign Keys:

- patient_id in appointments links to patients.id, establishing that an appointment must be associated with an existing patient.
- doctor_id in appointments links to doctors.id, establishing that an appointment must be associated with an existing doctor.
- appointment_id in treatments links to appointments.id, ensuring that a treatment record corresponds to a specific appointment.

Data Types:

- Appropriate data types are used for each column (e.g., INT for IDs, VARCHAR for names and emails, DATE for dates, TIME for times, TEXT for longer descriptions like notes and diagnosis, ENUM for predefined statuses).
- **Constraints:**
- NOT NULL constraints ensure that essential information (like names, emails, and core appointment details) is always present.
- UNIQUE constraints on email in both doctors and patients tables prevent duplicate email addresses, which are crucial for user authentication.
- The status ENUM in appointments provides a controlled set of values for appointment states, ensuring consistency.

Separation of Concerns:

Doctors and Patients:

- Separate tables for doctors and patients allow for distinct attributes and roles within the system.

Appointments:

- The appointments table acts as a central linking entity between patients and doctors, capturing the scheduling aspect.

Treatments:

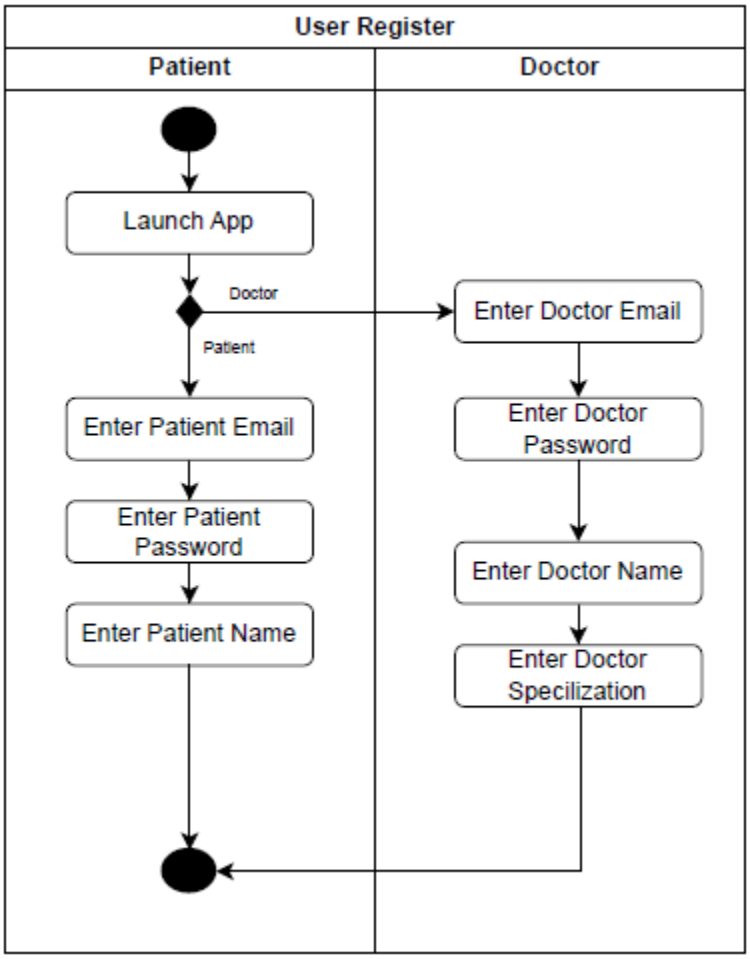
- The treatments table is separate from appointments to store detailed medical information that is only relevant once an appointment has occurred and a diagnosis/treatment has been made. This keeps the appointments table cleaner and focused on scheduling

BUSINESS LOGIC

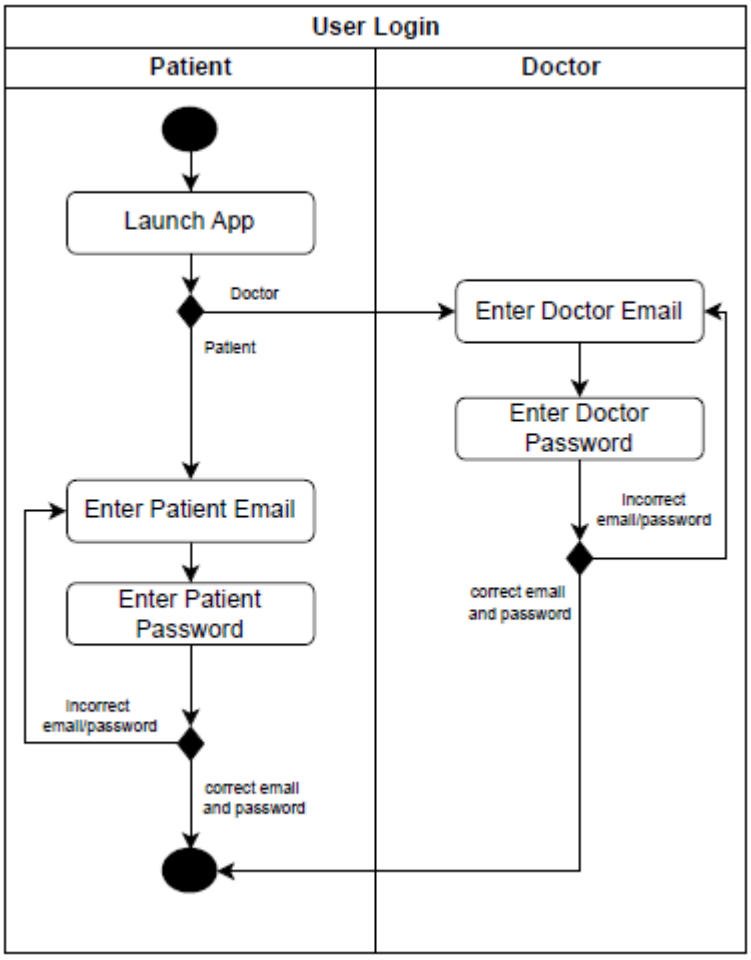
Use Case Diagram

FLOWCHART

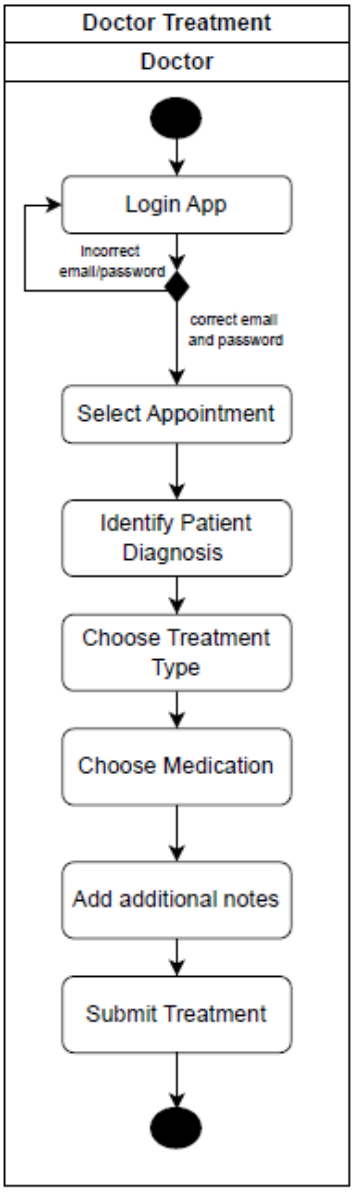
User Registration



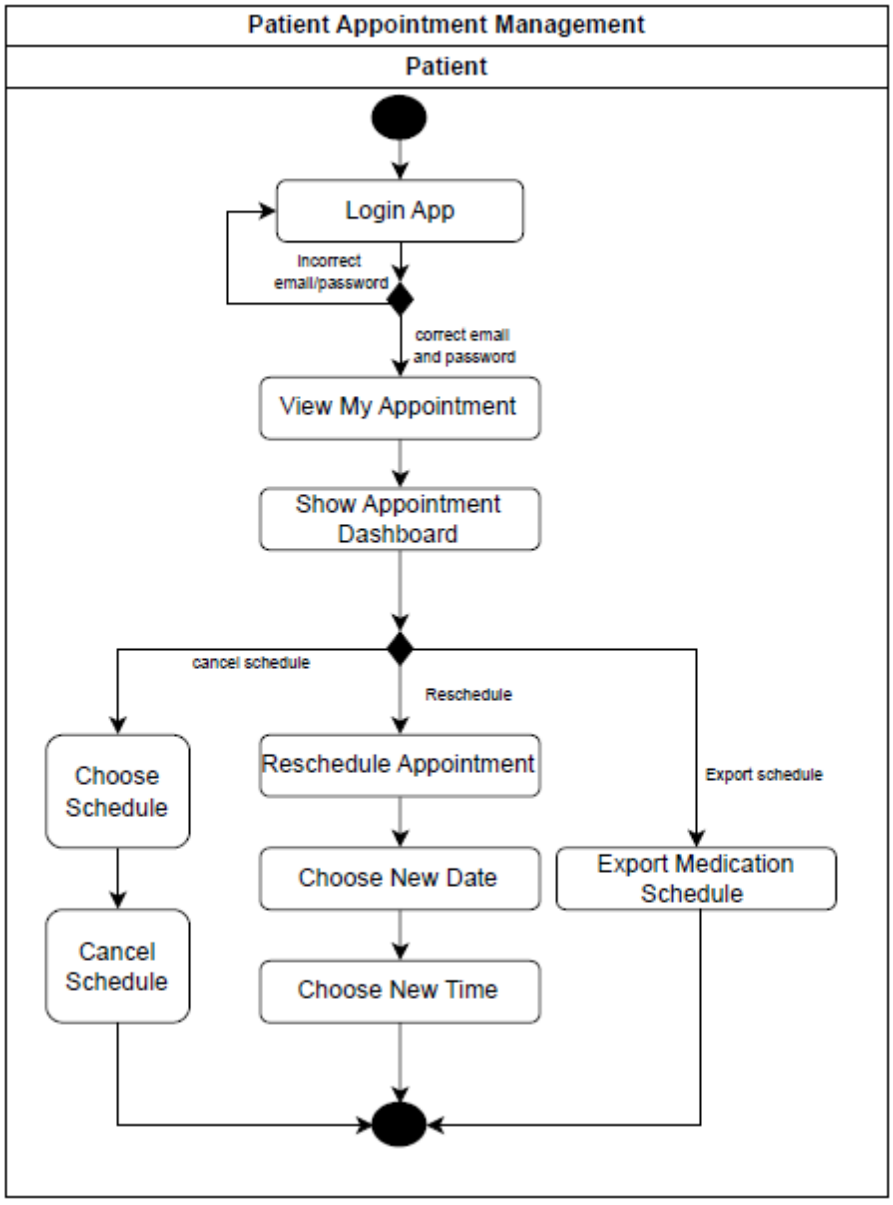
User Login


User Login
Patient
Doctor
Launch App
Doctor
Patient
Enter Doctor Email
Enter Doctor Password
Incorrect email/password
correct email and password
Enter Patient Email
Enter Patient Password
Incorrect email/password
correct email and password

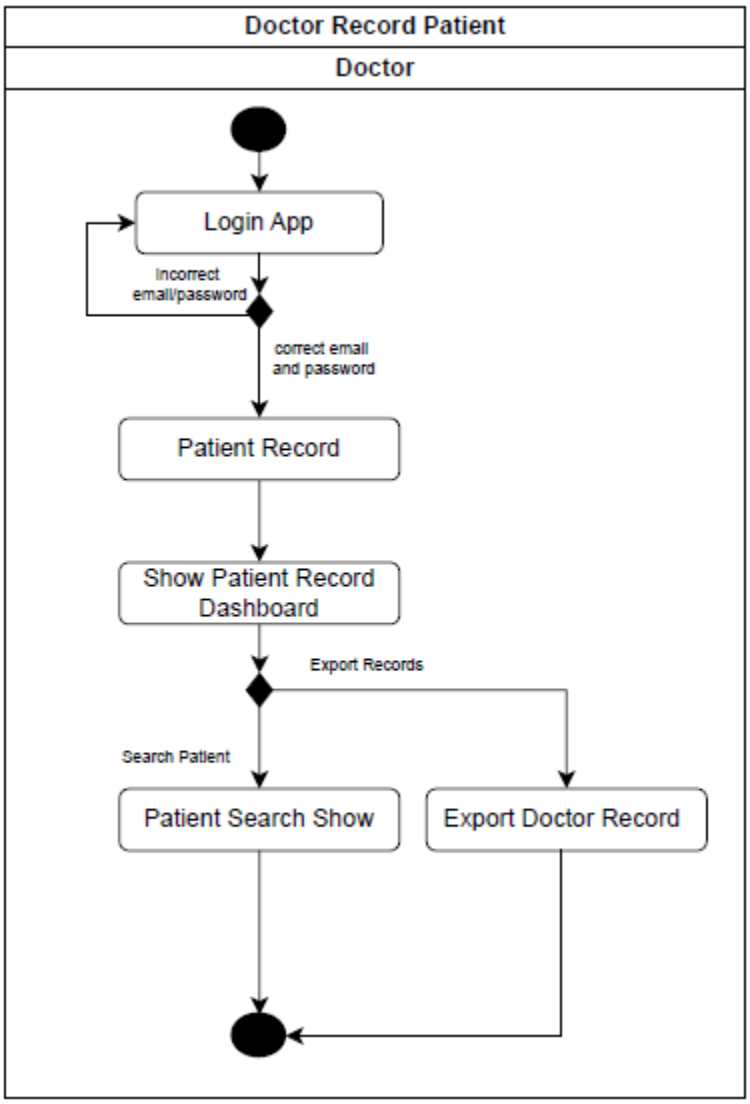
Doctor Treatment



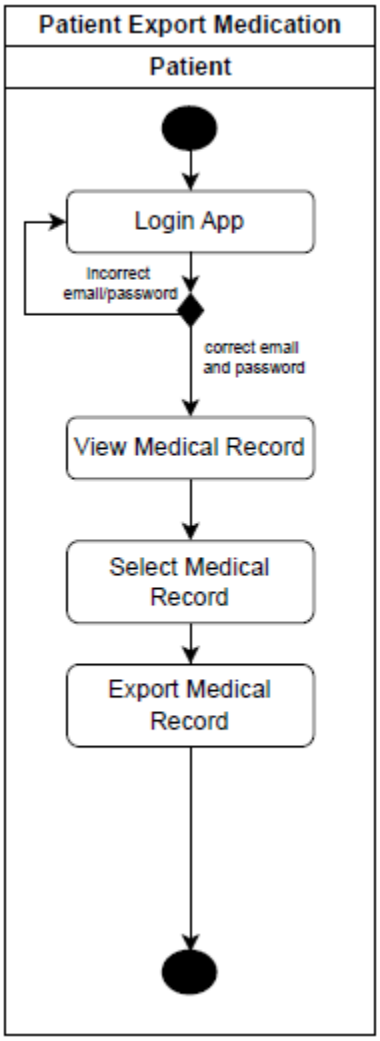
Patient Appointment Management



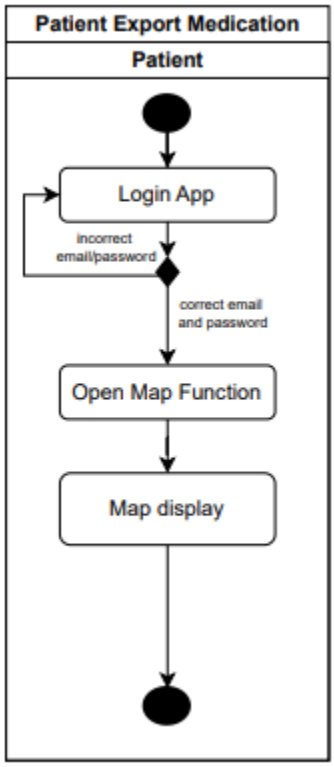
Doctor Record Patient



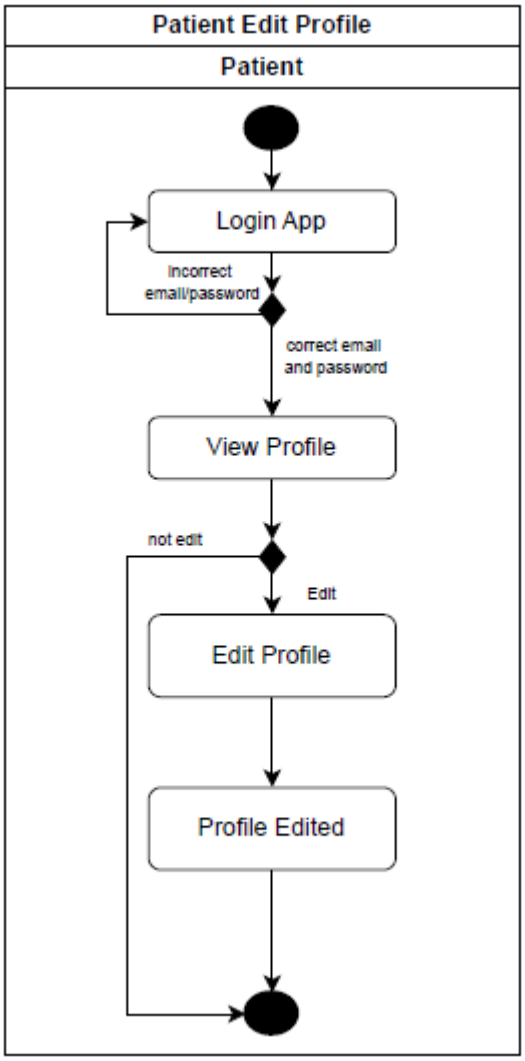
Patient Export Medication



Patient Open Map



Patient Edit Profile



DATA VALIDATION

1. Frontend Validation (GUI Level)

- Empty Field Checks:
- Login: Ensures "Email" and "Password" fields are not empty before attempting authentication.
- Appointment Booking: Ensures a doctor is selected.
- Treatment Submission: Ensures "Diagnosis" field is not empty.

Format Validation:

- Login: Checks if the entered "Email" adheres to a standard email format (e.g., using a regex pattern).
- Logical Checks (Pre-API Call):
- Appointment Reschedule/Cancel: Prevents rescheduling or canceling appointments that are already 'completed' or 'cancelled'.
- Appointment Booking: Displays a message if no doctors are loaded.

2. Backend Validation (REST Server/DBConnection Level)

- Missing Parameter Checks (ClinicRestServer Handlers):
- AppointmentsHandler (GET): Checks for the presence of patientId or doctorId parameters.
- AppointmentsHandler (POST): Validates that patientId, doctorId, date, and time are present in the request body.
- TreatmentsHandler (POST): Validates that appointmentId, diagnosis, treatmentType, and medication are present.
- RescheduleAppointmentHandler: Checks for valid appointmentId in the path and date, time in the request body.
- AppointmentStatusHandler: Checks for valid appointmentId in the path and status in the request body.

Data Integrity (DBConnection):

- Foreign Key Constraints: The database schema enforces that patient_id, doctor_id, and appointment_id must refer to existing records in their respective parent tables. This prevents orphaned records.
- Unique Constraints: The email columns in doctors and patients tables have UNIQUE constraints, preventing the creation of multiple user accounts with the same email address.
- ENUM Type: The status column in appointments only allows predefined values ('pending', 'confirmed', 'completed', 'cancelled', 'rescheduled'), ensuring data consistency.

- ON DUPLICATE KEY UPDATE (during initialization/sync): When populating the database from JSON files, this SQL clause is used to prevent inserting duplicate records based on unique keys (like email for doctors/patients, or a combination of patient/doctor/date/time for appointments), instead updating existing ones.

Business Logic Validation (DBConnection):

- Appointment Conflict Check (checkAppointmentConflict): Before booking a new appointment, the backend explicitly checks if the selected doctor already has an appointment at the exact date and time that is not 'cancelled' or 'completed'. This prevents double-booking.
- Treatment Existence Check (insertTreatment): Before inserting a new treatment, the backend checks if a treatment record already exists for that appointment_id. If it does, it updates the existing record instead of creating a new one, ensuring a one-to-one relationship between completed appointments and treatments.
- Status Updates: The insertTreatment method automatically updates the appointment status to 'completed' after a treatment is recorded, reflecting the business process.
- Reschedule/Cancel Logic: While some checks are on the frontend, the backend methods (rescheduleAppointment, cancelAppointment, updateAppointmentStatus) are designed to handle the actual database updates, ensuring that the status changes are correctly applied and persisted.
- Error Handling: Both frontend and backend include robust error handling (try-catch blocks, JOptionPane messages, HTTP status codes) to inform users and developers about issues, whether they are network errors, database errors, or validation failures.