POLITÉCNICO DE SANTARÉM

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Licenciatura de Engenharia de Informática

Software Engineering

Requirements

Work done by

Beatriz Fernandes, 230001155

Bianca Fernandes, 230001154

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Executive Summary
Hospital Management System

1.1 Problem Context

Digitalization is becoming a necessity in the healthcare sector in order to reduce human errors and improve resource management. Fragmented data is a common problem in hospital settings, which in turn causes medication errors resulting from unidentified drug interactions, scheduling conflicts causing long waiting times for patients, and inefficiencies in laboratory tracking. The aforementioned issues have a negative impact on the quality of care, and at the same time, they lead to higher operational costs and administrative burnout.

1.2 System Purpose

The purpose of the system is to provide a unified digital platform that integrates clinical, administrative, and logistical hospital workflows. The system is designed to be a “safety net” for medical professionals and an efficiency tool for administrative staff. By centralizing patient records and automating complex checks, specifically drug interaction detection and appointment conflict resolution, the system ensures a safer environment for patients and a more organized workspace for employees.

1.3 StakeHolder Overview

The success of the system depends on addressing the specific needs of five primary stakeholder groups:

- **Clinical Staff(Doctors and Nurses):** They require immediate access to patient history and automated alerts to prevent medical error, like Drug Interaction Checking, and manage daily triages.
- **Patients:** They seek a smooth experience, from easy appointment booking to clear access to their medical records and billing information.
- **Administrative Staff:** They focus on the operational health of the hospital, requiring tools for staff scheduling, insurance processing, and accurate billing.
- **Insurance Companies(External):** While not direct users, they require standardized and accurate data for claim processing and financial reconciliation.

Stakeholder Analysis

2.1 Clinical Stakeholders

2.1.1 Doctors

- **Role:** Primary decision-makers for patient diagnosis and medical treatment.
- **Goals:** To provide high-quality medical care, minimize diagnosis errors, and ensure patient safety during treatment.
- **Needs:** Real-time access to accurate Electronic Health Records, including allergies, chronic conditions and previous test results. They need a safety measure when prescribing medications.
- **Concerns:** Their biggest concern is medical negligence or errors caused by missing information. Specifically, they worry about drug-to-drug interactions.

2.1.2 Nurses

- **Role:** Front-line healthcare providers who manage patient triage, monitoring and daily coordination.
- **Goals:** To maintain an organized ward and ensure that patients transition smoothly from arrival to consultation and treatment.
- **Needs:** A centralized Appointment Schedule that shows doctor availability and room assignments. They also need a way to track the status of laboratory tests without manual follow-ups.
- **Concerns:** Their primary concern is Schedule Conflicts. Overlapping appointments or room double-booking.

2.2 Administrative And Support Stakeholders

2.2.1 Administrative Staff

- **Role:** Responsible for the hospital's operational and financial health, including registration and billing.
- **Goals:** To maximize hospital resource utilization and ensure accurate financial transactions with patients and insurers.
- **Needs:** Tools for Staff Scheduling to manage shifts and an automated Billing Calculator that can handle complex insurance coverage rules.
- **Concerns:** Financial loss due to insurance claim rejections or billing errors. They are also concerned about inefficient staff allocation that leaves some departments understaffed while others are idle.

2.2.2 Pharmacists

- **Role:** Responsible for dispensing medication and maintaining the hospital's drug supply.
- **Goals:** To ensure the right medication in the right dosage and to prevent medical shortages.
- **Needs:** Digital access to prescriptions to avoid misreading handwriting and a Medical Inventory Management system with automated low-stock alerts.
- **Concerns:** Inventory stockouts of medications and the legal/safety risks of dispensing a medication that has a high risk of adverse interaction with the patient's profile.

2.3 External Stakeholders

2.3.1 Patients

- **Role:** The users receiving the medical services.
- **Goals:** To receive fast, effective and transparent healthcare.
- **Needs:** A simple way to book/reschedule appointments and a clear view of their medical history and final bills
- **Concerns:** Data privacy is a major concern, patients worry about who can see their sensitive health data. They also fear long wait times caused by inefficient scheduling.

2.3.2 Insurance Companies

- **Role:** Financial partners that provide health coverage to patients and reimburse the hospital for medical services.
- **Goals:** To ensure that all claims submitted by the hospital are accurate, medically justified and follow the specific terms of the patient's policy.
- **Needs:**
    - **Standardized Billing Data:** Clear invoices that break down costs.
    - **Verification of Service:** Proof that the prescribed drugs and tests match the diagnosis recorded in the system.
- **Concerns:**They are highly concerned about over-billing or errors in the billing calculator. They require the system to correctly apply the "co-pay" versus "coverage" to avoid financial disputes.

Functional Requirements

3.1 Patient Management and Electronic Health Records

This module serves as all patient data. It replaces physical files with a digital dashboard, ensuring that doctors have immediate access to medical history. The core function is to maintain data integrity and ensure that patient demographics and medical timelines are accurate and accessible only to authorized personnel.

- **FR-EHR-01 (Record Creation):** The system shall allow authorized administrative staff to create new patient profiles including name, age, gender, contact details and insurance provider.
- **FR-EHR-02 (Centralized Dashboard):** The system shall provide doctors with a unified dashboard displaying a patient's active medications, past diagnoses and laboratory results on a single screen.
- **FR-EHR-03 (History Tracking):** The system shall maintain a chronological log of all medical consultations and treatments assigned to a patient, that cannot be deleted.

3.2 Clinical Support and Drug Interaction Engine

This module acts as the critical safety measure for clinical operations. By automating the validation of prescriptions, it mitigates the risk of human error in medication management. The engine checks every new prescription against the patient's existing profile to detect allergies and dangerous drug interactions.

- **FR-MED-01 (Allergy Validation):** The system shall automatically cross-reference any new prescription against the patient's recorded allergies and block the prescription if a match is found.
- **FR-MED-02 (Drug Interaction Checking):** Upon entering a new medication, the system shall analyze the patient's current active prescriptions for known drug-to-drug interactions.
- **FR-MED-03 (Severity Alerts):** The system shall categorize drug interactions into "Low", "Moderate" and "High" severity, requiring a mandatory digital signature and justification from the doctor to override a "High" risk alert.

3.3 Appointment Scheduling and Conflict Detection

Efficient resource allocation is vital for hospital operations. This module manages the logic of matching patients with doctors and medical rooms. It addresses the challenge of double-booking through an automated conflict detection algorithm, ensuring that resources are never assigned to two tasks simultaneously.

- **FR-SCH-01(Real-time Availability):** The system shall display the real-time availability of doctors and medical rooms to prevent scheduling during non-working hours or maintenance.

- **FR-SCH-02 (Conflict Detection):** The system shall prevent the booking of an appointment if the assigned doctor, patient or medical room is already committed to another task at the same time.
- **FR-SHC-03(Lab Tracking):** The system shall allow nurses to update the status of laboratory tests and notify the prescribing doctor automatically upon completion.

3.4 Billing and Insurance Processing

This module automates the financial workflow of the hospital. It integrates directly with the clinical modules to generate accurate invoices based on services rendered. A key feature is the "Insurance Calculator", which applies complex coverage rules to split costs between the insurance provider and the patient, reducing administrative errors.

- **FR-BIL-01(Automated Billing Calculator):** The system shall calculate the total cost of a patient visit based on consultation fees, laboratory tests and medications dispensed.
- **FR-BIL-02(Insurance Integration)**: The system shall automatically apply the patient's insurance coverage percentage to the total bill, displaying both the "Insurance Coverage" and the "Patient Co-pay" amounts.

3.5 Pharmacy and Inventory Control

The Pharmacy module links the doctor's digital prescription to the physical inventory. It ensures that medication stock is tracked in real-time, preventing stockouts of drugs. It also enforces safety by preventing the dispensing of expired or previously fulfilled prescriptions.

- **FR-PHAR-01(Inventory Management):** The system shall decrement medication stock automatically whenever a pharmacist marks a prescription as "Dispensed".
- **FR-PHAR-02(Low-stock Alerts):** The system shall generate an automated alert for the administrative staff when any medication stock falls below the threshold.
- **FR-PHAR-03(Batch Tracking):** The system shall record the batch number and expiration date for every medication dispensed to ensure traceability in case of product recall.
- **FR-PHAR-04(Prescription Validation):** The system shall prevent a pharmacist from dispensing a medication if the prescription status is "Expired" or has already been "Fulfilled".

3.6 Nurse Triage and Patient Monitoring

This module streamlines the workflow for nursing staff, focusing on the initial patient intake and ongoing monitoring. By digitizing vital signs entry and automating patient triage, the system ensures that critical cases are identified and treated first, improving emergency room coordination.

- **FR-NUR-01(Vital Signs Entry):** The system shall allow nurses to record vital signs during the triage process.
- **FR-NUR-02(Priority Scoring):** The system shall calculate a “Priority Score” based on the triage data to rank patients in the waiting queue automatically.
- **FR-NUR-03(Bed Management):** The system shall track the occupancy status of hospital beds in real-time.

3.7 Laboratory Information

This module bridges the communication gap between doctors and the laboratory. It eliminates paper requisitions and provides instant feedback on test results. The system automatically validates numerical results against biological reference ranges to flag abnormalities immediately.

- **FR-LAB-01(Electronic Requisition):** The system shall allow doctors to digitally select and submit test requests from a standardized catalog of available laboratory procedures.
- **FR-LAB-02(Result Range Validation):** The system shall automatically flag lab results as “Critical” if the numerical values fall outside the biological reference range defined in the system.
- **FR-LAB-03(Sample Tracking):** The system shall generate a unique barcode for each lab sample to link the physical specimen to the patient’s digital record.

3.8 Administrative Management

This module provides the tools necessary for managing the hospital’s human resources. It allows administrators to plan shifts effectively while ensuring compliance with labor regulations regarding working hours. It also maintains a real-time roster of specialists available for emergency calls.

- **FR-ADM-01(Shift Scheduling):** The system shall allow administrators to assign doctors and nurses to specific shifts as specific departments.
- **FR-ADM-02(On-Call Tracking):** The system shall maintain a real-time list of “On Call” specialists available for emergency consultations.
- **FR-ADM-03(Staff Conflict Prevention):** The system shall block a staff assignment if it exceeds the maximum allowed working hours per 24-hour period.

3.9 Reporting and Analytics

To support strategic decision-making, this module aggregates data from all other components to generate insights. It provides financial summaries for administration and safety audits for clinical directors, tracking metrics such as wait times and overridden safety alerts.

- **FR-REP-01(Financial Reports):** The system shall generate monthly reports showing total revenue, pending insurance claims and outstanding patient co-pays.
- **FR-REP-02(Safety Audits):** The system shall produce a report of all “Drug Interaction Alerts” triggered, including which ones were overridden by doctors and why.
- **FR-REP-03(Efficiency Metrics):** The system shall calculate the average “Waiting Time” for patients from triage to the actual consultation.

3.10 Security and Access Control

Given the sensitive nature of medical data, security is a functional necessity, not just a non-functional quality.This module enforces strict access controls, ensuring that users can only view data relevant to their role.

- **FR-SEC-01(Role-Based Access):** The system shall restrict read/write access to specific modules based on the user’s role.
- **FR-SEC-02(Audit Logging):** The system shall automatically record a timestamped log entry including User ID and IP address for every modification made to a patient record.
- **FR-SEC-03(Session Timeout):** The system shall automatically log out inactive users after 15 minutes to prevent unauthorized access at shared terminals.

3.11 Notification and Alert System

This module serves as the central communication hub of the application. It aggregates alerts, such as low inventory, critical lab results or scheduling conflicts, and presents them to the user in an actionable format to ensure timely responses to critical events.

- **FR-NOT-01(Centralized Notification Center):** The system shall provide a dashboard widget that aggregates all active alerts and tasks for the logged-in user.
- **FR-NOT-02(Urgent Interruption):** The system shall display modal pop-up windows for “High Severity" safety alerts that must be acknowledged before the user can proceed.

Non-Functional Requirements

4.1 Performance and Efficiency

In a hospital, time is literally life. The system is required to handle the most vital clinical data in an almost instantaneous manner, for example drug interaction checks and emergency triage updates. There is absolutely no room for slow response times in the Emergency Room module. On top of that, the system should be able to handle a large number of users at the same time because, during busy shifts, hundreds of doctors, nurses, and administrative staff will be accessing the database concurrently.

- **NFR-PER-01(Response Time):** The system shall load patient medical records and display the dashboard in under 2 seconds for 95% of requests over a standard hospital network connection.
- **NFR-PER-02(Critical Interaction Latency):** The Drug Interaction Engine must process a new prescription against a patient's active medication list and return safety alerts in less than 1 second.

4.2 Security and Data Privacy

Medical records fall under the category of highly sensitive Personally Identifiable Information. The system is required to meet rigorously high standards in data protection. Any unauthorized access to patient history or a fraudulent alteration of prescription data can lead to serious legal consequences and safety risks.

- **NFR-SEC-01(Data Encryption):** All patient data must be encrypted.
- **NFR-SEC-02(Authentication Standards):** The system shall enforce strong password policies and require Multi-Factor Authentication for all accounts with "Doctor" or "Administrator" privileges.
- **NFR-SEC-03(Audit Integrity):** The audit logs must be stored in a format to prevent administrators from tampering with security evidence.
- **NFR-SEC-04(Session Security):** The system must not cache sensitive patient data in the browser cache or local storage of the client machine.

4.3 Usability and Accessibility

With the hospital staff often working long shifts and under a lot of stress, the software interface has to be very intuitive and involve minimal cognitive load. In a situation where the UI is complex or confusing, it is possible that errors in data entry would be made or that patient treatment will be delayed. It should be a system that is so designed that a staff that is temporary or a new hire can use the basic functions with hardly any training.

- **NFR-USA-01(Learning Curve):** A new user with the "Nurse" role shall be able to complete a standard "Patient Triage Entry" task within 3 minutes after receiving only 1 hour of system training.

- **NFR-USA-02(Error Recovery):** Error messages must be descriptive and actionable. Instead of “Error 500”, the system shall display “Unable to save prescription: Patient ID not found. Please verify the ID."
- **NFR-USA-03(Click Efficiency):** Critical workflows, specifically “Prescribing a Medication” and “Booking an Emergency Appointment”, must be achievable in fewer than 5 clicks from the main dashboard.
- **NFR-USA-04 (Accessibility):** The user interface shall be accessible specifically regarding color contrast, ensuring that alerts are distinguishable by color-blind staff.

4.4 Reliable and Availability

The Hospital Management System is a mission-critical application. Downtime translates to operational chaos, manual fallback processes and potential patient harm. The system architecture must ensure that the service remains available even during hardware hiccups and data must never be lost due to system crashes.

- **NFR-REL-01(System Availability):** The system shall achieve an uptime of 99.9% during operating hours.
- **NFR-REL-02(Data Recovery):** In the event of a system failure, the Recovery Point Objective shall be less than 15 minutes and the Recovery Time Objective shall be less than 2 hours.
- **NFR-REL-03(Fault Tolerance):** The “Prescription Module” must function in “Read-Only” mode if the “Insurance Billing” service goes offline, ensuring clinical care is not stopped by administrative failures.

4.5 Scalability and Maintainability

Hospitals grow over time, adding new wings, more patients and archived medical history. The system must handle this growth without requiring a complete rewrite. Additionally, the code structure needs to support the easy addiction of new features without breaking existing functionality.

- **NFR-SCA-01(Data Volume):** The database architecture must support the storage of at least 5 million patient records without query retrieval times exceeding the performance limits defined.
- **NFR-SCA-02(Horizontal Scaling):** The application server must be stateless to allow for horizontal scaling as the user base grows beyond 1000 users.
- **NFR-MAI-01(Code Modularity):** The system shall be built using a modular architecture where the “Billing Logic” is completely decoupled from the “Clinical Logic”, allowing updates to insurance rules without redeploying the medical modules.
- **NFR-MAI-02(Documentation):** All Java Classes and Public API’S must be documented using Javadoc and the code must follow standard naming conventions to ensure 70% of the codebase is easily understandable by new developers.

Requirements Traceability Matrix

Req ID	Description	Stakeholder	Priority	Design Ref	Test Case Ref
FR-EHR-01	Record Creation	Admin Staff	High	Class:PatientService	TC-EHR-001
FR-EHR-02	Centralized Dashboard	Doctors	High	Class: DashboardUI	TC-EHR-002
FR-MED-01	Allergy Validation	Doctors	Critical	Class: InteractionEngine	TC-MED-001
FR-MED-02	Drug Interaction Check	Doctors Patients	Critical	Class: InteractionEngine	TC-MED-002
FR-SCH-02	Conflict Detection	Nurses/Admin	High	Class: ScheduleManager	TC-SCH-001
FR-BIL-01	Automated Billing	Admin Staff	Medium	Class: BillingService	TC-BIL-01
FR-BIL-02	Insurance Integration	Insurance Co.	Medium	Class: InsuranceStrategy	TC-BILL-002
FR-PHAR-02	Low-stock Alerts	Pharmacists	Medium	Pattern: Observer	TC-PHAR-001
FR-NUR-01	Vital Signs Entry	Nurses	Low	Class: TriageRecord	TC-NUR-001
FR-SEC-01	Role-Based Access	All Users	Critical	Class: AuthService	TC-SEC-001
NFR-PER-01	Response Time	All Users	High	Architecture	TC-PERF-001