Orthopedic Medical Supplies Management System

Team 6
21102033 Kwon Daehun
21102056 Joo Youngjin
21102052 Lee Jeongyun

1. Problem Description

1.1 Background and Current Situation

In orthopedic hospitals, managing the inventory and distribution of various **medical consumables**—such as implants, sutures, sterilized gauze, syringes, and surgical instruments—is a critical operational task. However, many hospitals still rely on **manual or spreadsheet-based management systems**, which often result in issues such as **overstocking, shortages, data inconsistency, and the absence of approval records**. These inefficiencies not only disrupt daily operations but also compromise patient safety and administrative transparency.

1.2 Key Problems

The current management practices lead to several major issues:

- Overstocking, expired items, and duplicate orders increase unnecessary costs and waste.
- Insufficient real-time stock information causes delays in surgeries and treatment procedures.
- Manual data entry and the absence of automated approval workflows reduce data reliability and traceability.
- Lack of structured approval processes for high-cost and high-risk items leads to reduced transparency and accountability within the hospital's inventory management.

1.3 Necessity of the Solution

To ensure safety, audit readiness, cost efficiency, and transparent approval workflows, a digitalized inventory management system is essential. The proposed system aims to replace manual and fragmented management with an integrated, web-based solution that can be readily adopted by small- and medium-sized hospitals. By introducing this system, hospitals can achieve real-time visibility of inventory, enforce approval-based control for sensitive items, and maintain reliable audit logs for all critical transactions.

2. Functional Requirements Specification

ID	Requirement	Acceptance Criteria (AC)
FR-01	Item Registration / Query / Update	Each item shall be managed with a unique `itemCode` (e.g., *ITEM-2025-0001*) and include category, specification, expiration date, and storage location. Creation, modification, and deletion must be supported.
FR-02	Inbound / Outbound Record Management	All inventory movements shall be recorded at the *lotNumber* level. The system must allow viewing of all transaction histories, including inbound, disbursement, and adjustments.
FR-03	Electronic Approval Workflow	The approval process must follow the sequence: Request → Approve/Reject → Disbursement. Disbursement is not permitted before approval. Each stage must be logged.
FR-04	Automated Approval Criteria	The system shall automatically determine whether approval is required based on item policies (e.g., high-cost, high-risk). Any policy changes must be reflected immediately.
FR-05	Role-Based Access Control (RBAC)	Roles include Doctor (approval), Nurse (request), Inventory Manager (inbound/outbound), and Admin (policy management). Screen and API access must be restricted by role.
FR-06	Approval Notification	When the request, approval, or disbursement status changes, the system must send a notification via the UI or email to the relevant users.

FR-07	Audit Log History	All operations such as requests, approvals, and disbursements must be recorded with user, timestamp, action, result, and reason. Logs must be immutable.
FR-08	Statistics and Reports	The system must visualize monthly usage, approval processing time, rejection rate, inventory turnover, and top 10 frequently used items. Export to CSV or PDF must be available.
FR-09	Administration Tools	The system shall provide tools for managing item policies, categories, and user permissions. All changes must be recorded in history logs.

---

3. Non-Functional Requirements Specification

ID	Requirement	Criteria / Target
NFR-01	**Performance**	The average response time of major screens shall be ≤ **1.5 seconds**.
NFR-02	**Availability**	The system shall operate under a **9×5 service schedule** with a target of **zero critical failures** during demonstrations.
NFR-03	**Security**	Passwords shall be hashed using **BCrypt**, and the system shall enforce **Role-Based Access Control (RBAC)** and maintain audit logs for all critical actions.
NFR-04	**Auditability & Traceability**	All state changes must be recorded as **immutable logs** to ensure full traceability.

NFR-05	**Reliability**	Approval and disbursement transactions shall guarantee **atomic commits** to prevent partial updates or data loss.
NFR-06	**Scalability**	The system shall maintain the same **Service Level Agreement (SLA)** performance even when the number of items increases tenfold.
NFR-07	**Compatibility**	The system shall be compatible with the latest **two versions of Chrome and Edge browsers**.
NFR-08	**Standards & Coding Conventions**	All APIs must follow the **RESTful architecture**, be **documented using OpenAPI**, and comply with defined **commit message conventions**.

---

4. Domain Specification

4.1 Main Entities

Entity	Attributes	Description
Item	`itemCode`, `name`, `category`, `spec`, `policy`, `unit`	Defines the characteristics and policy of each consumable item. The `policy` field determines whether approval is required (e.g., *NORMAL*, *HIGH_VALUE*, *HIGH_RISK*).
Lot	`lotNumber`, `itemCode`, `expDate`, `quantity`, `locationId`	Represents a specific batch (lot) of an item, including expiration date and quantity. Created automatically upon inbound registration.
Location	`locationId`, `type` (e.g., Central Storage / Operating Room), `name`	Defines the storage location type and name.
User	`userId`, `name`, `role` (Doctor / Nurse / Admin)	Represents system users and their assigned roles. *(Inventory role is merged with Nurse in this project.)*

Request	`reqId`, `requesterId`, `itemCode`, `lotNumber`, `qty`, `reason`, `status`	Represents a disbursement request for consumables, including quantity, purpose, and approval status.
Approval	`apprId`, `reqId`, `approverId`, `decision`, `comment`, `ts`	Records the approval or rejection decision of a request, along with timestamp and comments.
Movement	`mvId`, `lotNumber`, `from`, `to`, `qty`, `ts`, `cause` (*Inbound / Disbursement / Adjustment*)	Represents physical movement of stock by lot, including inbound, disbursement, and adjustments.
AuditLog	`logId`, `actor`, `action`, `target`, `ts`, `meta`	Immutable log of all critical actions (request, approval, disbursement, etc.) for audit and traceability.
Notification	`notiId, receiverId, type, message, ts, status`	Represents the alert or message generated by the system when an event such as a request, approval, or disbursement occurs. The notification is delivered to the corresponding user and may be displayed through the UI or sent via email. The *status* field indicates whether the notification has been read (READ/UNREAD)

4.2 Business Rules

The system follows a set of business rules designed to maintain data consistency, operational accuracy, and regulatory compliance within the hospital environment.

Each consumable item is assigned a unique identifier that is automatically generated in the format ITEM-YYYY-NNNN, ensuring clear traceability across all records.

When an item is registered as inbound stock, a corresponding lot record is automatically created, containing essential attributes such as the expiration date and quantity.

For high-value or high-risk consumables, the system enforces a strict approval workflow: such items cannot be disbursed until the approval is fully completed by the authorized personnel. This mechanism prevents unauthorized or accidental usage of critical medical supplies.

Furthermore, every inventory transaction—whether inbound, outbound, or adjustment—is recorded at the lot level to ensure detailed traceability. The system also prohibits negative inventory quantities, thereby maintaining logical and accurate stock levels across all storage locations.

---

5. Scenarios

Use Case Scenario: UC-01 — General Consumable Inbound Registration

Use Case Name	General Consumable Inbound Registration
Objective	The nurse registers newly delivered general consumables in the system using lot numbers printed on the products.
Actor(s)	Nurse (Inventory role combined)
Precondition	The application is running, and the delivery note and item information are available in the system.
Main Flow	1. The nurse logs into the system. 2. Selects the *Inbound Registration* menu. 3. Clicks *Update Inventory* and enters **item name, lot number, quantity, and expiration date**. 4. The system validates the input and updates inventory records. 5. The system displays a success message and returns to the main screen.
Alternative Flow (A1)	**A1. New Item Registration** 1. If the item does not exist, the nurse navigates to *New Item Registration*. 2. Registers the item and returns to resume the inbound process.
Exception Flow (E1–E3)	**E1. Missing Required Fields:** The system prompts the user to input missing values. **E2. Invalid Quantity:** If quantity ≤ 0, the system displays a warning and rejects the entry. **E3. Duplicate Lot Number:** The system rejects registration if the lot number already exists.

Special Requirements	- The lot number must match the manufacturer's unique code from the delivery note. - All inbound data must be recorded in the **Audit Log**.

Use Case Scenario: UC-02 — General Consumable Disbursement

Use Case Name	General Consumable Disbursement
Objective	When the nurse requests general consumables, the system automatically approves and processes the disbursement.
Actor(s)	Nurse (Inventory role combined)
Precondition	The item is classified as a general consumable, and sufficient stock exists.
Main Flow	1. The nurse logs into the system. 2. Selects the *Disbursement Request* menu. 3. Enters the requested item and quantity. 4. The system verifies that approval is not required and automatically approves the request. 5. The nurse confirms the auto-approved request and completes disbursement. 6. The system records the transaction and returns to the main screen.
Alternative Flow (A1)	*(None)*
Exception Flow (E1)	**E1. Insufficient Stock:** If the requested quantity exceeds available stock, the system displays a warning and blocks the request.
Special Requirements	Automatically approved items must still be recorded in the **Audit Log** with the label *"Auto-Approved."*

Use Case Scenario: UC-03 — High-Value Consumable Approval Request and Disbursement

Use Case Name	High-Value Consumable Approval Request and Disbursement
Objective	When the nurse requests high-value medical consumables (e.g., artificial joints, bone cement), the doctor must approve before disbursement.
Actor(s)	Nurse (Inventory role combined), Doctor
Precondition	The item is classified as a high-value or high-risk item requiring approval.
Main Flow	1. The nurse registers a disbursement request. 2. The system identifies that approval is required and sets status to *Pending Approval.* 3. The doctor receives an approval notification. 4. The doctor reviews the request and approves or rejects it. 5. Upon approval, the nurse receives a notification. 6. The nurse disburses the approved item. 7. The system records all actions in the **Audit Log**.
Alternative Flow (A1)	**A1. Delayed Decision Notification:** If no decision is made within one hour, the system automatically sends a reminder to the doctor.
Exception Flow (E1)	**E1. Rejection:** Managed under **UC-04**.
Special Requirements	The approval workflow must be handled as a single **transaction**, with rollback on intermediate failure.

Use Case Scenario: UC-04 — Rejection Process

Use Case Name	Rejection Process
Objective	The doctor reviews a pending request and rejects it with a reason.
Actor(s)	Doctor, Nurse
Precondition	A pending approval request exists, created by the nurse.
Main Flow	1. The doctor opens the *Approval Inbox.* 2. Reviews the request details and clicks *Reject.* 3. Enters a rejection reason and saves. 4. The system updates the request status to *Rejected.* 5. The nurse receives a rejection notification.
Alternative Flow (A1)	*(None)*
Exception Flow (E1)	**E1. Missing Reason:** The system prevents saving if no rejection reason is entered.
Special Requirements	- Rejection reasons must be recorded in the **Audit Log** and cannot be modified. - The rejection message must appear in the nurse's notification panel.

Use Case Scenario: UC-05 — Expiration Date Alert

Use Case Name	Expiration Date Alert
Objective	The nurse monitors consumables by lot expiration date and receives alerts for expiring items.
Actor(s)	Nurse (Inventory role combined)
Precondition	Each item includes an expiration date (`expDate`).
Main Flow	1. The nurse opens the *Inventory Status* screen. 2. The system checks expiration dates for all lots. 3. Lots with ≤ 30 days remaining are marked *Expiring Soon.* 4. The system displays a warning and highlights affected items.
Alternative Flow (A1)	**A1. Automatic Notification:** If the nurse enables *Auto Notification,* the system emails the expiring lot list daily.
Exception Flow	*(None)*
Special Requirements	Expiring lots must be automatically filtered and visually highlighted (e.g., yellow marker).

Use Case Scenario: UC-06 — Prevention of Unauthorized Disbursement

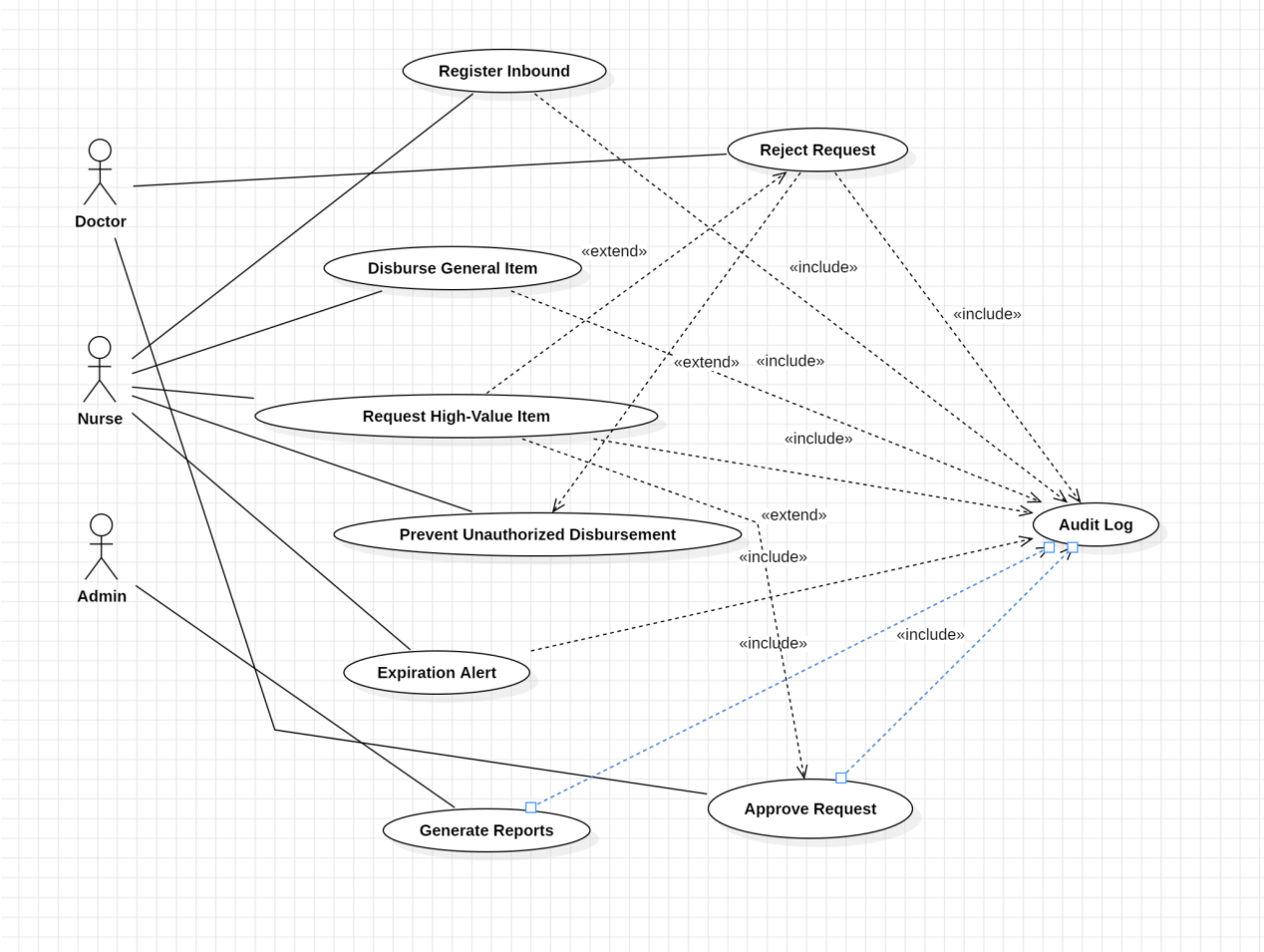
Use Case Name	Prevention of Unauthorized Disbursement
Objective	Prevent disbursement of high-value or high-risk items before approval is completed.
Actor(s)	Nurse, Doctor
Precondition	A pending approval request exists, and the approval process is incomplete.
Main Flow	1. The nurse opens the *Disbursement Requests* screen. 2. The system shows the current status (Pending / Approved / Rejected). 3. The *Disburse* button is disabled for *Pending* requests. 4. If the nurse attempts to proceed, a popup displays: *"Disbursement is only allowed after doctor approval."* 5. When approved, the button becomes active for disbursement.
Alternative Flow (A1–A2)	**A1. Real-Time Status Update:** Approval status updates immediately upon doctor action. **A2. Emergency Use:** In urgent cases, the nurse clicks *Post-Report,* provides a reason, and the request becomes *Emergency Use (Post-Approval Pending).* The doctor later approves it retroactively.
Exception Flow (E1)	**E1. Approval Desynchronization:** If UI shows *Approved* but the server update is delayed, the system blocks the action and displays *"Approval data not synchronized."*

Special Requirements	- Approval completion is determined solely by <Request.status = APPROVED>. - Unauthorized disbursements must be blocked both in UI and API. - All related events are recorded in the **Audit Log**.

Use Case Scenario: UC-07 — Statistics and Report Generation

Use Case Name	Statistics and Report Generation
Objective	The administrator visualizes monthly usage, approval time, and rejection rate, and generates reports.
Actor(s)	Administrator
Precondition	Inbound, approval, and disbursement data exist.
Main Flow	1. The administrator logs into the system. 2. Opens the *Statistics / Reports* menu. 3. Selects a time period (monthly / quarterly). 4. The system aggregates **usage volume, approval duration, rejection rate, and inventory turnover.** 5. Displays results as bar or line charts. 6. The administrator clicks *Export CSV* or *Generate PDF Report.* 7. The system generates the file and provides a download link.
Alternative Flow (A1)	**A1. Item Filtering:** The administrator filters data by item category (e.g., high-value).
Exception Flow (E1)	**E1. No Data:** If no records exist, the system displays *"No Data Available"* and cancels report generation.
Special Requirements	- Report generation time ≤ 2 seconds. - All reports must be recorded in the **Audit Log**.

6. Use Case Diagram



Three primary actors: Doctor, Nurse, and Admin.

The Nurse is responsible for daily operational tasks such as Register Inbound, Disburse General Item, and Request High-Value Item. When a request involves high-value or high-risk items, the workflow automatically invokes the approval process, represented by the Approve Request use case. Exceptional cases, such as Prevent Unauthorized Disbursement or Expiration Alert, are modeled using the <<extend>> relationship, indicating that these scenarios are triggered only under specific conditions.

The Doctor performs the Approve Request or Reject Request actions, verifying high-value item requests and ensuring compliance with hospital policy. Each of these approval-related operations includes the <<include>> relationship with the Audit Log use case, which records all actions for traceability and accountability.

The Admin actor manages system-level tasks such as Generate Reports, which aggregates usage, approval time, and rejection statistics. These actions also connect to the Audit Log to guarantee comprehensive auditability across all administrative activities.

The Audit Log use case serves as the central shared component for accountability, referenced by multiple use cases through <<include>> relationships. This ensures that every critical operation—such as registration, request, approval, or reporting—is automatically recorded for transparency and future auditing.