

# FlowTrack Database Schema & Entity Relationship Documentation

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## Document Overview

**Project:** FlowTrack - Inventory Management System

**Database:** MySQL 8.0

**ORM Framework:** JPA/Hibernate

**Total Entities:** 11

**Last Updated:** February 6, 2026

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## Database Design Philosophy

The FlowTrack database follows a **normalized relational design** pattern with clear separation of concerns:

- **Core Business Logic:** Item, Borrower, Loan (lending workflow)
- **Organizational Data:** Vendor, ItemType, ItemRepair (supply chain)
- **Authentication & Authorization:** User, Role (Spring Security)
- **Analytics:** DashboardSnapshot (time-series metrics)
- **Legacy:** InventoryManager, ManagerType (deprecated)

### Design Principles:

1.  **Normalization** - Minimize data redundancy
  2.  **Referential Integrity** - Foreign key constraints
  3.  **Lazy Loading** - Performance optimization for related entities
  4.  **Cascading** - Proper cascade rules for relationships
  5.  **Soft Delete Ready** - Can add **deleted** flag without schema changes
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## Entity Catalog

Entity	Table Name	Purpose	Status	Relationships
<b>Item</b>	<b>Inventory_item</b>	Physical inventory items	<input checked="" type="checkbox"/> Active	→ ItemType, Vendor, Loan
<b>Borrower</b>	<b>Borrower</b>	People borrowing items	<input checked="" type="checkbox"/> Active	→ Loan
<b>Loan</b>	<b>Loan</b>	Borrowing transactions	<input checked="" type="checkbox"/> Active	→ Item, Borrower
<b>User</b>	<b>users</b>	System users (staff)	<input checked="" type="checkbox"/> Active	→ Role
<b>Role</b>	<b>roles</b>	Access control roles	<input checked="" type="checkbox"/> Active	← User

Entity	Table Name	Purpose	Status	Relationships
<b>Vendor</b>	Vendor	Item suppliers	<input checked="" type="checkbox"/> Active	← Item, ItemRepair
<b>ItemType</b>	item_type	Item categories	<input checked="" type="checkbox"/> Active	← Item
<b>ItemRepair</b>	item_repair	Damaged item repairs	<input checked="" type="checkbox"/> Active	→ Item, Vendor
<b>DashboardSnapshot</b>	dashboard_snapshot	Analytics snapshots	<input checked="" type="checkbox"/> Active	Standalone
<b>InventoryManager</b>	Inventory_Manager	Old auth system	<input type="checkbox"/> Legacy	→ ManagerType
<b>ManagerType</b>	manager_type	Old manager types	<input type="checkbox"/> Legacy	← InventoryManager

## 📘 Entity Detailed Documentation

### 1 Item (Core Entity)

**Table Name:** `Inventory_item`

**Purpose:** Represents physical items available for lending

**Schema:**

```

@Entity
@Table(name = "Inventory_item")
public class Item {
    @Id @GeneratedValue
    @Column(name = "item_id")
    private long id;                                // Primary Key

    @Column(name = "item_name")
    private String name;                            // Item name (e.g., "Laptop")

    @Column(name = "item_quantity")
    private int quantity;                          // Available stock

    @Column(name = "item_price")
    private double price;                           // Purchase price (₹)

    @Column(name = "item_fine_rate")
    private double fineRate;                      // Late fee per day (₹)

    @Column(name = "item_invoice_number")
    private long invoiceNumber;                  // Purchase invoice reference
  
```

```

// Relationships
@OneToOne(fetch = LAZY)
@JoinColumn(name = "item_type_fk")
private ItemType itemType; // FK → item_type

@OneToOne(fetch = LAZY)
@JoinColumn(name = "vendor_id_fk")
private Vendor vendor; // FK → Vendor

@OneToMany(mappedBy = "item")
private List<Loan> loan; // One item, many loans
}

```

## Design Rationale:

### Why separate quantity and price?

- **quantity**: Tracks availability (decreases on issue, increases on return)
- **price**: Stores item value for loss/damage calculations

### Why store fineRate per item instead of global?

- Expensive items (laptop) need higher fines than cheap items (pen)
- Flexibility to adjust fine rates per item

### Why invoiceNumber as long not String?

- Numeric invoices are standard in accounting systems
- Enables sorting and range queries
- Future: Can migrate to String if alphanumeric needed

### Why OneToOne with ItemType instead of ManyToOne?

- **Current**: Each item has one type, type can belong to multiple items
- **Issue**: This should be `@ManyToOne` (multiple items → one type)
- **Legacy Decision**: Likely a modeling error, works but not optimal
- **Fix Required**: Change to `@ManyToOne` in future refactor

## Business Methods:

```

decreaseQuantity() // Called when item issued
increaseQuantity() // Called when item returned
addLoan(Loan) // Bidirectional relationship helper
removeLoan(Loan) // Cleanup helper

```

## Evolution History:

1. **Initial**: Simple item table with name and quantity
2. **v1.1**: Added `price` and `invoiceNumber` for procurement tracking

- 3. **v1.2:** Added **fineRate** for flexible fine calculation
  - 4. **v1.3:** Added relationships to **ItemType** and **Vendor**
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## 2 Borrower (Core Entity)

**Table Name:** Borrower

**Purpose:** Individuals who borrow items (students, employees, customers)

**Schema:**

```

@Entity
@Table(name = "Borrower")
public class Borrower {
    @Id @GeneratedValue
    @Column(name = "borrower_id")
    private long id;                                // Primary Key

    @Column(name = "first_name")
    private String firstName;                         // Given name

    @Column(name = "last_name")
    private String lastName;                          // Family name

    @Column(name = "email")
    private String email;                            // Contact email

    // Relationships
    @OneToMany(mappedBy = "borrower")
    private List<Loan> loan;                      // Borrowing history
}

```

**Design Rationale:**

**Why separate entity from User?**

- **Borrower:** External people who borrow items (students, customers)
- **User:** Internal staff who operate the system (admin, staff, manager)
- **Separation of Concerns:** Different authentication needs

**Why no username/password?**

- Borrowers don't log into the system
- Staff issues items on their behalf
- Email is sufficient for identification

**Why no phone number?**

- **Initial Design:** Minimal fields
- **Future Enhancement:** Should add **phone**, **studentId**, **department**

## Why no address?

- Not needed for current use case (on-premises system)
- Can add if mailing receipts/notices needed

## Business Methods:

```
totalFine()           // Sum all unpaid fines across loans
updateFine(amount)   // Pay off fines (oldest first)
addLoan(Loan)         // Add new borrowing record
removeLoan(Loan)      // Remove borrowing record
```

## Evolution History:

1. **Initial:** Basic borrower with name and email
2. **v1.1:** Added relationship to **Loan**
3. **v1.2:** Added fine calculation methods

## ③ Loan (Core Transaction Entity)

**Table Name:** **Loan**

**Purpose:** Records item lending transactions (issuance and return)

### Schema:

```
@Entity
@Table(name = "Loan")
public class Loan {
    @Id @GeneratedValue
    @Column(name = "loan_id")
    private long id;                      // Primary Key

    @Column(name = "issue_date")
    private String issueDate;              // When item was issued (YYYY-MM-DD)

    @Column(name = "return_date")
    private String returnDate;             // When item was returned (nullable)

    @Column(name = "loan_duration")
    private long loanDuration;            // Expected loan period (days)

    @Column(name = "total_fine")
    private double totalFine;              // Late return fine (₹)

    // Relationships
    @ManyToOne(fetch = LAZY)
    private Item item;                   // FK → Item
```

```

    @ManyToOne(fetch = LAZY)
    private Borrower borrower;           // FK → Borrower
}

```

## Design Rationale:

### Why dates as **String** instead of **Date/LocalDate**?

- **Current:** String format "YYYY-MM-DD"
- **Issue:** No database-level date validation, harder to query
- **Reason:** Likely early design decision for simplicity
- **Fix Required:** Migrate to **LocalDate** in future
- **Workaround:** Helper class converts String ↔ Date

### Why **loanDuration** separate from **dates**?

- Stores **expected** duration (policy limit)
- Due date = issueDate + loanDuration
- Allows flexible policies (7 days for books, 14 days for laptops)

### Why **totalFine** stored instead of calculated?

- **Performance:** Avoid calculation on every query
- **Audit Trail:** Fine amount at time of transaction
- **Business Rule:** Fine can be manually adjusted (waived, increased)

### Why nullable **returnDate**?

- **NULL** = item still borrowed (loan active)
- Not **NULL** = item returned (loan completed)
- Simple status tracking without separate status field

## Fine Calculation Logic:

```

calculateFine() {
    if (returnDate != null) {
        daysLate = returnDate - (issueDate + loanDuration)
        if (daysLate > 0) {
            fineRate = item.itemType == "High Precedence"
                ? highPrecedenceFineRate
                : lowPrecedenceFineRate
            totalFine = daysLate * fineRate
        }
    }
}

```

### Why two fine rates?

- **High Precedence:** Critical items (laptops, projectors) = ₹50/day

- **Low Precedence:** Common items (pens, books) = ₹10/day
- **Future:** Should move to `fineRate` per item (already added!)

## Evolution History:

1. **Initial:** Basic loan with item, borrower, dates
  2. **v1.1:** Added `loanDuration` for flexible policies
  3. **v1.2:** Added `totalFine` and fine calculation
  4. **v1.3:** Added precedence-based fine rates
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## 4 User (Authentication Entity)

**Table Name:** `users`

**Purpose:** System users (admin, staff, managers) who operate the application

**Schema:**

```

@Entity
@Table(name = "users")
public class User {
    @Id @GeneratedValue
    private Long id;                                // Primary Key

    @NotBlank @Column(unique = true)
    private String username;                         // Login username

    @Email @Column(unique = true)
    private String email;                            // Email address

    @NotBlank
    private String password;                        // Hashed password (BCrypt)

    @Column(name = "first_name")
    private String firstName;                       // Given name (optional)

    @Column(name = "last_name")
    private String lastName;                        // Family name (optional)

    @Column(nullable = false)
    private boolean enabled = true;                // Account active status

    // Relationships
    @ManyToMany(fetch = EAGER)
    @JoinTable(
        name = "user_roles",
        joinColumns = @JoinColumn(name = "user_id"),
        inverseJoinColumns = @JoinColumn(name = "role_id")
    )
    private Set<Role> roles;                      // User's assigned roles
}

```

## Design Rationale:

### Why separate from **Borrower**?

- **User**: Internal staff (authenticate, manage system)
- **Borrower**: External people (tracked, don't log in)
- **Different Needs**: Users need passwords, Borrowers don't

### Why separate from **InventoryManager**?

- **New System**: Spring Security-based RBAC
- **Old System**: Custom auth (InventoryManager)
- **Migration**: Moved to industry-standard Spring Security

### Why **username** AND **email** both unique?

- Username: Short, memorable login (e.g., "john\_doe")
- Email: Contact info, password reset
- Both unique: Prevents conflicts

### Why **enabled boolean**?

- Soft delete alternative
- Disable accounts without data loss
- Can re-enable later
- Audit trail preserved

### Why **ManyToMany** with **Role**?

- One user can have multiple roles
- One role belongs to many users
- Join table **user\_roles** stores relationships

### Why **EAGER** fetch for **roles**?

- Roles needed immediately on user load
- Authorization checks happen frequently
- Small data size (typically 1-3 roles per user)
- Avoids LazyInitializationException

## Evolution History:

1. **Initial**: InventoryManager with single manager type
2. **v2.0**: Complete rewrite to Spring Security
3. **v2.1**: Added User-Role ManyToMany
4. **v2.2**: Added **enabled** flag
5. **v2.3**: Added validation annotations

**Table Name:** roles**Purpose:** Define access control roles (ROLE\_ADMIN, ROLE\_MANAGER, etc.)**Schema:**

```

@Entity
@Table(name = "roles")
public class Role {
    @Id @GeneratedValue
    private Long id;                                // Primary Key

    @Column(unique = true, nullable = false)
    private String name;                            // Role name (e.g., "ROLE_ADMIN")
}

```

**Design Rationale:****Why separate table for roles?**

- **Reusability:** Same role assigned to many users
- **Centralized Management:** Change role permissions centrally
- **Spring Security Standard:** Follows Spring Security conventions

**Why "ROLE\_" prefix?**

- **Spring Security Convention:** Required by framework
- Framework automatically checks authorities with this prefix
- Example: hasRole('ADMIN') checks for ROLE\_ADMIN

**Current Roles:**

1. **ROLE\_USER** - Basic borrowing access
2. **ROLE\_STAFF** - Process loans/returns
3. **ROLE\_MANAGER** - Manage inventory, vendors
4. **ROLE\_ADMIN** - Full system access, user management

**Why simple design (only name)?**

- **Roles = Labels:** Permissions defined in code, not DB
- **Code-based Security:** @PreAuthorize("hasRole('ADMIN')")
- **Flexibility:** Easy to add new roles

**Future Enhancements:**

- Add permissions table (fine-grained permissions)
- Example: ROLE\_ADMIN → [CREATE\_USER, DELETE\_USER, VIEW\_REPORTS]

**Evolution History:**

1. **Initial:** Single "ManagerType" (basic/advanced)

2. **v2.0:** Migrated to Spring Security roles
  3. **v2.1:** Added 4 distinct roles
  4. **v2.2:** Implemented hierarchical access
- 

## 6 Vendor (Organizational Entity)

**Table Name:** Vendor

**Purpose:** Suppliers who provide inventory items

**Schema:**

```
@Entity
@Table(name = "Vendor")
public class Vendor {
    @Id @GeneratedValue
    @Column(name = "vendor_id")
    private long id; // Primary Key

    @Column(name = "vendor_name")
    private String name; // Vendor company name

    @Column(name = "vendor_email")
    private String email; // Vendor contact email
}
```

**Design Rationale:**

**Why track vendors?**

- **Procurement Management:** Know where items came from
- **Repair Tracking:** Send damaged items back to vendor
- **Reporting:** Analyze vendor reliability, costs
- **Business Intelligence:** Best suppliers, cost optimization

**Why minimal fields?**

- **MVP Approach:** Start simple
- **Future:** Add phone, address, contract terms, ratings

**Why no relationship to Item directly visible here?**

- **Item** has **@OneToOne** to Vendor
- Unidirectional relationship (Item → Vendor)
- Vendor doesn't need to know its items in memory

**Missing but useful fields:**

- **phone** - Contact number
- **address** - Physical location

- **contractStartDate** - Agreement period
- **contractEndDate** - Renewal tracking
- **rating** - Vendor performance score
- **status** - Active/Inactive

## Evolution History:

1. **Initial:** Basic vendor with name
  2. **v1.1:** Added email
  3. **v1.2:** Linked to Item and ItemRepair
- 

## ItemType (Classification Entity)

**Table Name:** item\_type

**Purpose:** Categorize items (Electronics, Furniture, Stationary)

### Schema:

```
@Entity
@Table(name = "item_type")
public class ItemType {
    @Id @GeneratedValue
    @Column(name = "item_type_id")
    private long id; // Primary Key

    @Column(name = "type_name")
    private String typeName; // Category name
}
```

### Design Rationale:

#### Why separate table?

- **Normalization:** Avoid repeating "Electronics" in every item
- **Consistency:** Standardized categories
- **Reporting:** Group items by type
- **Fine Rate Logic:** Type determines fine precedence

#### Current Types:

1. **Electronics** - Laptops, monitors, keyboards
2. **Furniture** - Chairs, desks, cabinets
3. **Stationary** - Pens, notebooks, staplers
4. **High Precedence** - Critical items (affects fine rate)
5. **Low Precedence** - Common items (lower fine rate)

#### Why "High/Low Precedence" as types?

- **Business Logic:** Fine calculation uses type
- **Issue:** Mixing classification (what) with priority (how important)
- **Better Design:** Add `precedence` field to `ItemType`
- **Current Workaround:** Works but not ideal

### Future Improvements:

```
@Column
private String precedence;           // "HIGH", "MEDIUM", "LOW"

@Column
private double fineRate;            // Per-type fine rate

@Column
private String description;          // Type details
```

### Evolution History:

1. **Initial:** Hardcoded types in code
2. **v1.1:** Moved to database table
3. **v1.2:** Added precedence types for fines
4. **v1.3:** Used in fine calculation logic

## 8 ItemRepair (Operations Entity)

**Table Name:** `item_repair`

**Purpose:** Track damaged items sent for repair

### Schema:

```
@Entity
@Table(name = "item_repair")
public class ItemRepair {
    @Id @GeneratedValue
    @Column(name = "repair_id")
    private long id;                      // Primary Key

    @Column(name = "repair_cost")
    private double cost;                  // Repair cost (₹)

    @Column(name = "item_price")
    private double price;                 // Original item price (₹)

    // Relationships
    @OneToOne(fetch = LAZY)
    @JoinColumn(name = "item_id_fk")
    private Item item;                   // FK → Item
```

```

@OneToOne(fetch = LAZY)
@JoinColumn(name = "vendor_id_fk")
private Vendor vendor; // FK → Vendor (repair service)
}

```

## Design Rationale:

### Why separate from Item?

- **Not all items get repaired:** Most items never need repair
- **Historical Tracking:** One item can have multiple repairs over time
- **Issue:** OneToOne prevents multiple repairs per item!
- **Fix Required:** Change to @ManyToOne (one item, many repairs)

### Why store both cost and price?

- **price:** Original item value (context for cost analysis)
- **cost:** Actual repair cost
- **Decision Logic:** If `cost > 0.7 * price`, consider replacement

### Why link to Vendor?

- Items sent to original vendor for warranty repair
- Or third-party repair shops tracked as vendors
- Cost analysis by repair vendor

### Missing Critical Fields:

- **repairDate** - When repair was done
- **returnDate** - When item returned from repair
- **status** - PENDING, IN\_REPAIR, COMPLETED, CANCELLED
- **damageDescription** - What's broken
- **notes** - Repair notes

### Current Issues:

1. **OneToOne Limitation:** Can't track multiple repairs per item
2. **No Status:** Don't know if repair is pending or done
3. **No Dates:** Can't track repair duration

### Recommended Schema Update:

```

@ManyToOne // Change from OneToOne!
private Item item;

@Column
private String status; // PENDING, IN_PROGRESS, COMPLETED

@Column
private LocalDate repairDate;

```

```

@Column
private LocalDate returnDate;

@Column(length = 500)
private String damageDescription;

```

## Evolution History:

1. **Initial:** Basic repair with cost
  2. **v1.1:** Added relationship to Item and Vendor
  3. **v1.2:** Added item price for comparison
  4. **Future:** Need to change OneToOne → ManyToOne
- 

## 9 DashboardSnapshot (Analytics Entity)

**Table Name:** dashboard\_snapshot

**Purpose:** Time-series data for dashboard charts and analytics

### Schema:

```

@Entity
@Table(name = "dashboard_snapshot")
public class DashboardSnapshot {
    @Id @GeneratedValue
    private Long id; // Primary Key

    @Column
    private LocalDateTime timestamp; // When snapshot was taken

    @Column
    private long itemsBorrowed; // Cumulative loans

    @Column
    private long itemsReturned; // Cumulative returns

    @Column
    private int inventoryRemaining; // Current stock level

    @Column
    private long itemsIssued; // Count of issued items

    @Column
    private String eventType; // Event trigger
}

```

### Design Rationale:

## Why snapshot vs. calculated?

- **Performance:** Pre-calculated data loads faster
- **Historical Tracking:** Preserve state at specific times
- **Trend Analysis:** Compare today vs. last week
- **Dashboard Speed:** No complex joins/calculations on page load

## When snapshots are created:

- **Event-Driven:** On item issue, return, add
- **Scheduled:** Daily midnight snapshot
- **On-Demand:** Admin triggers manual snapshot

## Why eventType?

```

"ITEM_ADDED"      - New item added to inventory
"ITEM_ISSUED"     - Item loaned out
"ITEM_RETURNED"   - Item returned
"DAILY_SNAPSHOT"  - Scheduled snapshot

```

## Use Cases:

1. **Dashboard Charts:** Plot items borrowed over time
2. **Trend Analysis:** Busiest days, peak usage
3. **Capacity Planning:** Predict inventory needs
4. **Reporting:** Monthly/yearly summaries

## Data Retention:

- Keep daily snapshots: 90 days
- Keep weekly summaries: 1 year
- Keep monthly summaries: Forever

## Query Example:

```

-- Last 7 days trend
SELECT DATE(timestamp), itemsBorrowed, itemsReturned
FROM dashboard_snapshot
WHERE timestamp >= NOW() - INTERVAL 7 DAY
    AND eventType = 'DAILY_SNAPSHOT'
ORDER BY timestamp;

```

## Evolution History:

1. **Initial:** Real-time calculations (slow)
2. **v1.5:** Added snapshot table for performance
3. **v1.6:** Added event-driven snapshots
4. **v1.7:** Added scheduled daily snapshots

## 10 InventoryManager (Legacy Entity) ⚠

**Table Name:** `Inventory_Manager`

**Purpose:** Old authentication system (replaced by User-Role)

**Status:** ⚠ DEPRECATED - DO NOT USE

**Schema:**

```
@Entity
@Table(name = "Inventory_Manager")
public class InventoryManager {
    @Id @GeneratedValue
    private long id;

    private String name;
    private String email;
    private String password;           // ⚠ Not hashed!

    @OneToOne(cascade = ALL)
    private ManagerType managerType;   // Basic/Advanced
}
```

### Why Deprecated:

#### 1. Security Issues:

- Password not hashed (stored plain text!)
- No proper password validation
- No session management

#### 2. Limited Functionality:

- Only 2 types: Basic/Advanced
- No fine-grained permissions
- Can't assign multiple roles

#### 3. Not Industry Standard:

- Custom auth vs. Spring Security
- Missing important features (remember-me, password reset)

### Migration Path:

- All `InventoryManager` → `User` (with appropriate Role)
- Data migration script available
- Old tables kept for backward compatibility (temporarily)

### Do NOT:

- ✗ Create new InventoryManager records
- ✗ Update existing InventoryManager
- ✗ Reference in new code

### Use Instead:

- ☑ User entity
- ☑ Role-based access control
- ☑ Spring Security

### Removal Plan:

1. **Phase 1:** All active managers migrated to User (DONE ☑)
  2. **Phase 2:** Code references removed (IN PROGRESS 🚧)
  3. **Phase 3:** Drop tables (FUTURE - after 6 months)
- 

## 1|1 ManagerType (Legacy Entity) ⚠

**Table Name:** manager\_type

**Purpose:** Old manager categorization (replaced by Role)

**Status:** ⚠ DEPRECATED - DO NOT USE

### Schema:

```
@Entity
@Table(name = "manager_type")
public class ManagerType {
    @Id @GeneratedValue
    private long id;

    private String typeName;           // "Basic", "Advanced"
}
```

### Why Deprecated:

#### 1. Too Simplistic:

- Only Basic/Advanced
- No granular permissions

#### 2. Replaced by Role:

- 4 roles instead of 2 types
- Spring Security integration
- Industry-standard RBAC

### Migration:

- Basic → ROLE\_STAFF or ROLE\_USER
- Advanced → ROLE\_MANAGER or ROLE\_ADMIN

**Removal Plan:** Same as InventoryManager

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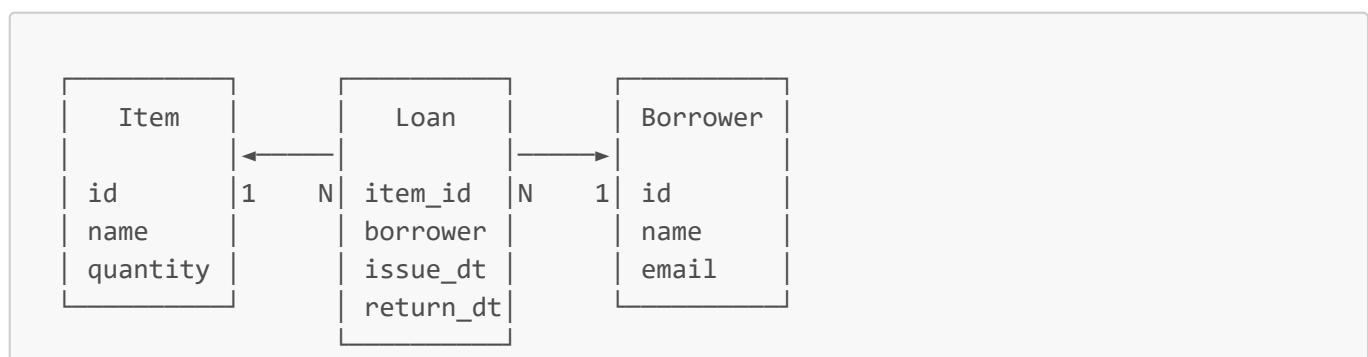
## 🔗 Relationship Mapping

### Relationship Summary Table:

From	To	Type	Cardinality	Foreign Key	Description
Item	ItemType	OneToOne	Many:1	item_type_fk	Each item has one type
Item	Vendor	OneToOne	Many:1	vendor_id_fk	Each item from one vendor
Item	Loan	OneToMany	1:Many	item_id	One item, many loans
Borrower	Loan	OneToMany	1:Many	borrower_id	One borrower, many loans
Loan	Item	ManyToOne	Many:1	(implicit)	Many loans for one item
Loan	Borrower	ManyToOne	Many:1	(implicit)	Many loans by one borrower
User	Role	ManyToMany	Many:Many	user_roles join	Users have multiple roles
ItemRepair	Item	OneToOne	1:1	item_id_fk	⚠ Should be ManyToOne
ItemRepair	Vendor	OneToOne	Many:1	vendor_id_fk	Repair vendor
InventoryManager	ManagerType	OneToOne	Many:1	manager_type_fk	⚠ Legacy

### Key Relationships Explained:

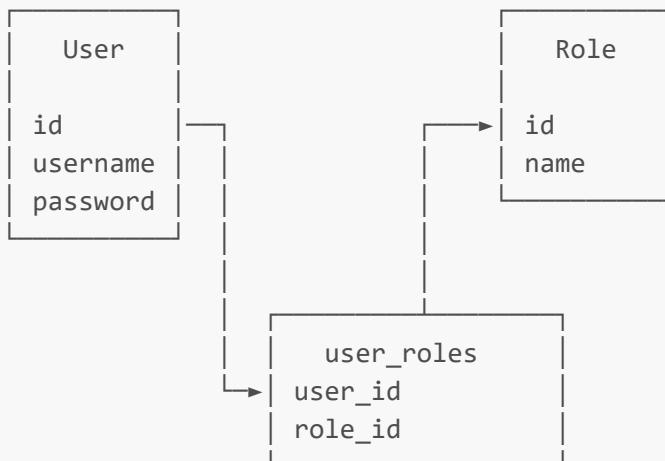
#### Item ↔ Loan ↔ Borrower (Core Workflow)



## How it works:

1. Item has quantity = 10
2. Staff issues item to Borrower → Creates Loan record
3. Item.quantity decreases to 9
4. Loan stores: which item, which borrower, when
5. Borrower returns item → Loan.returnDate set
6. Item.quantity increases to 10
7. If late: Loan calculates fine

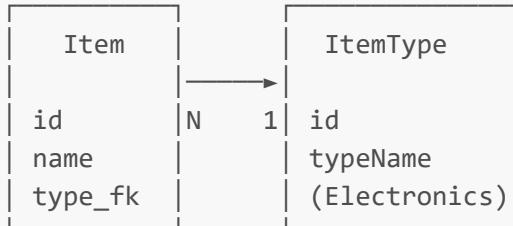
## User ↔ Role (Authentication)



## How it works:

1. User created with username/password
2. Admin assigns roles: User → [ROLE\_STAFF, ROLE\_USER]
3. user\_roles join table stores relationships
4. On login: Spring Security loads user + roles
5. Authorization: Check if user has required role

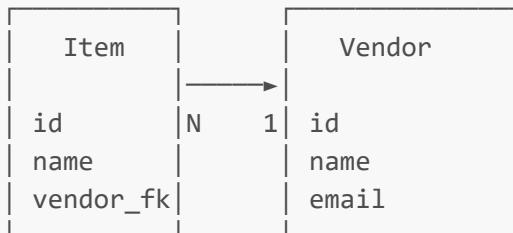
## Item → ItemType (Classification)



## Why OneToOne appears but acts like ManyToOne:

- Code says `@OneToOne` but behavior is ManyToOne
- Many items can have same ItemType
- Legacy modeling decision

### Item → Vendor (Supply Chain)



### Tracks:

- Which vendor supplied the item
- Invoice number for procurement
- Useful for: Reordering, warranty claims, vendor analysis

## 📐 PlantUML ER Diagram

### Complete Database Schema:

```

@startuml FlowTrack_ER_Diagram

!define TABLE(name) entity name << (T,#FFAAAA) >>
!define PRIMARY_KEY(x) <u>x</u>
!define FOREIGN_KEY(x) <i>x</i>

' Core Entities
TABLE(Item) {
    PRIMARY_KEY(item_id) : BIGINT
    --
    item_name : VARCHAR(255)
    item_quantity : INT
    item_price : DOUBLE
    item_fine_rate : DOUBLE
    item_invoice_number : BIGINT
    FOREIGN_KEY(item_type_fk) : BIGINT
    FOREIGN_KEY(vendor_id_fk) : BIGINT
}

TABLE(Borrower) {
    PRIMARY_KEY(borrower_id) : BIGINT
    --
    first_name : VARCHAR(255)
    last_name : VARCHAR(255)
}
  
```

```
email : VARCHAR(255)
}

TABLE(Loan) {
    PRIMARY_KEY(loan_id) : BIGINT
    --
    issue_date : VARCHAR(50)
    return_date : VARCHAR(50)
    loan_duration : BIGINT
    total_fine : DOUBLE
    FOREIGN_KEY(item_id) : BIGINT
    FOREIGN_KEY(borrower_id) : BIGINT
}

' Classification
TABLE(ItemType) {
    PRIMARY_KEY(item_type_id) : BIGINT
    --
    type_name : VARCHAR(255)
}

' Supply Chain
TABLE(Vendor) {
    PRIMARY_KEY(vendor_id) : BIGINT
    --
    vendor_name : VARCHAR(255)
    vendor_email : VARCHAR(255)
}

TABLE(ItemRepair) {
    PRIMARY_KEY(repair_id) : BIGINT
    --
    repair_cost : DOUBLE
    item_price : DOUBLE
    FOREIGN_KEY(item_id_fk) : BIGINT
    FOREIGN_KEY(vendor_id_fk) : BIGINT
}

' Authentication & Authorization
TABLE(User) {
    PRIMARY_KEY(id) : BIGINT
    --
    username : VARCHAR(255) UNIQUE
    email : VARCHAR(255) UNIQUE
    password : VARCHAR(255)
    first_name : VARCHAR(255)
    last_name : VARCHAR(255)
    enabled : BOOLEAN
}

TABLE(Role) {
    PRIMARY_KEY(id) : BIGINT
    --
    name : VARCHAR(50) UNIQUE
```

```
}

TABLE(user_roles) {
    FOREIGN_KEY(user_id) : BIGINT
    FOREIGN_KEY(role_id) : BIGINT
    --
    PRIMARY_KEY(user_id, role_id)
}

' Analytics
TABLE(DashboardSnapshot) {
    PRIMARY_KEY(id) : BIGINT
    --
    timestamp : DATETIME
    items_borrowed : BIGINT
    items_returned : BIGINT
    inventory_remaining : INT
    items_issued : BIGINT
    event_type : VARCHAR(50)
}

' Legacy (Deprecated)
TABLE(InventoryManager) {
    PRIMARY_KEY(manager_id) : BIGINT
    --
    manager_name : VARCHAR(255)
    manager_email : VARCHAR(255)
    manager_password : VARCHAR(255)
    FOREIGN_KEY(manager_type_fk) : BIGINT
    ..
    <<DEPRECATED>>
}

TABLE(ManagerType) {
    PRIMARY_KEY(manager_type_id) : BIGINT
    --
    manager_type_name : VARCHAR(255)
    ..
    <<DEPRECATED>>
}

' Relationships - Core Workflow
Item ||--o{ Loan : "has many loans"
Borrower ||--o{ Loan : "has many loans"
Item }o--|| ItemType : "has one type"
Item }o--|| Vendor : "supplied by"

' Relationships - Repair
ItemRepair }o--|| Item : "repairs"
ItemRepair }o--|| Vendor : "repair vendor"

' Relationships - Auth
User }o--o{ Role : "has roles"
(User, Role) .. user_roles
```

```

' Relationships - Legacy
InventoryManager }o--|| ManagerType : "has type"

' Notes
note right of Item
  **Core Entity**
  Tracks available inventory.
  Quantity decreases on issue,
  increases on return.
end note

note right of Loan
  **Transaction Entity**
  Records borrowing activity.
  returnDate NULL = still borrowed
  Calculates fines automatically.
end note

note right of User
  **Authentication**
  Replaced InventoryManager.
  Uses Spring Security.
  Password hashed with BCrypt.
end note

note right of DashboardSnapshot
  **Analytics**
  Time-series data for charts.
  Event-driven + scheduled.
end note

note right of InventoryManager
  **⚠ DEPRECATED**
  Use User entity instead.
  Will be removed in future.
end note

@enduml

```

---

## Visual ER Diagram (Alternative - Simpler)

```

@startuml FlowTrack_ER_Simple

skinparam linetype ortho
skinparam roundcorner 10

' Core Tables
entity "Item\n(Inventory_item)" as Item {
  * item_id : BIGINT <<PK>>

```

```
--  
* item_name : VARCHAR  
* item_quantity : INT  
* item_price : DOUBLE  
* item_fine_rate : DOUBLE  
invoice_number : BIGINT  
item_type_fk : BIGINT <<FK>>  
vendor_id_fk : BIGINT <<FK>>  
}  
  
entity "Borrower" as Borrower {  
* borrower_id : BIGINT <<PK>>  
--  
* first_name : VARCHAR  
* last_name : VARCHAR  
* email : VARCHAR  
}  
  
entity "Loan" as Loan {  
* loan_id : BIGINT <<PK>>  
--  
* issue_date : VARCHAR  
return_date : VARCHAR  
* loan_duration : BIGINT  
total_fine : DOUBLE  
* item_id : BIGINT <<FK>>  
* borrower_id : BIGINT <<FK>>  
}  
  
entity "ItemType\n(item_type)" as ItemType {  
* item_type_id : BIGINT <<PK>>  
--  
* type_name : VARCHAR  
}  
  
entity "Vendor" as Vendor {  
* vendor_id : BIGINT <<PK>>  
--  
* vendor_name : VARCHAR  
* vendor_email : VARCHAR  
}  
  
entity "ItemRepair\n(item_repair)" as ItemRepair {  
* repair_id : BIGINT <<PK>>  
--  
* repair_cost : DOUBLE  
* item_price : DOUBLE  
* item_id_fk : BIGINT <<FK>>  
* vendor_id_fk : BIGINT <<FK>>  
}  
  
entity "User\n(users)" as User {  
* id : BIGINT <<PK>>  
--
```

```

* username : VARCHAR <<UK>>
* email : VARCHAR <<UK>>
* password : VARCHAR
first_name : VARCHAR
last_name : VARCHAR
* enabled : BOOLEAN
}

entity "Role\n(roles)" as Role {
* id : BIGINT <<PK>>
--
* name : VARCHAR <<UK>>
}

entity "user_roles" as UserRoles {
* user_id : BIGINT <<PK,FK>>
* role_id : BIGINT <<PK,FK>>
}

entity "DashboardSnapshot\n(dashboard_snapshot)" as Dashboard {
* id : BIGINT <<PK>>
--
* timestamp : DATETIME
items_borrowed : BIGINT
items_returned : BIGINT
inventory_remaining : INT
event_type : VARCHAR
}

' Relationships
Item ||--o{ Loan : "1:N"
Borrower ||--o{ Loan : "1:N"
Item }o--|| ItemType : "N:1"
Item }o--|| Vendor : "N:1"
ItemRepair }o--|| Item : "N:1"
ItemRepair }o--|| Vendor : "N:1"

User ||--o{ UserRoles : "1:N"
Role ||--o{ UserRoles : "1:N"

@enduml

```

## ⌚ Relationship Cardinality Explained

Relationship	Read As	Cardinality	Example
Item → ItemType	Each item has one type	Many-to-One	100 laptops → 1 "Electronics" type
Item → Vendor	Each item from one vendor	Many-to-One	50 items → 1 "Office Supplies Co"

Relationship	Read As	Cardinality	Example
Item → Loan	One item can have many loans	One-to-Many	1 laptop → 25 loans (over time)
Borrower → Loan	One borrower can have many loans	One-to-Many	1 student → 5 loans (active + history)
Loan → Item	Each loan for one item	Many-to-One	100 loans → 1 specific laptop
Loan → Borrower	Each loan by one borrower	Many-to-One	50 loans → 1 student (over time)
User ↔ Role	Users have multiple roles, roles assigned to many users	Many-to-Many	admin user → [ADMIN, MANAGER] roles
ItemRepair → Item	Each repair record for one item	OneToOne (should be ManyToOne)	1 repair → 1 laptop
ItemRepair → Vendor	Each repair by one vendor	Many-to-One	10 repairs → 1 "Tech Repair Shop"

## 🔧 Schema Design Issues & Recommendations

### Issue 1: Date Storage as String ⚠️

**Current:**

```
@Column
private String issueDate; // "2026-02-06"
```

**Problem:**

- No database-level validation
- Harder to query (date ranges, sorting)
- String comparison vs. date comparison
- Time zone issues

**Recommendation:**

```
@Column
private LocalDate issueDate; // Proper Java 8 Date

// For timestamps
@Column
private LocalDateTime createdAt;
```

## Migration Script:

```
ALTER TABLE Loan
    MODIFY COLUMN issue_date DATE;

UPDATE Loan
    SET issue_date = STR_TO_DATE(issue_date, '%Y-%m-%d');
```

---

## Issue 2: ItemRepair OneToOne Relationship ⚠

### Current:

```
@OneToOne
private Item item; // Can only track one repair per item!
```

### Problem:

- Can't track multiple repairs for same item
- Historical data lost
- Need repair history for analytics

### Recommendation:

```
@ManyToOne // Many repairs for one item
private Item item;
```

### Impact:

- No data loss (existing repairs preserved)
- Can now add multiple repairs per item
- Better repair history tracking

---

## Issue 3: Item-ItemType Relationship Confusion ⚠

### Current:

```
@OneToOne // Misleading annotation
private ItemType itemType;
```

### Reality:

- Multiple items share one ItemType

- Behaves like ManyToOne

**Recommendation:**

```
@ManyToOne(fetch = LAZY)
@JoinColumn(name = "item_type_fk")
private ItemType itemType;
```

---

**Issue 4: Missing Timestamps** **Current:**

- No `createdAt`, `updatedAt` fields

**Problem:**

- Can't audit when records created/modified
- Can't track data history
- Hard to debug issues

**Recommendation:** Add to all entities:

```
@Column(updatable = false)
@CreationTimestamp
private LocalDateTime createdAt;

@Column
@UpdateTimestamp
private LocalDateTime updatedAt;
```

---

**Issue 5: No Soft Delete Support** **Current:**

- Hard delete only (data lost permanently)

**Problem:**

- Can't restore accidentally deleted records
- Audit trail broken
- Relationships break

**Recommendation:** Add to all entities:

```
@Column
private boolean deleted = false;
```

```
@Column
private LocalDateTime deletedAt;
```

Then use:

```
@Where(clause = "deleted = false") // JPA filter
```

## Issue 6: Missing Indexes

### Current:

- Only primary keys indexed

### Problem:

- Slow queries on frequently searched fields
- Poor performance on large datasets

### Recommendation:

```
@Table(name = "Borrower", indexes = {
    @Index(name = "idx_borrower_email", columnList = "email"),
    @Index(name = "idx_borrower_name", columnList = "first_name, last_name")
})

@Table(name = "Loan", indexes = {
    @Index(name = "idx_loan_dates", columnList = "issue_date, return_date"),
    @Index(name = "idx_loan_borrower", columnList = "borrower_id"),
    @Index(name = "idx_loan_item", columnList = "item_id")
})

@Table(name = "Item", indexes = {
    @Index(name = "idx_item_name", columnList = "item_name"),
    @Index(name = "idx_item_type", columnList = "item_type_fk")
})
```

## Future Schema Enhancements

### Phase 1: Payment Gateway

```
@Entity
public class Payment {
    @Id @GeneratedValue
    private Long id;
```

```
@ManyToOne  
private Loan loan; // Which loan's fine  
  
private BigDecimal amount;  
private String transactionId;  
private String paymentMethod; // CARD, UPI, WALLET  
private String status; // PENDING, SUCCESS, FAILED  
private LocalDateTime paymentDate;  
}
```

## Phase 2: Notifications

```
@Entity  
public class Notification {  
    @Id @GeneratedValue  
    private Long id;  
  
    @ManyToOne  
    private User user;  
  
    private String type; // LOAN_DUE, FINE_CHARGED, ITEM_RETURNED  
    private String message;  
    private boolean read;  
    private LocalDateTime createdAt;  
}
```

## Phase 3: Reservations

```
@Entity  
public class Reservation {  
    @Id @GeneratedValue  
    private Long id;  
  
    @ManyToOne  
    private Item item;  
  
    @ManyToOne  
    private Borrower borrower;  
  
    private LocalDate startDate;  
    private LocalDate endDate;  
    private String status; // PENDING, CONFIRMED, CANCELLED  
}
```

## Phase 4: Audit Trail

```
@Entity
public class AuditLog {
    @Id @GeneratedValue
    private Long id;

    @ManyToOne
    private User user; // Who made the change

    private String entityType; // Item, Loan, User, etc.
    private Long entityId;
    private String action; // CREATE, UPDATE, DELETE
    private String oldValue;
    private String newValue;
    private LocalDateTime timestamp;
}
```

## Schema Evolution History

### Version 1.0 (Initial - Academic Project)

- Core entities: Item, Borrower, Loan
- Simple authentication: InventoryManager
- Basic fields only

### Version 1.1 (Feature Additions)

- Added: Vendor, ItemType
- Enhanced Item with price, invoice, fine rate
- Added fine calculation

### Version 1.2 (Repair Tracking)

- Added: ItemRepair
- Linked repairs to vendors

### Version 1.3 (Advanced Fines)

- Added precedence-based fines
- ItemType drives fine calculation

### Version 2.0 (Spring Security Migration)

- **Major Refactor:** InventoryManager → User + Role
- Implemented proper RBAC
- Password hashing with BCrypt
- ManyToMany user-role relationship

### Version 2.1 (Analytics)

- Added: DashboardSnapshot
- Time-series data collection
- Event-driven snapshots

## Version 2.2 (Current - Production Ready)

- All core features stable
- Ready for Phase 2 enhancements
- Documentation complete

## Version 3.0 (Planned - Payment Gateway)

- Add: Payment entity
- Integrate Stripe/Razorpay
- Online fine payment

## Version 3.1 (Planned - Notifications)

- Add: Notification entity
- Email/SMS integration
- In-app notifications

## Version 4.0 (Planned - Advanced Features)

- Add: Reservation entity
  - Waiting list functionality
  - Item bundles/kits
- 

### Best Practices Applied

#### Normalization:

- No redundant data
- Separate tables for distinct entities
- Proper foreign key relationships

#### Naming Conventions:

- Clear, descriptive names
- Consistent prefixes (`item_`, `borrower_`)
- Following JPA conventions

#### Lazy Loading:

- Relationships marked `LAZY` by default
- Avoids N+1 query problems
- Load related entities only when needed

#### Bidirectional Relationships:

- Helper methods (`addLoan`, `removeLoan`)
- Maintains consistency automatically

## Business Logic in Models:

- `calculateFine()` in Loan
  - `totalFine()` in Borrower
  - `decreaseQuantity()` in Item
- 

## Summary

**Total Entities:** 11 (9 active, 2 deprecated)

### Core Business:

- **Item** - What can be borrowed
- **Borrower** - Who borrows
- **Loan** - The transaction

### Supporting:

- **ItemType** - Categorization
- **Vendor** - Supply chain
- **ItemRepair** - Maintenance
- **DashboardSnapshot** - Analytics

### Authentication:

- **User** - System users (staff)
- **Role** - Access control

### Legacy:

- **InventoryManager** - Old auth
- **ManagerType** - Old roles

**Total Tables:** 12 (11 entities + 1 join table `user_roles`)

**Lines of Code:** ~1,500 lines across all models

**Design Quality:** ★ ★ ★ ★ (4/5)

- Well-structured for MVP
  - Some optimization needed
  - Ready for production with Phase 2 enhancements
- 

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**Author:** Database Architecture Team

**Version:** 2.2

**Status:** Complete