Library Database ER Model Requirements

Introduction

Project Overview

The Library Management System (LMS) is designed to manage a small library's diverse collection of loanable items—including books, digital media, and magazines. The system supports key functions such as tracking loans and returns, managing multiple membership types (each with distinct borrowing limits and fee structures), processing reservations, and generating detailed reports to assist with decisions. The system is intended for both library staff and patrons, aiming to streamline daily operations and improve the overall user experience.

Scope

This project covers the complete data modeling for the library system. It includes the creation of a conceptual ER model that captures:

- **Data Entities:** Items (Books, Digital Media, Magazines), Clients, Membership Types, Loan Transactions, and Reservations.
- **Relationships:** How clients interact with items (borrow, return, reserve) and how membership types govern borrowing privileges.
- **Constraints:** Business rules such as borrowing limits, late fee calculations, and item availability status.
- **Feedback:** Additionally, the scope includes data entry, updates, deletions, and report generation functions.
- **Excluded:** Integration with external systems and advanced analytics is excluded in this phase.

Glossary

- **ERD:** Entity-Relationship Diagram, a visual representation of entities and their relationships.
- **Entity:** A real-world object or concept (e.g., Book, Client).
- **Attribute:** A property or characteristic of an entity (e.g., ISBN, Title).
- **PK:** Primary Key, a unique identifier for an entity.
- **FK:** Foreign Key, an attribute that links one entity to another.

- **Cardinality:** The numerical relationships between entities (e.g., one-to-many, many-to-many).
- **Supertype/Subtype:** A modeling technique where common attributes are grouped in a supertype (e.g., “Item”) and specialized entities (Book, DigitalMedia, Magazine) inherit those attributes.

ER Model Components

Entities

The major entities include:

- **Client:** Represents library patrons.
- **Membership:** Defines membership types with associated borrowing limits and fee structures.
- **Book:** Represents loanable printed books.
- **DigitalMedia:** Represents loanable digital items (e.g., e-books, DVDs).
- **Magazine:** Represents periodicals.
- **LoanTransaction:** Records each borrowing event (including dates, due dates, and fines).
- **Reservation:** Tracks client reservations for items that are currently on loan.

Note: Although it is possible to use an abstract “Item” supertype for Books, DigitalMedia, and Magazines, this model currently treats them as separate entities for clarity.

Attributes

Client

- **ClientID:** INT, PK, Auto-Increment
- **Name:** VARCHAR (Not Null)
- **MembershipType:** VARCHAR (FK referencing Membership)
- **ContactInfo:**
    - **PhoneNumber**: VARCHAR
    - **Email**: VARCHAR
- **AccountStatus:** ENUM('active', 'suspended', 'closed')

Membership

- **MembershipType:** VARCHAR, PK
- **Description:** VARCHAR
- **BorrowingLimit:** INT (Not Null)

- **FeeStructure:** DECIMAL (Not Null)

Book

- **BookID:** INT, PK, Auto-Increment
- **ISBN:** VARCHAR
- **Title:** VARCHAR (Not Null)
- **Author:** VARCHAR (Not Null)
- **PublicationYear:** YEAR
- **Genre:** VARCHAR
- **AvailabilityStatus:** ENUM('available', 'borrowed', 'reserved')

DigitalMedia

- **MediaID:** INT, PK, Auto-Increment
- **Title:** VARCHAR (Not Null)
- **Creator:** VARCHAR
- **PublicationYear:** YEAR
- **Format:** ENUM('DVD', 'Blu-ray', 'Digital')
- **AvailabilityStatus:** ENUM('available', 'borrowed', 'reserved')

Magazine

- **MagazineID:** INT, PK, Auto-Increment
- **Title:** VARCHAR (Not Null)
- **IssueNumber:** INT (Not Null)
- **PublicationDate:** DATE (Not Null)
- **AvailabilityStatus:** ENUM('available', 'borrowed', 'reserved')

LoanTransaction

- **TransactionID:** INT, PK, Auto-Increment
- **ClientID:** INT, FK referencing Client
- **ItemID:** VARCHAR or INT (depending on the item type)
- **ItemType:** ENUM('Book', 'DigitalMedia', 'Magazine')
- **BorrowDate:** DATE (Not Null)
- **DueDate:** DATE (Not Null)
- **ReturnDate:** DATE (Nullable)
- **CalculatedFine:** DECIMAL, Default 0, with CHECK (CalculatedFine >= 0)

Reservation

- **ReservationID:** INT, PK, Auto-Increment
- **ClientID:** INT, FK referencing Client
- **ItemID:** VARCHAR or INT (matching the referenced item)
- **ItemType:** ENUM('Book', 'DigitalMedia', 'Magazine')

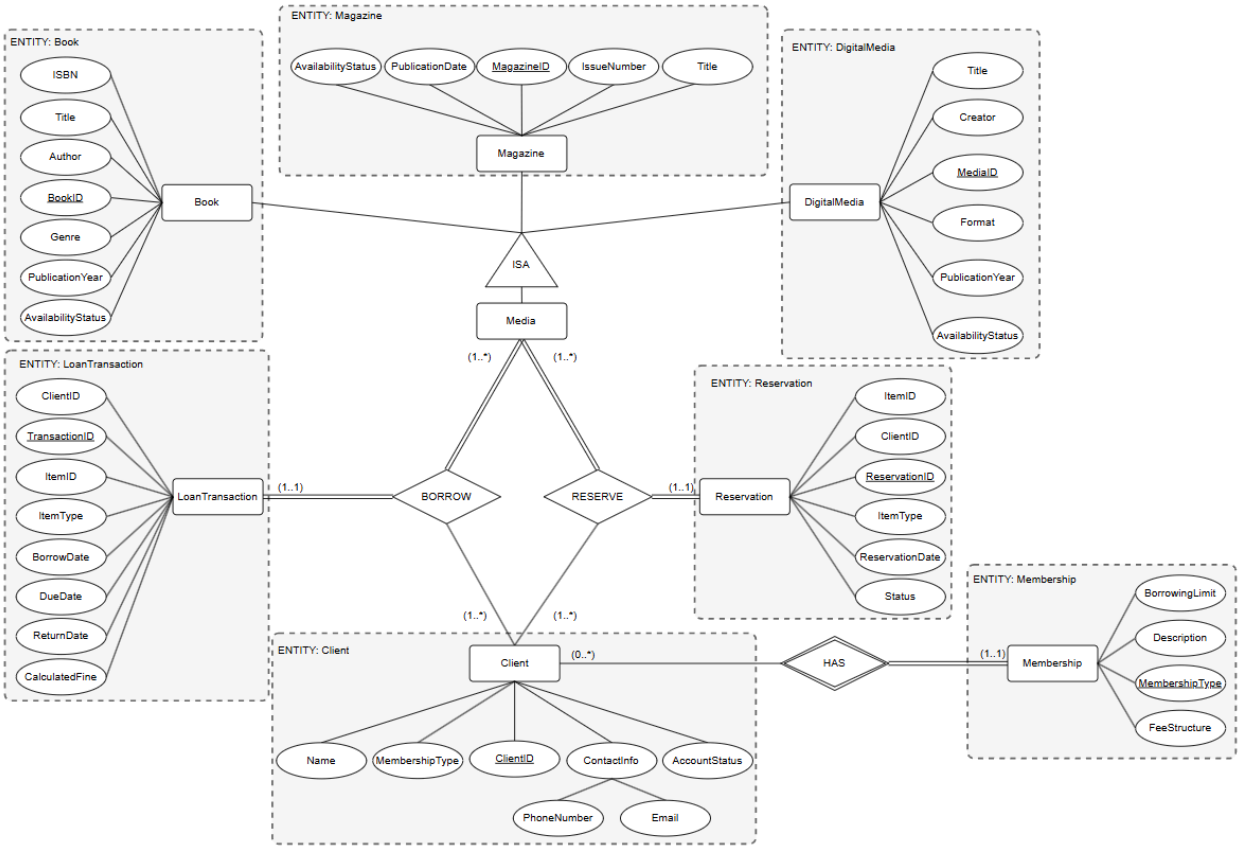
- **ReservationDate:** DATE (Not Null)
- **Status:** ENUM('active', 'cancelled', 'fulfilled')

Relationships

The key relationships and their cardinalities are as follows:

- **Client to LoanTransaction (BORROW):**
    - One-to-Many: A single client can have many loans.
    - Client (1..1) — (1..*) LoanTransaction
- **Client to Reservation (RESERVE):**
    - One-to-Many: A client can make multiple reservations.
    - Client (1..1) — (1..*) Reservation
- **Membership to Client (HAS):**
    - One-to-Many: Each membership type applies to many clients.
    - Membership (1..1) — (0..*) Client
- **Item (Book/DigitalMedia/Magazine) to LoanTransaction (BORROW):**
    - One-to-Many: Each item can be involved in multiple loan transactions over time.
    - For example, Book (1..1) — (1..*) LoanTransaction
    - Note: The relationship is indicated by the composite of ItemID and ItemType in LoanTransaction.
- **Item (Book/DigitalMedia/Magazine) to Reservation (RESERVE):**
    - One-to-Many: Each item may have multiple reservations.
    - For example, DigitalMedia (1..1) — (1..*) Reservation

ER Diagram



Appendices

Appendix: Design Choices and Assumptions

- **Item Modeling:**
  Books, DigitalMedia, and Magazines have been modeled as separate entities to capture their unique attributes. Alternatively, we could create an abstract “Item” supertype with subtypes to unify the common attributes.

- **LoanTransaction and Reservation Linking:**
  Both LoanTransaction and Reservation use a composite reference (ItemID and ItemType) to indicate which item is involved. This supports multiple item types without the need for separate transaction tables.

- **Business Rules:**

    - Clients cannot exceed their borrowing limits as defined by their Membership.

- Late fees are automatically calculated in LoanTransaction based on the difference between DueDate and ReturnDate.
- Only items with an AvailabilityStatus of 'available' may be loaned or reserved.