# The Logical Relational Model

The DataBasers™

# 1. Introduction

## 1.1 Project Overview

The objective of this project is to design and implement a relational database to be used by the staff and clientele of a small public library. It is meant to aid the daily needs of both library staff and clients, providing clients with a convenient source of information on the library's collection and staff with the means to record and track media loans, borrowing trends, and more.

## 1.2 Scope (Project Boundaries)

This project will include a Project Plan, which summarizes the project objectives and team organization; a Database Requirements document, which indicates the project requirements and preliminary design components; a Conceptual Modeling document, which details the complete conceptual design of the database, including an ER diagram; a Logical Relational Model document, which details the relational schema of the database; and a SQL-based Physical Database Design, which will be represented in a document displaying the process, testing, and results of the database implementation. The project will culminate in a full demonstration of the capabilities of the finished database.

## 1.3 Glossary

***Database:*** A highly structured and organized digital collection of data.
***DBMS:*** Short for Database Management System, a software that is used to store and manage data through the use of databases.
***DCL:*** Short for Data Control Language, a computer language used to manage privilege and access to users with respect to a database.
***DDL:*** Short for Data Definition Language, a computer language used to create and modify a database system
***DML:*** Short for Data Manipulation Language, a computer language used to add, delete, and manipulate data in a database.
***Domain:*** The type of data used to represent an attribute of a relation.
***ENUM:*** A data type that works as a list of constants, often strings of characters.
***ER Model:*** Short for Entity-Relationship model, which is used to create and model the conceptual design of a database system, highlighting key data entities, their attributes, and relationships with other entities.
***Foreign Key:*** An attribute of a relation that serves as the primary key for another relation.
***Functional Dependency:*** A relationship between two attributes in the same relation.
***INT:*** Short for integer, a whole number.
***ISBN:*** Short for International Standard Book Number, a unique identifier for virtually all books.
***ISSN:*** Short for International Standard Serial Number, a unique identifier for publication issues.

***Primary Key:*** An attribute or set of attributes used to distinguish one tuple in a relation from another.
***Query:*** A request prepared by a user of a database to a database system. The DBMS interprets the query and prepares and returns the results of the query.
***Relation:*** Within the context of a database, a relation is a set of tuples of a similar form. All tuples in the relation have the same set of attributes but may have differing values for each individual attribute.
***Relational Schema:*** Describes the logical layout of the database, defining the tables of the database, their columns, and the data types of each column.
***SQL:*** Short for Structured Query Language, a computer language that includes DDL and DML elements. It is used for creating, modifying, and using a database.
***Tuple:*** An object that holds multiple items. In the context of a database, a tuple could be considered a row in a table.
***VARCHAR:*** A string of text characters of varying length. Also known simply as a string.

# 2. Relational Schema Mapping

## 2.1 Relations

Each relation appears in the Relational Schema Diagram in Section 2.5 as a sequence of horizontally connected rectangles. The name of the relation is presented above the leftmost rectangle in bold. All entities represented in the ER Model from the Conceptual Modeling document are directly translated to identically named relations. The relationships shown in the ER Model are also translated into relations. However, many of them are given new names for clarity. A summary of these changes is included below:

***Makes(Member-to-Reservation):*** Reserves.
***Makes(Member-to-Payment)***: Pays.
***For(Reservation-to-Media):*** Reserved-In.
***For(Payment-to-Fine):*** Pays-For.
***Is Loaned In(Media-to-Loan)***: Loaned-In.
***Is Triggered By(Fine-to-Loan)***: Triggers.

## 2.2 Attributes and Domains

The attributes of each relation are presented in the Relational Schema Diagram in Section 2.5 as entries inside each of the rectangles used to compose the corresponding relation's representation. Descriptions and domains for each relation are presented in the Data Dictionary in Section 2.2.

## 2.3 Primary Keys

The primary key for each relation shown in the Relational Schema Diagram in Section 2.5 is underlined.

## 2.4 Foreign Keys

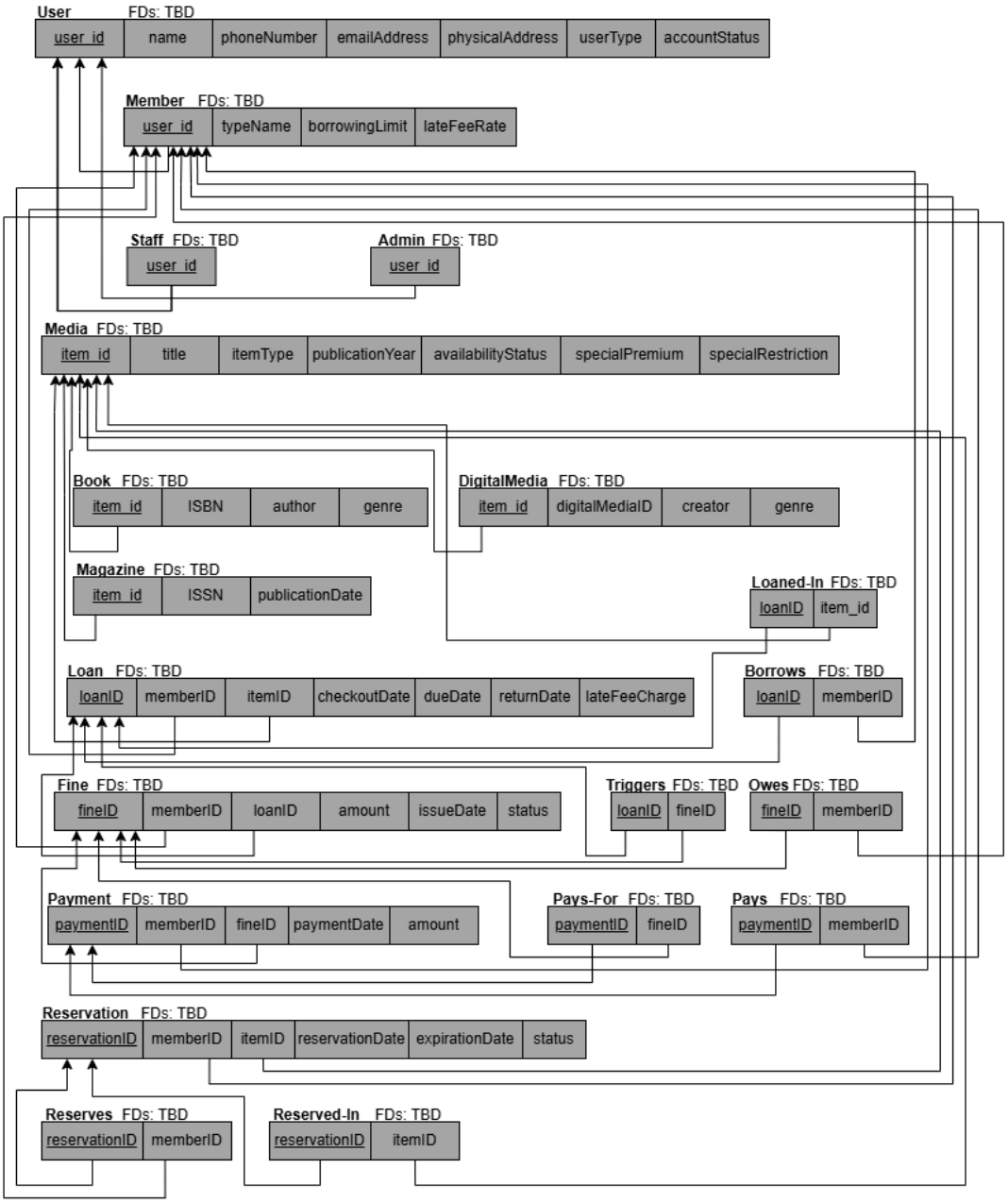
In the Relational Schema Diagram in Section 2.5, any foreign keys that may appear as attributes of a given relation are noted using arrows that point from the attribute in the referencing relation to the referenced key of another relation.

## 2.5 Functional Dependencies

The functional dependencies for each relation will be determined at a later date.

## 2.6 Relational Schema Diagram

A Relational Schema Diagram for the database is included below:



# 3. Schema Documentation

## 3.1 Data Dictionary

| Attribute Name | Data Type | Description |
|---|---|---|
| **User** | | General entity representing all users. |
| userID | INT (≥0) (Primary Key) | Unique identifier for a user. |
| name | VARCHAR | User's name. |
| phoneNumber | VARCHAR | A valid phone number for the user. A valid format would be "[THREE DIGITS]-[THREE DIGITS]-[FOUR DIGITS]" |
| emailAddress | VARCHAR | A valid email address for the user. A valid format would be "[username]@[email-provider]". |
| physicalAddress | VARCHAR | A valid mailing address for the user. A valid format would be "[number] [street], [city], [state initial] [ZIP code]". |
| userType | ENUM ("admin", "staff", "member") | A string representing the specific type of the user. |
| accountStatus | ENUM ("active", "inactive") | Status of user account. |
| **Member** | | A client of the library. |
| typeName | ENUM ("regular", "student", "senior") | Membership type. |
| borrowingLimit | INT (>0) | A policy defined limit on how many items a member can have loaned to them at any given time. |
| lateFeeRate | DECIMAL (>0) | A dollar amount applied to their late fee charge for every day past the due date an item is not returned. |

| Attribute Name | Data Type | Description |
|---|---|---|
| **Staff** | | Specialization of Users with more privileges than Members. No additional attributes. |
| **Administrator** | | Privileged User. No additional attributes. |
| **Media** | | Represents all media items, including copies, in the library. |
| itemID | INT (≥0) (Primary Key) | Unique identifier for all collection items. |
| title | VARCHAR | Title of the media. |
| itemType | ENUM ("book", "digital", "magazine") | Type of media. |
| publicationYear | INT (>0) | Year of publication. |
| availabilityStatus | ENUM ("available", "unavailable") | Availability status. |
| specialPremium | DECIMAL (≥ 0) | Special fee, set by policy. Added to the borrowing member's late fee rate for fine calculations. |
| specialRestriction | ENUM ("common", "rare") | Restriction level, set by policy. |
| **Book** | | Specialization of Media. |
| ISBN | INT (>0) | Book's unique identifier, but not its primary key. Useful for user's searches. |
| author | VARCHAR | Author of a book. |
| genre | VARCHAR | Genre of a book. |
| **DigitalMedia** | | Specialization of Media. |
| digitalMediaID | INT (>0) | A unique identifier, but not a primary key. Useful for a user's searches. |

| Attribute Name | Data Type | Description |
|---|---|---|
| creator | VARCHAR | Creator of the digital media. |
| genre | VARCHAR | Genre of the media. |
| **Magazine** | | Specialization of Media. |
| ISSN | INT (>0) | Magazine's unique identifier, but not its primary key. Useful for a user's search. |
| publicationDate | DATE | Date of publication. |
| **Loan** | | Represents a loan transaction. |
| loanID | INT (≥0) (Primary Key) | Unique identifier. |
| memberID | INT (Foreign Key) | References Member entity, specifying the member taking the loan. |
| itemID | INT (Foreign Key) | References Media entity, specifying the media item on loan. |
| checkoutDate | DATE | Loan start date. |
| dueDate | DATE (>checkoutDate) | Date the loan is due. |
| returnDate | DATE (>checkoutDate or NULL) | Date the item is returned. |
| lateFeeCharge | DECIMAL (≥ 0) | Fee for late return. Can be increased for every day the loan is considered late. |
| **Reservation** | | Represents media reservations. |
| reservationID | INT (≥0) (Primary Key) | Unique identifier. |
| memberID | INT (Foreign Key) | References Member entity, noting the member initiating the reservation. |
| itemID | INT (Foreign Key) | References Media entity, referencing the media item being reserved. |

| Attribute Name | Data Type | Description |
|---|---|---|
| reservationDate | DATE | Date of reservation. |
| expirationDate | DATE (≥ reservationDate) | Expiration date. |
| status | ENUM ("active", "inactive") | Status of reservation. |
| **Fine** | | Represents fines issued to users. |
| fineID | INT (≥0) (Primary Key) | Unique identifier. |
| memberID | INT (Foreign Key) | References Member entity, indicating the member responsible for the fine.. |
| loanID | INT (Foreign Key) | References Loan entity, referencing the loan for which the fine was made. |
| amount | DECIMAL (≥ 0) | Fine amount, which can scale. |
| issueDate | DATE | Date fine was issued. |
| status | ENUM ("unpaid", "paid") | Payment status. |
| **Payment** | | Represents payments of fines. |
| paymentID | INT (≥0) (Primary Key) | Unique identifier, ≥ 0. |
| fineID | INT (Foreign Key) | References Fine entity, indicating the fine the payment is associated with. |
| memberID | INT (Foreign Key) | References Member entity, indicating the member who made the payment. |
| paymentDate | DATE | Date payment was made. |
| amountPaid | DECIMAL (≥ 0) | Amount paid. |
| **Loaned-In** | | Relationship between a Loan and a Media item. |
| loanID | INT (≥0) (Primary Key) (Foreign Key) | References a specific loan. |

| Attribute Name | Data Type | Description |
|---|---|---|
| itemID | INT (≥0) (Foreign Key) | References a specific media item borrowed in the associated loan. |
| **Borrows** | | Relationship between a Loan and Member. |
| loanID | INT (≥0) (Primary Key) (Foreign Key) | References a specific loan. |
| borrowerID | INT (≥0) (Foreign Key) | References the member who has taken out the loan. |
| **Triggers** | | Relationship between a Loan and a Fine. |
| loanID | INT (≥0) (Primary Key) (Foreign Key) | References a given loan. |
| fineID | INT (≥0) (Foreign Key) | References the subsequent fine triggered by the loan. |
| **Owes** | | Relationship between a Fine and a Member. |
| fineID | INT (≥0) (Primary Key) (Foreign Key) | References a given fine. |
| memberID | INT (≥0) (Foreign Key) | References the member who owes the fine. |
| **Pays-For** | | Relationship between a Payment and a Fine. |
| paymentID | INT (≥0) (Primary Key) (Foreign Key) | References a given payment. |
| fineID | INT (≥0) (Foreign Key) | References the fine for which the payment was made. |
| **Pays** | | Relationship between a Payment and a Member. |
| paymentID | INT (≥0) (Primary Key) (Foreign Key) | References a given payment. |

| Attribute Name | Data Type | Description |
|---|---|---|
| memberID | INT (≥0) (Foreign Key) | References the member who made the payment. |
| **Reserves** | | Relationship between a Reservation and a Member. |
| reservationID | INT (≥0) (Primary Key) (Foreign Key) | References a given reservation. |
| memberID | INT (≥0) (Foreign Key) | References the member who made the reservation. |
| **Reserved-In** | | Relationship between a Reservation and a Media item. |
| reservationID | INT (≥0) (Primary Key) (Foreign Key) | References a given reservation. |
| itemID | INT (≥0) (Foreign Key) | References the item reserved in the associated reservation. |

## 3.2 Policy-Based Constraints

There are several constraints for this database that are defined explicitly by library policy. The relevant constraints are included below.

***Items on loan:*** A tuple in the loan relation can not be created for a specific media entity, defined by its item_id attribute, if its availability status is currently set to "unavailable" since an item meeting this criteria would already be on loan.

***Membership types:*** A member's membership type is defined through their typeName, borrowingLimit, and lateFeeRate, all initialized upon creation to policy defined values. A "regular" member has a borrowingLimit initialized to five media items and a lateFeeRate initialized to $4 per day. A "senior" member has a borrowingLimit of seven and a lateFeeRate of $2 per day. A "student" member has a borrowingLimit of ten and a lateFeeRate of $1 per day. These values can be specifically tailored to special circumstances. For instance, a member who frequently returns items late can have their borrowingLimit decreased, regardless of their type of membership.

***Loan period:*** The standard loan period for a media item is three weeks. Therefore, the dueDate of a loan should be three weeks from the checkoutDate.

***Borrowing limits:*** When a member attempts to check out a media item, it should only be loaned if the number of *active* loans for the member does not already

equal the member's borrowing limit. A specific loan is considered active when its returnDate is currently set to NULL.

***Payments of fines:*** There is a one-to-one relationship between fines and payments. When a payment is made for a fine, it must be for the entire amount of the fine ideally. In the event that this is not the case, the amount paid, represented by the amountPaid attribute, is recorded. This may result in disciplinary action against the member.

***Reservation expirations:*** Reservations for media items expire three days after an item becomes available in the library. When a member reserves a specific media item, such as a book, a separate reservation is actually made for each copy of that media item. If one copy becomes available before the rest and the member checks out that item, all reservations currently active for this media item are rendered "inactive".

***Special restriction and premium:*** The specialRestriction attribute of a media entity denotes its rarity. By library policy, a rare item will have a halving of the standard loan period. The specialPremium is a custom late fee rate that is added to the borrower's existing late fee rate. This premium is typically set by library staff.