Book My Show - Design

Contents

BookMyShow System Design

Overview

- Popular System: Frequently used, making it relevant for interviews.
- Concurrency Handling: No two persons should be able to book the same seat.

System Design Steps

1. Overview of the System
2. Requirements Gathering
3. Clarify Requirements
4. Class Diagram
5. Schema Design
6. Code Implementation (Spring Boot)

Overview of the System

- Overview part you will have two cases
    a. You know the application.
        - If you know the application you will have to tell the basics that, this is what I understand from the application named BookMyShow.
    b. You don't know the application.
        - If you don't know the application you will have to ask that, I don't know the application and I have not used BookMyShow. Can you please elaborate in brief what do you mean by what kind of application we are building.

Assuming that we don't know BookMyShow!

Interviewer will give you the problem statement.

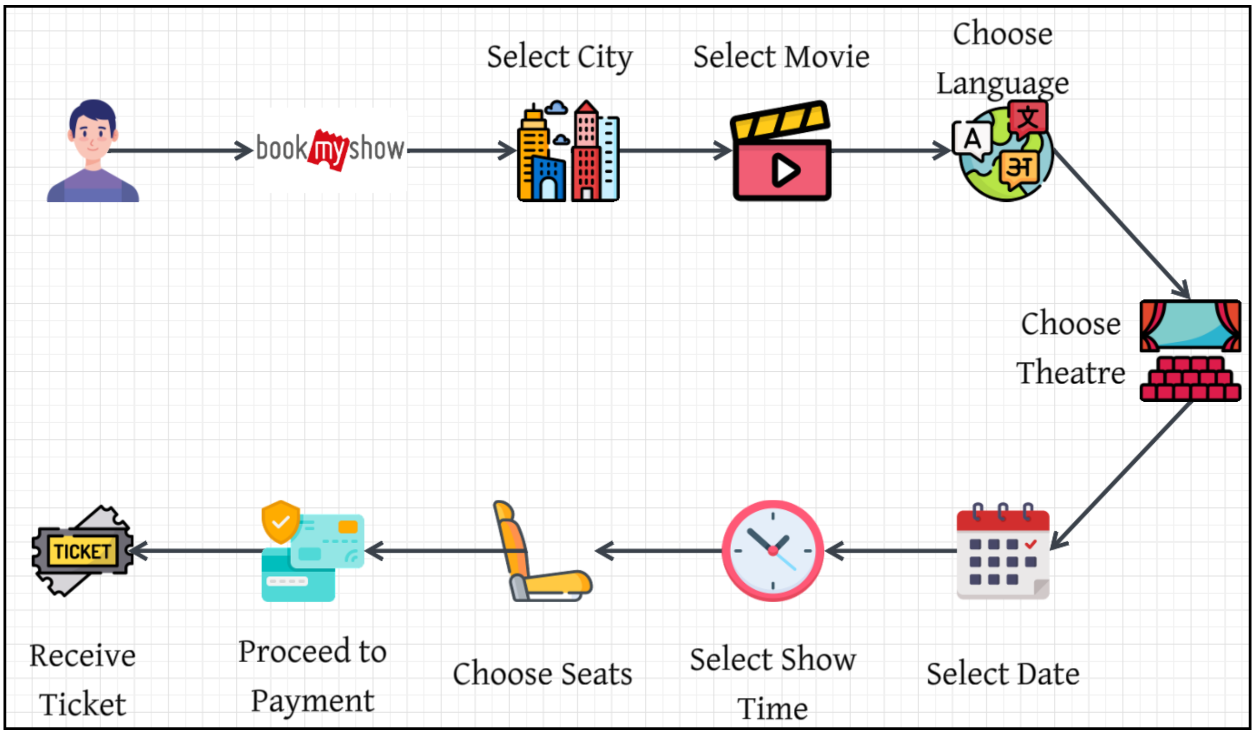
Problem Statement: BookMyShow System Design

- Design an online movie ticket booking system (BookMyShow) that allows users to:
    - Browse and search for movies.
    - Select a city and find available theatres.

- Choose a movie, language, date, showtime, and seats.
  - Make payments online to confirm bookings.
  - Ensure concurrency control so that no two users can book the same seat simultaneously.
- The system should be scalable to handle high traffic and support multiple cities, theatres, and screens with different seat types and pricing. It should also integrate with third-party payment providers and allow refunds and cancellations.

Requirements Gathering & Clarify Requirements

- We will start with user journey…
- User Journey & Flow



- Once we confirm the user journey, we can ask questions to the interviewer to gather the requirements.
- Start with the 1st spot in the user journey.

1. Cities & Theatres
   - There will be multiple cities.
   - Each city will have multiple theatres.

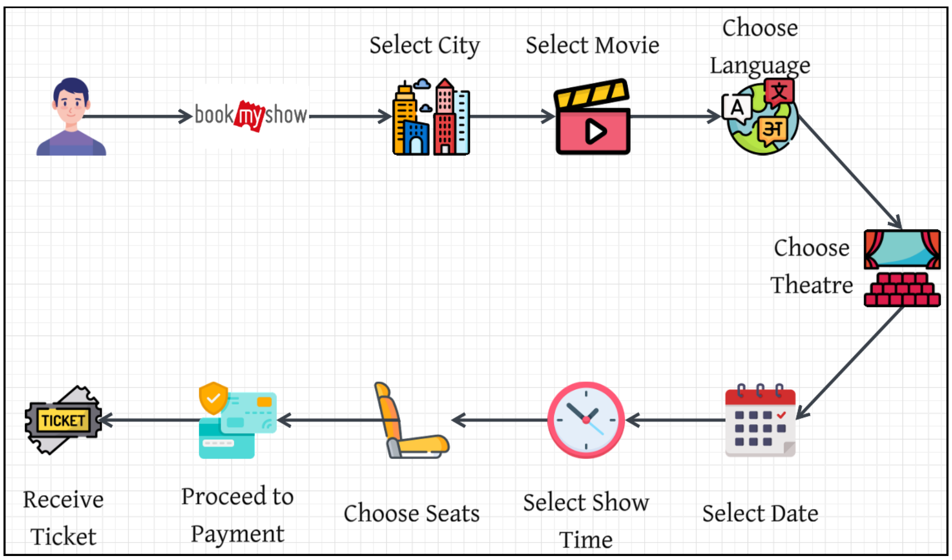
- Each theatre can have multiple screens.

2. Screens & Seats
    - Screens will have different features: 2D, 3D, IMAX, Dolby.
    - Each screen will have multiple seats.
    - Seats can be of different types: Sofa, Recliner, Platinum, Gold, Silver, etc…
3. Pricing
    - Pricing is based on:
        - Movie
        - Time of the show
        - Seat type
        - Theatre
        - Day of the week
    - Each type of seat will have a different price per show.
4. Shows & Movies
    - Each theatre will have multiple shows running at the same time.
    - Each show will have one movie running.
    - A movie can have multiple attributes:
        - Languages
        - Cast
        - IMDb rating
        - Genre
        - Features (2D, 3D, IMAX, Dolby, etc.)
5. Booking Restrictions
    - Users cannot book tickets 10 minutes before the show.
    - After seat selection, users proceed to payment.
    - Only online payments are supported.
    - Payment will be outsourced to third-party providers (e.g., Razorpay, PayU).
6. Partial Payments
7. Refunds & Cancellations
8. Concurrency Handling
    - A user can book a maximum of 10 seats per transaction.
    - Once payment is successful, a ticket is generated.

- Only one person should be able to book a particular seat.
- Once a user selects a seat, it will be locked for 5 minutes.

Identify Classes

- The two strategies for creating a class diagram are:
  1. **Visualization** – This includes understanding the system flow, identifying key interactions, and mapping user journeys.
  2. **Identifying Nouns** – Extracting relevant entities (nouns) from requirements or problem statements to determine the potential classes.
- As per the user journey, lets create classes.



- Each **class** in the diagram corresponds to a **table** in the **database**.
- Essential attributes for **database tables**:
  - ID column (Primary Key)
  - Other necessary attributes (e.g., Name, Address, etc.)

Identified Core Classes

- City
  - Attributes: ID, Name
  - Stores details of a city where theaters exist.
- Theater

- Attributes: ID, Name, Address, City ID (Foreign Key linking to City table)
    - Stores details of theaters in a city.
- Screen
    - Attributes: ID, Name, Features
    - Represents individual screens within a theater.
- Movie
    - Attributes: ID, Name, Genre, Language, Duration, Features
    - Represents movies playing in theaters.
- Show
    - Attributes: ID, Movie Name, Status
    - Represents scheduled showtimes for movies.
- Seat
    - Attributes: ID, Type, Price, Status (AVAILABLE, BOOKED)
    - Represents seats in a Screen.
- Payment
    - Attributes: Transaction ID, Amount, Status (CONFIRMED, CANCELLED)
    - Stores payment details.
- Ticket
    - Attributes: ID, Show, Seats, Amount, Status, Payment
    - Represents a booked ticket.

City-Theater Relationship and Access Patterns

- Two approaches to linking City and Theaters:
    - City stores a list of theaters (Redundant Data)
    - Theater stores City ID (Better Normalization)
- SQL Query for theaters in a city:

```sql
SELECT * FROM THEATERS WHERE CITY_ID = 'BANGALORE';
```

    - If city stores a list of theaters, it leads to redundancy.
    - If theater stores City ID, we can fetch theaters dynamically via queries.

What is an Access Pattern?

- An **Access Pattern** refers to the **way data is accessed, retrieved, and manipulated** in a system. It determines **how efficiently** data can be fetched based on the frequency and type of queries executed.
- In **database design and system architecture**, access patterns **influence schema design**, indexing, and caching strategies to optimize performance.

Types of Access Patterns

1. **Read-heavy Access Pattern**
   - The system performs frequent reads but fewer writes.
   - Example: **Fetching a list of theaters for a city multiple time**
   - Optimization:
     - Use **denormalization** (store redundant data for faster reads).
     - Apply **caching** (e.g., Redis, Memcached).
     - Use **indexes** to speed up queries.
2. **Write-heavy Access Pattern**
   - The system frequently writes or updates data (fewer reads).
   - Example: **Real-time stock price updates in a trading system**
   - Optimization:
     - Use **partitioning** to distribute writes across multiple nodes.
     - Use **event-driven architecture** (Kafka, RabbitMQ).
     - Employ **batch processing** to reduce database load.
3. **Search-based Access Pattern**
   - Data is accessed based on dynamic user input.
   - Example: **Searching for movies by genre, language, or rating**
   - Optimization:
     - Use **inverted indexes** (Elasticsearch, Solr).
     - Implement **full-text search** instead of SQL queries.
4. **Time-based Access Pattern**
   - Users access recent data more frequently than old data.

- Example: **Fetching recent transactions in a banking system**
- Optimization:
  - Use **Time Series Databases** (InfluxDB, TimescaleDB).
  - Implement **data archiving strategies**.

Access Patterns in the BookMyShow Example

In BMS, the **City-Theater relationship** was discussed in terms of access patterns.

- **Frequent Query**: "List all theaters for a selected city."
- Two possible approaches:
  1. **Normalized Schema**: Store only `CITY_ID` in the `THEATER` table and query it dynamically.

     ```
     SELECT * FROM THEATERS WHERE CITY_ID = 'BANGALORE';
     ```

     - **Pros**: Avoids redundancy, ensures data consistency.
     - **Cons**: Requires query execution every time.
  2. **Denormalized Schema**: Store a **list of theaters** inside the `CITY` table for **faster access**.
     - **Pros**: Quick retrieval without additional queries.
     - **Cons**: Increases storage, may cause **data inconsistency**.
- **Decision depends on how often the query is executed (Access Pattern).** If users frequently request a list of theaters for a city, **denormalization** may be preferable.

The `City` `class` and `Theater` `class`

- As per the above, we have `class City` and `class Theater` as shown below…

```
export module City;
import <string>;
export class City {
   int id;
   std::string name;
public:

   City(int id, std::string name);
   int getId() const;
   void setId(int id);
   const std::string& getName() const;
   void setName(const std::string& name);
};
```

```
export module Theater;

import Screen;
import City;
import <vector>;
import <string>;
import <memory>;

export class Theater
{
   int id;
   std::string name;
   std::string address;
   std::vector<std::unique_ptr<Screen>> screens;
   City city;
public:

   Theater(int id, std::string name, std::string address);
   void addScreen(std::unique_ptr<Screen> Screen);

   int getId() const;
   …
   …
};
```

The Screen class

- The Screen class has following…
    - **Id** attribute: which is used to map the corresponding table in the database…
    - **Name**: Name of the screen (Example: Screen 1, Screen 2…)
    - List of **Features**: Type of the Screen which is 2D, 3D, IMAX, Dolby…

```
export module FeatureType;

export enum class FeatureType {
   TwoD,
   ThreeD,
   IMAX,
   Dolby
};
```

    - List of `seats`:

```
export module Screen;

import FeatureType;
import Seat;

import <vector>;
import <string>;
import <memory>;

export class Screen
{
   int id;
   std::string name; // Screen 1, Screen 2
   std::vector<FeatureType> features;
   std::vector<Seat> seats;
public:

   Screen(int id, std::string name);

   int getId() const;
   …
   …
};
```

The `Seat class`

- The `Seat class` has the following…
    - `Id` attribute: which is used to map the corresponding table in the database…
    - `Row`: In which row this seat is present.
    - `Column`: In which column this seat is present.
    - `SeatType`: Type of the Seat (`VIP`, `Gold`, `Platinum`, etc…)
    - `Name`: Name of the Seat (`A1`, `B14`, etc…)

```
export module SeatType;
export enum class SeatType {
   VIP,
   Gold,
   Platinum,
   Regular,
   Invalid,   // For invalid seats or empty spaces
   Walkway    // For walkways or gaps
};
```

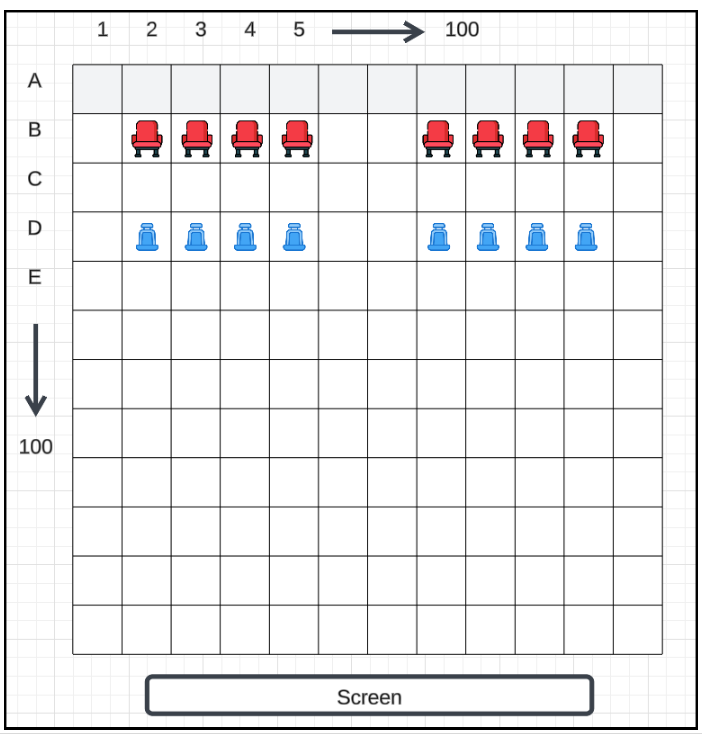
- We can't have `Price` attribute in the `Seat class` as it depends on the `Show` and `Seat`.
- Similarly, we can't have `Status` (`Booked`, `Empty`, etc...) attribute as it also depends on `Show` and `Seat`.

Understanding the Seating Layout

- A movie theater has a specific seating arrangement with different seat categories (VIP, Gold, Platinum, etc.).
- Each screen in a theater has a different layout.
- The layout includes gaps for walking, different seat sections, and labels for each seat.

Data Structure Used to Store Seats

- BookMyShow uses a predefined large 2D matrix (grid) of size 100x100.
- This grid serves as a universal seating template for all theaters.
- The actual layout is defined by marking certain positions as valid seats, while others remain empty.
- Example:
  - Valid seats are filled with seat identifiers (e.g., A1, B2, C3).
  - Empty spaces are ignored in display.



- Instead of a 2D matrix, for simplicity, we will be using a **list of valid seats**.
- This avoids storing empty spaces explicitly, saving memory.

```
export module Seat;

import SeatType;
import <string>;

export class Seat {
   int id;
   int row;
   int column;
   SeatType seatType;
   std::string name; // A1, B13
public:
   Seat(int id, int row, int column, SeatType seatType, std::string name);

   // Getters
   int getId() const;
   …
   …
};
```

The `Show class`

- There is a mapping between `Seat class` and `Show class` as discussed above (`Price` and `Seat Status`).
- First, we implement the `Show class` and then we can discuss the mapping.
- The `Show class` the following…
    - `Id` attribute: which is used to map the corresponding table in the database…
    - `startTime` attribute: When the show starts.
    - `endTime` attribute: When the show ends.
    - `Movie` attribute: Which movie is being shown.
    - `Screen` attribute: On which screen current show is running.
    - `Features` attribute:
        - `Movie` **Features**: A movie has its own set of features (e.g., `2D`, `Dolby`).
        - `Screen` **Features**: A screen has its own capabilities (e.g., supports `2D`, `3D`, `Dolby`).
        - Show Features:

        - The intersection of `Movie` and `Screen` features.
        - Example: If a movie supports `2D` & `Dolby`, but the screen supports `2D`, `3D`, and `Dolby` → The show can only be `2D` & `Dolby`.
    - Language attribute:
        - A movie can support multiple languages (e.g., `English`, `Hindi`, `Punjabi`).
        - A show will be in only one language.
        - Therefore, in the `Movie class`, we maintain a list of languages, while in the `Show class`, we specify only one language for a particular show.

```
export module Show;

import Movie;
import Screen;
import FeatureType;
import ShowStatus;

#include <chrono>
#include <memory>

export class Show {
private:
   int id;
   std::chrono::system_clock::time_point startTime;
   std::chrono::system_clock::time_point endTime;
   std::shared_ptr<Movie> movie;
   std::shared_ptr<Screen> screen;
   std::vector<FeatureType> features;
   std::chrono::system_clock::time_point date;
   ShowStatus status;
   std::string language;

public:
   Show(int id, std::chrono::system_clock::time_point startTime,
      std::chrono::system_clock::time_point endTime,
      std::shared_ptr<Movie> movie, std::shared_ptr<Screen> screen,
      std::chrono::system_clock::time_point date, ShowStatus status,
      const std::string& language);

   int getId() const;
   …
   …
};
```

The mapping `class` - `ShowSeat`

- A **`seat`** exists in a theater, but its **`availability`**, **`price`**, and **`booking status`** depend on the specific **`show`**.
- A single **`seat`** (e.g., `Seat` A1) can be part of multiple **`shows`** (e.g., 12 PM and 3 PM show).
    - The same **`seat`** in different **`shows`** may have different availability.
    - The **`price`** may change based on the time or demand for that **`show`**.
- Thus, a direct mapping between `Show` and `Seat` is required to track these variations, hence `ShowSeat` `class`.
- Attributes of `ShowSeat`:
    - **`Id`** attribute: which is used to map the corresponding table in the database…
    - Attribute **`show`**: refers to a show.
    - Attribute **`seat`**: refers to a seat.
    - Attribute **`price`**: Ticket price can vary depending on the show timing, promotions, or peak hours.
    - Attribute **`status`**: A seat's status (`Available`, `Booked`, `Locked`) depends on the show.
        - The same **`seat`** may be booked for the 12 PM **`show`** but available for the 3 PM **`show`**.

```
export module ShowSeat;

import Show;
import Seat;
import SeatStatus;

export class ShowSeat {
private:
   int id;
   std::shared_ptr<Show> show;
   std::shared_ptr<Seat> seat;
   SeatStatus status;

public:
   ShowSeat(int id, std::shared_ptr<Show> show,
      std::shared_ptr<Seat> seat, SeatStatus status);
```

```
    // Getters
    int getId() const;
    …
    …
};
```

- Instead of storing the price in ShowSeat for each individual seat, we introduce ShowSeatType mapping.
    - Many seats can have the same price for a particular Show and for a particular SeatType.
    - For example, **all the** GOLD, SeatType for 1 PM Show has the same price.
- Since this is repetitive data in the database, we can store the price in a separate class/table ShowSeatType.

```
export module ShowSeatType;

import SeatType;
import Show;

export class ShowSeatType {
private:
   int id;
   std::shared_ptr<Show> show;
   SeatType seatType;
   double price;

public:
   ShowSeatType(int id, std::shared_ptr<Show> show,
      SeatType seatType, double price);

   // Getters
   int getId() const;
   …
   …
};
```

The Movie class

- The Movie class should have the following attributes:
    - Id attribute: which is used to map the corresponding table in the database…
    - Name: Title of the movie.
    - List of Actors: Stores actors (both male & female) who acted in the movie.

- `Genre`: Type of movie (e.g., Comedy, Action, Drama).
- `List` of `Languages`: The languages in which the movie is available.
- `Duration`: Runtime of the movie (can be stored as a double).
- `Rating`: Movie rating (e.g., IMDb rating).
- `List` of `Features`: Special features of the movie (e.g., 3D, IMAX).
  - Instead of separate enums for movie features, screen features, and show features, a single shared enum is used across classes.

```
export module Movie;

import FeatureType;
import Actor;
import MovieGenre;

#include <string>
#include <vector>
#include <chrono>
#include <memory>

export class Movie {
private:
   int id;
   std::string name;
   std::vector<std::shared_ptr<Actor>> actors;
   std::vector<MovieGenre> genres;
   std::vector<std::string> languages;
   std::chrono::minutes duration; // Runtime in minutes
   double rating; // Movie rating (e.g., IMDb rating)
   std::vector<FeatureType> features;

public:
   Movie(int id, const std::string& name,
      const std::vector<MovieGenre>& genres,
      const std::vector<std::string>& languages,
      std::chrono::minutes duration, double rating);

   void addActor(std::shared_ptr<Actor> actor);

   // Getters
   int getId() const;
   …
   …
};
```

```
export module MovieGenre;

export enum class MovieGenre {
   Action,
   Comedy,
   Drama,
   SciFi,
   Horror,
   Thriller,
   Romance,
   Animation,
   Documentary,
   Fantasy,
   Mystery,
   Adventure,
   Crime,
   Musical,
   Western,
   Historical,
   War,
   Sport,
   Family,
   Other // For genres not explicitly listed
};
```

The Actor class

```
export module Actor;

import <string>;

export class Actor {
private:
   int id;
   std::string name;

public:
   Actor(int id, const std::string& name);

   // Getters
   int getId() const;
   …
   …
};
```

Finding Movies of an Actor

- To find all movies of an actor, we can query the **movies table**:

```
SELECT * FROM MOVIES WHERE ACTOR_ID = 'TOM CRUISE';
```

- Some may suggest storing a list of movies inside the `Actor class`, but this is not required unless frequent queries demand it.
- Decision depends on the access pattern:
  - If movie lists for an actor are frequently needed, caching them in the `Actor class` might be beneficial.
  - Otherwise, querying the movies table is sufficient.

The `Payment class`

- Attributes of Payment Class
  - `Id` attribute: which is used to map the corresponding table in the database…
  - `Amount`: Amount paid for the ticket.
  - `Status`: Payment status, represented as an `enum`:
    - `Successful`
    - `Failed`
    - `Refunded`
  - `Ticket`: The ticket associated with this payment.
  - `Transaction ID`: The **`transaction ID`** associated with the 3rd party transaction.
  - `Transaction Time`: The time when the transaction happened.

```
export module Payment;

import PaymentStatus;
import <memory>;
import <chrono>;

export class Ticket; // To avoid Cyclic Dependency
// Instead of using import Ticket we use export statement
// to avoid cyclic dependency.
```

```cpp
export class Payment {
private:
    int id;
    int transactionId;
    double amount;
    PaymentStatus status;
    std::weak_ptr<Ticket> ticket;
    std::chrono::system_clock::time_point transactionTime;

public:
    Payment(int id, int transactionId, double amount, PaymentStatus status,
       std::weak_ptr<Ticket> ticket,
       std::chrono::system_clock::time_point transactionTime);

    // Getters
    int getId() const;
    int getTransactionId() const;
    …

    …
};
```

```cpp
export module PaymentStatus;

export enum class PaymentStatus {
    SUCCESSFUL,
    FAILED,
    REFUNDED
};
```

The `Ticket class`

- Attributes of `Ticket Class`
    - `Id` attribute: which is used to map the corresponding table in the database…
    - `Show` Details – Information about the show (Movie, Date, Time).
    - `Show Seat` Objects – The specific seats booked for the show.
    - `Amount` Paid – Total price paid for the ticket.
    - `Status` – Ticket status, represented as an enum:
        - `Confirmed`
        - `Cancelled`
        - `Waiting`

- `List` of `Payments` – A ticket can have multiple payment objects (e.g., partial payments).
- `User` Details – Information about the user who booked the ticket.

```
export module Ticket;
import Show;
import ShowSeat;
import Payment;
import User;
import TicketStatus;
import <vector>;
import <memory>;

export class Ticket {
private:
   int id;
   std::shared_ptr<Show> show;
   std::vector<std::shared_ptr<ShowSeat>> showSeats;
   double amountPaid;
   TicketStatus status;
   std::vector<std::shared_ptr<Payment>> payments;
   std::shared_ptr<User> bookingUser;

public:
   Ticket(int id, std::shared_ptr<Show> show,
      const std::vector<std::shared_ptr<ShowSeat>>& showSeats,
      double amountPaid, TicketStatus status,
      const std::vector<std::shared_ptr<Payment>>& payments,
      std::shared_ptr<User> bookingUser);

   // Getters
   int getId() const;

   …

   …
};
```

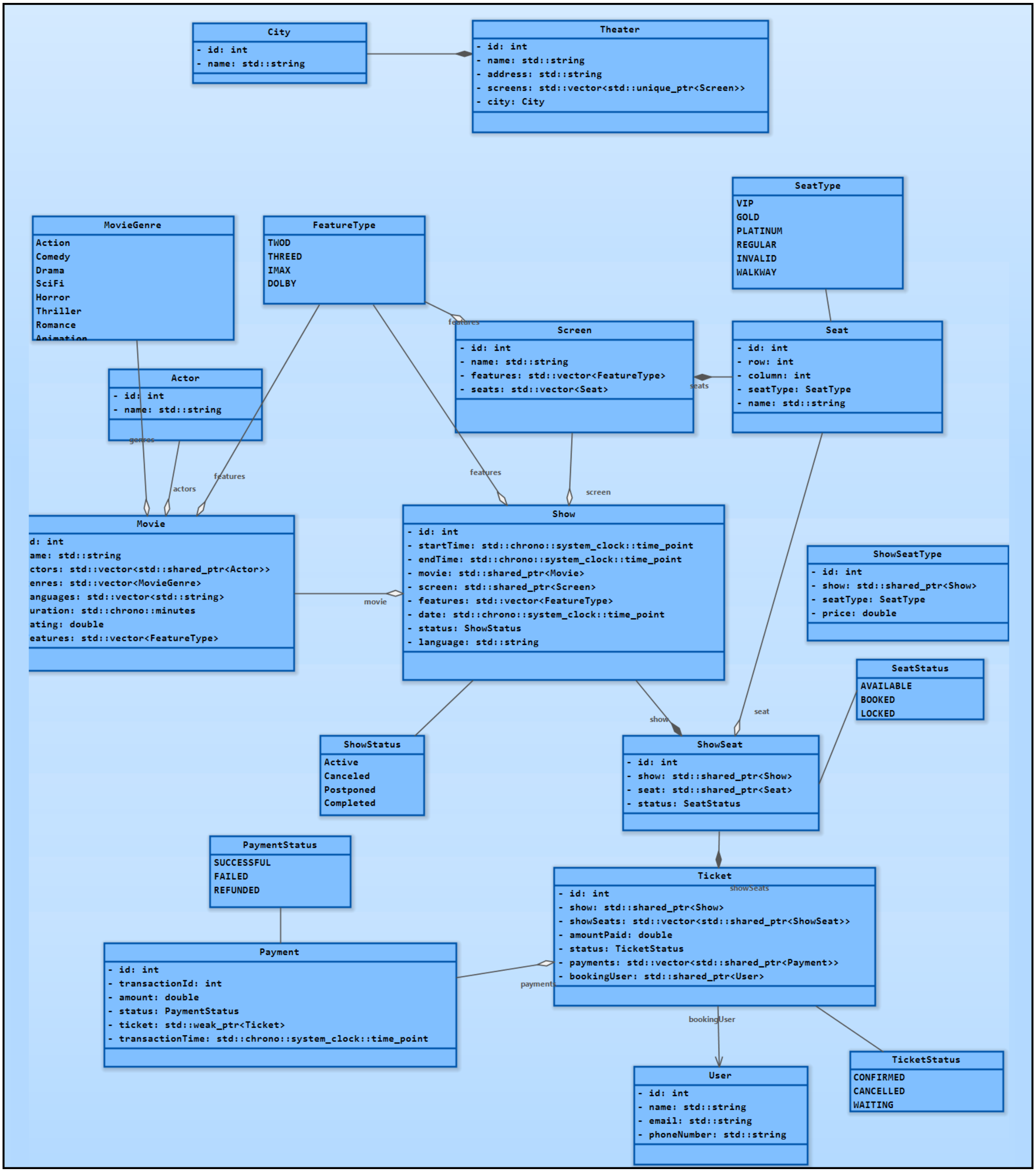
```
export module TicketStatus;

export enum class TicketStatus {
   CONFIRMED,
   CANCELLED,
   WAITING
};
```

The `User class`

- This class handles information about the user who booked the ticket.
- Attributes of `User Class`
    - `Id` attribute: which is used to map the corresponding table in the database…
    - `Name`: Name of the user who has booked the ticket.
    - `Email` address: Email address of the user who has booked the ticket.
    - `Phone` number: Phone number of the user who has booked the ticket.

```
export module User;

import <string>;

export class User {
private:
   int id;
   std::string name;
   std::string email;
   std::string phoneNumber;

public:
   User(int id, const std::string& name, const std::string& email,
      const std::string& phoneNumber);

   // Getters
   int getId() const;

   …

   …
};
```

Class Diagram



Schema Design

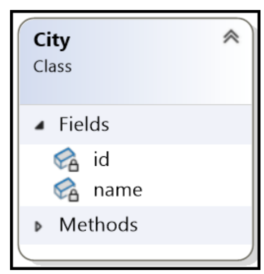
Schema Design Principles:

1. **Class to Table**: Every `class` in the `class` diagram corresponds to a `table` in the database.
2. **Cardinality Matters**: Cardinality (relationships) determines how `table`s connect.
    - **One-to-One**: Primary key of one table is added as a foreign key in the other table.
    - **One-to-Many/Many-to-One**: Primary key of the "one" side is added as a foreign key in the "many" side.
    - **Many-to-Many**: A mapping (junction) table is created with foreign keys from both original tables.
3. **Primitive vs. Non-Primitive Attributes**:
    - Primitive attributes (`int`, `string`, etc.) are directly added as columns.
    - **Non-primitive** attributes (objects of other `class`es) **require cardinality analysis**.

Table Schema (**Based on Primitive Attributes**):

1. Cities Table

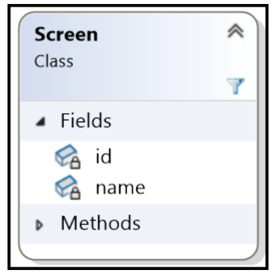
city_id	city_name		



2. Theaters Table

theater_id	name	address		

3. Screens Table

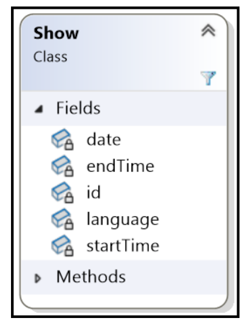


screen_id	screen_name		

4. Seats Table

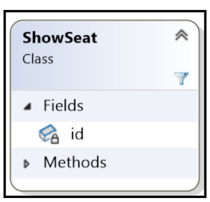
seat_id	row	column	name		

5. Shows Table



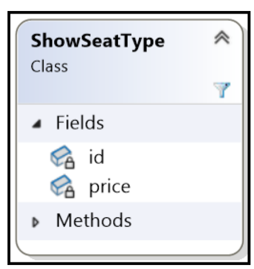
show_id	start_time	end_time	date	language		

6. Show_seats Table



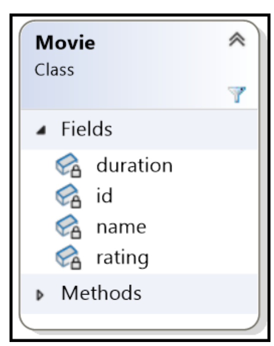
show_seat_id		

7. Show_seat_types Table



show_seat_type_id	price		

8. Movies Table



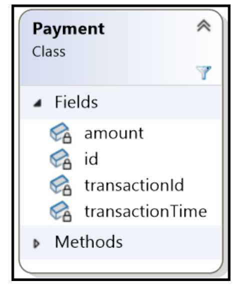
movie_id	name	duration	rating		

9. Actors Table

actor_id	name		

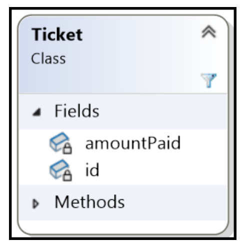
10. Payments Table

payment_id	transaction_id	amount	transaction_time		



11. Tickets Table

ticket_id	amount		



12. Users Table

user_id	name	email	phone_number		

- All enum classes will have the same type of table structure, consisting of an `id` column (typically an integer primary key) and a `value` column (typically a VARCHAR to store the enum's string representation).

13. Features Table

feature_id	feature_type

14. Movie_genres Table

genre_id	genre_name

15. Payment_status

payment_status_id	payment_status_name

16. Seat_status

seat_status_id	seat_status_name

17. Seat_types

seat_type_id	seat_type_name

18. Show_status

show_status_id	show_status_name

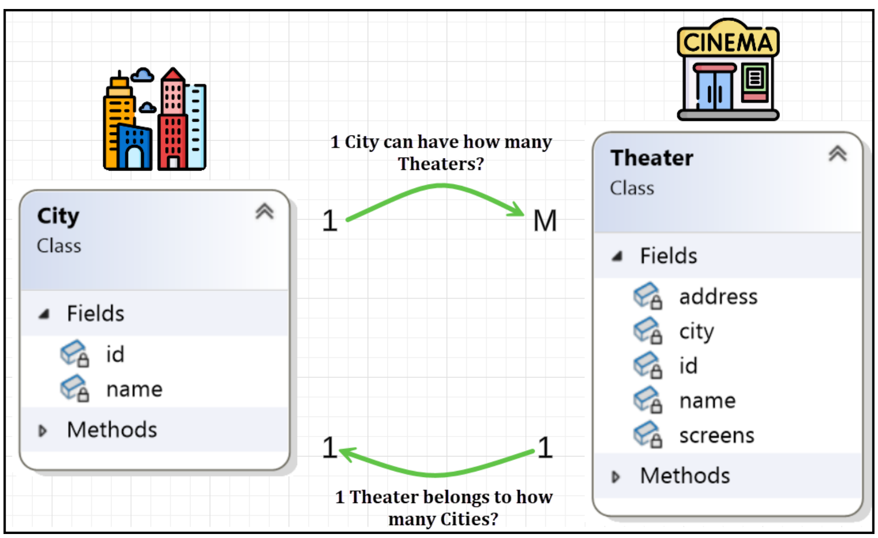
19. Ticket_statuses

ticket_status_id	ticket_status_name

Cardinality and Foreign Keys:

- Let's consider all the classes again and find the Cardinality between these classes.

1. `City class` and `Theater class`



- ID of '1' side on 'M' side.
- So, `Theaters` table should have `Cities` table ID column. Let's add it to `Theaters` table.

```sql
CREATE TABLE CITIES (
    CITY_ID INT PRIMARY KEY,
    CITY_NAME VARCHAR(255)
);
```

```sql
CREATE TABLE THEATERS (
    THEATER_ID INT PRIMARY KEY,
    NAME VARCHAR(255),
    ADDRESS VARCHAR(255),
    CITY_ID INT,
    FOREIGN KEY (CITY_ID) REFERENCES CITIES(CITY_ID)
);
```

- `Cities` Table

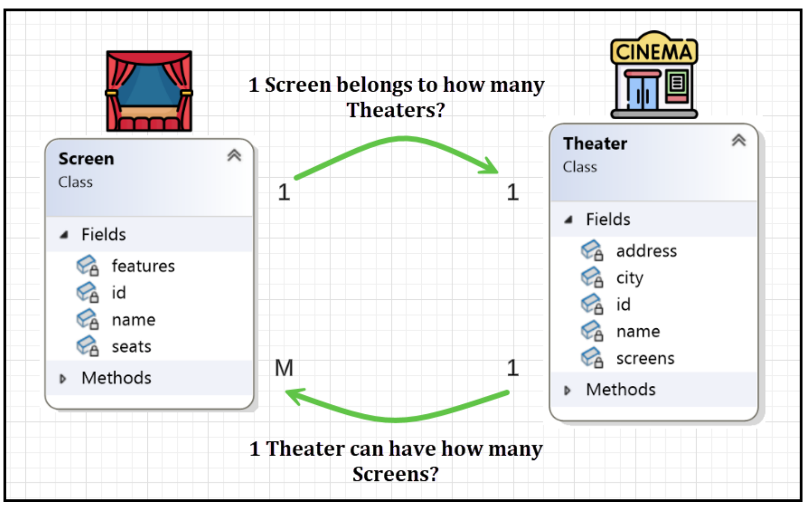
city_id	city_name

- `Theaters` Table

theater_id	name	address	city_id

2. `Theater` `class` and `Screen` `class`

- `Theater` also contains non primitive attribute `Screen`s.



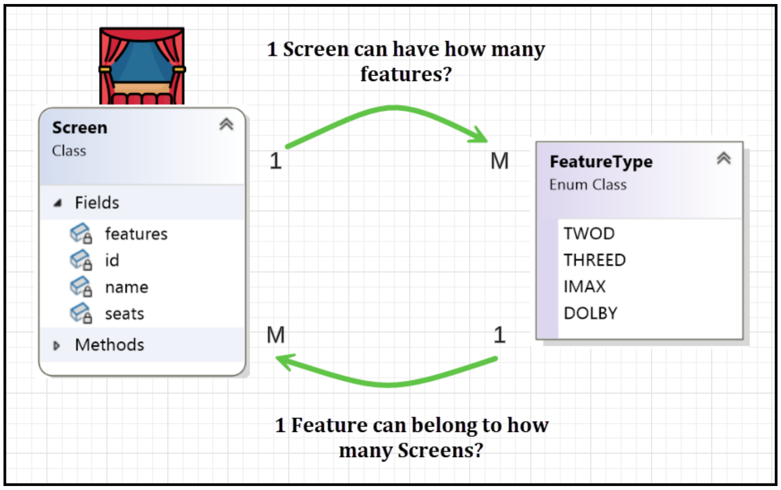
- ID of '1' side on 'M' side.
- So, `Screens` table should have `Theaters` table ID column. Let's add it to `Screens` table.

- Screens Table

screen_id	screen_name	theater_id

3. The Screen class and FeatureType enum

- Screen class also has the non-primitive attribute features.



  - A Screen can have multiple features (e.g., 2D, 3D, IMAX, Dolby).
  - A FeatureType can belong to multiple Screens. It is M:M relation.
  - To represent this relationship, we use a mapping table (junction table). Create screen_features table (Mapping Table)
    - Contains screen_id and feature_id as a composite primary key.
    - Establishes many-to-many mapping between screens and features.

```sql
-- CREATE SCREENS TABLE
CREATE TABLE SCREENS (
    SCREEN_ID INT PRIMARY KEY,
    SCREEN_NAME VARCHAR(255),
    THEATER_ID INT,
    FOREIGN KEY (THEATER_ID) REFERENCES THEATERS(THEATER_ID)
);
```

```sql
-- CREATE FEATURES TABLE
CREATE TABLE FEATURES (
    FEATURE_ID INT PRIMARY KEY,
    FEATURE_NAME VARCHAR(255) UNIQUE
);
```

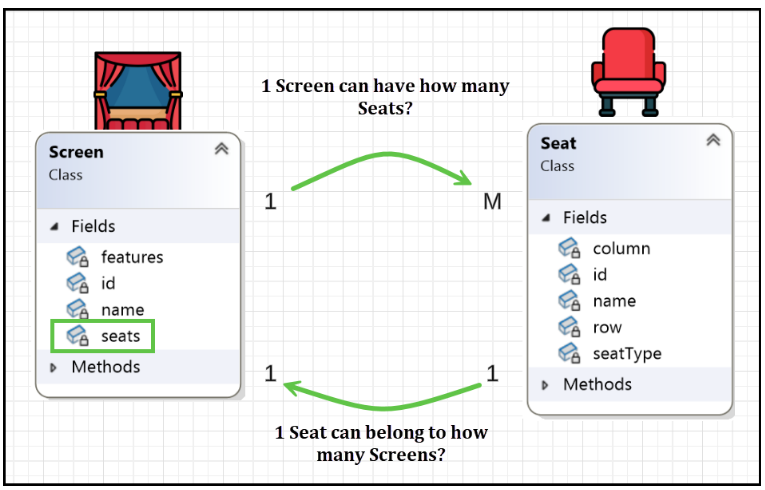
```sql
-- CREATE MAPPING TABLE (JUNCTION TABLE)
CREATE TABLE SCREEN_FEATURES (
    SCREEN_ID INT,
    FEATURE_ID INT,
    PRIMARY KEY (SCREEN_ID, FEATURE_ID),
    FOREIGN KEY (SCREEN_ID) REFERENCES SCREENS(SCREEN_ID),
    FOREIGN KEY (FEATURE_ID) REFERENCES FEATURES(FEATURE_ID)
);
```

- The `screen_features` table

screen_id	feature_id

4. The `Screen class` and `Seat class`

- The `Screen class` has non-primitive attribute **`seats`**.

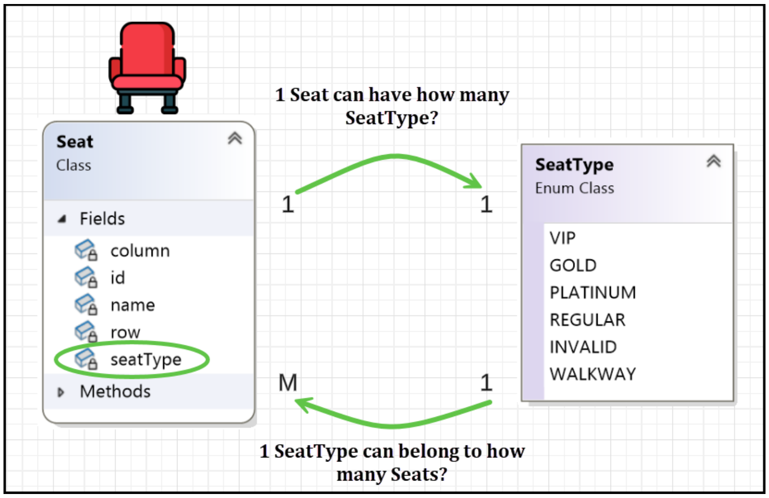


- ID of '1' side on 'M' side.
- So, `Seats` table should have `Screens` table ID column. Let's add it to `Seats` table.

seat_id	row	column	name	screen_id

5. The `Seat` **`class`** and `SeatType` **`enum`**

- `Seat` **`class`** table has non-primitive attribute **`seatType`**.



- ID of '1' side on 'M' side.
- So, `Seats` table should have `Seat_Types` table ID column. Let's add it to `Seats` table.

```
CREATE TABLE SEAT_TYPES (
    SEAT_TYPE_ID INT PRIMARY KEY,
    SEAT_TYPE_NAME VARCHAR(50) UNIQUE
);
```

```
CREATE TABLE SEATS (
    SEAT_ID INT PRIMARY KEY,
    ROW VARCHAR(10),
    COLUMN VARCHAR(10),
    NAME VARCHAR(255),
    SCREEN_ID INT,
    SEAT_TYPE_ID INT,
    FOREIGN KEY (SCREEN_ID) REFERENCES SCREENS(SCREEN_ID),
    FOREIGN KEY (SEAT_TYPE_ID) REFERENCES SEAT_TYPES(SEAT_TYPE_ID)
);
```

- The SEAT_TYPES table

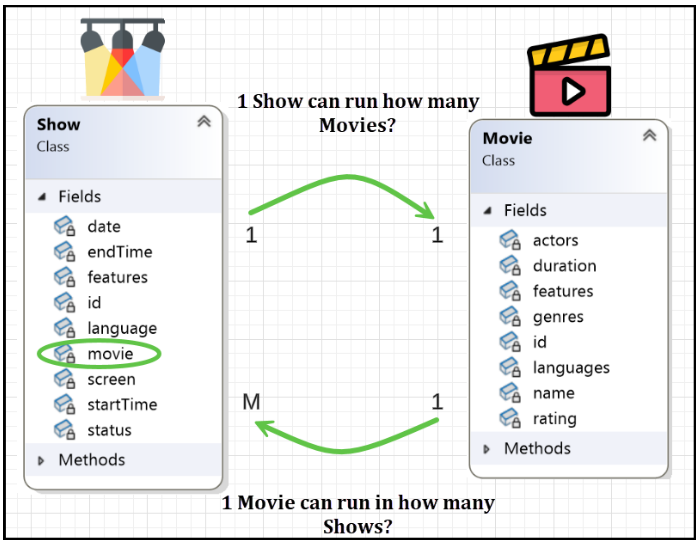
seat_type_id	seat_type_name

- The Seats table

seat_id	row	column	name	screen_id	seat_type_id

6. The Show class, Movie class, Screen class, ShowStatus enum and FeatureType enum

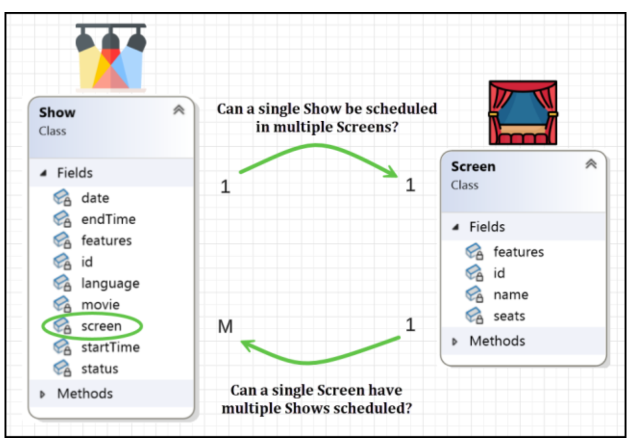
- The Show class has non-primitive attribute **movie**.



- ID of '1' side on 'M' side.
- So, 'Shows' table should have Movies table ID column. Let's add it to Shows table.

show_id	start_time	end_time	date	language	movie_id	

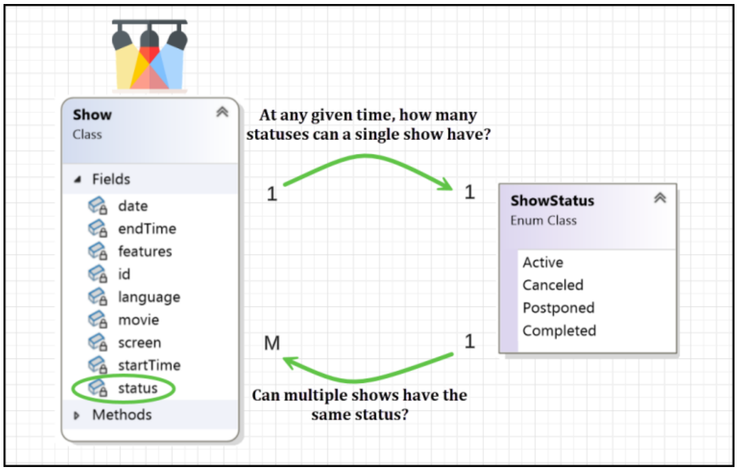
- The Show class also has non-primitive attribute **screen**.



- ID of '1' side on 'M' side.
- So, 'Shows' table should have Screens table ID column. Let's add it to Shows table.

show_id	start_time	end_time	date	language	movie_id	Screen_id

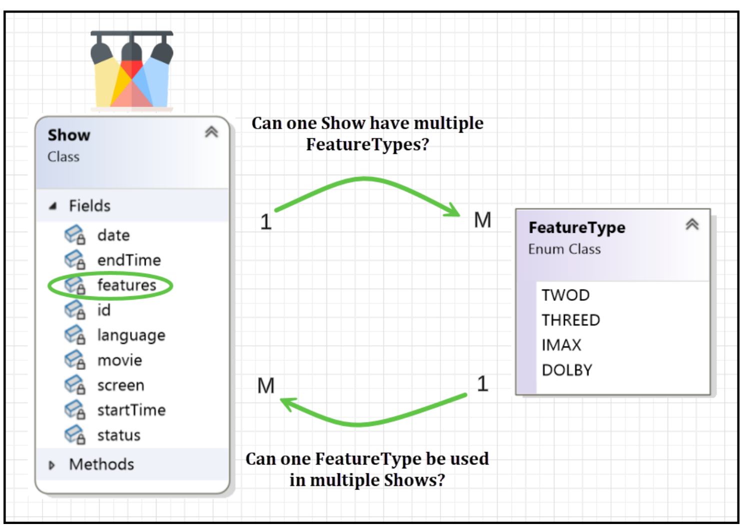
- The Show class also has non-primitive attribute status of type ShowStatus.



- ID of '1' side on 'M' side.
- So, 'Shows' table should have Show_status table ID column. Let's add it to Shows table.

show_id	start_time	end_time	date	language	movie_id	screen_id	status_id

- The Show class also has non-primitive attribute features of type FeatureType.



- It is M:M relation. To represent this relationship, we use a mapping table (junction table). Create `Show_Features` table (Mapping Table).
- We already have `Features` table. To create `Show_Features` table, we need to have '`Shows`' table first.
- Let's create show complete show table…

```
CREATE TABLE SHOWS (
    SHOW_ID INT PRIMARY KEY,
    START_TIME DATETIME NOT NULL,
    END_TIME DATETIME NOT NULL,
    DATE DATE NOT NULL,
    LANGUAGE VARCHAR(50) NOT NULL,
    MOVIE_ID INT NOT NULL,
    SCREEN_ID INT NOT NULL,
    STATUS_ID INT NOT NULL,
    FOREIGN KEY (MOVIE_ID) REFERENCES MOVIES(MOVIE_ID),
    FOREIGN KEY (SCREEN_ID) REFERENCES SCREENS(SCREEN_ID),
    FOREIGN KEY (STATUS_ID) REFERENCES SHOWSTATUS(STATUS_ID)
);
```

show_id	start_time	end_time	date	language	movie_id	screen_id	status_id

- Let's create `Show_Features` table

```
CREATE TABLE SHOW_FEATURES (
    SHOW_ID INT,
    FEATURE_ID INT,
    PRIMARY KEY (SHOW_ID, FEATURE_ID),
    FOREIGN KEY (SHOW_ID) REFERENCES SHOW(ID),
    FOREIGN KEY (FEATURE_ID) REFERENCES FEATURES(FEATURE_ID)
);
```

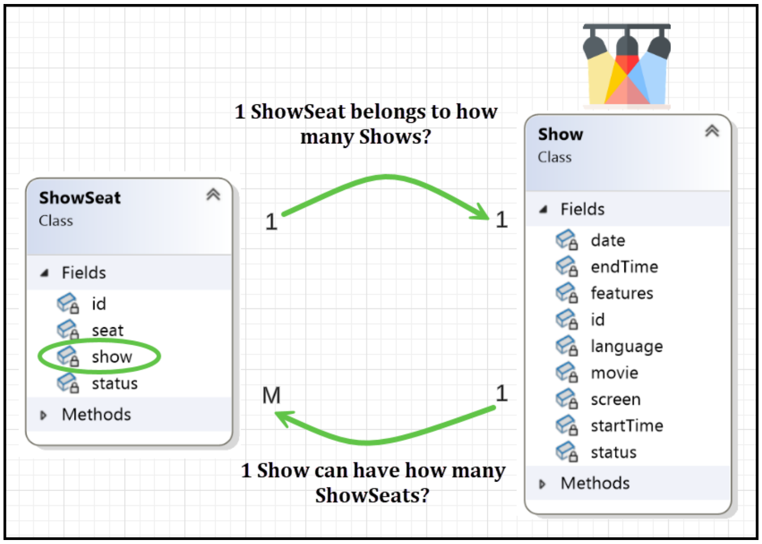
- `Show_Features` Table

show_id	feature_id

7. The `ShowSeat` **`class`**
    - We created this `ShowSeat` **`class`**, because
        - A **`seat`** exists in a theater, but its **`availability`**, **`price`**, and **`booking status`** depend on the specific **`show`**.
        - A single **`seat`** (e.g., `Seat` A1) can be part of multiple **`shows`** (e.g., 12 PM and 3 PM show).
            - The same **`seat`** in different **`shows`** may have different availability.

- The `price` may change based on the time or demand for that `show`.

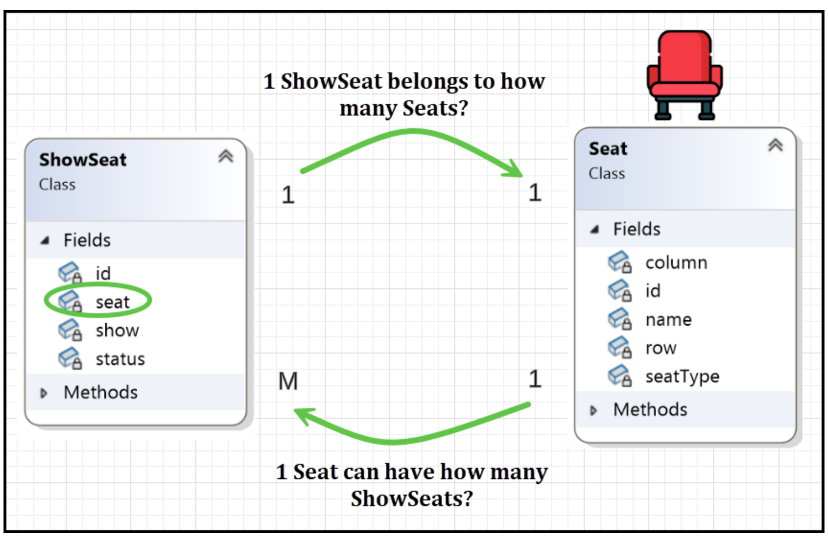
- Thus, a direct mapping between `Show` and `Seat` is required to track these variations, hence `ShowSeat class`.
- Let's see the cardinality between `ShowSeat class`, and `Show class`.



- ID of '1' side on 'M' side.
- So, '`ShowSeats`' table should have `Shows` table ID column. Let's add it to `ShowSeats` table.

show_seat_id	show_id	

- The `ShowSeat class` also has non-primitive `seat` attribute of type `Seat`.

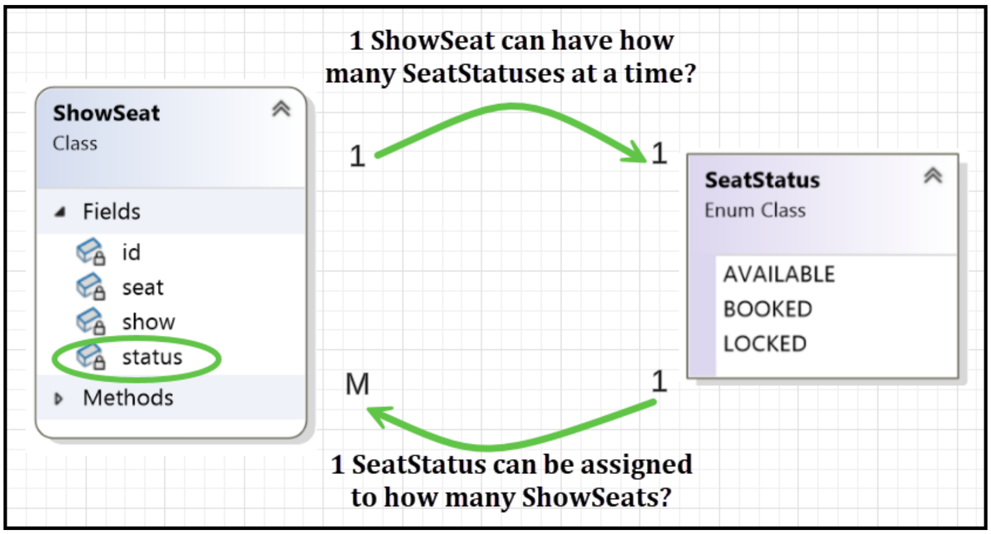


- One `Seat` can be part of multiple `ShowSeats` (because the same seat can be booked for different shows).
- One `ShowSeat` is associated with exactly one `Seat` (each ShowSeat tracks a seat's availability, price, and status for a specific show).

- ID of '1' side on 'M' side.
- So, '`ShowSeats`' table should have `Seats` table ID column. Let's add it to `ShowSeats` table.

show_seat_id	show_id	seat_id

- The `ShowSeat` **`class`** also has non-primitive **`status`** attribute of type `SeatStatus`.



- ID of '1' side on 'M' side.
- So, '`Show_Seats`' table should have `Seat_status` table ID column. Let's add it to `Show_Seats` table.
- The `Show_Seats` table

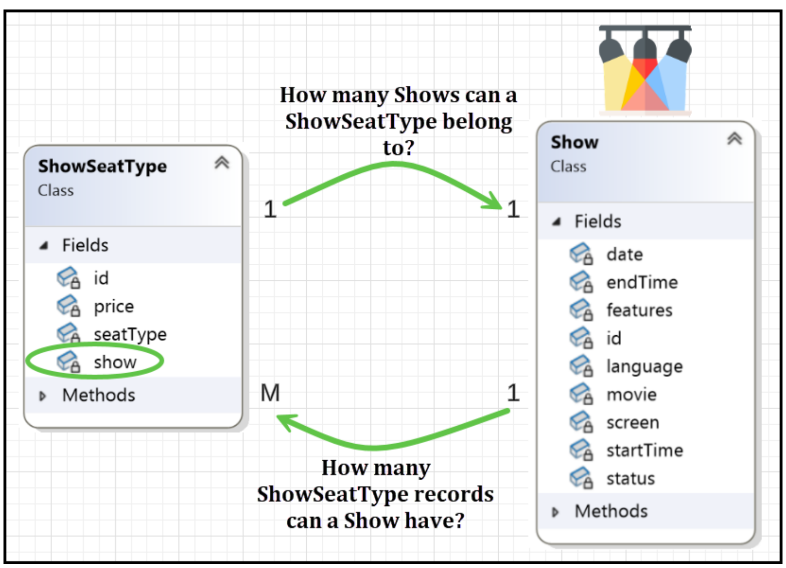
show_seat_id	show_id	seat_id	seat_status_id

```
CREATE TABLE SEAT_STATUSES (
    SEAT_STATUS_ID INT PRIMARY KEY,
    STATUS_NAME VARCHAR(20) UNIQUE NOT NULL
);
```

```
CREATE TABLE SHOW_SEATS (
    SHOW_SEAT_ID INT PRIMARY KEY,
    SHOW_ID INT,
    SEAT_ID INT,
    SEAT_STATUS_ID INT,
    FOREIGN KEY (SHOW_ID) REFERENCES SHOWS(SHOW_ID),
    FOREIGN KEY (SEAT_ID) REFERENCES SEATS(SEAT_ID),
    FOREIGN KEY (SEAT_STATUS_ID) REFERENCES SEAT_STATUSES(SEAT_STATUS_ID)
);
```

8. The `ShowSeatType` `class`, `Show` `class` and `SeatType` `enum`

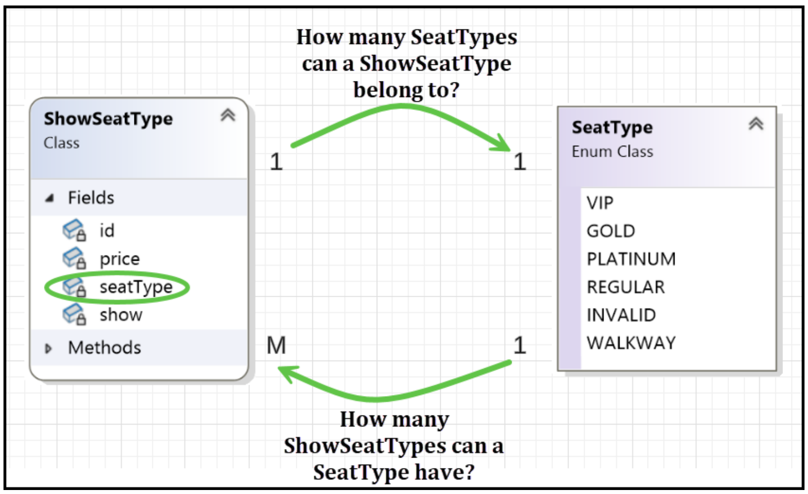
- The `ShowSeatType` `class` was introduced to improve data organization and optimize storage in the database. Here's why:
    - **Avoid Redundancy**: Instead of repeatedly storing the same price for multiple seats with the same `SeatType` (e.g., all "GOLD" seats for a specific show), the price is stored just once in the `ShowSeatType` table. This reduces data duplication.
    - **Better Maintainability**: If the price for a specific `SeatType` (e.g., "GOLD") changes for a show, you only need to update the price in one place, making maintenance easier and less error-prone.
    - **Improved Query Performance**: With a separate `ShowSeatType` `class`, lookups and updates for seat prices are more efficient since data is centralized in one table rather than scattered across multiple rows in the `ShowSeat` table.
- The `ShowSeatType` `class` has non-primitive attribute `show` of type `Show`.



- ID of '1' side on 'M' side.
- So, 'Show_Seat_Types' table should have Shows table ID column. Let's add it to Show_Seat_Types table.
- The Show_Seat_Types table

show_seat_type_id	price	show_id

- The ShowSeatType class also has non-primitive attribute seatType of type SeatType.



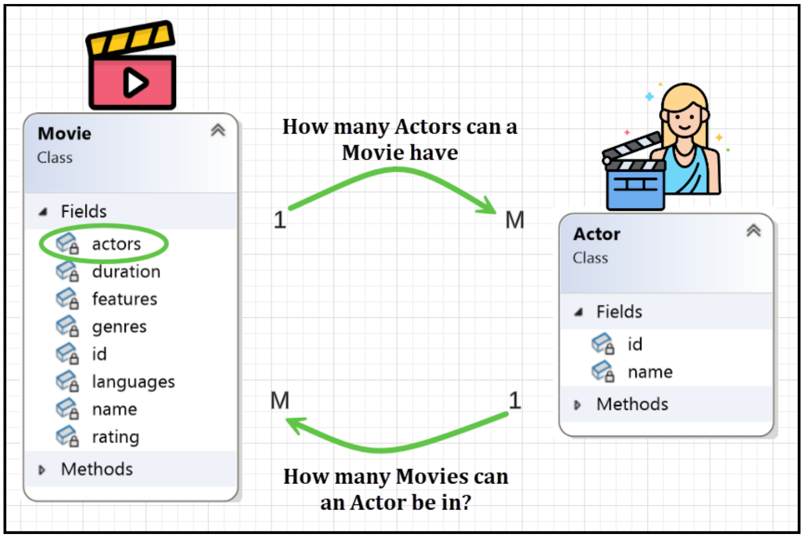
- ID of '1' side on 'M' side.
- So, 'Show_Seat_Types' table should have Seat_Types table ID column. Let's add it to Show_Seat_Types table.
- The Show_Seat_Types table

show_seat_type_id	price	show_id	seat_type_id

```
CREATE TABLE SHOW_SEAT_TYPES (
    SHOW_SEAT_TYPE_ID INT PRIMARY KEY,
    PRICE DECIMAL(10, 2),
    SHOW_ID INT,
    SEAT_TYPE_ID INT,
    FOREIGN KEY (SHOW_ID) REFERENCES SHOWS(SHOW_ID),
    FOREIGN KEY (SEAT_TYPE_ID) REFERENCES SEAT_TYPES(SEAT_TYPE_ID)
);
```

9. The `Movie class`, `Actor class` and `FeatureType enum`

- The `Movie class` also has non-primitive attribute **`actors`** of type `Actor`.

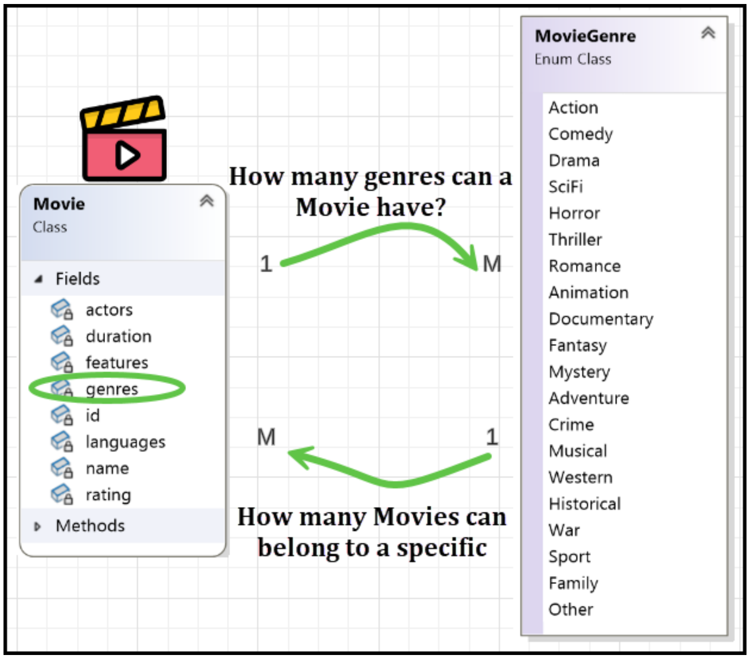


- A **single movie** can have **many actors**, and a **single actor** can act in **many movies.**
- Thus, this is a many-to-many (**M:M**) relationship, requiring a mapping table.
- The `Movie_Actors` table

movie_id	actor_id

```
CREATE TABLE MOVIE_ACTORS (
    MOVIE_ID INT NOT NULL,
    ACTOR_ID INT NOT NULL,
    PRIMARY KEY (MOVIE_ID, ACTOR_ID),
    FOREIGN KEY (MOVIE_ID) REFERENCES MOVIES(ID),
    FOREIGN KEY (ACTOR_ID) REFERENCES ACTORS(ID)
);
```

- The `Movie` `class` also has non-primitive attribute **`genres`** of type `MovieGenre`.

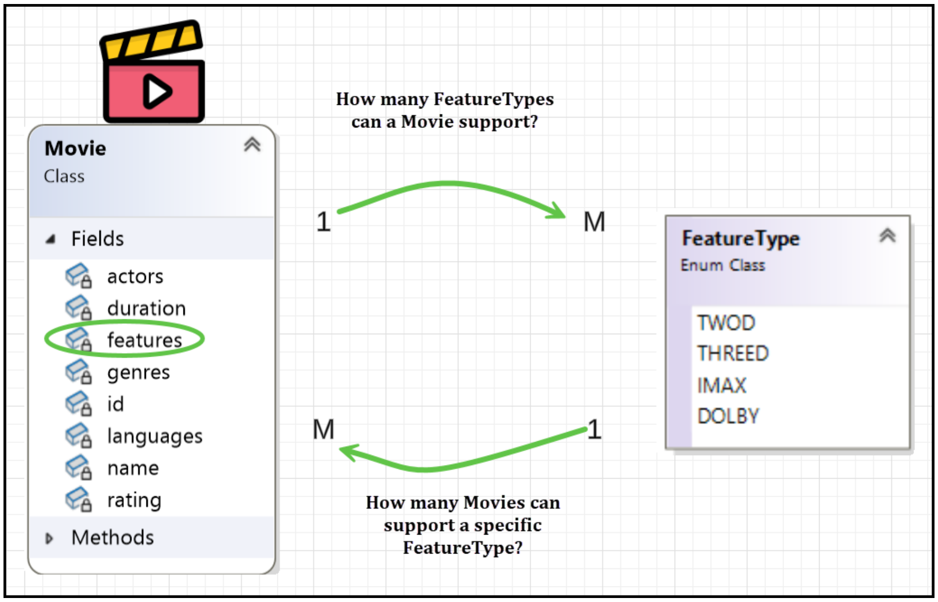


- A **single movie** can belong to **multiple genres** (e.g., *Inception* is **SciFi, Thriller, and Mystery**). A **single genre** can have **multiple movies** (e.g., *SciFi* includes *Inception*, *Interstellar*, *The Matrix*).
- Thus, this is a **many-to-many (M:M) relationship**, requiring a **mapping table.**
- The `Movie_Genres` table

movie_id	genre_id

```
CREATE TABLE MOVIE_GENRES (
    MOVIE_ID INT NOT NULL,
    GENRE_ID INT NOT NULL,
    PRIMARY KEY (MOVIE_ID, GENRE_ID),
    FOREIGN KEY (MOVIE_ID) REFERENCES MOVIES(ID),
    FOREIGN KEY (GENRE_ID) REFERENCES MOVIEGENRES(ID)
);
```

- The `Movie` `class` also has non-primitive attribute `features` of type `FeatureType`.

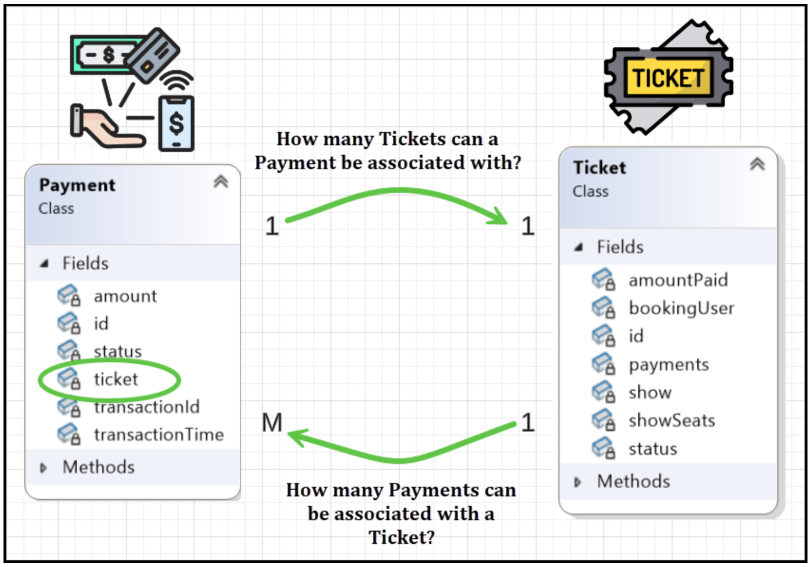


- A **single movie** can belong to **multiple genres** (e.g., *Inception* is **SciFi, Thriller, and Mystery**), and a **single genre** can have **multiple movies** (e.g., *SciFi* includes *Inception*, *Interstellar*, *The Matrix*).
- Thus, this is a **many-to-many (M:M) relationship**, requiring a **mapping table**.
- The `Movie_FeatureTypes` table.

movie_id	feature_type_id

10. The `Payment` **`class`**, `Ticket` **`class`** and `PaymentStatus` **`enum`**

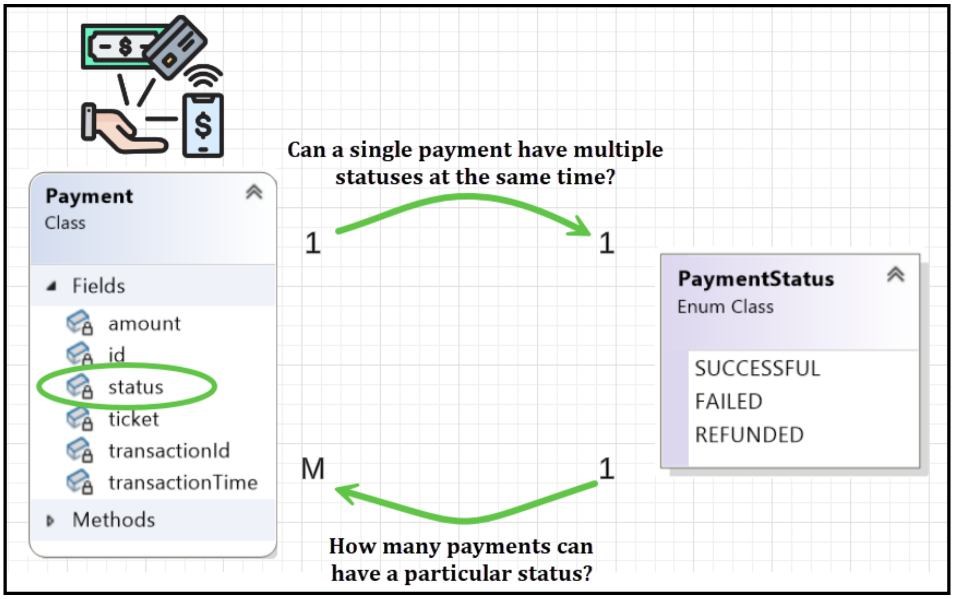
- The `Payment` **`class`** has non-primitive attribute **`ticket`** of type `Ticket`.



- A single ticket may be paid through **multiple partial payments**, **split payments**, or **retry attempts** (e.g., part credit card, part wallet).
- A single payment corresponds to **one ticket** only.
- ID of '1' side on 'M' side.
- So, '`Payments`' table should have `Tickets` table ID column. Let's add it to `Payments` table.
- The `Payments` table

id	transaction_id	amount	transaction_time	ticket_id

- The `Payment` **`class`** has non-primitive attribute **`status`** of type `PaymentStatus`.
  - One `Payment` can have one status.
  - One `PaymentStatus` (e.g., SUCCESSFUL) can apply to many payments.
- ID of '1' side on 'M' side.
- So, '`Payments`' table should have `Payment_statuses` table ID column. Let's add it to `Payments` table.



- The `Payments` table

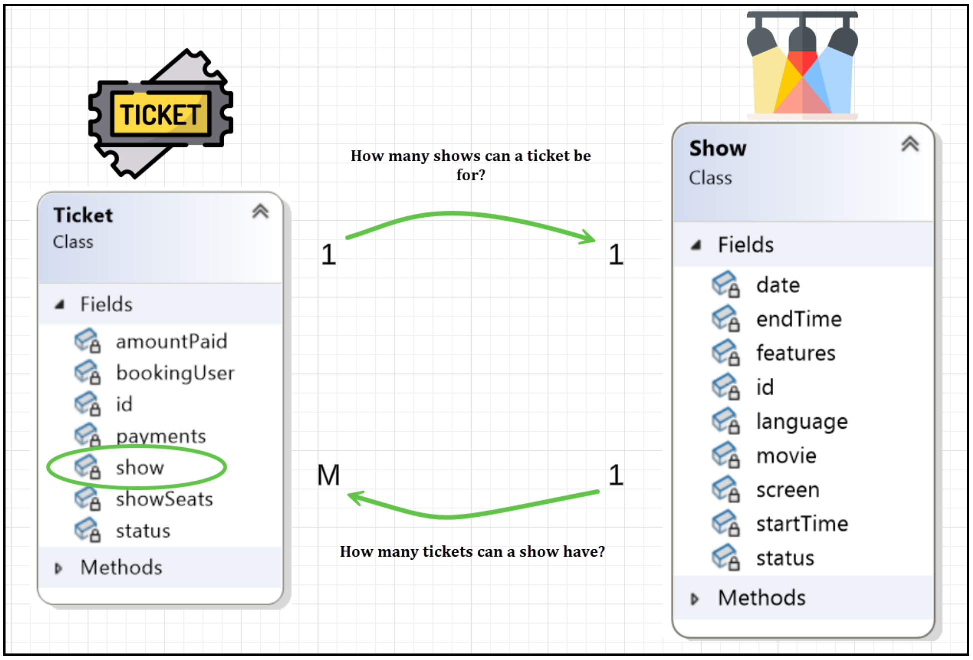
id	transaction_id	amount	transaction_time	ticket_id	payment_status_id

```
CREATE TABLE PAYMENT_STATUSES(
    PAYMENT_STATUS_ID INT PRIMARY KEY,
    VALUE VARCHAR(255) UNIQUE
);
```

```
CREATE TABLE PAYMENTS (
    ID INT PRIMARY KEY,
    TRANSACTION_ID INT NOT NULL,
    AMOUNT DECIMAL(10, 2) NOT NULL,
    PAYMENT_STATUS_ID INT,
    TICKET_ID INT,
    TRANSACTION_TIME DATETIME NOT NULL,
    FOREIGN KEY (PAYMENT_STATUS_ID) REFERENCES PAYMENT_STATUSES (PAYMENT_STATUS_ID),
    FOREIGN KEY (TICKET_ID) REFERENCES TICKETS(ID)
);
```

11. The `Ticket class`, `Show class`, `ShowSeat class`, `TicketStatus enum` and `User class`

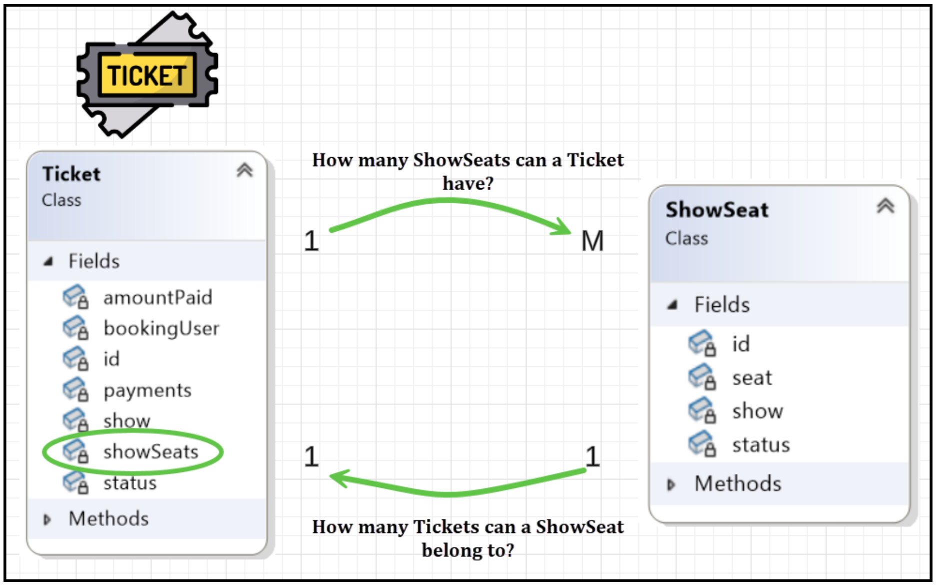
- The `Ticket class` has non-primitive attribute **`show`** of `Show`.



- ID of '1' side on 'M' side.
- So, '`Tickets`' table should have '`Shows`' table ID column. Let's add it to `Tickets` table.
- The `Tickets` table

id	amount_paid	show_id

- The `Ticket class` has non-primitive attribute **`showSeats`** of `ShowSeat`.
  - `Ticket` → `ShowSeat`
    - A `Ticket` represents a booking.
    - One ticket can include multiple `ShowSeats` (e.g., A1, A2, A3).
    - So, the cardinality is: One `Ticket` → Many `ShowSeats`
  - `ShowSeat` → `Ticket`
    - Each `ShowSeat` can only be booked by one `Ticket`.
    - So, one `ShowSeat` belongs to at most one `Ticket` (or null if it's still available).
    - So, the cardinality is: One `ShowSeats` -> One `Ticket`

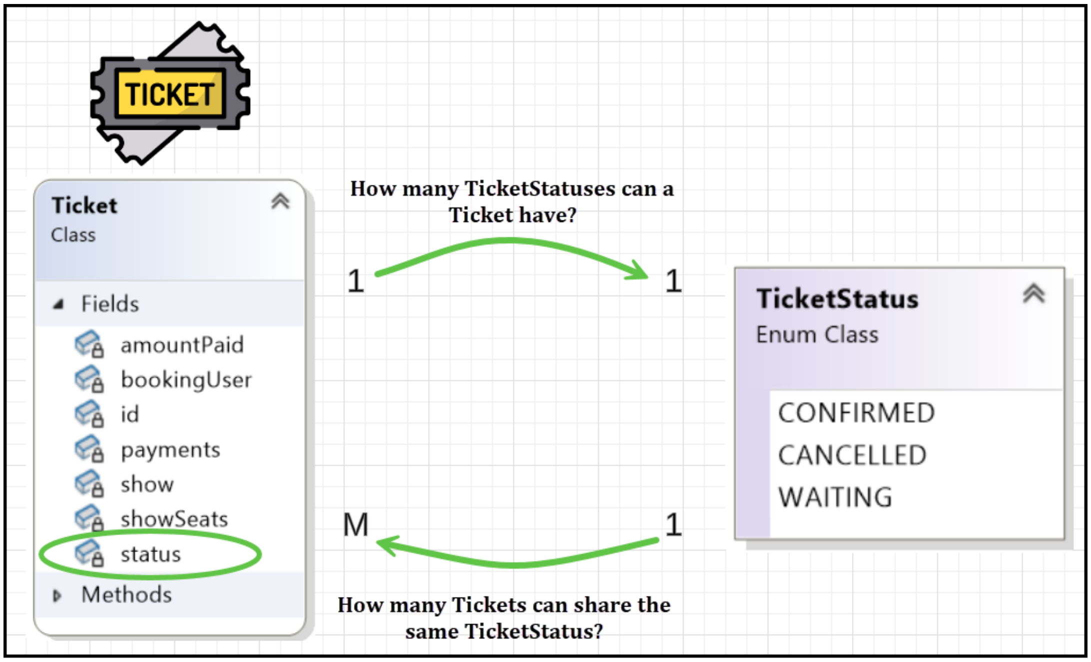


- ID of '1' side on 'M' side.
- So, 'ShowSeats' table should have 'Tickets' table ID column. Let's add it to ShowSeats table.
- The Show_Seats Table

show_seat_id	show_id	seat_id	seat_status_id	ticket_id

```
CREATE TABLE SHOW_SEATS (
    SHOW_SEAT_ID INT PRIMARY KEY,
    SHOW_ID INT,
    SEAT_ID INT,
    SEAT_STATUS_ID INT,
    TICKET_ID INT,  -- New column to reflect 1 Ticket : M ShowSeats
    FOREIGN KEY (SHOW_ID) REFERENCES SHOWS(SHOW_ID),
    FOREIGN KEY (SEAT_ID) REFERENCES SEATS(SEAT_ID),
    FOREIGN KEY (SEAT_STATUS_ID) REFERENCES SEAT_STATUSES(SEAT_STATUS_ID),
    FOREIGN KEY (TICKET_ID) REFERENCES TICKETS(TICKET_ID)
);
```

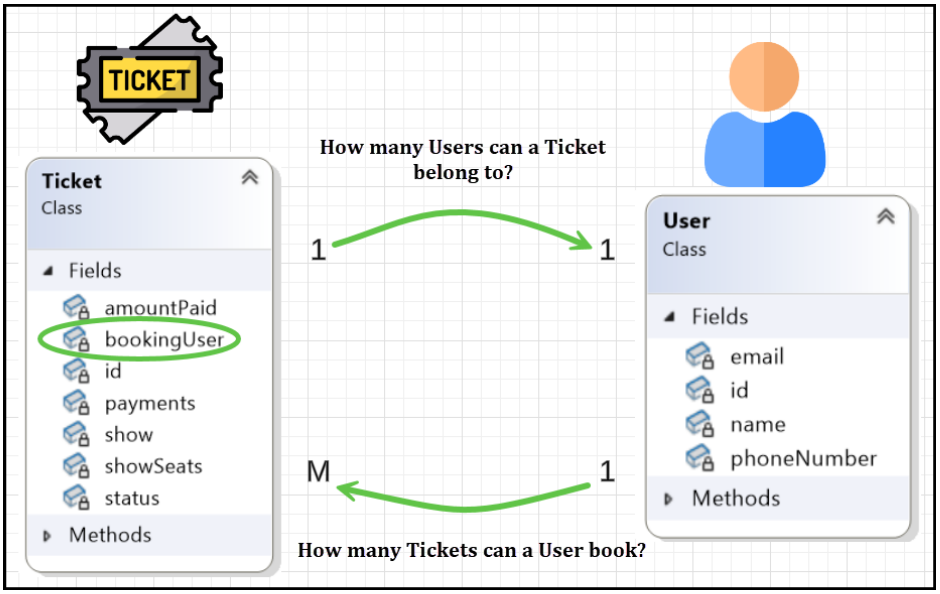
- The Ticket class has non-primitive attribute status of TicketStatus.



- Each Ticket has only one status: CONFIRMED, CANCELLED, or WAITING.
- Each TicketStatus can be associated with many tickets. For example, many tickets can be in the CONFIRMED status.
- ID of '1' side on 'M' side.
- So, 'Tickets' table should have 'TicketStatus' table ID column. Let's add it to Tickets table.
- The Tickets Table

id	amount_paid	show_id	status_id

- The `Ticket` `class` has non-primitive attribute `bookingUser` of `User`.



- ID of '1' side on 'M' side.
- So, '`Tickets`' table should have '`Users`' table ID column. Let's add it to `Tickets` table.
- The Tickets Table

id	amount_paid	show_id	status_id	booking_user_id

```
CREATE TABLE TICKETS (
    ID INT PRIMARY KEY,
    SHOW_ID INT NOT NULL,
    AMOUNT_PAID DOUBLE,
    STATUS_ID INT NOT NULL,
    BOOKING_USER_ID INT NOT NULL,
    FOREIGN KEY (SHOW_ID) REFERENCES SHOWS(ID),
    FOREIGN KEY (BOOKING_USER_ID) REFERENCES USERS(ID),
    FOREIGN KEY (STATUS_ID) REFERENCES TICKETSTATUS(ID)
);
```

Model-View-Controller (MVC) + Service Layer + Repository Pattern

- Created a visual studio solution with the below mentioned projects and folder structure.

```
BookMyShow
        ├───BMS.Common
        │    ├───include
        │    └───src
        ├───BMS.Controller
        │    ├───include
        │    └───src
        ├───BMS.DTO
        │    ├───include
        │    └───src
        ├───BMS.Model
        │    ├───include
        │    └───src
        ├───BMS.MySqlRepository
        │    ├───include
        │    └───src
        ├───BMS.Repository
        │    ├───include
        ├───BMS.Service
        │    ├───include
        │    └───src
        └───BMS.UI
```

Current Flow: (List all the movies)

1. UI Layer (`BMSUI`- View)

- The UI (Qt-based) contains buttons and user interaction elements.
- The **UI initializes the** `MovieController` with `MovieService`, which internally depends on `MySqlMovieRepository`.
- When a button ('List All Movies') is clicked, it calls the `MovieController`'s method.
- **UI initializing the controller with the service** a good approach?
    - Yes, **for small to medium applications**, this is **a practical and perfectly acceptable approach**.
    - Better approach is to use Dependency Inversion.

```
int main(int argc, char* argv[]) {
   QApplication app(argc, argv);

   auto repo = std::make_shared<MySqlMovieRepository>();
   auto service = std::make_shared<MovieService>(repo);
   auto controller = std::make_shared<MovieController>(*service);

   BMSUI ui(controller); // Pass controller via constructor injection
   ui.show();

   return app.exec();
}
```

2. Controller Layer (`MovieController`)

- The `MovieController` receives the UI request and delegates the call to the Service Layer (`MovieService`).
- It does not contain business logic—only delegates requests.

3. Service Layer (`MovieService`)

- The `MovieService` contains business logic.
- It calls the Repository Layer (`IMovieRepository`) to get data from the database.
- Converts `Movie` Model (database entity) to `MovieDTO` (Data Transfer Object) to avoid exposing raw database entities to the UI.

- All the logic of Price calculation, Applying discounts, Tax/fee computation, Validating booking happens here.

4. Repository Layer (`MySqlMovieRepository`)
- Responsible for fetching movies from MySQL using mysqlx API.
- Returns a `std::vector<std::shared_ptr<Movie>>` to the Service Layer.

5. Data Layer (Database)
- MySQL database holds movie records.
- Repository fetches and maps them to `Movie` objects.

Final Summary

Layer	Responsibility
UI (`BMSUI`)	Handles user interactions, calls `MovieController`, displays data.
Controller (`MovieController`)	Delegates UI requests to `MovieService`.
Service (`MovieService`)	Business logic, calls `IMovieRepository`, converts `Movie` → `MovieDTO`.
Repository (`MySqlMovieRepository`)	Fetches data from MySQL and returns `std::vector<Movie>`.
Database (MySQL)	Stores movie records.