

CIS 5500: Database and Information Systems

Homework 2: Relational DB Design

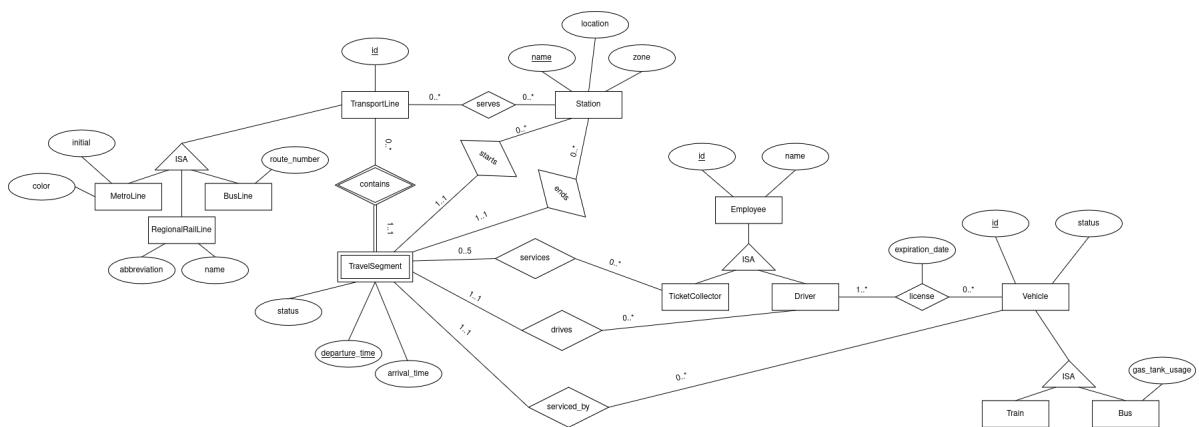
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Mustafa Rashid

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1. Question 1 (30 points)

A. (20 points)



B. (5 points)

Ans: A **TravelSegment** could start or end at a **Station** that is not served by its associated **TransportLine**. This would be valid in the ER diagram because there is no constraint requiring the start and end stations of a **TravelSegment** to be among the stations served by that **TransportLine**.

To enforce this constraint, we must require that the start and end stations of a **TravelSegment** appear in the **Serves** relationship with the same **TransportLine**. In other words, a **TravelSegment** may only start and end at stations that are served by its associated **TransportLine**.

C. (5 points)

Ans: Add an attribute to the relationship **Serves** called `no_of_platforms`. Add an attribute to the **Station** entity set called `maximum_no_of_platforms`.

We then add a constraint that, for each **Station**, the sum of `no_of_platforms` across all **TransportLines** assigned to that **Station** does not exceed `maximum_no_of_platforms`.

2. Question 2 (20 points)**A. 12 points****Ans:**

```
CREATE TABLE Artists(
ArtistID INT PRIMARY KEY,
Name VARCHAR(50) NOT NULL,
Nationality VARCHAR(50) NOT NULL,
BirthYear INT(4) NOT NULL
);

CREATE TABLE Customers(
CustomerID INT PRIMARY KEY,
Name VARCHAR(50) NOT NULL,
Email VARCHAR(100) NOT NULL
);

CREATE TABLE Artworks(
ArtworkID INT PRIMARY KEY,
OwnerID INT FOREIGN KEY REFERENCES Customers(CustomerID),
CreatorID INT FOREIGN KEY REFERENCES Artists(ArtistID),
Title VARCHAR(50) NOT NULL,
AYear INT(4),
Medium VARCHAR(50)
);

CREATE TABLE Exhibitions(
ExhibitionID INT PRIMARY KEY,
ExhibitionName VARCHAR(100) NOT NULL
);

CREATE TABLE DisplayedIn(
ArtworkID INT,
ExhibitionID INT,
PRIMARY KEY (ArtworkID, ExhibitionID),
FOREIGN KEY (ArtworkID) REFERENCES Artworks(ArtworkID),
FOREIGN KEY (ExhibitionID) REFERENCES
    Exhibitions(ExhibitionID),
StartDate DATE,
EndDate DATE
);
```

B. 4 points

Ans: We can create an assertion as follows

```
CREATE ASSERTION exhibition_cardinality
CHECK (
    NOT EXISTS (
        SELECT ExhibitionID
        FROM DisplayedIn
        GROUP BY ExhibitionID
        HAVING COUNT(*) NOT BETWEEN 5 AND 20
    )
);
```

C. 4 points

Ans: We change the cardinality on the Artists entity set from 0..* to 1..*. We also add the following assertion

```
CREATE ASSERTION artist_has_artwork
CHECK (
    NOT EXISTS (
        SELECT *
        FROM Artists A
        WHERE NOT EXISTS (
            SELECT *
            FROM Artworks W
            WHERE W.CreatorID = A.ArtistID
        )
    )
);
```

3. Question 3 (40 points)**A. 4 points**

Ans: No they cannot.

If they did then the functional dependencies $\text{PassengerID} \rightarrow \text{PassengerEmail}$ and $\text{PassengerEmail} \rightarrow \text{PassengerID}$ would not hold.

B. 4 points

Ans: Yes. The functional dependency $\text{TrainNo} \rightarrow \text{ConductorID}$ only ensures each train has one conductor, but it does not prevent multiple trains from having the same conductor.

C. 6 points

Ans: The candidate keys are $\{\text{TrainNo}, \text{PassengerID}\}$ and $\{\text{TrainNo}, \text{PassengerEmail}\}$. TrainNo determines DepartureDate and ConductorID , PassengerID determines PassengerEmail , and together TrainNo and PassengerID determine SeatNo and BaggageQty , giving all attributes. Since $\text{PassengerEmail} \leftrightarrow \text{PassengerID}$, replacing PassengerID with PassengerEmail also forms a key.

D. 5 points

Ans: The dependency $\text{TrainNo} \rightarrow \text{DepartureDate}$, ConductorID violates 3NF because TrainNo is not a superkey and neither DepartureDate nor ConductorID is a member of any candidate key. All other dependencies satisfy 3NF because either the left-hand side is a superkey or the right-hand side attribute is a member of some candidate key.

E. 2 points

Ans: Yes, the decomposition has a lossless join.

$$R_1 \cap R_2 = \{\text{TrainNo}, \text{PassengerID}\},$$

which is a candidate key of R and therefore a superkey of R_2 . By the lossless-join condition, a decomposition is lossless if the common attributes form a superkey of at least one of the relations, so the join is lossless.

F. 2 points

Ans: No, this decomposition does not have a lossless join.

$$R_1 \cap R_2 = \{\text{PassengerID}\},$$

which is neither a superkey of R_1 nor of R_2 (PassengerID alone does not determine DepartureDate or ConductorID, nor SeatNo or BaggageQty), so the lossless-join condition fails.

G. 12 points

Ans: We first compute a minimal cover F_c by splitting all RHS, removing redundant attributes from LHS, and removing redundant FDs:

$$F_c = \{ \text{TrainNo} \rightarrow \text{DepartureDate}, \text{TrainNo} \rightarrow \text{ConductorID}, \text{PassengerID} \rightarrow \text{SeatNo}, \text{PassengerID} \rightarrow \text{BaggageQty} \}$$

$\text{TrainNo}, \text{PassengerID} \rightarrow \text{SeatNo}, \text{TrainNo}, \text{PassengerID} \rightarrow \text{BaggageQty} \}$

Grouping by LHS and creating one relation per group gives:

Relation	Attributes	Preserved FDs
R_1	(TrainNo, DepartureDate, ConductorID)	$\text{TrainNo} \rightarrow \text{DepartureDate}, \text{ConductorID}$
R_2	(PassengerID, PassengerEmail)	$\text{PassengerID} \leftrightarrow \text{PassengerEmail}$
R_3	(TrainNo, PassengerID, SeatNo, BaggageQty)	$\text{TrainNo}, \text{PassengerID} \rightarrow \text{SeatNo}, \text{PassengerID} \rightarrow \text{BaggageQty}$

Since R_3 already contains the candidate key $\{\text{TrainNo}, \text{PassengerID}\}$ of R , no additional relation is needed.

H. 5 points

Ans: All three relations are in BCNF.

- R_1 : The only non-trivial FD is $\text{TrainNo} \rightarrow \text{DepartureDate}, \text{ConductorID}$, and TrainNo is the sole candidate key, so it is a superkey. BCNF holds.
- R_2 : Every non-trivial FD ($\text{PassengerID} \rightarrow \text{PassengerEmail}$ and $\text{PassengerEmail} \rightarrow \text{PassengerID}$) has a candidate key on the LHS. BCNF holds.
- R_3 : The only non-trivial FD is $\{\text{TrainNo}, \text{PassengerID}\} \rightarrow \text{SeatNo}, \text{BaggageQty}$, and $\{\text{TrainNo}, \text{PassengerID}\}$ is the candidate key. BCNF holds.