

CIS 5500: Database and Information Systems

Homework 2: Relational DB Design

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1. Question 1 (30 points)

A. (20 points)

 hw2-q1.png

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: Applying the 3NF decomposition algorithm to F (already a minimal cover):

- $\text{TrainNo} \rightarrow \text{DepartureDate}, \text{ConductorID}$: create R_1
- $\text{PassengerID} \rightarrow \text{PassengerEmail}$: create R_2
- $\text{PassengerEmail} \rightarrow \text{PassengerID}$: R_2 already contains PassengerEmail, PassengerID — skip
- $\text{TrainNo}, \text{PassengerID} \rightarrow \text{SeatNo}, \text{BaggageQty}$: create R_3

R_3 contains $\{\text{TrainNo}, \text{PassengerID}\}$, a candidate key of R — no additional relation needed.

- $R_1(\underline{\text{TrainNo}}, \text{DepartureDate}, \text{ConductorID})$
 - **Candidate Key:** $\{\text{TrainNo}\}$
 - **FDs Preserved:** $\text{TrainNo} \rightarrow \text{DepartureDate}, \text{ConductorID}$
- $R_2(\underline{\text{PassengerID}}, \text{PassengerEmail})$
 - **Candidate Keys:** $\{\text{PassengerID}\}, \{\text{PassengerEmail}\}$
 - **FDs Preserved:** $\text{PassengerID} \leftrightarrow \text{PassengerEmail}$
- $R_3(\underline{\text{TrainNo}}, \underline{\text{PassengerID}}, \text{SeatNo}, \text{BaggageQty})$
 - **Candidate Key:** $\{\text{TrainNo}, \text{PassengerID}\}$
 - **FDs Preserved:** $\text{TrainNo}, \text{PassengerID} \rightarrow \text{SeatNo}, \text{BaggageQty}$

H. 5 points

Ans:

Yes, all three relations are in BCNF. For every $X \rightarrow Y$ in F , either $X \rightarrow Y$ is

trivial or X is a superkey:

- $R_1(\text{TrainNo}, \text{DepartureDate}, \text{ConductorID})$: key = $\{\text{TrainNo}\}$. Both $\text{TrainNo} \rightarrow \text{DepartureDate}$ and $\text{TrainNo} \rightarrow \text{ConductorID}$ have TrainNo as LHS, which is a superkey.
- $R_2(\text{PassengerID}, \text{PassengerEmail})$: keys = $\{\text{PassengerID}\}$, $\{\text{PassengerEmail}\}$. $\text{PassengerID} \rightarrow \text{PassengerEmail}$ has superkey LHS, and $\text{PassengerEmail} \rightarrow \text{PassengerID}$ has superkey LHS.
- $R_3(\text{TrainNo}, \text{PassengerID}, \text{SeatNo}, \text{BaggageQty})$: key = $\{\text{TrainNo}, \text{PassengerID}\}$. Both $(\text{TrainNo}, \text{PassengerID}) \rightarrow \text{SeatNo}$ and $(\text{TrainNo}, \text{PassengerID}) \rightarrow \text{BaggageQty}$ have the full key as LHS.