

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 $\text{TrainNo} \rightarrow \text{DepartureDate}, \text{ConductorID}$ 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

F. 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.

G. 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 de-

termine DepartureDate or ConductorID , nor SeatNo or BaggageQty), so the lossless-join condition fails.

H. 12 points

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

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

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

Grouping by LHS and creating one relation per group gives:

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

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

I. 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.