COMP3013 2024 Fall
Assignment 3

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Schema of the Database

The schema of a database for public transportation companies is as follows. Keys are underlined.

- $company = (\underline{cID}, cname, address, phone)$
- $route = (\underline{rID}, departure, arrival, cID)$
- $vehicle = (\underline{plateNum}, model, capacity, manufacturer, cID)$
- $driver = (\underline{dID}, name, gender, age, cID)$
- $serve = (\underline{rID, plateNum})$
- $drive = (\underline{plateNum}, dID)$

Notes:

- cID is a foreign key to $company.cID$.
- rID is a foreign key to $route.rID$.
- $plateNum$ is a foreign key to $vehicle.plateNum$.
- dID is a foreign key to $driver.dID$.

Q1.

(a) Find the ID of routes which are not served by any vehicle. You must use subqueries.

```
SELECT rID
FROM route
WHERE rID NOT IN (SELECT rID FROM serve);
```

(b) Find the name of drivers who have served the route 69 (rID). You must use subqueries.

```
SELECT name
FROM driver
WHERE dID IN (
SELECT dID
FROM drive
WHERE plateNum IN (
SELECT plateNum
FROM serve
WHERE rID = 69
)
);
```

(c) Find the name of drivers who have driven all vehicles.

```
SELECT name
FROM driver d
WHERE NOT EXISTS (
SELECT plateNum
FROM vehicle
WHERE plateNum NOT IN (
SELECT plateNum
FROM drive
WHERE drive.dID = d.dID
```

```
)
);
```

(d) Find the plate number of vehicles which have served all routes operated by "Xinhe" (company name).

```
SELECT plateNum
FROM vehicle v
WHERE NOT EXISTS (
SELECT rID
FROM route
WHERE cID = (SELECT cID FROM company WHERE cname = 'Xinhe')
AND rID NOT IN (
SELECT rID
FROM serve
WHERE serve.plateNum = v.plateNum
)
);
```

(e) Implement constraints to guarantee the gender of a driver is either "Male" or "Female" and the age is from 20 to 60.

```
ALTER TABLE driver
ADD CONSTRAINT chk_gender CHECK (gender IN ('Male', 'Female'));

ALTER TABLE driver
ADD CONSTRAINT chk_age CHECK (age BETWEEN 20 AND 60);
```

Q2.

Given an instance of a relational schema $R = \{A, B, C\}$ and the following table:

Decide whether each of the following functional dependencies is satisfied by the instance:

A	B	C
1	2	2
1	3	2
1	4	2
2	5	2

a) $A \rightarrow B$: Does not hold. For $A = 1$, B has different values (2, 3, 4).

b) $A \rightarrow C$: Holds. For each A, C is consistently 2.

c) $B \rightarrow A$: Holds. Each B value corresponds to a unique A value.

d) $B \rightarrow C$: Holds. For all B values, C is always 2.

e) $C \rightarrow A$: Does not hold. Same C (2) corresponds to different A values (1 and 2).

f) $C \rightarrow B$: Does not hold. Same C (2) corresponds to different B values (2, 3, 4, 5).

g) $AB \rightarrow C$: Holds. Each AB pair corresponds to $C = 2$.

h) $AC \rightarrow B$: Does not hold. Same AC (1,2) corresponds to different B values (2, 3, 4).

i) $BC \rightarrow A$: Holds. Each BC pair corresponds to a unique A value.

Q3.

- $R = \{A, B, C, D, E\}$
- $F = \{AB \rightarrow CD, BC \rightarrow DE, CD \rightarrow E, DE \rightarrow A\}$

a) **Find all candidate keys of R. (6 pt)**

Analyze:

To find the candidate keys, we compute the closure of various sets of attributes.

$$AB^+ = \{A, B, C, D, E\}$$

The closure of AB contains all the attributes in R, so AB is a candidate key.

Other smaller combinations of attributes do not contain all attributes in their closures, so AB is the only candidate key.

Answer:

The candidate key is AB.

b) **Decompose R into BCNF. Show the steps. (15 pt)**

A relation is in BCNF if for every functional dependency $X \to Y$, X is a superkey. Let's check each dependency:

- $AB \to CD$: AB is a superkey, so this satisfies BCNF.
- $BC \to DE$: BC is not a superkey, so this violates BCNF.

Since $BC \to DE$ violates BCNF, we need to decompose R.

- Create a relation for $BC \to DE$: $R_1(B, C, D, E)$.
- Create a relation for the remaining attributes: $R_2(A, B)$.

- $R_1(B, C, D, E)$ satisfies BCNF because BC is a superkey.
- $R_2(A, B)$ satisfies BCNF because AB is a superkey.

Answer:

The BCNF decomposition is:

$$R_1(B, C, D, E), \quad R_2(A, B)$$

c) **Does the BCNF decomposition in part b) preserve all functional dependencies? (4 pt)**

Answer:

The BCNF decomposition does not preserve all functional dependencies. Specifically, the following dependencies are not preserved:

- $CD \to E$
- $DE \to A$

These dependencies cannot be directly enforced in the decomposed relations.

d) **Decompose R into 3NF. Show the steps. (15 pt)**

A relation is in 3NF if for every functional dependency $X \to Y$, at least one of the following holds:

(a) X is a superkey, or

(b) Every attribute in Y is a prime attribute (part of a candidate key).

Checking each dependency:

- $AB \to CD$: Satisfied since AB is a superkey.
- $BC \to DE$: Violates 3NF because BC is not a superkey, and D and E are non-prime.
- $CD \to E$: Violates 3NF because CD is not a superkey, and E is non-prime.
- $DE \to A$: Violates 3NF because DE is not a superkey, and A is non-prime.

- Create a relation $R_1(B, C, D, E)$ to handle $BC \to DE$.
- Create a relation $R_2(C, D, E)$ to handle $CD \to E$.
- Create a relation $R_3(D, E, A)$ to handle $DE \to A$.

- $R_1(B, C, D, E)$ satisfies 3NF because BC is a superkey.
- $R_2(C, D, E)$ satisfies 3NF because CD is a superkey.
- $R_3(D, E, A)$ satisfies 3NF because DE is a superkey.

Answer:

$$R_1(B, C, D, E), \quad R_2(C, D, E), \quad R_3(D, E, A)$$