Exercise 3: Theoretical Problems

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7. Turn the given UML into a relational model using the techniques taught in the lectures. Remember to underline the key attributes.

Solution.

- PackageTruck(registerNumber, model, capacity)
- Delivery(date, arrivalOffice, departureOffice, deliverer, packageTruck)
- Office(name, address, openingTime, closingTime)
- Deliverer(register, name, dateOfBirth)
- Package(ID, weight, receiver, sender)
- Customer(customerID, name, address, phoneNumber, closestOffice)
- PackageType(type)
- DeliveringBy[1](package, deliveryDate, deliveryArrivalOffice)
- isAt(package, office)
- PackageTypeInfo(package, packageType)

[1]This handles the *contains* association between Delivery and Package

8. Consider the relational schema R(A, B, C, D), and the dependencies AB → C, B → D, C → A, and D → A.

(a) Is the relation in BCNF? If not, prove this by counting the closures, and then use the decomposition algorithm until all the relations are in BCNF. Document each step and prove that the decomposed relations are in BCNF.

(b) What functional dependencies hold in the new relations?

(c) List for each relation which attributes form the minimal key.

Solution.

8 $R_0 = \{A, B, C, D\}$

$S_0 = \{AB \to C,\ B \to D,\ C \to A,\ D \to A\}$

a) Is it in BCNF? NO

FD1. $AB \to C$

$\{A,B\}^+ = \{A,B,C,D\}$ (AB→C, B→D)

superkey ✓

FD2. $B \to D$

$\{B\}^+ = \{BD\}$

$\Rightarrow \{B\}^+ = \{A,B,D\}$ (B→D)

$\Rightarrow \{B\}^+ = \{A,B,C,D\}$ (AB→C) ✓ superkey

FD3 $C \to A$

$\{C\}^+ = \{A,C\}$ (C→A) ✗ not superkey

R_0 is not in BCNF

⇒ Decomposition Algorithm

Let's take FD3 which violates BCNF: $C \to A$

We split R_0 into $R_1 = \{C\}^+$ and $R_2 = \{C\} \cup (R_0 - \{C\}^+)$

$R_1 = \{A,C\}$

$R_2 = \{C\} \cup (\{A,B,C,D\} - \{A,C\})$
$= \{C\} \cup \{B,D\}$
$= \{C,B,D\}$

$R_1 = \{A,C\}$

$S_1 = \{C \to A\}$

BCNF as $\{C\}^+ = \{A,C\}$ ✓

LHS of all FD for each relation is superkey

$R_2 = \{C,B,D\}$

$S_2 = \{B \to D,\ B \to C\}$ → chain: B→D; D→A; AB→C ⇒ B→C

BCNF as $\{B\}^+ = \{C,B,D\}$ ✓ superkey

b. $R_1 = \{A,C\}$

$S_1 = \{C \to A\}$

$R_2 = \{C,B,D\}$

$S_2 = \{B \to D,\ B \to C\}$

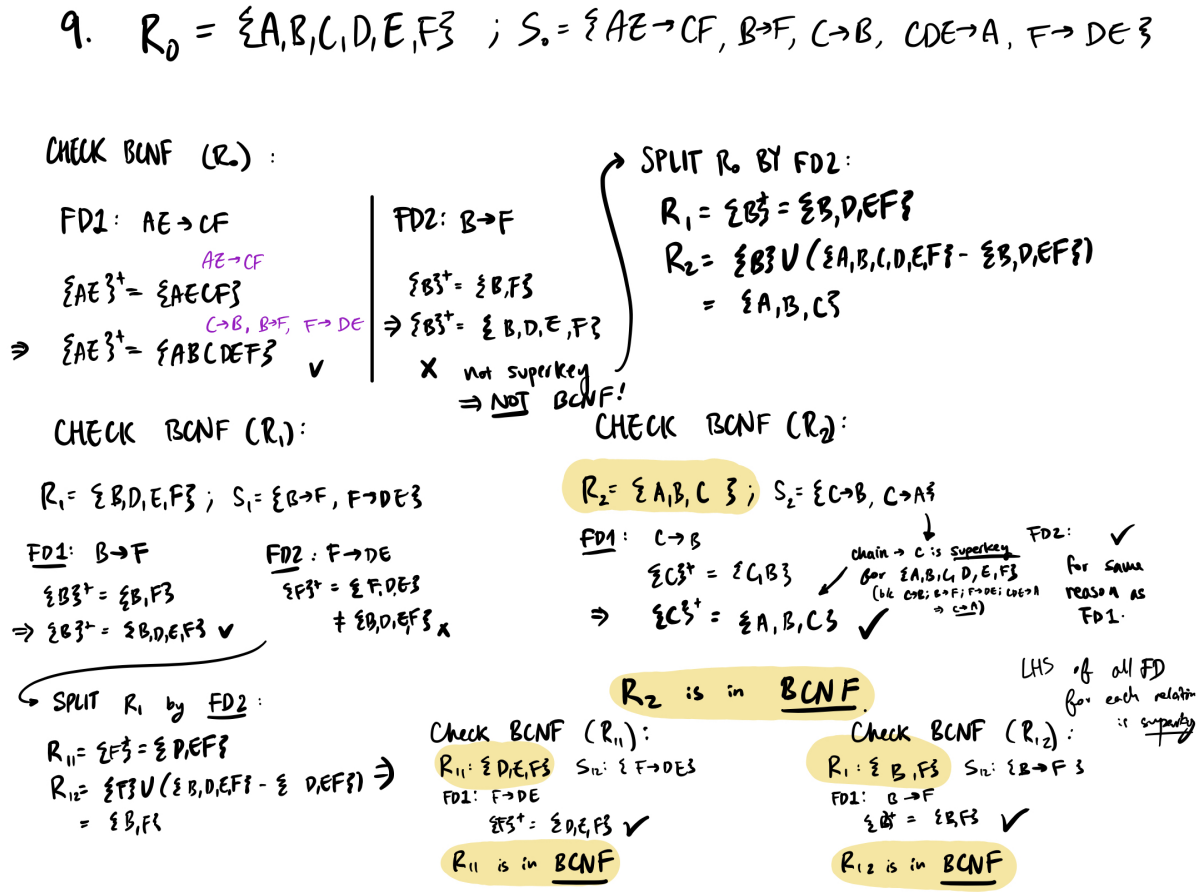
c. MINIMAL KEY

$\{C\}$

$\{B\}$

9. Consider the relational schema R(A, B, C, D, E, F) with functional dependencies AE → CF, B→F, C→B, CDE→A, and F→DE. Prove that the relation is not in BCNF and use the decomposition algorithm to break it to relations that are in BCNF. Document all the steps and reason why the resulting relations are in BCNF.

Solution.



FINAL RELATIONS: {A,B,C}, {D,E,F}, and {B,F}