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CS143-HW4

Part 1:

1. A decomposition is said to be lossless if for 2 relations R1 and R2 if,

$$R1 \cap R2 \rightarrow R1 \text{ or } R2$$

In the given case,

$$R1 \cap R2 = A$$

Given the dependencies we know,
$A \rightarrow BC, B \rightarrow D$ and $CD \rightarrow E$.

Thus, A is a candidate key for R2. Thus, $R1 \cap R2 = A \rightarrow R2$.
Hence, this is a lossless decomposition.

2. The given table is:

A	B	C
a1	b1	c2
a1	b1	c2
a2	b1	c1
a2	b1	c3

From the table, it is clear that the non-trivial functional dependencies are :

A->B and C->B

Thus, we can conclude that the set

F = {AC->B}

3. For R(A, B, C, D, E) given

$$F = \{ A \rightarrow BC, CD \rightarrow E, B \rightarrow D, E \rightarrow A\}$$

a) For E in R,
    We know that $E \rightarrow A$ and $A \rightarrow BC$. Thus $E \rightarrow BC$.

    Now, $B \rightarrow D$ and $E \rightarrow BC$. Thus, $E \rightarrow BCD$. Finally, We know that $E \rightarrow A$ and obviously $E \rightarrow E$.

    Thus, $E \rightarrow ABCDE$. So, Yes E is a candidate key.

b) For BC in R,

We know that $B \rightarrow D$ and $CD \rightarrow E$. Thus $BC \rightarrow DE$.

Now we see that $E \rightarrow A$ and we know that $BC \rightarrow BC$.

Thus, $BC \rightarrow ABCDE$. So, Yes BC is also a candidate key.

4. From the given dependencies, R is not in BCNF because A is not a candidate key of R. The set of relations of BCNF possible would be

R1(A, B, C) = {A->BC} and R2(A, D, E, F).

These now constitute a set of relations in BCNF.

5. For R(A, B, C, D) and $A \twoheadrightarrow BC$, given tuples (a,b1,c1,d1), (a,b2,c2,d2), and (a,b3,c3,d3) exist in R.

The other tuples that should also exist in R given the above are,

(a,b1,c1,d2), (a,b1,c1,d3), (a,b2,c2,d1), (a,b2,c2,d3), (a,b3,c3,d1) and (a,b3,c3,d2).

6. For R(A, B, C, D, E, F) given

$$AB \rightarrow E, AB \twoheadrightarrow C, A \twoheadrightarrow B$$
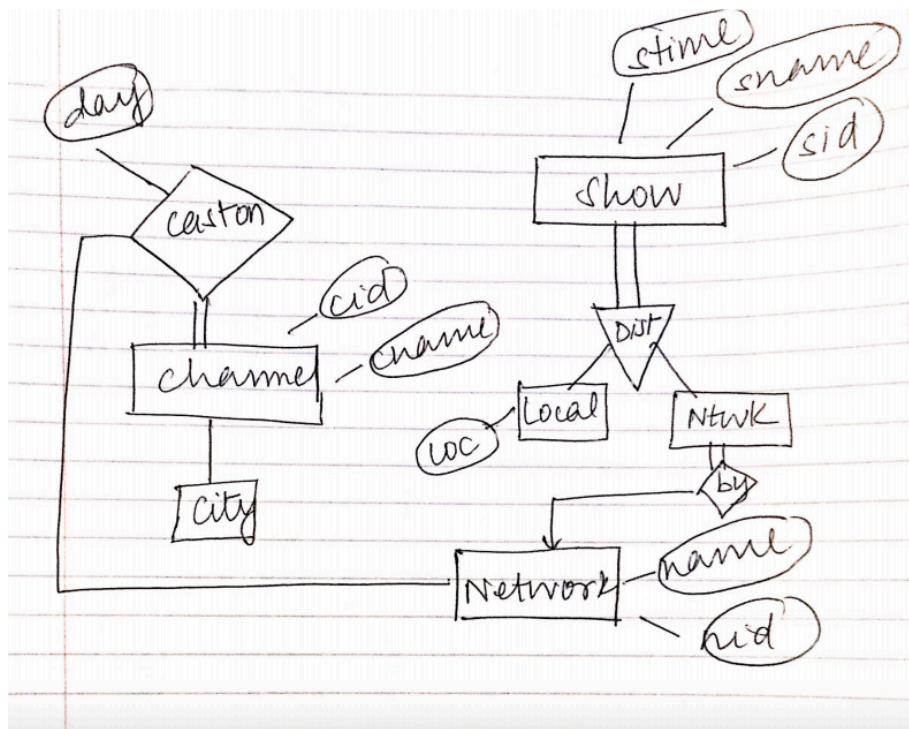
We see that R is not in 4NF because given functional dependency $AB \rightarrow E$, we conclude that ABCD is the candidate key. Thus, the MVDs $AB \twoheadrightarrow C, A \twoheadrightarrow B$ don't hold for the 4NF. Thus R is not in 4NF.

We decompose this relation into 3 different relations:
The set of Relations R1(AB), R2(AC) and R3(ADE) are a set of relations that are in 4NF now.
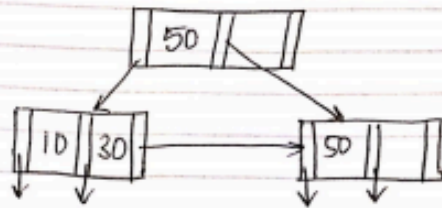

Part 2.

1.

2.
assembly(cost, <u>number</u>)
parts(<u>number</u>)
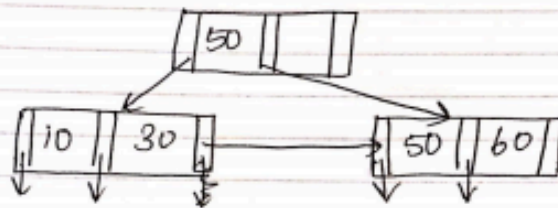composed_of(<u>number</u>, <u>part_number</u>, quantity)
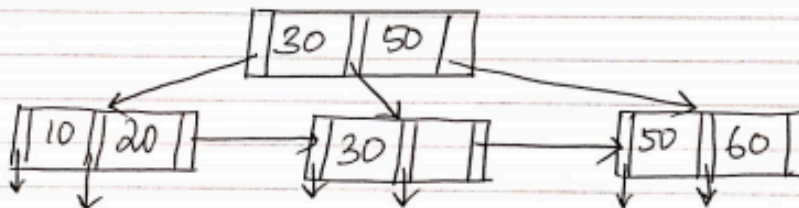
Part 3.

1.

1] Initial B+ tree,

```
          ┌──┬──┐
          │50│  │
          └──┴──┘
         ╱        ╲
   ┌──┬──┐        ┌──┬──┐
   │10│30│───────▶│50│  │
   └──┴──┘        └──┴──┘
    ↓  ↓           ↓  ↓
```

✱ AFTER inserting 60

```
          ┌──┬──┐
          │50│  │
          └──┴──┘
         ╱        ╲
   ┌──┬──┐        ┌──┬──┐
   │10│30│───────▶│50│60│
   └──┴──┘        └──┴──┘
    ↓  ↓  ↓        ↓  ↓
```

✱ AFTER inserting 20

```
          ┌──┬──┐
          │30│50│
          └──┴──┘
       ╱     │      ╲
  ┌──┬──┐  ┌──┬──┐   ┌──┬──┐
  │10│20│─▶│30│  │──▶│50│60│
  └──┴──┘  └──┴──┘   └──┴──┘
   ↓  ↓     ↓  ↓      ↓  ↓
```

✱ AFTER inserting 80

```
                ┌──┬──┐
                │50│  │
                └──┴──┘
             ╱            ╲
       ┌──┬──┐            ┌──┬──┐
       │30│  │            │80│  │
       └──┴──┘            └──┴──┘
      ╱      ╲           ╱       ╲
 ┌──┬──┐  ┌──┬──┐   ┌──┬──┐   ┌──┬──┐
 │10│20│─▶│30│  │──▶│50│60│──▶│80│  │
 └──┴──┘  └──┴──┘   └──┴──┘   └──┴──┘
  ↓  ↓     ↓         ↓  ↓      ↓
```
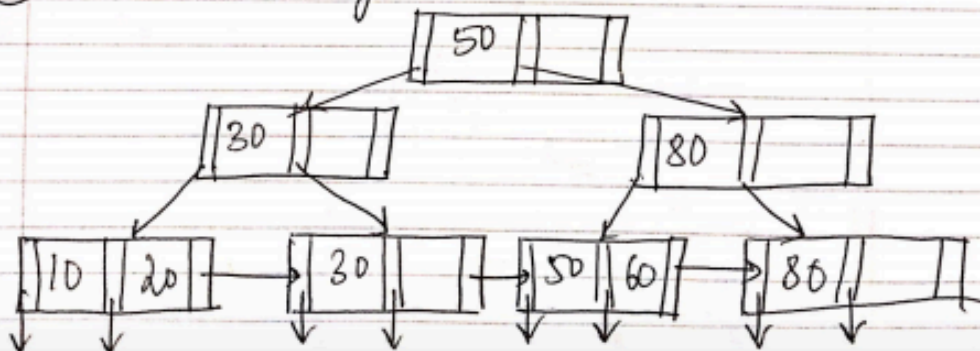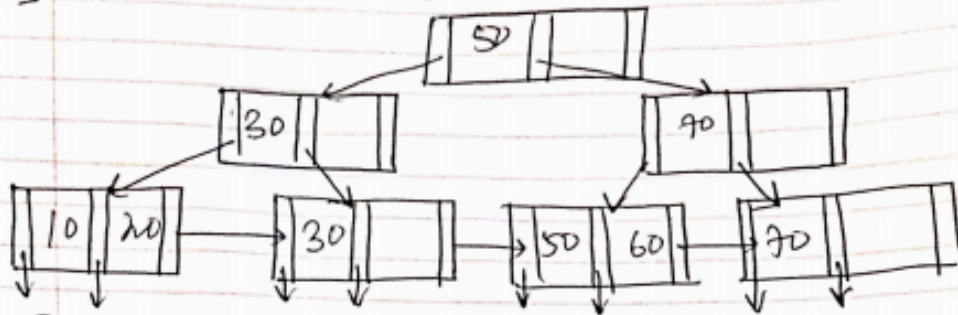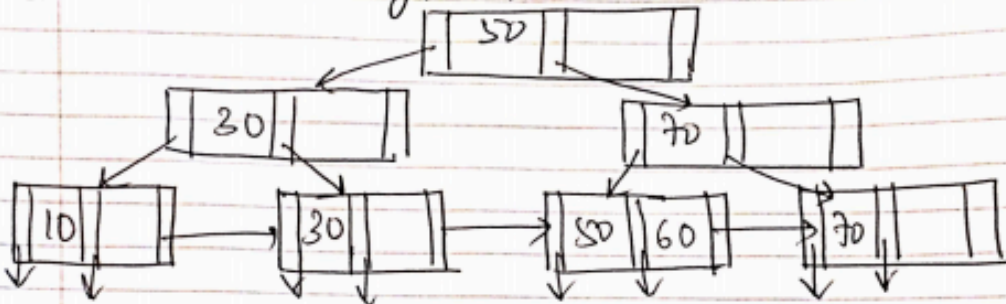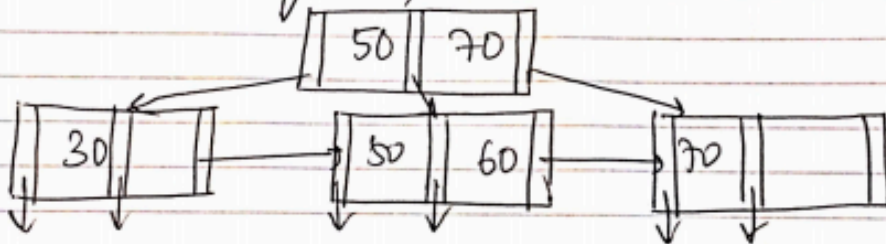
2.

2] Initial B+ Tree

* AFTER deleting 20,

* AFTER deleting 10,

* AFTER deleting 70