DBS Assignment IV

1. **Write an algorithm that can perform dependency-preserving, lossless decomposition into *Third Normal Form*.**

```
Let Fc be a canonical cover for F;
i := 0;
for each  functional dependency α → β in Fc do
  if none of the schemas Rj, 1 ≤ j  ≤ i contains  α β
        then begin
                i := i  + 1;
                Ri  := α β
             end
if none of the schemas Rj, 1 ≤ j  ≤ i contains a candidate key for R
  then begin
            i := i  + 1;
            Ri := any candidate key for R;
        end
/* Optionally, remove redundant relations */
 repeat
if any schema Rj is contained in another schema Rk
      then /* delete Rj  */
        Rj = Ri;;
        i=i-1;
return (R1, R2, ..., Ri)
```

(Source)

2. Explain *Multivalued Dependency* and *4NF* with an example.

Let R be a relation schema and let $\alpha \subseteq R$ and $\beta \subseteq R$. The **multivalued dependency**

$$\alpha \rightarrow\rightarrow \beta$$

holds on R if in any legal relation $r(R)$, for all pairs for tuples t_1 and t_2 in r such that $t_1[\alpha] = t_2[\alpha]$, there exist tuples t_3 and t_4 in r such that:

$$\begin{aligned} t_1[\alpha] = t_2[\alpha] &= t_3[\alpha] = t_4[\alpha] \\ t_3[\beta] &= t_1[\beta] \\ t_3[R - \beta] &= t_2[R - \beta] \\ t_4[\beta] &= t_2[\beta] \\ t_4[R - \beta] &= t_1[R - \beta] \end{aligned}$$

- Suppose we record names of children, and phone numbers for instructors:
  - *inst_child*(*ID*, *child_name*)
  - *inst_phone*(*ID*, *phone_number*)
- If we were to combine these schemas to get
  - *inst_info*(*ID*, *child_name*, *phone_number*)
  - Example data:
    (99999, David, 512-555-1234)
    (99999, David, 512-555-4321)
    (99999, William, 512-555-1234)
    (99999, William, 512-555-4321)

A relation schema R is in **4NF** with respect to a set D of functional and multivalued dependencies if for all multivalued dependencies in D^+ of the form $\alpha \rightarrow\rightarrow \beta$, where $\alpha \subseteq R$ and $\beta \subseteq R$, at least one of the following hold:

- $\alpha \rightarrow\rightarrow \beta$ is trivial (i.e., $\beta \subseteq \alpha$ or $\alpha \cup \beta = R$)
- α is a superkey for schema R

(Source)

3. **Decompose the following into BCNF (showing each step involved) for the given Relation and F.D below. Is your answer unique? Why?**

`RELATION R = (A, B, C, D)`

`FD = A → B, C → D, B → C`

Logically, since B, C, and D are the only attributes that can be determined via other attributes, we can deduce that the keys will contain the other attributes, thus we perform a smaller attribute closure:

```
A → ABCD
AB → ABCD
AC → ABCD
AD → ABCD
ABC → ABCD
ABD → ABCD
ACD → ABCD
```

Violations:

`B → C, C → D`

Decomposing the relations into collections of relations that are in BCNF.

Breakdown based on `B → C`
`(BC), (ABD)`
Breakdown based on `B → D`
`(AB), (BD)`

So we get R_1 `(BC)`, R_2 `(AB)`, R_3 `(BD)`.

Note: `C → D` is not preserved by the BCNF decomposition.
(Source)

4. **Find the candidate keys for relation schema R = (A, B, C, D, E). Explain (in detail) your answer.**

```
RELATION R = (A, B, C, D, E)
FD = A → BC, CD → E, B → D, E → A
```

A → BC, B → D so A → D so A → DC → E
therefore A → ABCDE

E → A, A → ABCDE, so E → ABCDE
CD → E, so CD → ABCDE
B → D, BC → CD, so BC → ABCDE

Attribute closure:

```
A → ABCDE
B → BD
C → C
D → D
E → ABCDE

AB → ABCDE
AC → ABCDE
AD → ABCDE
AE → ABCDE
BC → ABCDE
BD → BD
BE → ABCDE
CD → ABCDE
CE → ABCDE
DE → ABCDE

ABC → ABCDE
ABD → ABCDE
ABE → ABCDE
ACD → ABCDE
ACE → ABCDE
ADE → ABCDE
BCD → ABCDE
BDE → ABCDE
CDE → ABCDE

ABCD → ABCDE
ABCE → ABCDE
ABDE → ABCDE
ACDE → ABCDE
BCDE → ABCDE
```

The candidate keys are A, E, CD, and BC.

Any combination of attributes that includes those is a super key. (Source)

5. **Using Armstrong's axioms, prove :**

i. **Union Rule**

TO prove :

If $\alpha \rightarrow \beta$ and $\alpha \rightarrow \gamma$ holds, then $\alpha \rightarrow \beta\gamma$ holds.

$\alpha \rightarrow \beta$ ——— (1)

$\beta \rightarrow \gamma$ ——— (2)

Augmenting (2) with α, we get,

$\alpha \rightarrow \alpha\gamma$ ——— (3)

Augmenting (1) with γ, we get,

$\alpha\gamma \rightarrow \beta\gamma$ ——— (4)

From (3) and (4), by transitivity, we get

$\alpha \rightarrow \beta\gamma$

ii. **Pseudo Transitivity Rule**

TO prove :

if $\alpha \rightarrow \beta$ and $\gamma\beta \rightarrow \delta$ holds then $\alpha\gamma \rightarrow \delta$ holds

Given:

$\alpha \rightarrow \beta$ ——— (1)

Augmenting (1) with γ, we get,

$\alpha\gamma \rightarrow \beta\gamma$ ——— (2)

Also,

$\gamma\beta \rightarrow \delta$ ——— (3)

$\beta\gamma \rightarrow \delta$ $(\beta\gamma = \gamma\beta)$

From (2) and (3) from transitivity, we get

$\alpha\gamma \rightarrow \delta$

THANKS MAYANK AGGRAWAL FOR THE ANSWERS.