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 = R;;
          i=i-1;
return (R1, R2, ..., Ri)
```

[(Source)]

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

The *multivalued dependency* $X \twoheadrightarrow Y$ holds in a relation R if whenever we have two tuples of R that agree in all the attributes of X, then we can swap their Y components and get two new tuples that are also in R.

For example:

Drinkers(name, addr, phones,beersLiked) with MVD name $\twoheadrightarrow$ phones. If Drinkers has the two tuples:

name	addr	phones	beersLiked
sue	a	$p1$	$b1$
sue	a	$p2$	$b2$

it must also have the same tuples with phones components swapped:

name	addr	phones	beersLiked
sue	a	$p1$	$b2$
sue	a	$p2$	$b1$

To eliminate the redundancy due to the multiplicative effect of MVDs, 4NF is formed, treating MVDs as FDs for decomposition but not for finding keys.

Formally: R is in Fourth Normal Form if whenever MVD $X \twoheadrightarrow Y$ is *nontrivial* (Y is not a subset of X, and $X \cup Y$ is not all attributes), then X is a superkey.

- ✦ Remember, $X \rightarrow Y$ implies $X \twoheadrightarrow Y$, so 4NF is more stringent than BCNF.

For example: (Source)

Drinkers(name, addr, phones, beersLiked)

- FD: name $\rightarrow$ addr
- Nontrivial MVD's: name $\twoheadrightarrow$ phones and name $\twoheadrightarrow$ beersLiked.
- Only key: {name, phones, beersLiked}
- All three dependencies above violate 4NF.
- Successive decomposition yields 4NF relations:

  D1(<u>name</u>, addr)
  D2(<u>name</u>, <u>phones</u>)
  D3(<u>name</u>, <u>beersLiked</u>)

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)

$\alpha \rightarrow \gamma$ ——— (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 ANSWER(S).