

**CSc4710 / CSc6710**  
**Spring 2023**  
**Assignment 3**  
**Due Date: April 10, 2023**

**Problem 1 (10 points)**

Consider the relation  $R(M, N, O, P, Q)$  and the FD set  $F = \{M \rightarrow N, O \rightarrow Q, OP \rightarrow M\}$ .

**(i) Compute  $(MO)^+$ .**

$$(MO)^+ = \{MONQ\}$$

**(ii) Is R in 3NF?**

No, R is not in 3NF because  $M \rightarrow N$  and since M and N are both non-prime attributes, there is a transitive dependency which violates 3NF.

**(iii) Is R in BCNF?**

No, if R is not in 3NF then it cannot be in BCNF

**Problem 2 (30 points)**

Consider the relation  $R(P, Q, S, T, U, V, W)$  and the FD set  $F = \{PQ \rightarrow S, PS \rightarrow Q, PT \rightarrow U, Q \rightarrow T, QS \rightarrow P, U \rightarrow V\}$ . For each of the following relations, do the following:

- (i) List the set of dependencies that hold over the relation and compute a minimal cover.
- (ii) Name the strongest normal form that is not violated by the relation containing these attributes.
- (iii) Decompose it into a collection of BCNF relations if it is not in BCNF.

(a)  $R_1(P, Q, S)$

- (i)  $\{PQ \rightarrow S, QS \rightarrow P, PS \rightarrow Q\}$
- (ii) Highest normal form is BCNF
- (iii) No decomposition needed

(b)  $R_2(P, Q, T)$

- (i)  $\{Q \rightarrow T\}$
- (ii) Highest normal form is BCNF
- (iii) No decomposition needed

(c)  $R_3(P, T, U, V)$

- (i)  $\{PT \rightarrow U, U \rightarrow V\}$
- (ii) Highest normal form is 2NF
- (iii)  $R_{31}(U, V), R_{32}(P, T, U)$   
 $\{U \rightarrow V\} \quad \{PT \rightarrow U\}$

(d) R4(P, Q, T, U)

- (i)  $\{PT \rightarrow U, Q \rightarrow T\}$
- (ii) Highest normal form is 1NF
- (iii)  $R_{4_1}(P, T, U), R_{4_2}(Q, T)$   
 $\{PT \rightarrow U\} \quad \{Q \rightarrow T\}$

(e) R5(P, S, U, V, W)

- (i)  $\{U \rightarrow V\}$
- (ii) Highest normal form is 1NF
- (iii)  $R_{5_1}(P, S, U, V), R_{5_2}(U, V)$   
 $\{\} \quad \{U \rightarrow V\}$

**Problem 3 (20 points)**

Decide whether each of the following decomposition of R(P, Q, S, T, U, V), with the FD set  $F = \{PQ \rightarrow S, PS \rightarrow Q, PT \rightarrow U, Q \rightarrow T, QS \rightarrow P, U \rightarrow V\}$ , is (i) dependency-preserving. (ii) lossless-join.

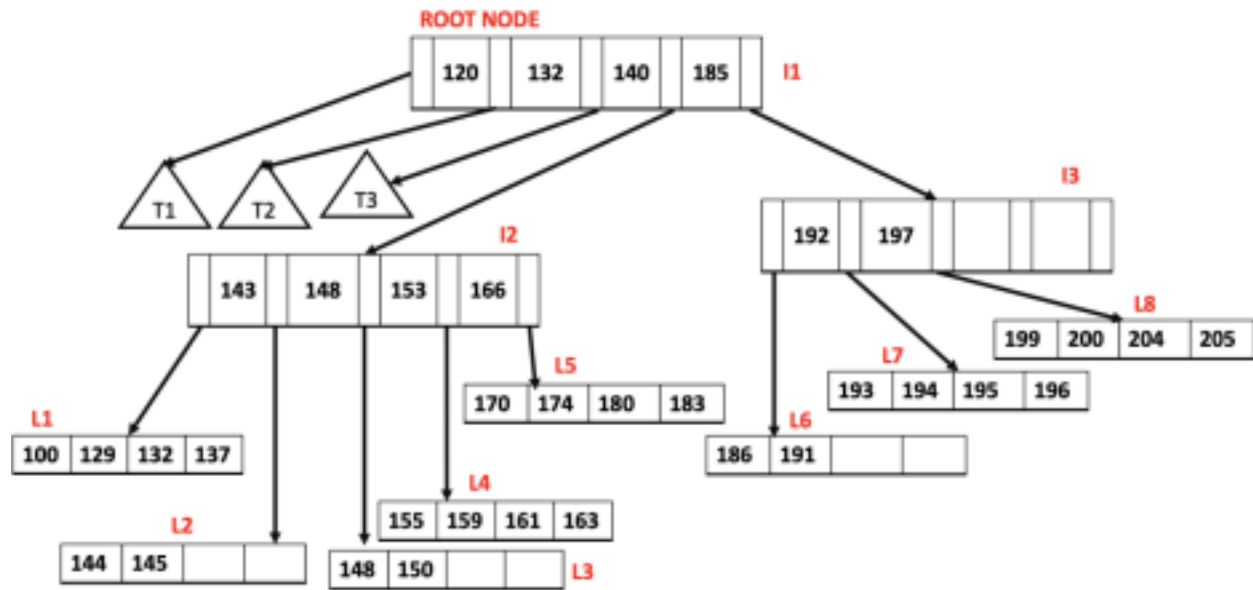
(a) R1(P, Q) R2(P, S) R3(P, Q, U) R4(U, V)

- (i) This decomposition does not cover the functional dependency  $QS \rightarrow P$ . So, it is NOT dependency-preserving.
- (ii) Since P (common attribute between R1 and R2) is not a superkey in any of the relations, the join is lossy. Thus, it is NOT lossless-join.

(b) R1(P, Q, S) R2(P, S, T, V) R3(P, T, U)

- (i) All functional dependencies from the original set are covered in this decomposition. So, it is dependency-preserving.
- (ii) The join between R1 and R3 is lossy because P (common attribute) is not a superkey in any of the relations. Thus, it's NOT lossless-join.

#### Problem 4 (40 points)



LEAF NODES ARE DOUBLE LINKED ALTHOUGH NOT SHOWN IN THE FIGURE

NOTE: Perform all the operations on the original tree provided above. Do not carry forward the changes in each question to the next.

- a. In the above index, which nodes need to be accessed to find all the data entries which are greater than 180?

Follow path less than 185 from root node, then in index 2 go to values greater than 166, then leaf 5 to check for values greater than 180. From index 3 you could get all the data entries that are pointed to from its nodes since they should be greater than 180.

- b. After 203 is inserted, how the structure will be changed?

Leaf 8 will split, and a new index will be added to point at the new leaf.

- c. After removing 144 from the original index, how the structure will be changed assuming to carry out redistribution from the right sibling?

Removing 144 will cause Leaf 2 to only have 1 entry which isn't allowed. 150 will replace 148 as the index and then the data entries 145 and 148 will be put into the L2 leaf and L3 will be deleted.

- d. After inserting 181, how the structure will be changed? Show the new index.

A new index will be created with 170 and 180 in it and 181 will be inserted to the leaf to the right of 180.

- e. What is the height of T1, T2, and T3? What are the entries in each of them?

T1, T2, T3 should all have a height of 2 because that is the height of the current tree.

T1 = data entries that are less than 120

T2 = data entries between 120 and 132

T3 = data entries between 132 and 140