BSCCS2001: Graded with Solutions
Week 6

1. Consider the relational schema $\mathbf{R}(A, B, C, D, E)$, where the domains of A, B, C, D and E include only atomic values. Identify the possible set of functional dependencies that $\mathbf{R}$ can have such that $\mathbf{R}$ is in 3NF but not in BCNF.

[MCQ: 2 points]

◯ FD: $\{AB \rightarrow CDE\}$
◯ FD: $\{AB \rightarrow CD, B \rightarrow E\}$
◯ FD: $\{AB \rightarrow CD, C \rightarrow D, D \rightarrow E\}$
√ FD: $\{AB \rightarrow CDE, D \rightarrow A, E \rightarrow B\}$

Solution: Given that in $\mathbf{R}$ each attribute is a single-valued attribute. Thus $\mathbf{R}$ is already in 1NF.
Option-1: FD: $\{AB \rightarrow CDE\}$
The only candidate key (thus primary key) is: AB as $(AB)^+ = \{ABCDE\}$.
As all the non-prime attributes are fully functionally dependent on the candidate key, it is already in 2NF.
$\{AB \rightarrow CDE\}$, where AB is a superkey. Thus, it is in 3NF and also in BCNF.
Option-2: $\{AB \rightarrow CD, B \rightarrow E\}$
The only candidate key (thus primary key) is: AB as $(AB)^+ = \{ABCDE\}$.
$B \rightarrow E$ is a partial functional dependency. Thus, it is in 1NF but not in 2NF.
Option-3: FD: $\{AB \rightarrow CD, C \rightarrow D, D \rightarrow E\}$
The only candidate key (thus primary key) is: AB as $(AB)^+ = \{ABCDE\}$.
There is no partial functional dependency. Thus, it is already in 2NF.
$AB \rightarrow CD$, where AB is superkey.
But, for $C \rightarrow D$, $D \rightarrow E$

- the functional dependencies are not trivial.
- L.H.S of the functional dependencies are not superkeys.
- R.H.S of the functional dependencies are not prime attributes.

Thus, these two FDs violate 3NF rules. So, $\mathbf{R}$ is in 2NF but not in 3NF based on this set of FDs.
Option-4: FD: $\{AB \rightarrow CDE, D \rightarrow A, E \rightarrow B\}$
The candidate keys are: AB and DE as $(AB)^+ = \{ABCDE\}$ and $(DE)^+ = \{ABCDE\}$. The prime attributes are A, B, D, E.
There is no partial functional dependency. Thus, it is already in 2NF.
$AB \rightarrow CDE$, where AB is superkey.
For $D \rightarrow A$, $E \rightarrow B$ R.H.S of the functional dependencies are prime attributes. Thus, it is in 3NF. However, these two FDs do not satisfy BCNF (as L.H.S are not superkeys). **So, R is in 3NF but not in BCNF based on this set of FDs.**

2. Consider the relational schema $\mathbf{R}(A, B, C, D, E, F)$, where the domains for A, B, C, D, E and F include atomic values only. If $\mathbf{R}$ satisfies the functional dependencies $\{AB \rightarrow CDE, ABC \rightarrow EF, E \rightarrow F\}$, then identify the correct statement(s).

[MSQ: 2 points]

- ◯ **R** is in 2NF and also in 3NF
- √ **R** is in 2NF but not in 3NF
- ◯ **R** is in BCNF but not in 3NF
- ◯ **R** is in 3NF and also in BCNF

Solution:
Since $(AB)^+ \rightarrow ABCDEF$, AB is the candidate key.
There is no partial functional dependency in set F. Therefore, it is in 2NF.
If we test for 3NF, $E \rightarrow F$ violates 3NF as:

- it is not trivial,
- E is not a superkey,
- F is not prime attribute.

Thus, **R is in 2NF but not in 3NF**

3. Consider the relation $\mathbf{A}(P,Q,R,S,T)$ with the following Functional Dependencies:

   - $PQ \rightarrow RT$
   - $T \rightarrow PQ$
   - $R \rightarrow S$

   What is the highest normal form of the given relation?

   [MCQ: 2 points]

   ◯ 1NF
   √ 2NF
   ◯ 3NF
   ◯ BCNF

Solution: The two possible candidate keys of the given relation are PQ and T. Therefore, the prime attributes are P,Q, and T, and the non-prime attributes are R and S.

Conditions for 2NF

1. It should be in the first normal form.
2. It should not have partial dependencies.

Conditions for 3NF

1. It should be in the second normal form.
2. It should not have transitive dependencies.

The relation is in 2NF because there are no partial dependencies on any of the keys. The relation is not in 3NF because in the functional dependency $R \rightarrow S$, neither R is a superkey nor S is a prime attribute.

4. Consider the relation **IPL**(*TeamID, TeamName, Fours, Sixes*) with the following functional dependencies.

[MCQ: 3 points]

- *TeamID* → *(TeamName, Fours, Sixes)*
- *(TeamName, Fours)* → *(TeamID, Sixes)*
- *Sixes* → *TeamName*

Which one of the following statement(s) is **FALSE** with respect to the information given above?

◯ The relation **IPL** is in 3NF

◯ The functional dependency, *Sixes* → *TeamName* violates BCNF

√ The relation **IPL** is in BCNF

◯ All the above

Solution: The relational **IPL** is not in BCNF, because the functional dependency- *Sixes* → *TeamName* violates BCNF

5. Consider the following relational schema for the Assignment Evaluation database.
Student($registration\_num, course, enrollment\_num, name, contact\_num, email$)
Assignment($assignment\_num, submission\_date$),
Progress_Report($assignment\_num, registration\_num, grade$).
Given below are the functional dependencies for this schema.

   - $registration\_num \rightarrow course, enrollment\_num, name, contact\_num, email$
   - $course, enrollment\_num \rightarrow name, registration\_num, contact\_num, email$
   - $assignment\_num \rightarrow submission\_date$
   - $assignment\_num, registration\_num \rightarrow grade$

   The given schema is in:

   [MCQ: 3 points]

   ◯ 1NF but not in 2NF
   ◯ 2NF but not in 3NF
   ◯ 3NF but not in BCNF
   √ BCNF

   Solution:
   From the given functional dependencies, the candidate keys of the relations are as follows:

   - $registration\_num$ and $\{course, enrollment\_num\}$ are the candidate keys for the relation **Student**.
   - $assignment\_num$ is the candidate key for the relation **Assignment**.
   - $\{assignment\_num, registration\_num\}$ is the candidate key for the relation **Progress_Report**.

   Thus, all the functional dependencies of the relations in the given schema fulfil the BCNF conditions and the schema is in BCNF.

6. Choose the correct set of option(s):

[MSQ: 1 point]

- ◯ 2NF is considered adequate for relational database design.
- √ A functional dependency of the form A → B is trivial if B ⊆ A.
- ◯ A relation produced from an E-R model will always be in BCNF.
- ◯ A functional dependency of the form A → B is trivial if A ⊆ B.

Solution: Option 2 follows from the basic definition.

7. Let **P** and **Q** be two relations. Let D(**P**) be a decomposition of **P** based on a set M of functional dependencies. Let D(**Q**) be a decomposition of **Q** based on a set N of functional dependencies. It is known that one among D(**P**) and D(**Q**) is in BCNF and the other is in 3NF.
In order to correctly classify D(**P**) and D(**Q**) as being in BCNF or 3NF, what is the MINIMAL test needed?

[MCQ: 1 point]

- ◯ Test whether both are in BCNF
- √ Test whether one of them is in BCNF
- ◯ Test whether both are in 3NF
- ◯ Test whether one of them is in 3NF

Solution:
Option 1 - Incorrect. This test is enough, but it is not a minimal test.
Option 2 - This is correct. Suppose we test D(**P**) for BCNF. If it is in BCNF, then by the description in the question, we know that D(**Q**) is in 3NF. On the other hand, if it is not in BCNF, then we know that it must be in 3NF and D(**Q**) is in BCNF.
Option 3 - Incorrect. Any decomposition that tests yes for 3NF may or may not be in BCNF. So, we will not be able to classify based on this test alone.
Option 4 - Incorrect. Any decomposition that tests yes for 3NF may or may not be in BCNF. So, we will not be able to classify based on this test alone.

8. Consider the schema $\mathbf{D}(P,\ Q,\ R,\ S)$ with the following functional dependencies
F = $\{R \rightarrow S, P \rightarrow Q, Q \rightarrow R, S \rightarrow P\}$
Let D_1, D_2 be a decomposition of $\mathbf{D}$ such that $D_1 \cap D_2 \neq \phi$.
Then, D_1 and D_2 are

[MCQ: 2 points]

- ◯ not in 2NF
- ◯ in 2NF but not in 3NF
- ◯ in 3NF but not in 2NF
- √ in both 2NF and 3NF

Solution: Candidate keys of relation **D** are *P, Q, R, S*.
Decomposition is in both 2NF and 3NF as there is no partial dependency or transitive dependency.

9. Consider the relational schema:
department($dept\_num, dept\_name, mgr\_num, mgr\_name, building\_num, employee\_count, space\_requirement$), where the domains of all the attributes consist of atomic values. Consider the following FDs for the relation **department**.

   - $dept\_num \rightarrow mgr\_num, dept\_name$,
   - $mgr\_num \rightarrow mgr\_name$,
   - $dept\_num, building\_num \rightarrow employee\_count$,
   - $employee\_count \rightarrow space\_requirement$,
   - $space\_requirement \rightarrow building\_num$

   Identify the appropriate decomposition(s) which is/are in BCNF.

   [MSQ: 3 points]

   √ (mgr_num, mgr_name),
   $(dept\_num, mgr\_num, dept\_name)$,
   $(employee\_count, space\_requirement)$, and
   $(dept\_num, building\_num, employee\_count)$

   ◯ (mgr_num, mgr_name),
   $(dept\_num, mgr\_num, dept\_name)$, and
   $(dept\_num, employee\_count, space\_requirement, building\_num)$

   ◯ (mgr_num, mgr_name),
   $(dept\_num, mgr\_num, dept\_name)$,
   $(dept\_num, building\_num)$, and
   $(building\_num, employee\_count, space\_requirement)$

   ◯ (mgr_num, mgr_name),
   $(dept\_num, mgr\_num, dept\_name)$,
   $(space\_requirement, building\_num)$, and
   $(dept\_num, employee\_count, space\_requirement)$

Solution:

10. Considering temporal relations, which of the following statement(s) is/are true?

[MSQ: 1 point]

- √ Valid time in a temporal relation is considered as historical information.
- √ Transaction time in a temporal relation is considered as rollback information.
- ◯ Valid time in a temporal relation is considered as rollback information.
- ◯ Transaction time in a temporal relation is considered as historical information.

Solution:

- Valid time provide historical information.
- Transaction time provide rollback information.