**Chapter 3**

**Exercise 3.2.1:**

Consider a relation with schema R(A,B,C,D) and FD’s AB🡪C, C🡪D and D🡪A

1. What are all the non-trivial FD’s that follow from the given FD’s? You should restrict yourself to FD’s with single attributes on the right side.
2. What are all the keys of R?
3. What are all the superkeys for R that are not keys?

**Answers:**

a) Nontrivial FD’s (Implied FD’s), given FD’s: AB🡪C, C🡪D, D🡪A

Compute the closures:

// for one attribute

A+=A, B+=B, C+={C, D, A}, D+={D, A}

// for two attributes

AB+={A, B, C, D},AC+={A, C, D},AD+={A, D},

BC+={B, C, D, A},BD+={B, D, A, C},CD+={C, D, A}

// for three attributes

ABC+= ABD+=BCD+={B, C, D, A} ACD+={A, C, D}

So the non-trivial FD’s derived from the given FD’s are:

C->A, AB->D, AC->D, BC->A, BC->D, BD->A,

BD->C, CD->A, ABC->D, ABD->C, BCD->A.

b) Keys: AB, BC, and BD

c) Superkeys that are not keys: ABC, ABD, BCD, and ABCD

**Issues from students:**

Some students didn’t know how to derive implied FD’s from given FD’s, and some failed to correctly compute the closures of all the subsets of attributes. Meanwhile, some students only consider the (implied) FD’s whose left side attributes are AB, C and D (which appeared in the left side of given FD’s), namely AB->C, AB->D, C->A, C->D, D->A.

**Exercise 3.5.2:**

Consider the relation Courses(C, T, H, R, S, G),whose attributes may be thought of informally as course, teacher, hour, room, student and grade. FD’s: C🡪T, HR🡪C, HT🡪R, HS🡪R, CS🡪G. intuitively, the first says that a course has a unique teacher, and the second says that only one course can meet in a given room at a given hour. The third says that a teacher can be only on room at a given hour, and the fourth says the same about students. The last says that students get only one grad in a course.

1. What are all the keys for Courses?
2. Verify that the given FD’s are their own minimal basis.
3. Use the 3NF synthesis algorithm to find a lossless-join, dependency-preserving decomposition of R into 3NF relations. Are any of the relations not in BCNF?

**Answers:**

1. Keys for Courses: HS
2. They are the minimal basis. Because Right sides are single attributes. No FD can be removed. No attribute can be removed from a left side.
3. According to 3NF synthesis, the relation is decomposed into R1(C, T), R2(H, R, C), R3(H, T, R), R4(H, S, R), R5(C, S, G) they are also in BCNF.

**Issues from students:**

To find the keys of relation Courses, procedures same as exercise 3.2.1 need to be conducted. So the issues of exercise 3.2.1 a) mainly come from failing to correctly compute the closures of possible subsets of attributes. Some students omitted to take into account the closure of {H, S}, and then {C, H, S}, {T, H, S}, {H, R, S} and {H, S, G} were falsely considered as the keys. They are the superKeys.

For question b), few students made mistakes as they understood the definition of minimal basis.

For question c), most students could use 3NF synthesis algorithm to obtain correct 3NF relations, but some students thought that not all of these 3NF relations were in BCNF.

**Exercise 3.6.3:**

For each of the following relation schemas and dependencies

1. R(A,B,C,D) with MVD’s A🡪🡪B, A🡪🡪C
2. A relation R(A,B,C,D) with MVD AB🡪🡪C, and FD B🡪D

Do the following:

1. Find all the 4NF violations.
2. Decompose the relations into a collection of relation schemas in 4NF.

**Answers:**

a) Solution is as following

As no FD’s defined, so the key is **ABCD**. Given MVD’s A🡪🡪B, A🡪🡪C，we can derive new MVD’s A🡪🡪CD, A🡪🡪BD, and none of the MVD’s has superkey as its left side. According to the definition of 4NF, it’s demonstrated that all all MVD’s are 4NF violations.

With the violation A🡪🡪B, we can decompose R(A, B, C, D) into R1(A, B) R2(A, C, D). And R1(A, B)is in 4NF, while R2(A, C, D) still has violation A🡪🡪C, therefore decompose it into R21(A, C), R22(A, D).

c) Solution is as following

1) find all the 4NF violation:

* The first step is to know what a key for the relational schema is based on FD’s
* It’s easy to see that **ABC** is the only key of R. So the given MVD’s AB→→C, B→D and derived MVD’s AB→→D, B→→AC are all 4NF violations.

2) Decompose the relations

By using AB→→C, we decompose R into R1(A, B, C) and R2(A, B, D). Now B→D is again a 4NF violation for R2 and we further decompose R2 into R21(B, D) and R22(A, B). R22 is a part of R1, so we omit it. Obviously, R1, R21 together constitute a 4NF decomposition of R.

**Issues from students:**

There were mainly following issues in this exercise

1. Failed to find the key

Some students used MVD’s to search relation’s primary key. We know the key for the relational schema is based on FD’s.

1. Didn’t list derived 4NF violations

Most students only listed the given 4NF violations, but they didn’t list the implied 4NF violaitons. For example, question a) has four 4NF violations, but only two given violations A🡪🡪B, A🡪🡪C were listed, and A🡪🡪CD, A🡪🡪BD were not taken into account.

1. Failed to consider violations for trivial MVD’s in decomposed relation

For question a) of this exercise, some students decomposed R(A, B, C, D) into R1(A, B) and R2(A, C, D), and then stopped further decomposition for relation R2(A, C, D). Because they thought, for R2(A, C, D), although A was not primary key, A→→CD was trivial MVD’s. It’s obvious that they didn’t take into account the violation A🡪🡪C any more.

1. Didn’t discard the decomposed relation contained by other relations

For question a) of this exercise, some students kept the decomposed relation R22(A, B) even if it’s contained in decomposed relation R1(A, B, C).