Rel. Design Quiz 1 Answers
Functional Dependencies

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Introduction

In this document I'll provide the solutions for the Relational Design Functional Dependencies quiz questions from the (infamous) dbclass MOOC kindly provided by Prof. Jennifer Widom.

Since markdown does not convey maths as it should, I created this document in order to preserve the intended notation as well as maintain cohesion; thus, since I got into all this trouble anyway solutions are a bit more detailed than the other (plain markdown) solutions in most chapters.

An **important** note is that the provided answers are the ones that were generated in my instance but the system is smart enough to generate *different* possible answers and mixes up the order as well, so your mileage may vary.

Finally you should use this documents (and my solutions for the dbcourse in general) as a *reference* and just copy-paste; you're just hurting yourself if you do so. Now without further delays, off we go!

Question 1

Let's consider a relation $\mathcal{R}(A, B, C, D, E)$ which has the following functional dependencies:

- $AB \rightarrow C$
- $C \rightarrow D$
- $BD \rightarrow E$

Given the following options, which one does **not** functionality determine E?

Q1 Options

In my instance the options to select the answer from, were the following:

a) BC

b) AC

c) BCD

d) BE

Q1 Answer

Recall from the lectures that in order to find if a set of attributes, $\bar{b}$ is functionally determined by another set of attributes $\bar{a}$ only if it it's contained in its *closure*. Thus to find which one of the given options does not functionally determine E, we have to compute their closures.

Calculate closures for given attribute sets:

- $(BC)^+ \stackrel{C \to D}{=} (BCD)^+ \stackrel{BD \to E}{=} BCDE$
- $(AC)^+ \stackrel{C \to D}{=} ACD$
- $(BCD)^+ \stackrel{BD \to E}{=} BCDE$
- $(BE)^+ = BE$

We can easily see that in the only closure we computed E is **not** contained in the third option; hence the correct answer to this question is option: **b**, which has the AC attribute set.

Question 2

Let's consider a relation $\mathcal{R}(A, B, C, D, E)$ which has the following functional dependencies:

- $D \to E$
- $CE \to A$
- $D \to A$
- $AE \to D$

Given the following options, which one of the following is a **key** of $\mathcal{R}$?

Q2 Options

In my instance the options to select the answer from, were the following:

a) AD

b) CDE

c) BCE

d) A

Q2 Answer

Recall again from lectures that for a set of attributes $\bar{a}$ to be the key of a given relation $\mathcal{R}$, then it's closure must contain all the attributes of that relation. So again we have to compute the closured of the given options as before.

Calculate closures for given attribute sets:

- $(AD)^+ \overset{D \to C}{=} ACD$
- $(CDE)^+ \overset{CE \to A}{=} ACDE$
- $(BCE)^+ \overset{CE \to A}{=} (ABCE)^+ \overset{AE \to D}{=} ABCDE = \mathcal{R}$
- $(A)^+ = A$

Given our computed closures the only one that contains **all** attributes of relation $\mathcal{R}$, is option: **c**, BCE which is a key to the given relation.

Question 3

Let's consider a relation $\mathcal{R}(A, B, C, D, E, F, G, H)$ which has the following functional dependencies:

- $A \to B$
- $CH \to A$
- $B \to E$
- $BD \to C$
- $EG \to H$
- $DE \to F$

Given the following options, which one of the following functional dependencies is guaranteed to be satisfied by $\mathcal{R}$?

Q3 Options

In my instance the options to select the answer from, were the following:

a) $BCD \to FH$

b) $ADE \to CH$

c) $BED \to CF$

d) $CGH \to BF$

Q3 Answer

This question might seem a bit confusing if you have not encountered this type before; to solve this you have to think in *reverse*. Using composition you have to "construct" one of the given functional dependencies in options. Although the easiest way of going about it is to again calculate the closures of each option and see which contains the given attributes in the right-hand side. You'll see what I mean in a moment; first, let's again calculate the closures.

Calculate closures for given attribute sets:

- $(BCD)^+ \overset{B \to E}{=} (BCDE)^+ \overset{DE \to F}{=} BCDEF$
- $(ADE)^+ \overset{A \to B}{=} (ABDE)^+ \overset{DE \to F}{=} (ABDEF)^+ \overset{BD \to C}{=} ABCDEF$
- $(BED)^+ \overset{BD \to C}{=} (BCDE)^+ \overset{DE \to F}{=} BCDEF$
- $(CGH)^+ \overset{CH \to A}{=} (ACGH)^+ \overset{A \to B}{=} ABCGH$

Now the only closure from the ones we calculated above that contains one of our given options right-hand side is option: **c** which contains CF. Recall from the lectures that we can *break* these relations in this way using the splitting rule: $BED \to B$, $BED \to C$, $BED \to D$, $BED \to E$, and $BED \to F$ we can also do that for pairs: $BED \to CF$, $BED \to B$, and $BED \to DE$. Finally, it is obvious that the given functional dependency is already *implied* by the existing functional dependencies of the given relation $\mathcal{R}$.

Question 4

Let's consider a relation $\mathcal{R}(A, B, C, D, E, F)$ which has the following functional dependencies:

- $CDE \to B$
- $ACD \to F$
- $BEF \to C$
- $B \to D$

Given the following options, which one of the following is a **key** of $\mathcal{R}$?

Q4 Options

In my instance the options to select the answer from, were the following:

a) ABE

b) $ACDE$

c) BCF

d) CD

Q4 Answer

Again in the previous question that asked us to find a relation key we need to calculate the closures of the given options and check which one "leads" to all of the relations' attributes.

Calculate closures for given attribute sets:

- $(ABE)^+ \stackrel{B \to D}{=} ABDE$
- $(ACDE)^+ \stackrel{ACD \to F}{=} (ACDEF)^+ \stackrel{CDE \to B}{=} ABCDEF = \mathcal{R}$
- $(BDF)^+ = BDF$
- $(CD)^+ = CD$

We can easily see from the computed closures that the options which encloses the relation $\mathcal{R}$ in its entirety (and hence is a **key**) is the option: **b**, $ACDE$.

Question 5

Let's consider a relation $\mathcal{R}(A, B, C, D, E, F, G)$ which has the following functional dependencies:

- $AB \to C$
- $CD \to E$
- $EF \to G$
- $FG \to E$
- $DE \to C$
- $BC \to A$

Given the following options, which one of the following is a **key** of $\mathcal{R}$?

Q5 Options

In my instance the options to select the answer from, were the following:

a) $ACDF$

b) $ABFG$

c) $BDEF$

d) $BCDE$

Q5 Answer

Again in the previous question that asked us to find a relation key we need to calculate the closures of the given options and check which one "leads" to all of the relations' attributes.

Calculate closures for given attribute sets:

- $(ACDF)^+ \overset{CD \to E}{=} (ACDEF)^+ \overset{EF \to G}{=} ACDEFG$
- $(ABFG)^+ \overset{AB \to C}{=} (ABCFG)^+ \overset{FG \to E}{=} ABCEFG$
- $(BDEF)^+ \overset{EF \to G}{=} (BDEFG)^+ \overset{DE \to C}{=} (BCDEFG)^+ \overset{BC \to A}{=} ABCDEFG = \mathcal{R}$
- $(BCDE)^+ \overset{BC \to A}{=} ABCDE$

We can easily see from the computed closures that the options which encloses the relation $\mathcal{R}$ in its entirety (and hence is a **key**) is the option: **c**, $BDEF$.

Question 6

Let's consider a relation $\mathcal{R}(A, B, C, D, E)$ which has the following functional dependencies:

- $AB \to C$
- $BC \to D$
- $CD \to E$
- $DE \to A$
- $AE \to B$

Given the following options, which one of the following functional dependencies is guaranteed to be satisfied by $\mathcal{R}$?

Q6 Options

In my instance the options to select the answer from, were the following:

a) $BD \to E$

b) $B \to A$

c) $CD \to A$

d) $C \to A$

Q6 Answer

Similarly to before, we will have to calculate the closures of the given options which follows.

Calculate closures for given attribute sets:

- $(BD)^+ = BD$
- $(B)^+ = B$
- $(CD)^+ \overset{CD \to E}{=} (CDE)^+ \overset{DE \to A}{=} (ACDE)^+ \overset{AE \to B}{=} ABCDE = \mathcal{R}$
- $(C)^+ = C$

Now the only closure from the ones we calculated above that contains one of our given options right-hand side is option: **c** which contains CD. Recall from the lectures that we can *break* these relations in this way using the splitting rule: $CD \to A$, $CD \to B$, $CD \to C$, $CD \to D$, and $CD \to E$ we can also do that for pairs: $CD \to AB$, $CD \to BC$, and $CD \to DE$. Finally, it is obvious that the given functional dependency is already *implied* by the existing functional dependencies of the given relation $\mathcal{R}$.

Question 7

Let's consider a relation $\mathcal{R}(A, B, C, D)$ which has the following functional dependencies:

- $A \to B$
- $B \to C$
- $C \to A$

Let's call the above set of functional dependencies s_1, and let's assume that there is a different set s_2 of functional dependencies which is *equivalent*. An equivalent set of functional dependencies is one that have exactly the same functional dependencies that follow each set. Given the following options, which one of the following sets is guaranteed to be equivalent to set s_1?

Q7 Options

In my instance the options to select the answer from, were the following:

a) $\mathcal{S}_a : B \to AC,\ C \to AB$

b) $\mathcal{S}_b : A \to BC,\ C \to AB$

c) $\mathcal{S}_c : C \to B,\ B \to A,\ A \to C$

d) $\mathcal{S}_d : A \to BC,\ B \to AC$

Q7 Answer

Let's establish all of the functional dependencies that exist and follow from set s_1 first, these are:

- $A \to B$
- $A \to C$
- $B \to A$
- $B \to C$
- $C \to A$
- $C \to B$

Now, the only set which accomplishes that circular behavior is the one in $\mathcal{S}_c$, which is the correct answer, hence the answer is **c**.

Question 8

Let's assume that we have a relation $\mathcal{R}(A, B, C)$ which currently has *only one* tuple $\mathcal{T}_0(0, 0, 0)$, and this relation has to satisfy the following functional dependencies:

- $A \to B$
- $B \to C$

Given the following tuples, which can be **legally** be inserted into $\mathcal{R}$?

Q8 Options

a) $\mathcal{T}_a : (1, 2, 0)$

b) $\mathcal{T}_b : (0, 2, 1)$

c) $\mathcal{T}_c : (0, 0, 2)$

d) $\mathcal{T}_d : (0, 0, 1)$

Q8 Answer

This one is fairly easy to answer if you got this far without a problem; but let's elaborate on the answer a bit. First of all there is a transitive functional dependency from $A \to C$; this is because $A \to B$ and $B \to C$, hence using the transitive rule follows that $A \to C$ as well. Notice that three out of four option tuples have 0 as their A attribute value, this immediately violates the constraints set by the functional dependencies. Thus the only allowed tuple to insert is $\mathcal{T}_a : (1, 2, 0)$, so the answer to this question is to select option: **a**.