POSSIBLE QUESTIONS-THERE WILL BE ALSO SQL QUERIES

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What is "functional" about functional dependencies? [4 pts]
A1, A2, ... An -> B is a functional dependency because in
principle there is a function that takes a list
of values, one for each of the attributes A1, A2, ... An and
produces a unique value (or no value at all)
for B. This function is only "computed" by look-up in the relation.
The functional dependency is a
property of the semantics or meaning of the attributes.
2) List the steps of 3NF synthesis algorithm as described in class.
[4 pts]
Synthesis algorithm for computing the decomposition on the basis
of F:
Step1: Determine a canonical cover F
for F.
Step2: For each FD A \rightarrow B
E
Fc:
- create a relation schema Ra := A v B
- assign the FDs F
Α
= \{ C \rightarrow D \}
€
F
|C \upsilon D|
\subset
R
Α
} to R
Step3: If all schemas R
created in Step2 do not contain a candidate key of the original
schema R,
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additionally create a relation with the schema R
Κ
= K and F
= \emptyset where K is candidiate key of R.
Step4: Eliminate schemas R
that are contained in another schema RA.
3) What is meant by the closure of a set of functional
dependencies? [4 pts]
Closure of a set F of FDs is the set F of all FDs that can be inferred
from F
Closure of a set of attributes X with respect to F is the set X
of all attributes that are functionally
determined by X
Χ
can be calculated by repeatedly applying IR1, IR2, IR3 using the
FDs in F.
[Refer section 14.2.2 in textbook]
4) When are two sets of functional dependencies equivalent? How
can we determine their equivalence?
[4 pts]
Two sets of FDs F and G are equivalent if:
- every FD in F can be inferred from G, and
- every FD in G can be inferred from F
Hence, F and G are equivalent if F
=G
Definition: F covers G if every FD in G can be inferred from F
(i.e., if G
subset-of F
+
F and G are equivalent if F covers G and G covers F. Refer text for
the algorithm to check equivalence
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of sets of FDs.

5). Multiple Choice Questions: [2pts each]

1. Consider relation R(A;B;C;D) with FD's A \rightarrow D, B \rightarrow D, and D \rightarrow BC.

Which of the following is true about the decomposition of R into relations with schemas AB

and BCD? Explain your answer.

(a) The decomposition is neither lossless nor dependency-preserving.

(b) The decomposition is lossless, but not dependency-preserving.

(c) The decomposition is dependency-preserving, but not lossless.

(d) The decomposition is both lossless and dependency-preserving. Ans:

The decomposition is lossless because the intersection of the two schemas, that is B,

functionally determines one of the two schemas, namely $B \rightarrow BCD$. To check, compute B

,

which is BCD.

To check dependency preservation, note that A

= ABCD, thus, when we project dependencies

onto AB, we get $A \rightarrow B$. The projection onto BCD surely gives us the second and third of the

given FD's: $B \rightarrow D$ and $D \rightarrow BC$. We claim that the three dependencies $A \rightarrow D$, $B \rightarrow D$, and $D \rightarrow BC$

are equivalent to the three dependencies that we can preserve in the projection: $A \rightarrow B$, $B \rightarrow D$,

and $D \rightarrow BC$. The last two in each set are the same. Also, $A \rightarrow B$ is easily seen to follow from the

first three, and $A \rightarrow D$ follows from the last three. If we can preserve an equivalent set of FD's in

the projections, then surely we can preserve the given set.

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2. Suppose we have a relation R(A;B;C;D;E) and the FD's $A \rightarrow$ DE, D \rightarrow B, and E \rightarrow C. If we project R (and therefore its FD's) onto schema ABC, what is true about the key(s)for ABC? Explain why. (a) Only ABC is a key (b) Only A is a key (c) Only DE is a key (d) A, B, and C are each keys. Ans: (b) First, note that A = ABCDE. Thus, when we project the FD's onto ABC, A is certainly a key. However, there cannot be any other keys, because neither B nor C have anything else in their closures, because they are not on the left sides of any FD's. Thus, A is the only key.

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Exercise 2 : Functional Dependencies and Normalization

[80 points]

1) Consider the relation STUDENT (SNO, SNAME, CNO, CNAME, ADDRESS) where the following FDs hold:
SNO → SNAME
CNO → CNAME
SNO → ADDRESS
Let attribute set (SNO, CNO) be denoted by A. Compute the closure of A, i.e. A
⁺
[5pts]
Answer:

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Α
= (SNO, CNO, SNAME, CNAME, ADDRESS)
2) Use your own words to explain how the closure of attribute set
A, i.e. A
, can be used to determine
the containment of a FD in a closure F
. [5pts]
Answer:
Assume we have a FD A \rightarrow B and a set of FDs, which is denoted by
F. First, we generate the
closure of A, which is denoted by A
, according to F. If B
\subseteq
Α
, then we can conclude that FD
A \rightarrow B is in the closure F
3) Consider the relation R (CLASS, MEET DAY, STUDENT,
GRADE, COMPLEX, MANAGER)
with the meaning:
• A STUDENT takes a CLASS that meets on several day or days
every week (given by the
attribute MEET DAY).
• A STUDENT can take multiple classes.
• The STUDENT gets a GRADE in the CLASS.

    Each STUDENT lives in only one COMPLEX

• Each COMPLEX has only one MANAGER, but each manager
can manage one or more
COMPLEXes.
(a) Find all the non-trivial FDs (Functional Dependencies) that
hold in R. [5pts]
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Answer: $(STUDENT, CLASS) \rightarrow GRADE$ STUDENT \rightarrow COMPLEX $COMPLEX \rightarrow MANAGER$ $(STUDENT, CLASS) \rightarrow COMPLEX$ $(STUDENT, CLASS) \rightarrow (GRADE, COMPLEX)$ STUDENT → MANAGER $(STUDENT, CLASS) \rightarrow (GRADE, COMPLEX, MANAGER)$ $(STUDENT, CLASS) \rightarrow MANAGER$ $(STUDENT, CLASS) \rightarrow (GRADE, MANAGER)$ STUDENT \rightarrow (COMPLEX, MANAGER) (b) What kind of problems does relation R have? Give an explanation for each problem you found. [5pts] Answer: Redundancies Update anomalies Insertion anomalies **Deletion** anomalies

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4) Consider a relation R with four attributes, XYZW, and a set of functional dependencies F

 $F: XY \to Z, XY \to W, Z \to X, W \to Y$

a. Identify the candidate key(s) for R.

b. Identify the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF).

c. Is R in BCNF? If *R* is not in BCNF, decompose it into a set of BCNF relations that preserve the

dependencies.

[10 points]

a. Candidate keys: XY, ZW, ZY, XW

b. R is in 3NF but not BCNF due to the FDs: Z → X and W → Y.
Neither W nor Z is a candidate key.
c. No.

One possible decomposition that is in BCNF is XZ, WZ and WY. But this decomposition does not preserve the dependencies $XY \rightarrow Z$ and $XY \rightarrow W$. If we include a relation such as XYZ then we are left with the violating FD: $Z \rightarrow X$. Similarly for XYW. So, there is no dependency-preserving decomposition into BCNF unless we do a join. 5) Consider the relation R1 (CLASS, MEET DAY, STUDENT, GRADE, TRANSFER CLASS, CREDITS AWARDED) with the following FDs: $\{CLASS, STUDENT\} \rightarrow \{GRADE\}$ $\{$ STUDENT, TRANSFER CLASS $\} \rightarrow \{$ CREDITS AWARDED $\}$ Please decompose the relation *R1* into BCNF and list each step of your work. [10 points] Answer: Canonical cover: FD1: {CLASS, STUDENT} \rightarrow {GRADE} FD2: {STUDENT, TRANSFER CLASS} \rightarrow {CREDITS AWARDED} Candidate key: {CLASS, STUDENT, MEET DAY, TRANSFER CLASS} Decomposition: From FD1: R1a = {CLASS, STUDENT, GRADE} From FD2: R1b = {STUDENT, TRANSFER CLASS, CREDITS AWARDED} Since no relations contain candidate key, additionally create a relation $R1c = \{CLASS, STUDENT, MEET DAY, TRANSFER CLASS\}$ Now R1a, R1b and R1c are in the 3NF. Also it is in BCNF. 6) Let AB be a shortcut for $\{A, B\}$. Imagine that we have the relation R2(ABCD) with FDs $AB \rightarrow C, C \rightarrow D, D \rightarrow A$. Explain why this relation is not in BCNF, but is in 3NF. Why would it be problematic to decompose R2 into BCNF? [5 points]

Answer:

The candidate key of R2 is {AB} {BC} or {BD}. So the right side of all the FDs is part of a key. That is to say, R2 is in 3NF. But the left side of FD $C \rightarrow D$, $D \rightarrow A$ is not a superkey, which violates the BCNF. It would be a bad idea to decompose this relation, however, because if we did so it would mean that there is some FD that is not present in any relation. 7) Now consider the relation R3 (ABCDEFGH), with FDs BC \rightarrow AD, $E \rightarrow FH$, $F \rightarrow GH$. Please decompose R3 into BCNF and list each step of the process. [10 points] Answer: Canonical cover: FD1: $BC \rightarrow AD$

FD2: $E \rightarrow F$ FD3: $F \rightarrow GH$ Candidate key: $\{B, C, E\}$ Decomposition: From FD1: $R3a = \{B, C, A, D\}$ From FD2: $R3b = \{E, F\}$ From FD3: $R3c = \{F, G, H\}$ Since no relation contains the candidate key, additionally create a relation $R3d = \{B, C, E\}$ Now R3a, R3b, R3c and R3d are in 3NF and BCNF. 8) Given the following relational schema R R(A,B,C,D,E,F,G,H,I,J)and functional dependencies: $B \rightarrow E ; E \rightarrow F,H ; B,C,D \rightarrow G ; C,D \rightarrow A ; A \rightarrow J$ $I \rightarrow B, C, D, E ; H \rightarrow I$ Answer these questions: [10 points] (a) Does the functional dependency $B \rightarrow J$ hold?

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(b) List the candidate keys of R.

(c) Normalize R into BCNF. Make sure to underline primary key fields.

Answer:

(a) The functional dependency $B \rightarrow J$ holds as J is in the closure of $B = B + = \{A, B, C, D, E, F, G, H, I, J\}.$

(b) The candidate keys of R are $\{B\}$, $\{E\}$, $\{H\}$, $\{I\}$.

(c) Since there are so many keys of R, there is not much normalization to be done.

The only two FDs that violate BCNF are: $C,D \rightarrow A$ and $A \rightarrow J$. Final normalized relations are:

R1 (A,J)

R2 (C,D,A)

R3 (B,C,D,E,F,G,H,I)

Note that could chose any of the candidate keys as the primary key.

9) Suppose functional dependency $B \rightarrow C$ holds in relation R(A;B;C;D).

For every additional functional dependency, state if it makes R to be in 3NF, BCNF or both. [5 points]

(a) $D \rightarrow AB$

- (b) $AC \rightarrow D$
- (c) $CD \rightarrow B$
- (d) $AD \rightarrow B$

Answer:

In (a), *D* is the only key, so $B \rightarrow C$ is both a 3NF and BCNF violation.

In (b), *AB* is the only key, so both FD's are 3NF and BCNF violations.

In (c), we can check that the keys are *ACD* and *ABD*. Both FD's violate BCNF, but all the

attributes are prime, so there can be no 3NF violation.

In (d), AD is the only key, so $B \rightarrow C$ violates both normal forms.

10) Exercise 14.33 from textbook. [10 points]

Consider the relation for published books:

BOOK (Book_title, Authorname, Book_type, Listprice, Author_affil, Publisher) Author_affil refers to the affliation of author. Suppose the following dependencies exist:

Book-title \rightarrow Publisher, Book type Book type \rightarrow Listprice Authorname \rightarrow Author affil a. What normal form is the relation in? Explain you answer. b. Apply normalization until you cannot decompose the relations further. State the reasons behind each decomposition. Answer: a. The key for this relation is Book title, Authorname. This relation is in 1NF and not in 2NF as no attributes are FFD (Fully Functionally Dependent) on the key. It is also not in 3NF. b. 2NF decomposition: Book0(Book title, Authorname) Book1(Book title, Publisher, Book type, Listprice) Book2(Authorname, Author affil) This decomposition eliminates the partial dependencies. 3NF decomposition: Book0(Book title, Authorname) Book1-1(Book title, Publisher, Book type) Book1-2(Book type, Listprice) Book2(Authorname, Author affil) This decomposition eliminates the transitive dependency of Listprice. ***