Database Systems

Spring Semester 2018

Assignment #4 (Solution)

Note: errors and omissions are possible. The solution may not contain graphic contents but students are expected to provide the complete solution.

Question 1: Consider a relation R*(A, B, C, D)* with FD's

A B -> C,

B C -> D,

CD -> A,

And *AD->B.*

a) What are all the nontrivial FD's that follow from the given FD's? You should restrict yourself to FD's with single attributes on the right side.

$[A]^+ = \{A\}$

$[B]^+ = \{B\}$

$[C]^+ = \{C\}$

$[D]^+ = \{D\}$

$[AB]^+ = \{ABCD\}$

AB → D

AB → C

$[BC]^+ = \{BCDA\}$

BC -→ D

BC -→ A

$[CD]^+ = \{CDAB\}$

CD -→ A

CD -→ B

$[AD]^+ = \{ADBC\}$

AD -→ B

AD -→ C

b) What are all the keys of *R?*

$[A]^+ = \{A\}$

$[B]^+ = \{B\}$

$[C]^+ = \{C\}$

$[D]^+ = \{D\}$

$[AB]^+ = \{ABCD\}$

$[BC]^+ = \{BCDA\}$

$[CD]^+ = \{CDAB\}$

$[AD]^+ = \{ADBC\}$

So the keys are AB, BC, CD, AD. Adding another attribute further in any of the key will make it super key not a key any more.

c) List any five superkeys for *R* that are not keys?

[ABC]

[ABD]

[ADC]

[ABCD]

[BCD]

Question 2: Show that each of the following are *not* valid rules about FD's by giving relational instance that satisfy the given FD's (following the "if") but not the FD that allegedly follows (after the "then").
b) If *AB* -> *C* and *A* -> C, then *B* -> *C.*

A	B	C
bilal@hotmail.com	Bilal	Lahore
ali@gmail.comm	Ali	Karachi
bilal01@gmail.com	Bilal	Karachi

c) If AB -> C, then A -> C or B -> C.

A(empid)	B-(project id)	C-(manager)
bilal@hotmail.com	1	Shah Nawaz
ali@gmail.comm	2	Shah Nawaz
ali@gmail.com	1	Murtaza Jahanzaib
bilal@hotmail.com	2	Murtaza Jahanzaib

**Question 3: Find out whether the following set of functional dependencies for a relation R (A,B,C,D,E)
are equivalent or not.**

1.F = E->D, ED->C, B->EC, B->A, D->A

2.G = E->ADC, B->AE, D->B

First Check if F Covers G

Checking for FD E->ADC

$[E]^+$ = {EDC}

E->ADC cannot be inferred from above closure i.e F do not cover G. So two sets of FDs are not equivalent

Question 4: Consider the relation R(A,B,C,D,E,F,G,H,I) and a set of functional dependencies:
FD's = {A -> B, $ABCD$ -> E, EF -> GH and $ACDF$-> EG.}
i. Find Keys for the above relation R?

Check if any attribute is not present on the RHS. If not then it will be essentially part of all candidate keys.

A C D F I

$[ACDFI]^{+=}$ ABCDEFGHI

So ACDFI is the key of the above relation. Adding any other attribute to it will make it a super key

ii. Find a minimal cover for the above set of FDs'?

Step1 (Rule 1 states that RHS of all FDs should be single attributes.):

A -> B,

ABCD -> E,

EF -> G

EF -> H

ACDF-> E

ACDF-> G

Step2 Rule 2 says to eliminate extraneous attributes:

A -> B,

ACD -> E

EF -> G

EF -> H

ACD-> E

ACDF-> G

Step3 Rule 3 says to eliminate redundant functional dependencies. :

A -> B,

ACD -> E

EF -> G

EF -> H

iii. Decompose the above relation into 3NF that preserve all the dependencies.

Using the Above Result

R1 (A, B)

R2(A, C,D E)

R3(E, F G,H)

None of the relation contains key. Adding Relation containing key

R4(A, C, D, F , I)

Question 5: Suppose you are given a relation *R(A ,B, C,D)*. For each of the following sets of FDs, assuming
they are the only dependencies that hold for *R*, do the following:

(a) Identify the candidate key(s) for *R*.
(b) State whether or not the proposed decomposition of *R* into smaller relations is a good decomposition (lossless, dependency preserving, attribute preserving), and briefly explain why or why not.
a) *AB* -> *C*, *C* -> *A*, *C* -> *D*; decompose into *ACD* and *BC*.

i. Candidate Keys

B is the must attribute of the candidate keys

$[AB]^+$ ={ABCD}

$[BC]^+$ = {BCAD}

so AB, BC are the candidate keys

ii.

No, because AB → C will be lost in the proposed relation and dependency will not be preserved. However it is lossless decomposition because ACD ∪ BC = ABCD
ACD ∩ BC = C which is key in R1.

b) *A* -> *BC*, *C* -> *AD*; decompose into *ABC* and *AD*.

i. $[A]^+$ = {ABCD}
$[C]^+$ = {CADB}
$[BD]^+$ = {BD}
Only A and C are the candidate keys.

ii. It is a bad decomposition because the C → AD dependency will be lost. Moreover it is lossy decomposition because ABC ∩ AD = C that is not key in either decomposed relations.

c)

A -> B, B -> C, C -> D; decompose into AB and ACD.

i. $[A]^+$ = {ABCD}

Only A is the candidate key.

ii. It is bad decomposition because B→ C will be lost in the result relations

However it is lossless decomposition because ACD ∪ AB = ABCD

ACD ∩ AB = A that is key in relation AB.

d) A -> B, B -> C, C -> D; decompose into AB, AD and CD.

i. $[A]^+$ = {ABCD}

Only A is the candidate key.

ii. It is bad decomposition because B→ C will be lost in the result relations

However it is lossy decomposition because AB ∪ AD ∪ CD = ABCD

But AD ∩ CD = ϕ and AB ∩ CD = ϕ i.e there is no common attribute to join the relation.

Question 6:

Figure given above shows a shipping manifest. Your assignment is as follows:

a. Identify the functional dependencies between the attributes.

Shipment Id → Destination, Shipment Date, Ship Number, Origin

Ship Number → Captain

Destination, Origin, Shipment Date → Expected Arrival

Item Number → Weight, Description, Type

Item Number, Shipment ID → Quantity

b. Draw a relational schema and diagram the functional dependencies in the relation.

Shipment Id	Origin	Destination	Ship Number	Expected Arrival	Captain	Shipment Date

Item No	*Shipment ID*	Type	Description	Weight	Quantity	Total Weight

See the FDs in part a

c. In what normal form is this relation(1NF,2NF,3NF,BCNF,4NF)? Decompose the above relation into a set of 3NF relations.

The relation does not satisfy any of the normal form. Because Captain Attribute is non-atomic as well as the relations have partial and transitive dependencies.

1NF:

Captain ID	Captain Name

Shipment Id	Origin	Destination	Ship Number	Expected Arrival	*Captain ID*	Shipment Date

Item No	*Shipment ID*	Type	Description	Weight	Quantity	Total Weight

Converting into 3NF using the (MC) Algorithm:

Candidate Keys

R1: Captain Id

R2: Shipment ID

R3: Item No, Shipment ID

Minimal Cover of R1 {

Captain ID → Captain Name

}

Captain ID	Captain Name

Minimal Cover of R2 {

Shipment ID → Origin, Destination, Ship No, Shipment Date

Ship No → Captain ID

Origin, Destination, Shipment Date → Expected Arrival

}

3NF:

Shipment ID	Origin (FK)	Destination(FK)	*Ship No(fk)*	Shipment Date(fk)

Ship No	Captain ID(fk)

Origin	Destination	Shipment Date	Expected Arrival

Minimal Cover of R3 {

Item No → Weight, Description, Type

Item Number, Shipment ID → Quantity

}

3NF:

Item Number	Weight	Description	Type

Item Number(fk)	Shipment ID (FK)	Quantity

d. Draw a relational schema for your 3NF relations and show the referential integrity constraints.

See the above question

Question 7:

The following statement is presented to the patient (or patient representative) when the patient is discharged. Assume that each item on the bill has a unique description and that the charge for a particular
item may vary from one patient to another.
Using the normalization, develop a set of BCNF relations for the patient billing system shown below.
Draw a relational schema for the BCNF relations you developed. Be sure to show the functional dependencies and referential integrity constraints.

1. Functional Dependencies

{Patient# → Patient Name, Date Admitted, Date Discharged, Address

Code → Description

Code → Total Charge

Invoice Date, Patient# → Due Date, Account#}

2. Converting into 3NF (through MC method)

{

Patient# → Patient Name, Date Admitted, Date Discharged, Address

Code → Description, Total Charge

Invoice Date, Patient# → Due Date, Account#

}

Relations:

Patient#	Patient Name	Date Admitted	Date Discharged	Address

Code	Description	Total Charge

Invoice Date	Patient#(FK)	Due Date	Account#

The Above Relations are already in BCNF form