SFU SIMON FRASER UNIVERSITY

CMPT 354 Module 4 Assignment

Due: April 16, 2021 @ 11:59 PM

Weighting: 8%

1. Overview

The purpose of this assignment is to test your ability to use and apply functional dependencies and normalisation in the database design process. You will gain experience in isolating problems with relational schema by determining the appropriate normal form and finding examples of potential anomalies in relation instances. Finally, you will generate an efficient database schema using both the BCNF and 3NF approach to normalisation.

This assignment must be completed individually.

2. Submission

All submissions must be made through an electronic marking tool called Gradescope, which will also be used for providing feedback (enroll with the entry code M68KZM). You **must** record all your answers in the spaces provided in this document. Altering the format or layout of this document in anyway will attract penalties. You may however add landscape images in the submission boxes without changing the orientation of the page.

3. Marking

The Module 4 assignment counts for 8% of course mark.

4. Task

This assignment has been split into five sections which each examine a key topic covered in Module 4 of this course. Each section will have several questions with appropriate instructions to assist you in completing that question. You must complete all sections of this assignment and submit your answers using the boxes provided.

Section A – Anomalies & Functional Dependencies

Question 1

A local grocery shop *Kimchi N' Bread*™ uses a database to store transactions related to customer purchases. A sample of a table in their database has been provided below. For simplicity, the attribute names have been simplified to single letters.

A	B	C	D	E	F
1	Bread	Grace	12/10/2020	4	1000
2	Kimchi	Jack	12/10/2020	1	2000
3	Milk	Grace	14/10/2020	4	2000
4	Bread	Andrew	18/10/2020	8	1000
5	Kimchi	Charlie	18/10/2020	7	2000
6	Milk	Jack	19/10/2020	1	2000

Based on the data above, provide a list of *all possible* non-trivial functional dependences for this table. You do not need to justify your answers.

Note: For this question, non-trivial FD's with more than one attribute on the left-hand side should also not be included. For example, the following two FD's should not be included:

{A} → {A} {A, B} → {A}

{A} -> {B, C, D, E, F}
{B, C} -> {D, E, F}
{C} -> {E}
{B} -> {F}

Question 2

SFU has decided to create an efficient database to help tutors manage their teaching schedule. The schema for their Tutor table and a sample of the instance data can be seen below.

ID	BuildingNumber	BuildingName	DayTime	TutorNumber	TutorName
10	7	ASB	Thursday 12:00 PM	1345	Jelena
12	7	ASB	Thursday 1:00 PM	1345	Jelena
13	47	Physics	Thursday 1:00 PM	4123	Jason
14	68	Chemistry	Friday 08:00 AM	2289	Tahlia
15	68	Chemistry	Friday 10:00 AM	4123	Jason
16	7	ASB	Friday 08:00 PM	2289	Tahlia

This table contains the following non-trivial functional dependencies:

{ID} → {BuildingNumber, BuildingName, DayTime, TutorNumber, TutorName}
{BuildingNumber} → {BuildingName}
{TutorNumber} → {TutorName}

Using the table above, you must provide a brief example and explanation of database operations which would cause an insertion, modification and deletion anomaly. Your explanation should be brief and not exceed 50 words. A dummy example of the format your answers should be written in can be seen on the next page.

Example format:

Operation:
Insert <11, 7, ‘ASB’, ‘Monday 8:00 AM’, 0007, ‘Jack’> into Tutor

Explanation:
This operation would cause an insert anomaly to occur because …

Insertion Anomaly:

Operation: Insert <11, null, null, ‘ Monday 8:00 AM’ , null, ‘ Jack’ > into Tutor

Explanation: This operation would cause an insert anomaly to occur since BuildingName relys on the BuildingNumber, BuildingName can not be null.

Modification Anomaly:

Operation: Update <11, 7, 'Physics', ‘ Monday 8:00 AM’ , 1345, ‘ Jason’ > into Tutor

Explanation: This operation would cause an modification anomaly to occur since BuildingName relys on the BuildingNumber, 'Physice' has BuildingNumber 47, thus update the 'Physice' with BuildingNumber 7 will cause error.

Deletion Anomaly:

Operation: Delete <13, 47, 'Physics', ‘ Thursday 1:00 PM’ , 4123, ‘ Jason’ > into Tutor

Explanation: This operation would cause an deletion anomaly to occur since deleting buildingName 47 will lose the only information regarding buildingName 'Physics'. If we delete that row, we will lose the information.

Section B – Keys

For each question in this section, you are required to list all possible candidate keys for the given schema based on the functional dependencies provided. You may wish to compute the closure of your key(s) to confirms they are valid.

Question 1

R [A, B, C, D, E, F, G, H, I, J]

{A} → {B}

{C} → {B}

{B} → {D, E, F, G, H}

{D, F} → {I, J, A}

Candidate Key(s):

(C)+ = {C}
= {CB}
= {CBDEFGH}
= {CBDEFGHAIJ}
= R

Question 2

R [A, B, C, D, E, F, G, H]

{A, B} → {C, D, E}

{C} → {A, B, D, E}

{D} → {G}

{E} → {F}

Candidate Key(s):

(A, B, H)+ = {ABH}
= {ABHCDE}
= {ABHCDEFG}
= R

(C, H)+ = {C, H}
= {ABCDEH}
= {ABCDEFGH}
= R

Question 3

R [A, B, C, D, E, F, G, H, I, J, K]

{A, C, D} → {K, J, E}

{C} → {A, B, K}

{D, H, I} → {E, C, G}

{B} → {A}

{K, G} → {B, C, H, I}

Candidate Key(s):

(D, F, H, I)+ = {DFHI}
= {DFHIECG}
= {ABCDEFGHIK}
= {ABCDEFGHIJK}
= R

(D, F, K, G)+ = {BCDFGHIK}
= {ABCDEFGHIK}
= {ABCDEFGHIJK}
= R

(D, F, C, G)+ ={DFCG}
={ABCDFCG}
={ABCDEFGHIJK}
= R

Section C – Highest Normal Form

For each question in this section, you are required state and justify the highest normal form of the relation given a schema and functional dependencies. Your explanations should be brief and concise. *Hint*: It may be useful to identify the candidate keys for each relation.

Question 1

R [A, B, C, D, E, F]

{B, C} → {D, E, F}

{A} → {D, E, F}

Highest Normal Form: 1NF

Explanation:

Candidate Key is {A, B, C}

[1] Check BCNF: {B, C} is not a Super Key
[2] Check 3NF: {B, C} is not a Super Key, and {D, E, F} is not a prime attribute
[3] Check 2NF: {B, C} is a prime attribute and {D, E, F} is a nun-prime attribute, forming a partial functional dependency.
[4] Check 1NF: there is no multivalue, is 1NF

Question 2

R [A, B, C, D, E, F, G, H]

{A, B, C} → {D, E, F, G, H}

{G, H} → {A, B, C}

Highest Normal Form: BCNF

Explanation:

Candidate Keys are: {A, B, C}, {G, H}

[1] Check BCNF: {A, B, C} and {G, H} are Super Key, is BCNF.
[2] Check 3NF: {A, B, C} and {G, H} are Super Key, is 3NF.
[3] Check 2NF: No partial functional dependency, is 2NF.
[4] Check 1NF: No multivalue, is 1NF

Question 3

R [A, B, C, D, E, F, G, H, I, J, K, L]

{A, C, L} → {E}

{C, E, L} → {A}

{H, B, C, F, L, A} → {I, J, K}

{K} → {D, G}

Highest Normal Form: 1NF

Explanation:

Candidate Key:{H, B, C, F, L, A}

[1] Check BCNF:{A, C, L} is not a super key
[2] Check 3NF: {A, C, L} is not a super key, and {E} is not a prime attribute.
[3] Check 2NF: {A, C, L} is a prime attribute, {E} is not a prime attribute, it forming a partial functional dependency.
[4] Check 1NF: there is no multivalue, is 1NF

Section D – BCNF Decomposition

For each question in this section, you are required to decompose the given relation into BCNF form and state any new relations created in the process with their functional dependencies and identify any functional dependencies which are lost during the decomposition. You must show your working using the tree method presented in tutorials. Consider the functional dependencies in the order presented in the question.

Question 1

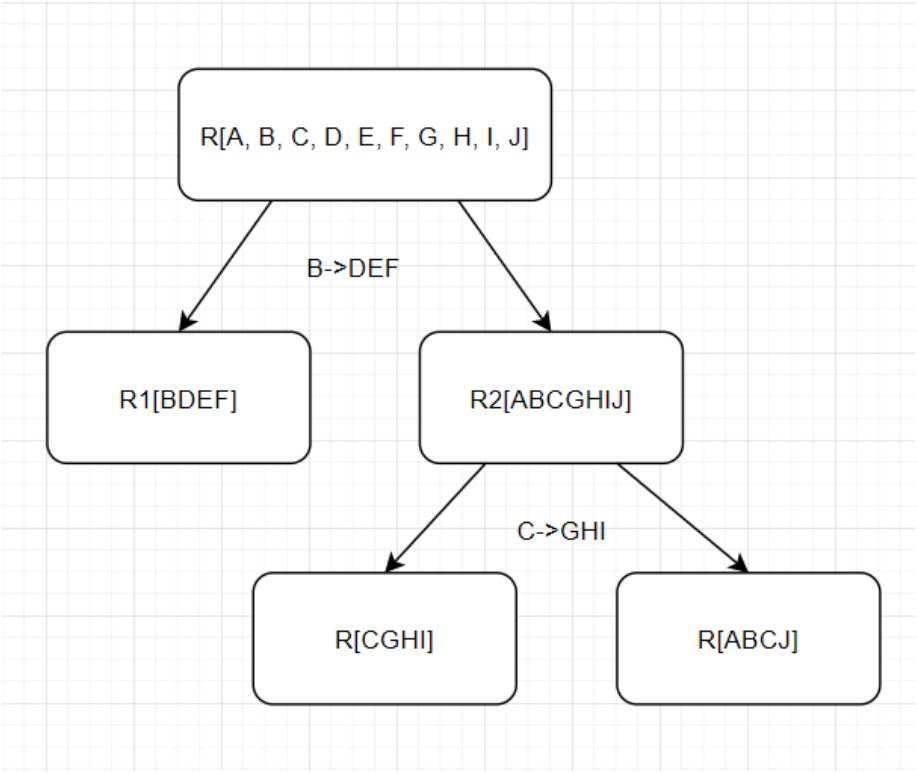
R [A, B, C, D, E, F, G, H, I, J]

{A} → {B, C}

{B} → {D, E, F}

{C} → {G, H, I}

{H, I} → {F, J}



R1[BDEF]
R2[CGHI]
R3[ABCJ]

No dependency added or lost.

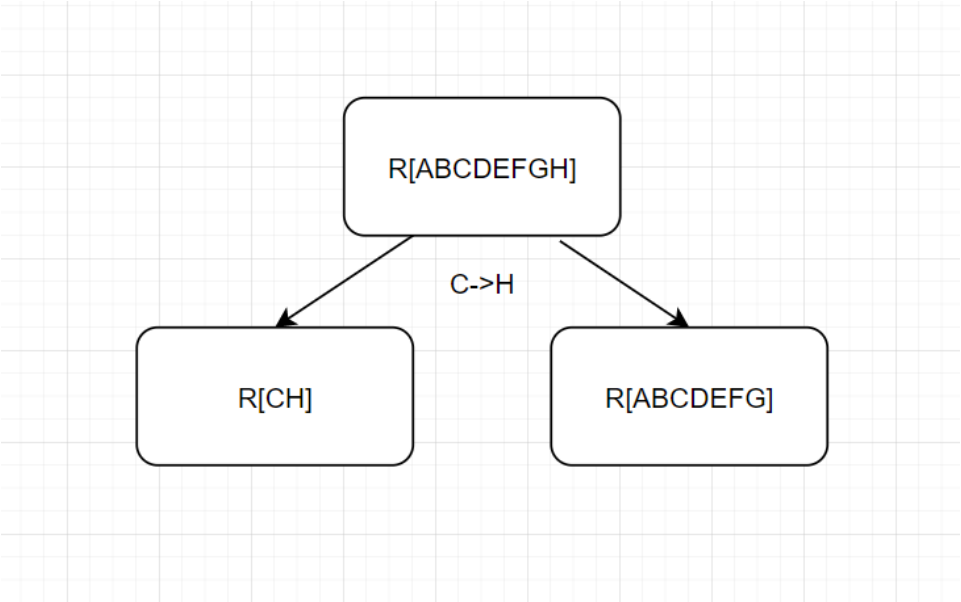
Question 2

R [A, B, C, D, E, F, G, H]

{A, B, C} → {D, E, F, G}

{G, H} → {A, B, C}

{C} → {H}



R1[CH]
R2[ABCDEFG]

Lost dependency: {G, H} -> {A, B, C}

Section E – 3NF Decomposition

Question 1

Based on the following relational schema and functional dependencies, find minimal cover for relation R.

R [A, B, C, D, E, F, G, H, I, J, K, L, M, N]

{A} → {C, D, F, G}

{B} → {E}

{A, G} → {J, C}

{D, E, B} → {H, I, J}

{J} → {K, L, M}

{M} → {N}

(1). Standard form:
A->C
A->D
A->F
A->G
B->E
AG->J
AG->C
DEB->H
DEB->I
DEB->J
J->K
J->L
J->M
M->N

(2). Minimum Cover:
A->CDFGJ
B->E
DB->HIJ
J->KLM
M->N

Question 2

The minimal cover has been provided below for a given relation with a set of functional dependencies. Using the minimal cover, normalise the relation to 3NF such that all functional dependencies are preserved.

R [A, B, C, D, E, F, G, H]

{A} → {D, F}

{B} → {G, E}

{F, G} → {H}

Minimal Cover: {

{A} → {D}, {B} → {G}, {B} → {E}, {A} → {F}, {F, G} → {H}

}

A->DF
B->GE
FG->H

Candidate key: {A, B, C}
3NF:
R1[A, D, F]
R2[B,G, E]
R3[F, G, H]
R4[A, B, C]

Question 3

Based on the following relational schema and functional dependencies, find minimal cover for relation R and then decompose R to 3NF such that all functional dependencies are preserved.

R [A, B, C, D, E, F, G, H, I, J, K]

{A, B, D} → {F, H}

{H, B} → {G, E, I}

{I} → {J, K}

{A, I} → {J, H, K}

(1) Standard form:
ABD->F
ABD->H
HB->G
HB->E
HB->I
I->J
AI->J
AI->H
AI->K

Minimum Cover:
ABD->F
ABD->H
HB->G
HB->E
HB->I
I->J
I->K
AI->H

Candidate key: ABCD

3NF: R1[ABDHF], R2[HBGEI], R3[IJK], R4[AIH], R5[ABCD]