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Media Engineering and Technology Faculty
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January 5, 2020

CSEN501 Databases I
Winter Semester 2019

Final Exam

Bar Code

Instructions: Read carefully before proceeding.

1) Please tick your major

CSEN	
DMET	
BI	

2) Duration of the exam: 3 hours.

3) (Non-programmable) Calculators are allowed.

4) No books or other aids are permitted for this test.

5) This exam booklet contains 15 pages, Including this one. Three extra sheets of scratch paper are attached and have to be kept attached. **Note that if one or more pages are missing, you will lose their points. Thus, you must check that your exam booklet is complete**.

6) Write your solutions in the space provided. If you need more space, write on the back of the sheet containing the problem or on the three extra sheets and make an arrow indicating that. **Scratch sheets will not be graded unless an arrow on the problem page indicates that the solution extends to the scratch sheets**.

7) When you are told that time is up, stop working on the test.

Good Luck!

Don't write anything below ;-)

Exercise	1	2	3	4	5	6	7	8	$\sum$
Possible Marks	10	8	15	12	12	20	8	20	105
Final Marks									

Exercise 1

Consider the relation $R(A, B, C, D, E, F)$ with the following functional dependencies:

$$A \rightarrow C$$

$$DE \rightarrow F$$

$$B \rightarrow D$$

a) What is the primary key for R. Show your workout

Solution:

ABE

b) Add to the above set of functional dependencies the dependency $A \rightarrow B$. In case we want A to be the key. What functional dependency should we add in order for A to be the key. **The functional dependency can have only one attribute on the left hand side and one attribute on the right hand side**

Solution:

$A \rightarrow E$

Exercise 2

Consider the relation $R(A, B, C)$, write a relational algebra expression that returns empty if and only if the functional dependency $A \rightarrow B$ holds on R.

Solution:

$\rho_{R1}(R) \bowtie_{R1.A=R1.A \wedge R1.B<>R2.B} \rho_{R1}(R)$

Exercise 3

R	
A	B
1	2
3	2
5	6
7	8
9	8

S	
B	C
6	2
2	4
8	1
8	3
2	5

T	
A	C
7	1
1	2
9	3
5	4
3	5

Tabelle 1: Option I

A	B	C
1	2	4
1	2	5
3	2	4
3	2	5
5	6	2
7	8	1
7	8	3
9	8	1
9	8	3

Tabelle 2: Option II

A	B	C
1	2	2
3	2	5
5	6	4
7	8	1
9	8	3

Tabelle 3: Option III

A	B	C
3	2	5
7	8	1
9	8	3

Tabelle 4: Option IV

A	B	C

All the join operations are natural joins. For each of the below queries, pick the output. If the output is none of the above, write what the output is.

a) What is the result of $R \bowtie (S \bowtie T)$

Solution:

IV

b) What is the result of $(S \bowtie R) \bowtie T$

Solution:

IV

c) What is the result of $\pi_{A,B}(R \bowtie S) \bowtie \pi_{A,C}(S \bowtie T)$

Solution:

II

d) What is the result of $\pi_{A,B}(R \bowtie T) \bowtie \pi_{B,C}(S \bowtie T)$

Solution:

I

e) Let table R have attributes A and B, and table S likewise have attributes A and B. The relational algebra expressions below are equivalent except for which one? **Justify**

1. $R \cup S$
2. $R - (S - R)$
3. $S - (S - R)$

4. $R \bowtie S$
5. $(\mathbb{R} \cap S) - ((R - S) \cap (S - R))$

Solution:

$R - (S - R)$ and $R \cup S$

The following schema should be used throughout the next 3 questions:

```
Customer(CID, name, address)
Magazine(title, publisher,topic, frequency, url)
Pricing(title, publisher, period, discount, price)
Pricing.(title, publisher) references Magazine
Subscribes(cid,title, publisher, period, discount, from)
Subscribes.(cid) refs Customer
Subscribes.(title, publisher, period, discount) references Pricing
```

The schema manages customers and their subscriptions to magazines. Customers can subscribe to magazines. Every magazine offer different types of subscriptions according to the subscription period.

Exercise 4

Represent the following in Relational Algebra

a) Find the magazines that have a price less than 100

Solution:

$\pi_{title,publisher}(\sigma_{price<100}(Pricing))$

b) What is the largest available subscription period in any magazine.

Solution:

$\pi_{period}(Subscribes) - \pi_{S1.period}(\rho_{S1}Subscribes \bowtie_{S1.period<S2.period} \rho_{S2}Subscribes)$

c) Find the pairs of customer names such that all of their subscriptions are always done on the same day.

Solution:

Actually this cannot be solved with relational algebra; but also this answer was considered correct:
$[(\pi_{cid}Subscribes * \pi_{cid}Subscribes) - \pi_{S1.cid,S2.cid}(\sigma_{S1.from\neq S2.from}(\rho_{S1}(Subscribes) \bowtie_{S1.cid\neq S2.cid} \rho_{S2}(Subscribes)))] \bowtie_{S1.cid=cid} (Customer) \bowtie_{S2.cid=cid} (Customer)$

d) Find the names of customers that are subscriber to all magazines that offer a subscription with a yearly frequency.

Solution:

$\pi_{name}[Customer \bowtie (\pi_{title,publisher,cid}(Subscribes)/\pi_{title,publisher}(\sigma_{frequency='yearly'}Magazine))]$

Exercise 5

Represent the following in Relational Calculus

a) Find the names of customers who have one subscription only

Solution:

$\{C.name|Customer(C) \wedge \exists_S(Subscribes(S) \wedge C.cis = S.cid \wedge \neg(\exists_{S1}(Subscribes(S1) \wedge S1.cid = S.cid \wedge S1 \neq S)))\}$

b) What is the name of the publisher that has at least magazine in any topic (publishes in all topics).

Solution:

$\{m.publisher|Magazine(M) \wedge \forall_{M1}(Magazine(M1) \rightarrow \exists_{M2}(\exists_{M2}(Magazine(M2) \wedge M1.publisher = M.publisher \wedge M2.topic = M1.topic)))\}$

c) Find the names of customers that are not subscribed in "sports" magazines.

Solution:

$\{C.name|Customer(C) \wedge \neg(\exists_S(Subscribes(S) \wedge S.cid = C.cid \wedge \exists_M(Magazine(M) \wedge M.title = S.title \wedge M.publisher = S.publisher \wedge M.topic <>' Sports')))\}$

d) What is the shortest possible subscription period

Solution:

$\{S.period|Subscribes(S) \wedge \forall_{S1}(Subscribes(S) \rightarrow S.period <= S1.period)\}$

Exercise 6

Represent the following in SQL

a) What is the name of the publisher that has at least magazine in any topic (publishes in all topics).

Solution:

```
SELECT M.publisher
FROM Magazine M
WHERE NOT EXISTS
(
    SELECT N.topic
    FROM Magazine Z
    EXCEPT
    SELECT
    L.Topic
    FROM magazine L WHERE L.publisher = M.publisher
)
```

b) Implement a view for magazines with no subscribers

Solution:

```
CREATE VIEW VNAME AS
SELECT M.*
FROM Magazine M LEFT OUTER JOIN Subscribes S
ON M.title = S.title AND M.publisher=S.publisher
WHERE S.cid IS NULL
```

c) Create a stored procedure that takes as an input the title of a magazine (magazine1) and returns the title of another magazine (magazine2) that is usually associated (subscribed to) along with the input title. In other words, most users subscribed to magazine1 are also subscribed to magazine2.

Solution:

```
CREATE PROC pname
@magazine1 VARCHAR(20),
@magazine2 VARCHAR(20) OUTOUT
AS
SELECT COUNT(*) AS C, S2. title  AS Sa, S1.title AS Sb
FROM Subscribe S1 INNER JOIN Subscribe S2
ON S1.cid=S2.cid
WHERE S1.title<>S2.title
GROUP BY S1.title, S2.title
HAVING C>= ALL
(
    SELECT COUNT(*)
    FROM Subscribe S INNER JOIN S3
    ON S.cid = S3.cid
    WHERE S.title = @magazie1
    AND S.title <> S3.title
    GROUP BY S.title, S3.title
)
```

d) Find the names of customers such that all their subscriptions are yearly.

Solution:

```
SELECT C.name
FROM Customer C
WHERE NOT EXISTS
(
    SELECT *
    FROM Subscribes S, Magazine N
    ON S.publisher =N.publisher AND S.title =N.title
    WHERE S.cid = C.cid AND N.frequency NOT LIKE '%yearly%'
)
```

e) Find the magazine with most number of subscriptions in the "scientific" category

Solution:

```
SELECT M.title
FROM Magazine M INNER JOIN Subscribes S
ON M.title=S.title AND M.publisher = S.publisher
WHERE M.topic='Scientific'
GROUP BY M.title, M.publisher
HAVING COUNT(*)>= ALL
    (
    SELECT COUNT(*)
    FROM FROM Magazine M1 INNER JOIN Subscribes S1
    ON M1.title=S1.title AND M1.publisher = S1.publisher
    AND M1.topic = 'Scientific'
    GROUP BY M2.title, M2.publisher
    )
```

Exercise 7

Given the following Armstrong axioms:

$$Reflexivity \quad if \quad Y \subseteq X \; then \; X \rightarrow Y.$$

$$Augmentation \quad if \quad X \rightarrow Y \; then \; XZ \rightarrow YZ.$$

$$Transitivity \quad if \quad X \rightarrow Y \; Y \rightarrow Z then \; X \rightarrow Z.$$

Given the following functional dependencies

$$A \rightarrow BC$$

$$CD \rightarrow E$$

$$B \rightarrow D$$

$$E \rightarrow A$$

Prove or disprove $A \rightarrow E$. In case you will prove, use Armstrong axioms. In case you will prove, give a counter example.

Exercise 8

For the relation $R(A, B, C, D)$ and the functional dependencies

$$A \rightarrow BD$$

$$CD \rightarrow B$$

$$C \rightarrow D$$

$$B \rightarrow D$$

a) What are the candidate keys. **Show your workout**

Solution:

AC^+: A,B,C,D, hence a superkey and its subsets must be tested A^+: A,B,D and C^+: C,D,B. Accordingly, AC is a candidate key.
To get the full mark other combinations must be tested, however AC is the only candidate key.

b) Find a minimal cover for the dependencies. **Show your workout**

Solution:

Step 1: Let the right-handside be a single attribute {A → B, A → D, CD → B, C → D, B → D}
Step 2: Check for redundant functional dependencies:
A^+ without $A \rightarrow B$: {A,D}; not redundant
A^+ without $A \rightarrow D$: {A,B,D}; redundant
CD^+ without $CD \rightarrow B$: {C,D}; not redundant
C^+ without $C \rightarrow D$: {C}; not redundant
B^+ without $B \rightarrow D$: {B}; not redundant
Step 3: Try to minimize the left-handside;
C^+ from the set of FDs:{C,D,B}; so we can replace CD → B with C → B
Because in step 3, the FDs have been changed we need to repeat step 2. C^+ without C → B: {C,B,D} hence it is redundant and can be removed.

The final minimal cover is: {A → B, C → B, B → D}

c) Decompose R into the 3rd normal form using the algorithm

Solution:

R1(<u>A</u>,B)
R2(<u>C</u>,B)
R3(<u>B</u>,D)
Since the only candidate key A,C is not part of any of the previous relations we need to add R4(<u>A,C</u>)

Scratch paper

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