

MIDTERM EXAM - 600.315/415 - Database Systems

Date: October 23, 2008, 3:00 PM

The total number of points in this exam is 68 for 600.315 students, and 78 for 600.415 students. If you work at approximately 1 minute per point, you should finish on time.

Some questions should only be done by 600.415 student, and are are marked with a “*” **and** by the phrase (*600.415 only*). There are 3 questions (Question 1a, 1b, 10a) that should only be done by *600.315* . These are marked with a # **and** (*600.315 only*).

Question 1 - Relational Algebra (5 points) - *600.315 only*

Express the following query in the Relational Algebra. The tables that are used in this (and following) questions are found on your supplementary handout.

- (#5 points) List the names of all countries with a literacy rate below 50% that border a country with a literacy rate above 99% or border a country with a female prime minister.

```
Below50 ← Πcname ( σLitRate<50 ( Country ) )
Above99 ← Πcname ( σLitRate>99 ( Country ) )
FemalePM ← Πcname ( Country ⋈ σCName=Country Politician )
Result ← Πcname
( Below50 ⋈ σCName=Country1 Borders ⋈ σCountry2=Cname ( Above99 ∪ FemalePM ) )
```

Question 2 - Relational Algebra (5 points) - *600.315 only*

- (#5 points) List the names of all countries that border every other country in their continent. (e.g. Assuming North America has 3 countries, USA borders both Mexico and Canada.)

```
C1 ← ρcountry1=cname ( Country )
C2 ← ρcountry2=cname ( Country )
CountriesCont ←
  Πcountry1,country2 ( σcountry1<>country2 ( C1 ⋈ σc1.Continent=c2.Continent C2 ) )
NotBorderEvery ← Πcountry1 ( CountriesCont - Border )
AllCountries ← Πcname ( Country )
Result ← AllCountries - NotBorderEvery
```

Question 3 - Tuple Relational Calculus (5 points)

Express the following query in Tuple Relational Calculus:

- (5 points) Print the name and GNP of all countries that border Austria or have a female prime minister but not both.

```
{ t |  
  ∃ c ∈ COUNTRY ( t[CName] = c[CName] ∧ t[GNP]=c[GNP] ∧ (  
    ∃ b ∈ BORDERS ( b[country1]=c[CName] ∧ b[country2]='Austria'  
  ) ∪ ∃ p ∈ POLITICIAN (  
    p[country]=c[CName] ∧ p[office] = 'Prime Minister' ∧ P[gender]='female'  
  ) ) ∧ ( ¬ ∃ b1 ∈ BORDERS, p1 ∈ POLITICIAN (  
    b1[country] = c[cname] ∧ b1[country2]='Austria' ∧ p1[country]=c[cname] ∧ p1[office]='Prime  
    Minister' ∧ p1[gender] = 'female'  
  ) ) ) }
```

Question 4 - Relational Algebra (5 points)

Express the following query in the relational algebra.

- (a) (5 points) List the names of all people who are either (a) an elected official, (b) directly related to an elected official, or (c) directly related to someone who is directly related to an elected official.

```
Elected ←  $\Pi_{pname}$  ( Politician )  
D_ElectedInit ←  $\Pi_{politician2}$  ( IsRelated  $\bowtie$   $\sigma_{politician1=pname}$  Elected )  
D_Elected ←  $\rho_{pname=politician2}$  ( D_ElectedInit )  
D2_ElectedInit ←  $\Pi_{politician2}$  ( IsRelated  $\bowtie$   $\sigma_{politician1=pname}$  D2_Elected )  
D2_Elected ←  $\rho_{pname=politician2}$  ( D2_ElectedInit )  
Result ← Elected  $\cup$  D_Elected  $\cup$  D2_Elected
```

Question 5 - Relational Algebra (5 points)

Express the following query in the relational algebra:

- (a) (* 5 points) List the names and populations of all countries that have a smaller GNP than every country that they border. (600.415 only)

```
Bordering ← Πcountry1,GNP1,population1,country2,GNP2  
( Country ⋈σcname=country1 Borders ⋈σcountry2=cname Country )  
LessThanAtLeastOne ← Πcountry1,population1,country2 ( σGNP1<GNP2 ( Bordering ) )  
Result ← Πcountry1,population ( LessThanAtLeastOne ⋈σcountry1<>country2 LessThanAtLeastOne )
```

Question 6 - Relational Algebra (6 points)

Express the following query in the relational algebra:

List the full names of all politicians who hold elective office in a country and who have a sister who also holds elective office in the same country

```
AreSis ← Πpolitician1,politician2 ( σType='sister' ( IsRelated ) )  
OfficeSis ← Πpolitician1,country ( Politician ⋈σpname=politician2 AreSis )  
Result ← Πpname ( Politician ⋈σcountry=country^pname=politician1 OfficeSis )
```

Question 7 - SQL (20-30 points)

Express the following queries in SQL:

- (a) List the name, GNP and population of the country with the smallest GNP per capita (GNP/population) in the entire database.

```
SELECT Cname,GNP,Population
FROM Country
WHERE GNP/Population = (SELECT min(GNP/Population)
                        FROM country);
```

- (b) List the names of all countries that do not border Russia directly, but border a country that borders Russia.

```
(SELECT country1
   FROM BORDERS
   WHERE country2 IN
                        (SELECT country1
                         FROM Borders
                         WHERE country2="Russia") )
MINUS
(SELECT country1
   FROM Borders
   WHERE country2 ="Russia");
```

- (c) For each continent, list the name of the country with the lowest literacy rate in the continent (along with the name of the continent).

Your output should be a single table and not use multiple queries.

```
SELECT  C.Continent, C.Cname
FROM    Country C
GROUP BY C.Continent,C.litRate
HAVING  C.litRate IN (
SELECT MAX (C2.litRate)
FROM Country C2
Where C2.Continent = C.Continent
)
```

- (d) List the pair of bordering countries with the greatest absolute difference in life expectancy (give both names and do not repeat them).

```
SELECT b.country1,b.country2
FROM Borders b, Country C1, Country C2,
      (SELECT C1.Cname, C2.Cname, Max(C1.lifeExp-C2.lifeExp) as Maximum
       FROM Country C1, Country C2
       GROUP BY C1.Cname, C2.Cname) T
WHERE b.country1=T.Cname1
      AND b.country2=T.Cname;
```

- (e) * List the name of all politicians who have a son or daughter who hold political office in a different country from the one in which they (the father or mother being considered) hold political office. (600.415 only)

```
SELECT R.Politician1
FROM IS_RELATED R
WHERE Type= "Mother" or Type="Father"
      AND
      (SELECT Country FROM Politician P1 where P1.Pname = R.Politician1)
<>
      (SELECT Country FROM Politician P2 where P2.Pname = R.Politician2)
)
```

- (f) * List the name and continent of the country with the smallest population in the continent that has the largest total population. (600.415 only)

```
SELECT C1.Cname, C1.Continent
FROM Country C1
WHERE C1.Population = ( SELECT MIN(C2.Population)
                        FROM Country C2
                        WHERE C2.Continent = (
                        SELECT C3.Continent
                        FROM (
                        SELECT MAX(C4.Population),C4.Continent
FROM (
      SELECT SUM(C5.Population) As Population,C5.Continent
      FROM Country C5
      GROUP BY C5.Continent
      ) C4
      ) C3
      )
      )
```

Question 8 - QBE (10-15 points)

Express the following queries in QBE. To simplify your work, table shells have been provided. Just fill in the appropriate cells with variables/values.

- (a) (5 points) List the name and continent of every country that borders a country that borders a country that has a female prime minister.

COUNTRY	<u>CName</u>	Continent	GNP	Population	LitRate	LifeExp
	P. _C1	P.				

BORDERS	<u>Country1</u>	<u>Country2</u>
	_C1	_C2
	_C2	_C3
	_C3	_C4

POLITICIAN	<u>PName</u>	Gender	Office	Country	Age
		Female	Prime Minister	_C4	

- (b) (5 points) List the name and gender of all politicians who are prime ministers of a country and older than the prime minister *or* president of at least one country that they border.

COUNTRY	<u>CName</u>	Continent	GNP	Population	LitRate	LifeExp

BORDERS	<u>Country1</u>	<u>Country2</u>
	_C1	_C2

POLITICIAN	<u>PName</u>	Gender	Office	Country	Age
	P.	P.	Prime Minister	_C1	_A1
			President	_C2	_A2
			Prime Minister	_C2	_A3

CONDITIONS
_A1 > _A2 OR _A1 > _A3

- (c) (* 5 points) List the name of all continents that contain at least two countries that do not border each other. (600.415 only)

COUNTRY	<u>CName</u>	Continent	GNP	Population	LitRate	LifeExp
	<u>_C1</u> <u>_C2</u>	P. <u>_CT</u> <u>_CT</u>				

BORDERS	<u>Country1</u>	<u>Country2</u>
\neg	<u>_C1</u>	<u>_C2</u>

Question 9 - Relational Algebra (6 points)

Given the following relations r, s and t:

r

A	<u>B</u>	<u>C</u>
g	20	2
e	40	1
e	50	2
d	10	1
g	10	2
g	10	3
d	30	1
d	30	2
d	30	3

s

<u>C</u>
1
2
3

t

<u>A</u>	B
g	10
d	30

- (a) (3 points) Compute $r - (t \times s)$:

A	B	C
g	20	2
e	40	1
e	50	2
d	10	1

- (b) (3 points) Compute $r \div s$:

A	<u>B</u>
d	30

Question 10 - Functional Dependencies (6 points)

- (a) (#6 points - 600.315 only) List *all* the nontrivial functional dependencies over A, B and C that are **not** incompatible with the data presented in the following relation. If in doubt about whether a functional dependency is trivial or not, list it to be safe.

A	B	C
10	5	30
10	5	40
20	5	30
20	5	50

A → B
C → B
AC → B
AC → ABC

- (b) (* 6 points - 600.415 only)

Compute the canonical cover (F_c) for the following set of functional dependencies F (assuming A, B, C, D, etc. are individual attributes):

$A \rightarrow BCE$
 $AB \rightarrow DE$
 $BI \rightarrow J$

A → BCDE
BI → J

CERTIFICATION PAGE

By signing below, I promise that my answers on this exam are entirely my own work. I have not looked at the answers written by others and I have not allowed others to look at my answers.

My Signature: