Homework 2

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Question 1:
Exercise 16.2.2: Give examples to show that:
a) Projection cannot be pushed below set union.
b) Projection cannot be pushed below set or bag difference.
Answer:
a) The following example shows that projection cannot be pushed below set union.
Suppose relation A is,

a1	a2
1	2

Suppose relation B is,

a1	a2
1	3

Then, π_{a1}(A U B) is,

a1
1
1

And π_{a1}(A) U π_{a1}(B) is,

a1
1

The example shows that π_{a1}(A U B) ≠ π_{a1}(A) U π_{a1}(B), which means projection cannot be pushed below set union.

b) The following example shows that projection cannot be pushed below set difference.
Suppose relation A is,

a1	a2
1	2
3	4

Suppose relation B is,

a1	a2
1	3

Then, π_{a1}(A - B) is

a1
1
3

And π_{a1}(A) - π_{a1}(B) is

a1
3

The example shows that $\pi_{a1}(A - B) \neq \pi_{a1}(A) - \pi_{a1}(B)$, which means projection cannot be pushed below set difference. Because a set is also a bag, then we proved that project cannot be pushed below bag difference either.

Question 2:

Exercise 16.2.4: Some laws that hold for sets hold for bags; others do not. For each of the laws below that true for sets, indicate whether or not it is true for bags by giving a proof that the law for bags is true, or by giving a counterexample.

a) R U R = R (the idempotent law for union).

b) R ∩ R = R (the idempotent law for intersection).

Answer:

a) The following example shows that R U R = R does not hold for bags.

Suppose relation R is,

a1
1

Then, R U R is,

a1
1
1

The example shows that R U R ≠ R, which means R U R = R does not hold for bags.

b) To prove R ∩ R = R holds for bags, we suppose R have m (m>=0) different tuples, denoted by t_1, t_2, …, t_m, the number of these tuples are n_1, n_2, …, n_m. Based on the definition of intersection for bags (see page 207 in the textbook), R ∩ R will also have tuples t_1, t_2, …, t_m, and the number of these tuples will be min{n_1, n_1}, min{n_2, n_2}, …, min{t_m, t_m}, which equals to n_1, n_2, …, n_m. So R ∩ R is identical to R, R ∩ R = R does hold for bags.

Question 3:

Write the following queries in both SQL and extended relational algebra (for bags), based on the Spy database schema

a) Find the average salary of an agent.

b) Find the average salary of agents in the USA.

c) Find the average salary of agents on team # 12

d) Find the number of agents who either speak German or are demolition experts.

e) Find the average salary of an agent for each country.

f) Find the average salary of an agent for each skill_id.

g) Find the agent id for agents who speak at least three languages.

h) Find the maximum salary of agents who speak French.

i) For each agent with clearance ID above 2, find the average salary

j) Find the average salary of agents from the USA for each mission, where the mission has a clearance_id = 5.

Answer:

a) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT AVG(salary) FROM agent
extended relational algebra	$\gamma_{AVG(salary)}$(agent)

b) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT AVG(salary) FROM agent WHERE country='USA'
extended relational algebra	$\gamma_{AVG(salary)}(\sigma_{country='USA'}$(agent))

c) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT AVG(salary) FROM agent,teamrel WHERE team_id=12 AND agent.agent_id=teamrel.agent_id
extended relational algebra	$\gamma_{AVG(salary)}(\sigma_{team\_id=12 \text{ AND } agent.agent\_id=teamrel.agent\_id}$(agent x teamrel))

d) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT COUNT(agent_id) FROM ((SELECT agent_id FROM languagerel,language WHERE languagerel.lang_id=language.lang_id AND language.language='German') UNION (SELECT agent_id FROM skillrel,skill WHERE skillrel.skill_id=skill.skill_id AND skill.skill='Demolition Expert')) res
extended relational algebra	$\gamma_{COUNT(agent\_id)}(\pi_{agent\_id}(\sigma_{languagerel.lang\_id=language.lang\_id \text{ AND } language.language='German'}$(languagerel x language))) U $(\pi_{agent\_id}(\sigma_{skillrel.skill\_id=skill.skill\_id \text{ AND } skill.skill='Demolition Expert'}$(skillrel x skill)))

e) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT country,AVG(salary)

	FROM agent GROUP BY country
extended relational algebra	$\gamma_{country,AVG(salary)}(agent)$

f) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT skill_id,AVG(salary) FROM agent,skillrel WHERE agent.agent_id=skillrel.agent_id GROUP BY skill_id
extended relational algebra	$\gamma_{skill\_id,AVG(salary)}(\sigma_{agent.agent\_id=skillrel.agent\_id}(agent \times skillrel))$

g) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT agent_id FROM languagerel GROUP BY agent_id HAVING COUNT(lang_id)>=3
extended relational algebra	$\sigma_{COUNT(lang\_id)>=3}(\gamma_{agent\_id,COUNT(lang\_id)}(languagerel))$

h) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT MAX(salary) FROM agent,languagerel,language WHERE agent.agent_id=languagerel.agent_id AND languagerel.lang_id=language.lang_id AND language.language='French'
extended relational algebra	$\gamma_{MAX(salary)}(\sigma_{agent.agent\_id=languagerel.agent\_id \text{ AND } languagerel.lang\_id=language.lang\_id \text{ AND } language.language='French'}(agent \times languagerel \times language))$

i) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT AVG(salary) FROM agent WHERE agent.clearance_id>2
extended relational algebra	$\gamma_{AVG(salary)}(\sigma_{agent.clearance\_id>2}(agent))$

j) The queries in both SQL and extended relational algebra (for bags) are listed bellow,

SQL	SELECT mission_id,AVG(salary) FROM agent,teamrel,mission WHERE agent.country='USA' AND agent.agent_id=teamrel.agent_id AND teamrel.team_id=mission.team_id AND mission.access_id=5 GROUP BY mission_id
extended relational algebra	$\gamma_{mission\_id,AVG(salary)}(\sigma_{agent.country='USA' \text{ AND } agent.agent\_id=teamrel.agent\_id \text{ AND } teamrel.team\_id=mission.team\_id \text{ AND } mission.access\_id=5}(agent \times teamrel \times mission))$

Question 4:

Suppose relations R and S have tuples m and n tuples, respectively. Give the minimum and maximum numbers of tuples that the results of the following expressions can have.

a) $R \cap S$.

b) R Full Outer Join S.

Answer:

a) $R \cap S$.

min: 0

max: min{m,n}

b) R Full Outer Join S.

min: max{m,n}

max: m+n

Question 5:

The Circle and Sphere relations in a Geometry database give the center point of a circle or sphere of radius 5. Given the following data for these two tables:

Circle(X,Y): {(1,2), (3,4), (1,2), (3,5), (4,5)}

Sphere(X,Y,Z): {(1,2,3), (3,5,7), (3,6,2), (4,5,5), (1,3,5), (4,5,2)}

Compute the query answer for the following queries:

Note: these queries use the extended relational algebra operators that are defined for bags.

a. $\pi_{X+Y,2*X,2*Y}$ (Circle)

b. $\pi_{X+1,Y*2,Z-1}$ (Sphere)

c. $\tau_{Y,X}$(Circle)

d. $\tau_{Y,Z}$(Sphere)

e. δ (Circle)

f. δ (Sphere)

g. $\gamma_{X,\ SUM(Y)}$ (Circle)

h. $\gamma_{Y,\ AVG(Z),\ AVG(X)}$ (Sphere)

i. γ_{X} (Circle)

j. $\gamma_{X,Y,MAX(Z)}$ (Circle C $\bowtie_{C.X = S.X \text{ and } C.Y = S.Y}$ Sphere S)

k. Circle Left Outer Join $_{C.X = S.X \text{ and } C.Y = S.Y}$ Sphere

l. Circle Right Outer Join $_{C.X = S.X \text{ and } C.Y = S.Y}$ Sphere

Answer:

a. $\pi_{X+Y,2*X,2*Y}$ (Circle) = {(3,2,4), (7,6,8), (3,2,4), (8,6,10), (9,8,10)}

b. $\pi_{X+1,Y*2,Z-1}$ (Sphere) = {(2,4,2), (4,10,6), (4,12,1), (5,10,4), (2,6,4), (5,10,1)}

c. $\tau_{Y,X}$(Circle) = {(1,2) , (1,2), (3,4), (3,5), (4,5)}

d. $\tau_{Y,Z}$(Sphere) = {(1,2,3), (1,3,5), (4,5,2), (4,5,5), (3,5,7), (3,6,2)}

e. δ (Circle) = {(1,2), (3,4), (3,5), (4,5)}

f. δ (Sphere) = {(1,2,3), (3,5,7), (3,6,2), (4,5,5), (1,3,5), (4,5,2)}

g. $\gamma_{X,\ SUM(Y)}$ (Circle) = {(1,4), (3,9), (4,5)}

h. $\gamma_{Y,\ AVG(Z),\ AVG(X)}$ (Sphere) = {(2,3,1), (3,5,1), (5,4.66667,3.66667), (6,2,3)}

i. γ_{X} (Circle) = {(1),(3),(4)}

j. $\gamma_{X,Y,MAX(Z)}$ (Circle C $\bowtie_{C.X = S.X \text{ and } C.Y = S.Y}$ Sphere S) = {(1,2,3), (3,5,7), (4,5,5)}

k. Circle Left Outer Join $_{C.X = S.X \text{ and } C.Y = S.Y}$ Sphere = {(1,2,1,2,3), (3,4,NULL,NULL,NULL), (1,2,1,2,3), (3,5,3,5,7), (4,5,4,5,5), (4,5,4,5,2)}

l. Circle Right Outer Join $_{C.X = S.X \text{ and } C.Y = S.Y}$ Sphere = {(1,2,1,2,3), (1,2,1,2,3), (3,5,3,5,7), (NULL,NULL,3,6,2), (4,5,4,5,5), (NULL,NULL,1,3,5), (4,5,4,5,2)}