1. Formulating queries in Relational Algebra, RA SQL and TRC

1. Find each triple (c, p, s) where c is the cname of a company, p is the pid of a person who earns the lowest salary at that company and knows at least someone who has Operating Systems skill, and s is the salary of p.

(a) Formulate this query in Relational Algebra in standard notation. (4.5 points)
ANSWER:
πcname, pid, salary((Company ▷◁ worksFor) ⋈ worksFor) ⋈ Knows ⋈ (πpid, skill(personSkill) ⋈ σskill=Operating Systems(personSkill)))

(c) Formulate this query in Tuple Relational Calculus. (4.5 points)
ANSWER:
{(c, p, s) | Company(c) ∧ worksFor(w) ∧ w.cname = c.cname ∧ pid = w.pid ∧ s = w.salary ∧ Knows(k) ∧ k.pid1 = w.pid ∧ ∃(p2)(personSkill(ps) ∧ ps.pid = k.pid2 ∧ ps.skill = 'Operating Systems')}

2. Find the name, salary and city of each person who (a) lives in a city where no one has the Networks skill and (b) earns the highest salary in his/her company.

(a) • Formulate this query in Relational Algebra in standard notation. (4.5 points)
ANSWER:
πpname, salary, city(Person ▷◁ worksFor ⋈ worksFor) - πpname, salary, city(πcity(personLocation ⋈ πpid, skill(personSkill) ⋈ σskill=Networks(personSkill)))

(c) • Formulate this query in Tuple Relational Calculus. (4.5 points)
ANSWER:
{(pname, salary, city) | Person(p) ∧ worksFor(w) ∧ p.pid = w.pid ∧ w.salary = (πmaxSalary(σw.cname = w.cname(MaxSalaries))) ∧ ∃(c)(companyLocation(cl) ∧ cl.cname = w.cname ∧ cl.city = city) ∧ city ∉ (πcity(σps.skill = 'Networks'(personSkill)) ∩ πcity(personLocation))}

3. Find each pair (c1, c2) of cnames of different companies such that no employee of c1 and no employee of c2 live in Chicago.

(a) • Formulate this query in Relational Algebra in standard notation. (4.5 points)
ANSWER:
πc1.cname, c2.cname(πw1.cname(σcity≠'Chicago'(worksFor ⋈ πpid, city(personLocation)))) ⋈ πw2.cname(σcity≠'Chicago'(worksFor ⋈ πpid, city(personLocation))))

(c) • Formulate this query in Tuple Relational Calculus. (4.5 points)
ANSWER:

{(c1, c2) | worksFor(w1) ∧ worksFor(w2) ∧ w1.cname < w2.cname ∧ ∀(p1)(personLocation(pl1) ∧ pl1.pid = w1.pid → pl1.city ≠ 'Chicago') ∧ ∀(p2)(personLocation(pl2) ∧

pl2.pid = w2.pid → pl2.city ≠ 'Chicago')}

4. Formulate these query in Relational Algebra in standard notation:

(a) • Find the pid, pname of each person who lives in MountainView, works for a company which is headquartered in MountainView , and has a salary less than or equal to 60000 (4 points)

ANSWER:
4a) πpid, pname(σcity=MountainView(Person) ⋈ worksFor ⋈ companyLocation ⋈ σheadquarter=MountainView(Company) ⋈ σsalary≤60000(worksFor)))

(b) • Find the pid, pname, and city of a person who knows at least one person who knows another person who earns more than 65000. Let us consider 3 people p1,p2, and p3. p1 knows p2 and p2 knows p3. p3 earns more than 65000. The query returns the pid, pname, and city of p1. (4 points)
ANSWER:
πpid, pname, city(πpid, pname, city(Person) ⋈ Knows ⋈ πpid2, pname2, city2(Knows ⋈ πpid3, salary(worksFor ⋈ σsalary>65000(worksFor)))))

5. Formulate these query in Tuple Relational Calculus:

(a) • Find the pid, pname, cname, and salary of a person who lives in Bloomington, earns at least 40000, and works for a company headquartered in Seattle. (4 points)
ANSWER:
{p.pid, p.pname, w.cname, w.salary | Person(p) ∧ worksFor(w) ∧ companyLocation(cL) ∧ p.pid = w.pid ∧ w.cname = cL.cname ∧ p.city = 'Bloomington' ∧ w.salary ≥ 40000 ∧ cL.headquarter = 'Seattle'}

(b) • Find the name of all skills of persons who don’t live in Bloomington but their managers live in Bloomington. (4 points)
ANSWER:
{sk.skill | Person(p1) ∧ Person(p2) ∧ hasManager(hm) ∧ personSkill(ps) ∧ ps.pid = p1.pid ∧ ps.skill = sk.skill ∧ p1.city ≠ 'Bloomington' ∧ p2.pid = hm.mid ∧ p2.city = 'Bloomington'}

2. Formulating constraints using Relational Algebra

6. Each manager knows all of his/her employees. (3 points)
ANSWER:
πeid(M) ⊆ πmid1(K1) ⋈ πmid2(K2) ⋈ ... ⋈ πmidn(Kn)

7. No person who works at Amazon knows at-most 2 people. (3 points)
ANSWER:
$\pi\text{pid}(P) \subseteq \pi\text{pid1}(K1) \bowtie \pi\text{pid2}(K2)$

8. • Some person who works for a company headquartered at Cupertino has a salary less than person with no skills. (3 points) (Assumption: Only 1 person with no skills)
ANSWER:
$\pi\text{pid1}(W1) \subseteq \pi\text{pid2}(W2) \bowtie \pi\text{pid3}(\sigma\text{skill}=\emptyset(P3))$

3. Formulating constraints in the Tuple Relational Calculus

9. Each Manager manages at least two people. (3 Points)
ANSWER:
$\forall m\ (\text{Manager}(m) \rightarrow \exists e1\ \exists e2\ (\text{hasManager}(hm1) \land hm1.\text{mid} = m.\text{mid} \land hm1.\text{eid} = e1.\text{eid} \land \exists hm2\ (\text{hasManager}(hm2) \land hm2.\text{mid} = m.\text{mid} \land hm2.\text{eid} = e2.\text{eid} \land e1.\text{eid} \neq e2.\text{eid})))$

10. Some person has a salary that is strictly lower than the salary of each of his or her managers. (3 Points)
ANSWER:
$\exists p\ \exists m1\ \exists m2\ (\text{Person}(p) \land \text{hasManager}(hm1) \land hm1.\text{eid} = p.\text{pid} \land \text{worksFor}(w1) \land w1.\text{pid} = p.\text{pid} \land \text{hasManager}(hm2) \land hm2.\text{mid} = hm1.\text{mid} \land \text{worksFor}(w2) \land w2.\text{pid} = hm2.\text{eid} \land w1.\text{salary} < w2.\text{salary})$

11. Each employee and his or her managers work for the same com□pany. (3 Points)
ANSWER:
$\forall e\ \exists m\ (\text{Employee}(e) \land \text{hasManager}(hm) \land hm.\text{eid} = e.\text{eid} \land \text{worksFor}(w1) \land w1.\text{pid} = e.\text{eid} \land \text{worksFor}(w2) \land w2.\text{pid} = hm.\text{mid} \land w1.\text{cname} = w2.\text{cname})$