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CMPUT 391: Database Management Systems

Solutions to Midterm Examination

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1. Consider a database consisting of the following two tables with obvious meanings

   course(course_id, course_name, no_credit, capacity),
   registration(student_id, course_id, grade).

   Note that the underlined attributes are keys of the tables. Write triggers to impose the constraint that no student can register a course that is not offered by the university (i.e., not recorded in course table). (Assume that no foreign key constraints are enforced in the database.)

   One needs to (1) give a list of events that must be monitored for imposing the constraint, and (2) present one trigger for any event in (1). [30]

   Solution: To enforce the given constraint, the following events must be monitored:

   - INSERT or UPDATE on registration
   - DELETE or UPDATE on course

   A trigger to monitor the first event is given below.

```
CREASTE TRIGGER foregin_key_on_registration
BEFORE  INSERT OR UPDATE ON registration
FOR EACH ROW
DECLARE counter INT
BEGIN
   SELECT COUNT(*) INTO counter
   FROM   course
   WHERE  course_id = NEW.course_id;

   IF (counter < 1 )
     THEN raise_exception('the foreign key constraint violated
END;
```

2. Consider a relation schema $R = ABCDE$, functional dependencies

   B → E
   E → A
   A → D
   D → E

   and a decomposition $D = \{AB, BCD, ADE\}$ of R. Is D dependency preserving? Explain. [5]

   Solution: Yes, D is dependency preserving. This is because the given set of FDs is equivalent to $F' = \{$B → A, E → A, A → D, D → E$\}$, and F' is dependency preserving with respect to D.

3. Consider the database schema $R = ABCDEF$, and the following FDs:

   ABF → C
   CF → B
   CD → A
   BD → AE
   C → F
   B → F

   (a) Find a minimal cover of the given set of FDs. Show all steps.

   Solution:

   i. Right reducing: Replace BD → AE with BD → A and BD → E.

ii. Left reducing: ABF → C can be replaced with: AB → C while CF → B can be replaced with: C → B. This is because (1) AB → C is entailed by ABF → C and B → F; and C → B is entailed by CF → B and C → F; (2) AB → C entails ABF → C and C → B entails CF → B; and therefore (3) the set AB → C, B → F is equivalent to ABF → C, B → F; and C → B, C → F is equivalent to CF → B, C → F.

That is, after Left-reducing, we have

AB → C
C → B
CD → A
BD → A
BD → E
C → F
B → F

iii. Eliminate redundant FDs: C → F is entailed by C → B and B → F, while CD → A is entailed by C → B and BD → A. Therefore, a minimal cover is

AB → C
C → B
BD → A
BD → E
B → F

(b) Construct a join lossless, dependency preserving, and 3NF decomposition of R. [20]

Solution: The 3NF decomposition that corresponds to this minimal cover is $\{ABC, BDAE, BF\}$. Note that BDAE is a super key of R.

4. Consider the database schema $R = ABCDE$ and a set of MVDs M = {AB →→D}. Prove or disprove that $D = \{ABE, ABCD\}$ is a join lossless decomposition of R with respect to M. Note that a proof must follow the definitions of the join lossless and MVD while a counter example is sufficient for a disproof. [5]

Solution: D is not a join lossless decomposition of R, as demonstrated in the following counter example.

Consider the following table r.

A	B	C	D	E
a	b	c1	d	e1
a	b	c2	d	e2

Obviously, r satisfies M = {AB →→D} but $r \neq \pi_{ABE} \bowtie \pi_{ABCD}$ as demonstrated below.

$\pi_{ABE} \bowtie \pi_{ABCD} =$

A	B	E
a	b	e1
a	b	e2

$\bowtie$

A	B	C	D
a	b	c1	d
a	b	c2	d

$=$

A	B	C	D	E
a	b	c1	d	e1
a	b	c1	d	e2
a	b	c2	d	e1
a	b	c2	d	e2

5. Consider the following database schema with obvious meanings:

prof(p_id, p_name, department)
course(c_code, department, c_name)
teaching(p_id, c_code, term)

and the following query

```
SELECT c.c_name, p.p_name
FROM   prof p, teaching t, course c
WHERE  t.term = 'Fall 2011' AND p.department = 'cs' AND
       p.p_id = t.p_id AND t.c_code = c.c_code
```

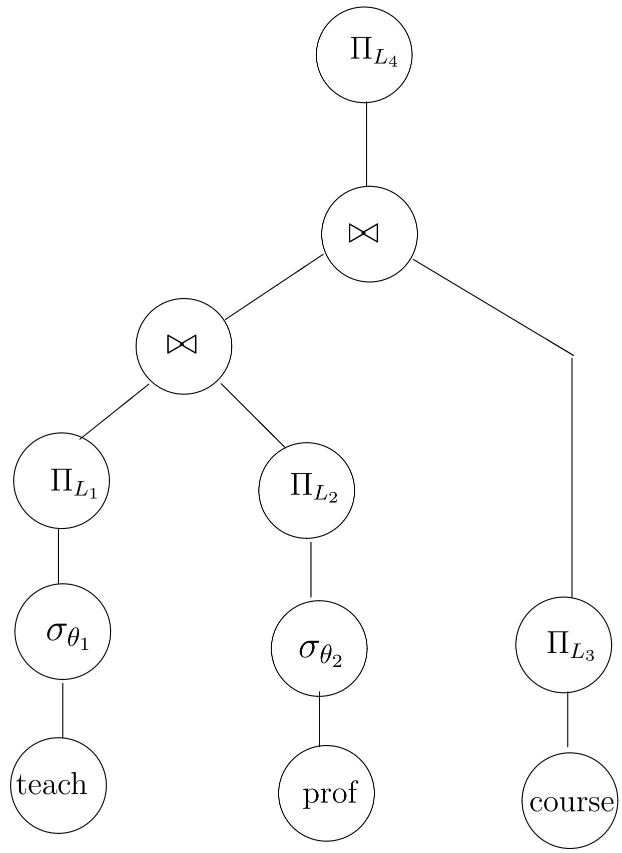
(a) Show the unoptimized relational algebra expression that corresponding to the above SQL query.

Solution: $\Pi_{course.c\_name,prof.p\_name}\sigma_{\theta}(prof \bowtie teaching \bowtie course)$

where θ represents $teaching.term = Fall\ 2007 \wedge prof.department = cs.$

(b) Draw the optimized query tree (i.e., with all selections and/or projections pushed as far down as possible) for the expression. [20]

Solution:



Where

θ_1: term = 'Fall 2007'

θ_2: department = 'CS'

L_1: p_id, c_code

L_2: p_id, p_name

L_3: c_code, c_name

L_4: course.c_name, prof.p_name