

Introduction to database systems

Relational calculus

Relational calculus

Relational calculus is nonprocedural or declarative query language.

- With relational algebra we define the procedure how the answers should be computed. **Relational calculus** allows us to **describe the set of answers** without being explicit how they should be computed.

There are two types of relational calculus:

- **Domain** Relational Calculus
 - The variables range over field values
- **Tuple** Relational Calculus
 - Variables take on tuples as values.

Quantifiers

- Using quantifiers we determine how many examples the predicate refers to.
- There are two quantifiers:
 - **Existential** quantifier \exists (we read: „there exists (at least one)“)
 - **Universal** quantifier \forall (we read: „for all“)

Domain Relational Calculus

- A DRC query has the form:
 $\{ \langle d1, d2, \dots, dn \rangle \mid F(\langle d1, d2, \dots, dn \rangle) \}$

Where:

$\langle d1, d2, \dots, dn \rangle$ set of domain variables or constants and

$F(\langle d1, d2, \dots, dn \rangle)$ DRC formula (The result of this query is the set of all tuples $(d1, d2, \dots, dn)$ for which the formula evaluates to true.)

Example DRC

Relation	Relational schema
Suppliers	SUPPLIERS(<u>sid</u> , sname, address)
Parts	PARTS(<u>pid</u> , pname, color)
Catalog	CATALOG(<u>#sid</u> , <u>#pid</u> , cost)

Using relational algebra and relational calculus, find:

- Names of suppliers, which supply a red part.

RA:

$$\pi_{sname}(\pi_{sid}((\pi_{pid} \sigma_{color = 'red'} Parts) \bowtie Catalog) \bowtie Suppliers)$$

DRC:

$$\{\langle Sn \rangle \mid \langle Ss, Sn, Sa \rangle \in Suppliers \wedge \exists Pp, Pc (\langle Pp, Pn, Pc \rangle \in Parts \wedge Pc = 'red' \wedge \exists Cs, Cp (\langle Cs, Cp, Cc \rangle \in Catalog \wedge Cp = Pp \wedge Cs = Ss))\}$$

Tuple relational calculus

- TRC has the form:

$$\{t \mid F(\langle t_1, t_2, \dots, t_n \rangle)\}$$

Where:

t relation of all tuples, that meet the condition in the formula and

$F(\langle t_1, t_2, \dots, t_n \rangle)$ TRC formula (Where the conditions are written down)

Example TRC

Relation	Relational schema
Suppliers	SUPPLIERS(<u>sid</u> , sname, address)
Parts	PARTS(<u>pid</u> , pname, color)
Catalog	CATALOG(<u>#sid</u> , <u>#pid</u> , cost)

Using relational algebra and relational calculus, find:

- Names of suppliers, which supply a red part.

RA:

$$\pi_{sname}(\pi_{sid}((\pi_{pid} \sigma_{color = 'red'} Parts) \bowtie Catalog) \bowtie Suppliers)$$

TRC:

$$\{s.sname \mid \exists s \in Suppliers \wedge \exists p \in Parts \wedge \exists c \in Catalog (p.color = 'red' \wedge s.sid = c.sid \wedge p.pid = c.pid)\}$$

Exercises from relational calculus

TASK 1: Suppliers

Using **domain and tuple relational calculus**, find:

1. Find the *sids* of suppliers who supply some red or green part.
2. Find the *sids* of suppliers who supply some red part or are at „Kopraska cesta 25“.
3. Find the *sids* of suppliers who supply every part.
4. Find the *sids* of suppliers who supply every red part.
5. Find the *sids* of suppliers who supply every red or green part.
6. Find the *pids* of parts supplied by at least two different suppliers.

Relation	Relational schema
Suppliers	SUPPLIERS(<u>sid</u> , sname, address)
Parts	PARTS(<u>pid</u> , pname, color)
Catalog	CATALOG(<u>#sid</u> , <u>#pid</u> , cost)

TASK 2: Airline flight information

Using **domain and tuple relational calculus**, find:

1. Find the *eids* of pilots certified for some Boeing aircraft.
2. Find the names of pilots certified for some Boeing aircraft.
3. Find the *aids* of all aircraft that can be used on non-stop flights from Paris to Vancouver.
4. Find the names of pilots who can operate planes with a range greater than 3,000 miles but are not certified on any Boeing aircraft.
5. Find the *eids* of employees who make the highest salary (multiple employees can have highest salary).

Relation	Relational schema
Flights	FLIGHTS(<u>flno</u> , from, to, distance, departs, arrives)
Aircraft	AIRCRAFT(<u>aid</u> , aname, cruisingrange)
Certified	CERTIFIED(<u>#eid</u> , <u>#aid</u>)
Employees	EMPLOYEES(<u>eid</u> , ename, salary)

TASK 3: Airline transportation

Relation	Relational schema
l airport	AIRPORT (<u>IdLE</u> , name, city, country)
a airplane	AIRPLANE (<u>IdTL</u> , type, description, manufacturer)
p lands	LANDS (<u>#IdLE</u> , <u>#IdTL</u> , dateFrom)

Relation LANDS includes information about where each type of an airplane can land, on what airports and since when.

Using **domain and tuple relational calculus**, find:

1. Find all names of the airports, where type B747 airplanes can land.
2. Find all IdLE of airports, on which type B747 or B748 airplanes can land
3. Find all IdLE of airports, which are located in Austria or that type B747 airplane can land on them.
4. Find all IdLE of airports, on which all types of planes can land.