

# Relational Calculus

# Tuple Relational Calculus

Tuple relational calculus is a declarative retrieval language based on mathematical logic

- ▶ Relational algebra is procedural – order of operations matters
- ▶ Relational algebra and relational calculus have equivalent expressive power
- ▶ A query language  $L$  is **relationally complete** if one can express in  $L$  any query that can be expressed in relational calculus

In this course we cover **tuple relational calculus** which, along with relational algebra, forms the theoretical basis of SQL. Another variant, **domain relational calculus** is the theoretical basis of Query by Example (QBE), which is far less common than SQL.

# Basic Tuple Relational Calculus Expressions

$$\{t \mid COND(t)\}$$

Where

- ▶  $t$  is a tuple variable
- ▶  $COND(t)$  is a boolean expression involving  $t$

The result of the expression is all tuples  $t$  for which  $COND(t)$  evaluates to *true*.

# Range Relations

To find all employees whose salary is above \$50,000:

$$\{t | EMPLOYEE(t) \text{ AND } t.Salary > 50000\}$$

- ▶  $EMPLOYEE(t)$  is a **range relation**. All tuples  $t$  come from the  $EMPLOYEE$  relation.
- ▶  $t.Salary$  is the value of attribute  $Salary$  for tuple  $t$

$$\{t.Fname, t.Lname | EMPLOYEE(t) \text{ AND } t.Salary > 50000\}$$

returns only the  $Fname$  and  $Lname$  attributes of.

# Typical Tuple Relational Calculus Expressions

$$\{t.Bdate, t.Address \mid EMPLOYEE(t)$$
$$\text{AND } t.Fname = 'John'$$
$$\text{AND } t.Minit = 'B'$$
$$\text{AND } t.Lname = 'Smith'\}$$

- ▶ Tuple variable,  $t$
- ▶ Range relation,  $R(t)$ . Without a range relation,  $t$  ranges over all tuples in the universe
  - ▶  $EMPLOYEE(t)$
- ▶ A condition to select tuples from the range
  - ▶  $t.Fname = 'John'$  AND  $t.Minit = 'B'$  AND  $t.Lname = 'Smith'$
- ▶ A set of attributes to be returned in the result
  - ▶  $t.Bdate, t.Address$

# Universal and Existential Quantification

# Example Company Database

## Employee

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	S
John	B	Smit	123	1965-01-09	731 Fondren	M	30000	3

## Complicated Example

List the names of employees who work on all the projects in Department 5.

```
{e.Lname, e.Fname|EMPLOYEE(e)
    AND ((∀x)(
        NOT(PROJECT(x))
        OR NOT (x.Dnum = 5)
        OR
        ((∃w)(WORKS_ON(w)
            AND w.Essn = e.Ssn
            AND x.Pnumber = w.Pno))))}}
```