Relational Algebra

An Intro to Relational Algebra

- Relational algebra is a mathematical abstraction of database operations
- Works procedurally
  - That is steps happen in order to get to the result
  - Contrast with relational calculus where conditions are just specified
- Probably wont use this in your day to day life unless you go into database theory
  - May be a question or two on the exam and will be an assignment

Basics

- A query is made from a collection of operators
- An operator takes as input one or two instances of a relation and returns a single relation
- Operators can be nested and combined to achieve the desired query

Core Set of Operators

- Selection
- Projection
- Union
- Intersection
- Differnece
- Cross-product

Selection

- Selection
  - $\sigma_{GPA>3.5}(Students)$
  - Returns the student instance containing only rows that have a GPA > 3.5
  - Same as SELECT * FROM STUDENTS WHERE GPA >3

Projection

- Projection
  - $\pi_{SID,SName,GPA}(Students)$
  - Returns just the SID,Sname,GPA columns from students
  - Similar to SELECT SID,SNAME,GPA FROM Students
- Projection can filter out columns, Selection and filter out rows

A Simple Query

- Display the ID and Name of students with a GPA > 3.5
- $\pi_{SID,SName}(\sigma_{GPA>3.5}(Students))$
- Order is important here
  - If we did projection first we would no longer have GPA to select from

Union

- Union of two sets of relation instances
- Sticks the rows together
- $R \cup S$

R

Homer	123
Marge	546

S

Bart	22
Lisa	33

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Homer	123
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Homer	123
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Union

- Duplicate rows are combined

R

Homer	123
Marge	546
Bart	22

S

Bart	22
Lisa	33

$R \cup S$

Homer	123
Marge	546
Bart	22
Lisa	33

Set Operators

- Union of two sets of relation instances
- $R \cup S$

R

Homer	123
Marge	546
Bart	22

S

Moe's Tavern	5pm-Midnight
Springfield Nuclear Plane	12am-11:59am

$R \cup S$

NOPE

Union-compatibility

- Must have the same number of attributes
- Corresponding attributes must have identical domains

Intersection

- Intersection of two sets of relation instances
- $R \cap S$
- Requires union-compatible relations

R

Homer	123
Marge	546
Bart	22

S

Bart	22
Lisa	33

$R \cap S$

Bart	22

Difference

- Difference of two sets of relation instances
- $R - S$
- Removes rows from R which are in S
- Requires union-compatible relations

R

Homer	123
Marge	546
Bart	22

S

Bart	22
Lisa	33

$R - S$

Homer	123
Marge	546

Set Operators

- Cross Product
  - All combinations of tuples

R

Homer	123
Marge	546
Bart	22

S

Moe's Tavern
Springfield Nuclear Plant

$R \times S$

Homer	123	Moe's Tavern
Marge	546	Moe's Tavern
Bart	22	Moe's Tavern
Homer	123	Springfield Nuclear Plant
Marge	546	Springfield Nuclear Plant
Bart	22	Springfield Nuclear Plant

Joins

- Can be created from just cross-products, projections and selections
- More often used than cross product
- Wont blow your stack as often

Joins

- Conditional Join

$$R \rhd\lhd cS = \sigma_C(R \times S)$$

- Example
- S1 Sailors(sid:integer, sname:string, rating:integer, age:real)
- S2 Boats(bid:integer, bname:string, color:string)
- R1 Reserves(sid:integer, bid:integer, day: date)

$$S_1 \rhd\lhd_{S1.sid=R1.sid} R_1$$

Joins

- Example
- S1 Sailors(sid:integer, sname:string, rating:integer, age:real)
- S2 Boats(bid:integer, bname:string, color:string)
- R1 Reserves(sid:integer, bid:integer, day: date)

$$S_1 \rhd\lhd_{S1.sid=R1.sid} R_1$$

- Returns a new table with all attributes of S1 and R1 with rows from S1 *joined* together with rows from R1 where the sid are the same

Joins

- Natural join

  $S_1 \rhd\lhd R_1$
- Special case in which we look at *all* common fields between two relations and select rows based on equality in those fields
- Just more shorthand

Wrapping Up

- These are the basic operations on relational algebra
- There are more complex operations
- You probably won't encounter this other than in the context of planning and building a DBMS or academic papers