Review
Relational Algebra

Relational Algebra

- Basic operations:
  - Selection (σ) Selects a subset of rows from relation
  - Projection (π) Deletes unwanted columns from relation.
  - Cross-product (x) Allows us to combine two relations.
  - Set-difference (-) Tuples in reln. 1, but not in reln. 2.
  - Union (∪) Tuples in reln. 1 or in reln. 2.
- Additional operations:
  - Intersection (∩)
  - join ⋈
  - division(/)
  - renaming (ρ)
  - Not essential, but (very) useful.

Projection

- Deletes attributes that are not in projection list.
- Schema of result contains exactly the fields in the projection list, with the same names that they had in the (only) input relation.
- Projection operator has to eliminate duplicates
  - Note: real systems typically don't do duplicate elimination unless the user explicitly asks for it (performance)

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sname	rating
yuppy	9
lubber	8
guppy	5
rusty	10

$\pi_{sname,rating}(S2)$

age
35.0
55.5

$\pi_{age}(S2)$

Selection

- Selects rows that satisfy selection condition

- Schema of result identical to schema of (only) input relation

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sid	sname	rating	age
28	yuppy	9	35.0
58	rusty	10	35.0

$$\sigma_{rating \geq 8}^{(S2)}$$

Composition of Operators

- Result relation can be the input for another relational algebra operation
  - Operator composition

sid	sname	rating	age
28	yuppy	9	35.0
58	rusty	10	35.0

$$\sigma_{rating>8}^{(S2)}$$

sname	rating
yuppy	9
rusty	10

$$\pi_{sname,rating}(\sigma_{rating>8}^{(S2)})$$

Union, Intersection, Set-Difference

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

- All of these operations take two input relations, which must be union-compatible:
  - Same number of fields.
  - `Corresponding' fields have the same type
  - same schema as the inputs

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0
44	guppy	5	35.0
28	yuppy	9	35.0

Union, Intersection, Set-Difference

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

- Note: no duplicate
  - "Set semantic"
  - SQL: UNION
  - SQL allows "bag semantic" as well: UNION ALL

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0
44	guppy	5	35.0
28	yuppy	9	35.0

Union, Intersection, Set-Difference

S1

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

S2

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sid	sname	rating	age
22	dustin	7	45.0

sid	sname	rating	age
31	lubber	8	55.5
58	rusty	10	35.0

Cross-Product

- Each row of S1 is paired with each row of R.
- Result schema has one field per field of S1 and R, with field names `inherited' if possible.
  - Conflict: Both S1 and R have a field called sid.

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

sid	bid	day
22	101	10/10/96
58	103	11/12/96

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

Renaming Operator ρ

$$(\rho_{sid \rightarrow sid1}\, S1) \times (\rho_{sid \rightarrow sid2}\, R1)$$

or

$$\rho(C(1 \rightarrow sid1, 5 \rightarrow sid2),\ S1 \times R1)$$

C is the new relation name

sid1	sname	rating	age	sid2	bid	day
22	dustin	7	45.0	22	101	10/10/96
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	22	101	10/10/96
31	lubber	8	55.5	58	103	11/12/96
58	rusty	10	35.0	22	101	10/10/96
58	rusty	10	35.0	58	103	11/12/96

- In general, can use ρ(<Temp>, <RA-expression>)

Joins

$$R \bowtie_C S = \sigma_C (R \times S)$$

(sid)	sname	rating	age	(sid)	bid	day
22	dustin	7	45.0	58	103	11/12/96
31	lubber	8	55.5	58	103	11/12/96

$$S1 \bowtie_{S1.sid < R1.sid} R1$$

- Result schema same as that of cross-product.
- Fewer tuples than cross-product, might be able to compute more efficiently

Find names of sailors who've reserved boat #103

Sailors(sid, sname, rating, age)

Boats(bid, bname, color)

Reserves(sid, bid, day)

Find names of sailors who've reserved boat #103

Sailors(<u>sid</u>, sname, rating, age)

Boats(<u>bid</u>, bname, color)

Reserves(<u>sid, bid, day</u>)

- Solution 1: $\pi_{sname}((\sigma_{bid=103}\text{Reserves}) \bowtie \text{Sailors})$
- Solution 2: $\pi_{sname}(\sigma_{bid=103}(\text{Reserves} \bowtie \text{Sailors}))$

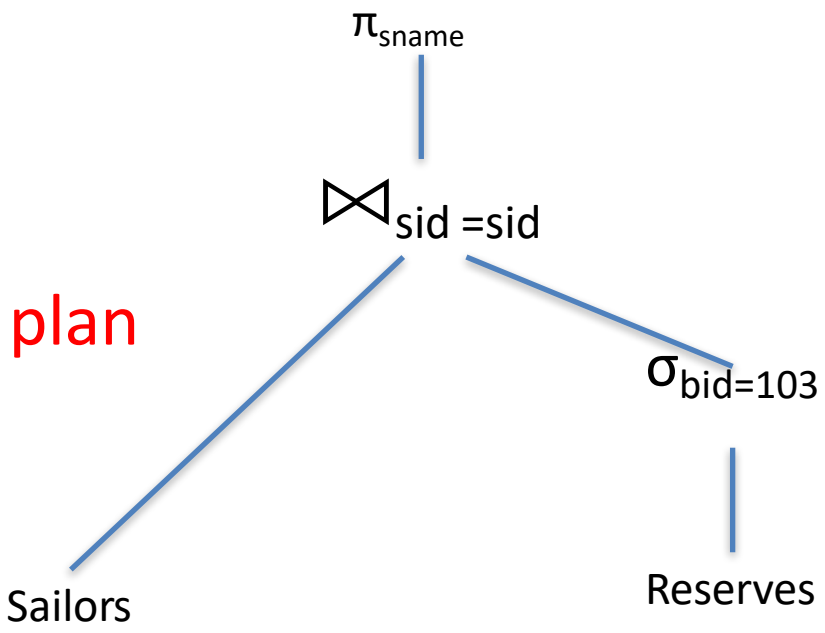
Expressing an RA expression as a Tree

Sailors(<u>sid</u>, sname, rating, age)

Boats(<u>bid</u>, bname, color)

Reserves(<u>sid, bid, day</u>)

Also called a
logical query plan



$$\pi_{sname}((\sigma_{bid=103}\,Reserves) \bowtie Sailors)$$

Find sailors who've reserved a red or a green boat

Sailors(sid, sname, rating, age)
Boats(bid, bname, color)
Reserves(sid, bid, day)

Use of rename operation

- Can identify all red or green boats, then find sailors who've reserved one of these boats:

$$\rho\ (Tempboats, (\sigma_{color='red' \vee color='green'}\ Boats))$$

$$\pi_{sname}(Tempboats \bowtie Reserves \bowtie Sailors)$$

Can also define Tempboats using union
Try the "AND" version yourself

What about aggregates?

Sailors(<u>sid</u>, sname, rating, age)
Boats(<u>bid</u>, bname, color)
Reserves(<u>sid, bid, day</u>)

- Extended relational algebra
- $\gamma_{age,\ avg(rating) \rightarrow avgr}$ Sailors
- Also extended to "bag semantic": allow duplicates
  - Take into account cardinality
  - R and S have tuple t resp. m and n times
  - R $\cup$ S has t m+n times
  - R $\cap$ S has t min(m, n) times
  - R – S has t max(0, m-n) times
  - sorting(τ), duplicate removal (δ) operators

Summary

- You learnt two query languages for the Relational DB model
  - SQL
  - RA
- All have their own purposes
- You should be able to write a query in both SQL and RA, and convert from one to another