# ICS 321 Fall 2012
# Algebraic and Logical Query Languages

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# Relational Algebra Review

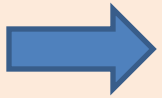
- Relations are **sets** of tuples – no duplicates allowed
- Basic operations:
  - *Selection* (σ) Selects a subset of rows from relation.
  - *Projection* (π) Deletes unwanted columns from relation.
  - *Cross-product* (×) Allows us to combine two relations.
  - *Set-difference* (−) Tuples in reln. 1, but not in reln. 2.
  - *Union* (∪) Tuples in reln. 1 and in reln. 2.
- Additional operations:
  - Intersection, *join*, division, renaming: Not essential, but (very!) useful.
- Each operation returns a relation, operations can be *composed*! (Algebra is "closed".)

# Bag Semantics

- Commercial DBMS implements relations as bags
- Avoid duplicate elimination
- Support aggregations

Bag

| A | B |
|---|---|
| 1 | 2 |
| 3 | 4 |
| 1 | 2 |
| 1 | 2 |



Set

| A | B |
|---|---|
| 1 | 2 |
| 3 | 4 |

Can relational algebra work with bags ?

# Selection & Projection

- Expected behavior
- No duplicate elimination of results

$\pi_{age}(\sigma_{rating>6}(S2))$

| sid | sname | rating | age |
|---|---|---|---|
| 28 | Yuppy | 9 | 35.0 |
| 31 | Lubber | 8 | 55.5 |
| 44 | Guppy | 5 | 35.0 |
| 58 | Rusty | 10 | 35.0 |

$\pi_{age}(S2)$

| sid | sname | rating | age |
|---|---|---|---|
| 28 | Yuppy | 9 | 35.0 |
| 31 | Lubber | 8 | 55.5 |
| 44 | Guppy | 5 | 35.0 |
| 58 | Rusty | 10 | 35.0 |

# Cross Product & Joins

R

| A | B |
|---|---|
| 1 | 2 |
| 1 | 2 |

S

| B | C |
|---|---|
| 2 | 3 |
| 4 | 5 |
| 4 | 5 |

Cross Product

$R \times S$

| A | R.B | R.B | C |
|---|---|---|---|
| 1 | 2 | 2 | 3 |
| 1 | 2 | 2 | 3 |
| 1 | 2 | 4 | 5 |
| 1 | 2 | 4 | 5 |
| 1 | 2 | 4 | 5 |
| 1 | 2 | 4 | 5 |

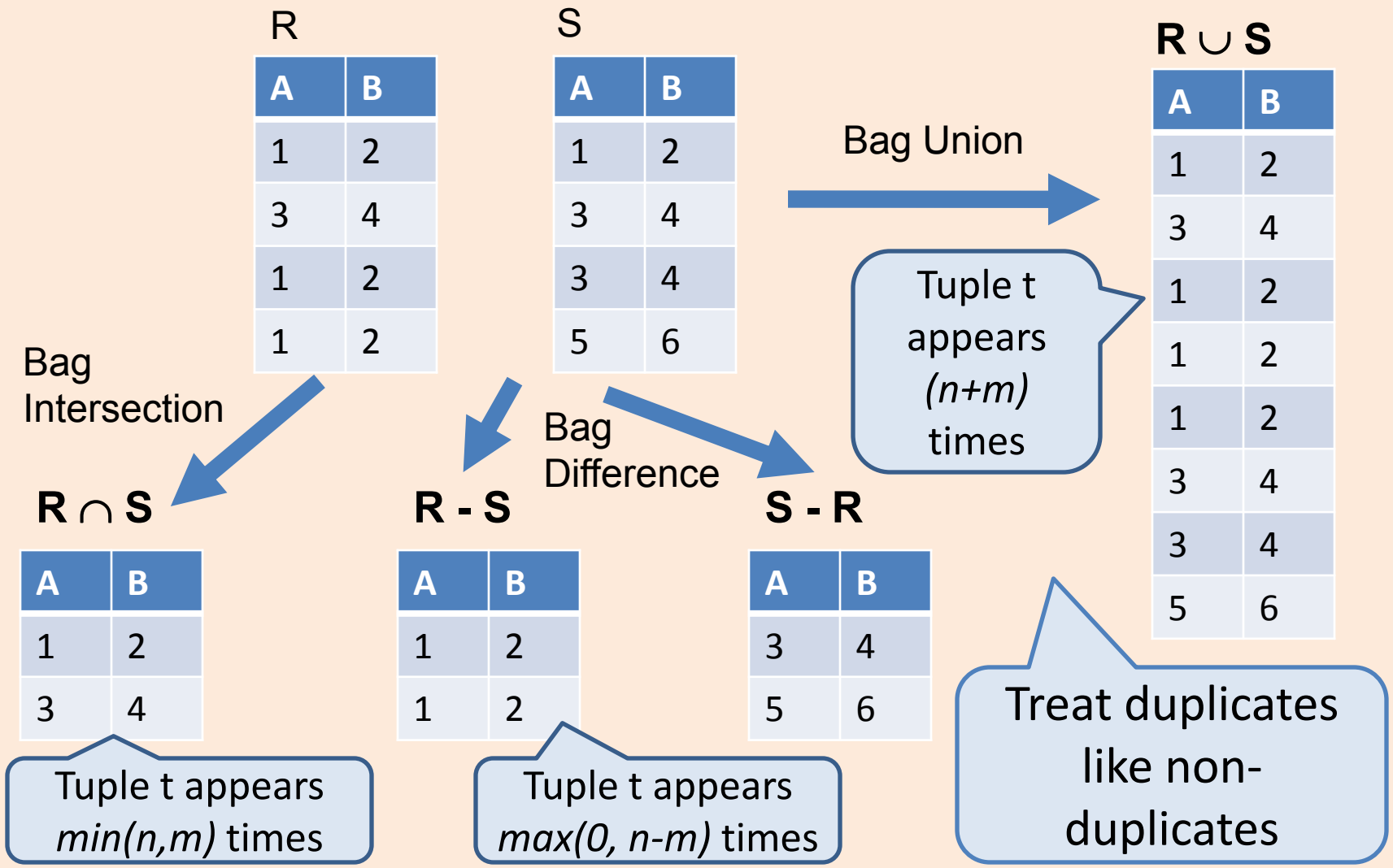
Join

$R \bowtie S$

| A | B | C |
|---|---|---|
| 1 | 2 | 3 |
| 1 | 2 | 3 |

Treat duplicates like non-duplicates

# Bag Union, Intersection & Difference



# Extended Operators

- Duplicate elimination $\delta$
  - turns a bag into a set
- Aggregation
  - calculates an aggregate (sum, average etc) over the values in a column
- Grouping $\gamma$
  - partitions tuples in a relation into groups based on values in some columns
- Extended projection $\pi$
  - allow computation on column values to produce new values
- Sorting $\tau$
  - sorts a relation according to the values in some column(s)
- Outer join
  - preserves dangling pointers in the results of joins

# Aggregation

- Standard:  SUM, AVG, MIN, MAX, COUNT
- DBMS supports more sophisticated functions like Variance, standard deviation etc.
- SUM(B) = 2+4+2+2 = 10
- AVG(A) = (1+3+1+1)/4 = 1.5
- MIN(A) = 1
- MAX(B) = 4
- COUNT(A) = 4

| A | B |
|---|---|
| 1 | 2 |
| 3 | 4 |
| 1 | 2 |
| 1 | 2 |

# Grouping

Movies

| Title | Year | Length | Genre | StudioName | producer |
|---|---|---|---|---|---|

- Grouping operator $\gamma$
  - Groups tuples by some columns
  - Apply aggregation function to each group
  - Generate a result tuple per group

For each studio, find the total lengths of movies produced

| | *studioName* | |
|---|---|---|
| | Disney | |
| | Disney | |
| | Disney | |
| | MGM | |
| | MGM | |
| | o | |
| | o | |
| | o | |

# Grouping Operator Arguments

Movies

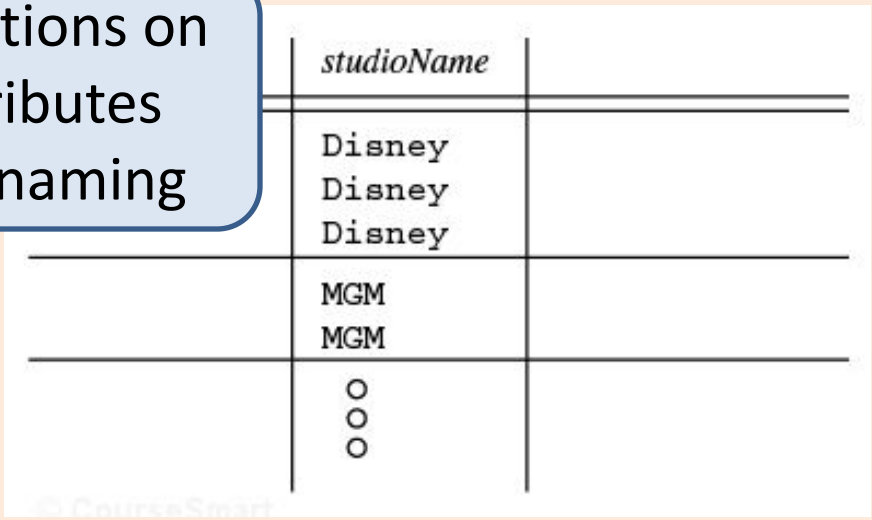
| Title | Year | Length | Genre | StudioName | producer |
|---|---|---|---|---|---|

$\gamma_{studioName,\ SUM(length) \rightarrow sumOfLengths}$

Grouping attributes

Aggregation functions on aggregated attributes with optional renaming

| StudioName | SumOfLengths |
|---|---|
| Disney | 12345 |
| MGM | 54321 |
| ... | ... |



# Extended Projection

| A | B | C |
|---|---|---|
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 3 | 4 | 5 |

$\pi_{A \rightarrow X,\ B+C \rightarrow Y}(R)$

| X | Y |
|---|---|
| 0 | 3 |
| 0 | 3 |
| 3 | 9 |

Renaming of attributes

Expressions that compute new values from attributes and naming the new values

# Outer Join

R

| A | B | C |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 8 | 9 |

S

| B | C | D |
|---|---|---|
| 2 | 3 | 10 |
| 2 | 3 | 11 |
| 6 | 7 | 12 |

$R \bowtie S$

| A | B | C | D |
|---|---|---|---|
| 1 | 2 | 3 | 10 |
| 1 | 2 | 3 | 11 |

Discard right & left dangling pointers

$R \overset{\bowtie}{}_L S$

| A | B | C | D |
|---|---|---|---|
| 1 | 2 | 3 | 10 |
| 1 | 2 | 3 | 11 |
| 4 | 5 | 6 | ⊥ |
| 7 | 8 | 9 | ⊥ |

Keep left dangling pointers

$R \overset{\bowtie}{}S$

| A | B | C | D |
|---|---|---|---|
| 1 | 2 | 3 | 10 |
| 1 | 2 | 3 | 11 |
| 4 | 5 | 6 | ⊥ |
| 7 | 8 | 9 | ⊥ |
| ⊥ | 6 | 7 | 12 |

$R \overset{\bowtie}{}_R S$

| A | B | C | D |
|---|---|---|---|
| 1 | 2 | 3 | 10 |
| 1 | 2 | 3 | 11 |
| ⊥ | 6 | 7 | 12 |

Keep right dangling pointers