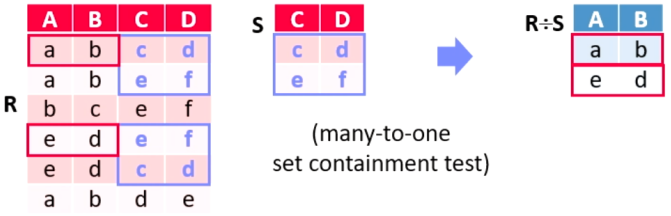
Intersection

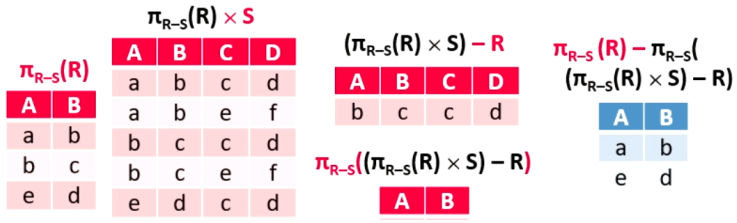
- R∩S
- each tuple within R and S
- set intersection derived from difference
- bag intersection with element multiplicity min(R,S)
- require compatible schema

Division

- R÷S
- counterpart to cartesian product
  - **Definition** $R \div S := \pi_{R-S}(R) - \pi_{R-S}((\pi_{R-S}(R) \times S) - R)$
    - Find instances in R that satisfy S (e.g., which students took ALL DB courses)
    - $R \div S := \{(a_1, \ldots, a_{r-s}) \mid \forall (b_1, \ldots, b_s) \in S : (a_1, \ldots, a_{r-s}, b_1, \ldots, b_s) \in R\}$
  - **Example**



  - **Example Derivation**



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(Inner) Join

- R S
- selection of tuples and attributes from R×S
  - equivalent in set/bag
- NULL never matches
- Theta Join
  - join by arbitrary condition
- Natural Join
  - equi join - join by equivalence
  - shared attributes only appearing once

Outer Join

- same as inner join but NULL matches
- left outer join

  - full left side, NULL for non-existing right side
- right outer join
  - full right side, NULL for non-existing right side
- full outer join
  - full left and right side, NULL for non-existing side

-
  - symbols different

Semi Join and Anti Join

- left semi join
  - join based on condition without left side
- right semi join
  - join based on condition without right side
- right/left anti join
  - returns tuples that do not appear within other side

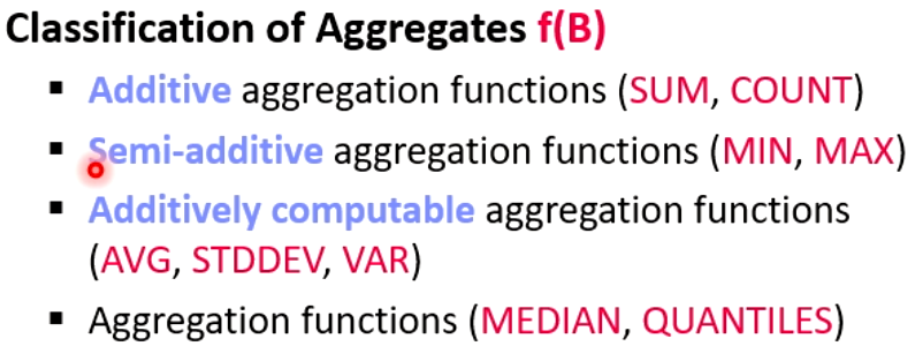
Deduplication, Sorting, Renaming

- deduplication
  - converts a bag into a set by removing duplicates
  - ALL/DISTINCT
    - indicate w/ or w/o duplicate elimination
- sorting
  - converts a bag into a sorted list of tuples
  - order lost if used in other ops
  - ASC/DESC
    - as/descending order
- Rename
  - defines new schema (new attribute/schema names)
  - tuples keep unchanged

Grouping and Aggregation

- grouping γ(R)
  - group input tuples R according to unique values in A
- aggregation

- compute aggregate per group of tuples (created by grouping)
- aggregation w/o grouping possible



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[[Relational Algebra]]

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