Relational Algebra and SQL

Chapter 5

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Relational Query Languages

- Languages for describing queries on a relational database
- *Structured Query Language* (SQL)
  - Predominant application-level query language
  - Declarative
- *Relational Algebra*
  - Intermediate language used within DBMS
  - Procedural

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What is an Algebra?

- A language based on operators and a domain of values
- Operators map values taken from the domain into other domain values
- Hence, an expression involving operators and arguments produces a value in the domain
- When the domain is a set of all relations (and the operators are as described later), we get the *relational algebra*
- We refer to the expression as a *query* and the value produced as the *query result*

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Relational Algebra

- *Domain*: set of relations
- *Basic operators*: select, project, union, set difference, Cartesian product
- *Derived operators*: set intersection, division, join
- *Procedural*: Relational expression specifies query by describing an algorithm (the sequence in which operators are applied) for determining the result of an expression

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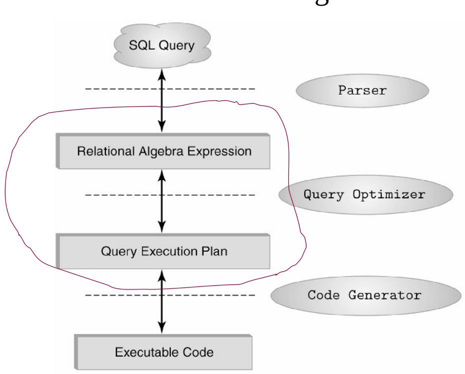
The Role of Relational Algebra in a DBMS



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Select Operator

- Produce table containing subset of rows of argument table satisfying condition

$$\sigma_{condition}\ (relation)$$

- Example:

Person

Id	*Name*	*Address*	*Hobby*
1123	John	123 Main	stamps
1123	John	123 Main	coins
5556	Mary	7 Lake Dr	hiking
9876	Bart	5 Pine St	stamps

$\sigma_{Hobby=\text{'stamps'}}$(Person)

Id	*Name*	*Address*	*Hobby*
1123	John	123 Main	stamps
9876	Bart	5 Pine St	stamps

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Selection Condition

- Operators: $<, \leq, \geq, >, =, \neq$
- Simple selection condition:
  - <*attribute*> *operator* <*constant*>
  - <*attribute*> *operator* <*attribute*>
- <*condition*> AND <*condition*>
- <*condition*> OR <*condition*>
- NOT <*condition*>

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Selection Condition - Examples

- $\sigma_{Id>3000 \text{ OR } Hobby=\text{'hiking'}}$ (Person)
- $\sigma_{Id>3000 \text{ AND } Id<3999}$ (Person)
- $\sigma_{\text{NOT}(Hobby=\text{'hiking'})}$ (Person)
- $\sigma_{Hobby\neq\text{'hiking'}}$ (Person)

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Project Operator

- Produces table containing subset of columns of argument table

$$\pi_{attribute\ list}(relation)$$

- Example:

Person

Id	*Name*	*Address*	*Hobby*
1123	John	123 Main	stamps
1123	John	123 Main	coins
5556	Mary	7 Lake Dr	hiking
9876	Bart	5 Pine St	stamps

$\pi_{Name,Hobby}$(Person)

Name	*Hobby*
John	stamps
John	coins
Mary	hiking
Bart	stamps

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Project Operator

- Example:

Person

Id	*Name*	*Address*	*Hobby*
1123	John	123 Main	stamps
1123	John	123 Main	coins
5556	Mary	7 Lake Dr	hiking
9876	Bart	5 Pine St	stamps

$\pi_{Name,Address}$(Person)

Name	*Address*
John	123 Main
Mary	7 Lake Dr
Bart	5 Pine St

Result is a table (no duplicates); can have fewer tuples than the original

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Expressions

$\pi_{Id,\ Name}$ ($\sigma_{Hobby=\text{'stamps'} \text{ OR } Hobby=\text{'coins'}}$ (Person))

Id	*Name*	*Address*	*Hobby*
1123	John	123 Main	stamps
1123	John	123 Main	coins
5556	Mary	7 Lake Dr	hiking
9876	Bart	5 Pine St	stamps

Person

Id	*Name*
1123	John
9876	Bart

Result

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Set Operators

- Relation is a set of tuples, so set operations should apply: $\cap$, $\cup$, $-$ (set difference)
- Result of combining two relations with a set operator is a relation => all its elements must be tuples having same structure
- Hence, scope of set operations limited to *union compatible relations*

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Union Compatible Relations

- Two relations are *union compatible* if
  - Both have same number of columns
  - Names of attributes are the same in both
  - Attributes with the same name in both relations have the same domain
- Union compatible relations can be combined using *union*, *intersection*, and *set difference*

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Example

Tables:

Person (*SSN, Name, Address, Hobby*)
Professor (*Id, Name, Office, Phone*)

are <u>not</u> union compatible.

But

π_{Name} (Person) and π_{Name} (Professor)

<u>are</u> union compatible so

π_{Name} (Person) - π_{Name} (Professor)

makes sense.

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Cartesian Product

- If *R* and *S* are two relations, $R \times S$ is the set of all concatenated tuples <*x*,*y*>, where *x* is a tuple in *R* and *y* is a tuple in *S*
  - *R* and *S* need not be union compatible
- $R \times S$ is <u>expensive to compute</u>:
  - Factor of two in the size of each row
  - Quadratic in the number of rows

R

A	*B*
x1	x2
x3	x4

S

C	*D*
y1	y2
y3	y4

$R \times S$

A	*B*	*C*	*D*
x1	x2	y1	y2
x1	x2	y3	y4
x3	x4	y1	y2
x3	x4	y3	y4

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Renaming

- Result of expression evaluation is a relation
- Attributes of relation must have distinct names. This is not guaranteed with Cartesian product
  - e.g., suppose in previous example *a* and *c* have the same name
- Renaming operator tidies this up. To assign the names $A_1, A_2, \ldots A_n$ to the attributes of the *n* column relation produced by expression *expr* use

  expr $[A_1, A_2, \ldots A_n]$

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Example

Transcript (*StudId*, *CrsCode*, *Semester*, *Grade*)
Teaching (*ProfId*, *CrsCode*, *Semester*)

$\pi_{StudId,\ CrsCode}$ (Transcript)[*StudId*, *CrsCode1*]

$\times\ \pi_{ProfId,\ CrsCode}$(Teaching) [*ProfId*, *CrsCode2*]

This is a relation with 4 attributes:

StudId, *CrsCode1*, *ProfId*, *CrsCode2*

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Derived Operation: Join

A (*general* or *theta*) *join* of *R* and *S* is the expression

$R \bowtie_{join\text{-}condition} S$

where *join-condition* is a *conjunction* of terms:

A_i *oper* B_i

in which A_i is an attribute of *R*; B_i is an attribute of *S*; and *oper* is one of =, <, >, ≥ ≠, ≤.

The meaning is:

$\sigma_{join\text{-}condition'} (R \times S)$

where *join-condition* and *join-condition´* are the same, except for possible renamings of attributes (next)

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Join and Renaming

- **Problem**: R and S might have attributes with the same name – in which case the Cartesian product is not defined
- **Solutions**:
  1. Rename attributes prior to forming the product and use new names in *join-condition´*.
  2. Qualify common attribute names with relation names (thereby disambiguating the names). For instance: Transcript.*CrsCode* or Teaching.*CrsCode*
     - This solution is nice, but doesn't always work: consider

$$R \bowtie_{join\_condition} R$$

In *R.A*, how do we know which R is meant?

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Theta Join – Example

Employee(*Name*,*Id*,*MngrId*,*Salary*)
Manager(*Name*,*Id*,*Salary*)

Output the names of all employees that earn more than their managers.

$$\pi_{\text{Employee}.Name}(\text{Employee} \bowtie_{MngrId=Id \text{ AND } Salary>Salary} \text{Manager})$$

The join yields a table with attributes:
Employee.*Name*, Employee.*Id*, Employee.*Salary*, *MngrId*
Manager.*Name*, Manager.*Id*, Manager.*Salary*

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Equijoin Join - Example

Equijoin: Join condition is a conjunction of *equalities*.

$$\pi_{Name,CrsCode}(\text{Student} \bowtie_{Id=StudId} \sigma_{Grade='A'}(\text{Transcript}))$$

Student

Id	*Name*	*Addr*	*Status*
111	John	…..	…..
222	Mary	…..	…..
333	Bill	…..	…..
444	Joe	…..	…..

Transcript

StudId	*CrsCode*	*Sem*	*Grade*
111	CSE305	S00	B
222	CSE306	S99	A
333	CSE304	F99	A

Mary	CSE306
Bill	CSE304

The equijoin is used very frequently since it combines related data in different relations.

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Natural Join

- Special case of equijoin:
  - join condition equates *all* and *only* those attributes with the same name (condition doesn't have to be explicitly stated)
  - duplicate columns eliminated from the result

Transcript (*StudId*, *CrsCode*, *Sem*, *Grade*)
Teaching (*ProfId*, *CrsCode*, *Sem*)

$$\text{Transcript} \bowtie \text{Teaching} =$$
$$\pi_{StudId,\ \text{Transcript}.CrsCode,\ \text{Transcript}.Sem,\ Grade,\ ProfId}(\text{Transcript} \bowtie_{CrsCode=CrsCode \text{ AND } Sem=Sem} \text{Teaching})$$
$$[StudId, CrsCode, Sem, Grade, ProfId]$$

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Natural Join (cont'd)

- More generally:

$$R \bowtie S = \pi_{attr\text{-}list}(\sigma_{join\text{-}cond}(R \times S))$$

where
$attr\text{-}list = attributes(R) \cup attributes(S)$
(duplicates are eliminated) and *join-cond* has the form:
$A_1 = A_1 \text{ AND } \ldots \text{ AND } A_n = A_n$
where
$\{A_1 \ldots A_n\} = attributes(R) \cap attributes(S)$

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Natural Join Example

- List all Ids of students who took at least two different courses:

$$\pi_{StudId}(\sigma_{CrsCode \neq CrsCode2}(\text{Transcript} \bowtie \text{Transcript}[StudId, CrsCode2, Sem2, Grade2]))$$

We don't want to join on *CrsCode*, *Sem*, and *Grade* attributes, hence renaming!

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Division

- Goal: Produce the tuples in one relation, r, that match *all* tuples in another relation, s
  - $r\ (A_1, \ldots A_n, B_1, \ldots B_m)$
  - $s\ (B_1 \ldots B_m)$
  - r/s, with attributes $A_1, \ldots A_n$, is the set of all tuples $<a>$ such that for every tuple $<b>$ in s, $<a,b>$ is in r
- Can be expressed in terms of projection, set difference, and cross-product

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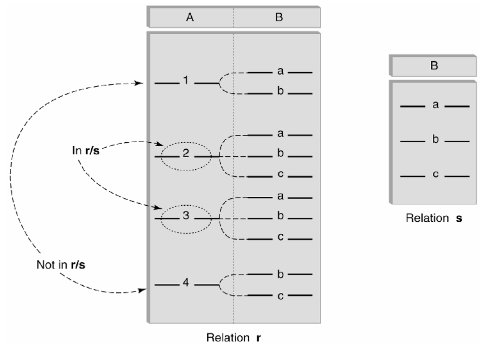
Division (cont'd)



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Division - Example

- List the Ids of students who have passed *all* courses that were taught in spring 2000
- *Numerator*:
  - *StudId* and *CrsCode* for every course passed by every student:

    $\pi_{StudId,\ CrsCode}\,(\sigma_{Grade \neq \text{'F'}}\ (\text{Transcript})\ )$
- *Denominator*:
  - *CrsCode* of all courses taught in spring 2000

    $\pi_{CrsCode}\ (\sigma_{Semester = \text{'S2000'}}\ (\text{Teaching})\ )$
- Result is *numerator/denominator*

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Schema for Student Registration System

Student (*Id*, *Name*, *Addr*, *Status*)
Professor (*Id*, *Name*, *DeptId*)
Course (*DeptId*, *CrsCode*, *CrsName*, *Descr*)
Transcript (*StudId*, *CrsCode*, *Semester*, *Grade*)
Teaching (*ProfId*, *CrsCode*, *Semester*)
Department (*DeptId*, *Name*)

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Query Sublanguage of SQL

```
SELECT  C.CrsName
FROM  Course C
WHERE  C.DeptId = 'CS'
```

- *Tuple variable* C ranges over rows of Course.
- Evaluation strategy:
  - FROM clause produces Cartesian product of listed tables
  - WHERE clause assigns rows to C in sequence and produces table containing only rows satisfying condition
  - SELECT clause retains listed columns
- Equivalent to: $\pi_{CrsName}\sigma_{DeptId=\text{'CS'}}(\text{Course})$

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Join Queries

```
SELECT  C.CrsName
FROM  Course C, Teaching T
WHERE  C.CrsCode=T.CrsCode AND T.Semester='S2000'
```

- List CS courses taught in S2000
- Tuple variables clarify meaning.
- Join condition "C.*CrsCode*=T.*CrsCode*"
  - relates facts to each other
- Selection condition " T.*Semester*='S2000' "
  - eliminates irrelevant rows
- Equivalent (using natural join) to:

$$\pi_{CrsName}(\text{Course} \bowtie \sigma_{Semester=\text{'S2000'}}\ (\text{Teaching})\ )$$
$$\pi_{CrsName}\,(\sigma_{Sem=\text{'S2000'}}\ (\text{Course} \bowtie \text{Teaching})\ )$$

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Correspondence Between SQL and Relational Algebra

SELECT C.*CrsName*
FROM Course C, Teaching T
WHERE C.*CrsCode* = T.*CrsCode* AND T.*Semester* = 'S2000'

Also equivalent to:

$\pi_{CrsName}\ \sigma_{C\_CrsCode=T\_CrsCode\ AND\ Semester=\text{'S2000'}}$
(Course [*C_CrsCode, DeptId, CrsName, Desc*]
$\times$ Teaching [*ProfId, T_CrsCode, Semester*])

- This is the simplest evaluation algorithm for SELECT.
- Relational algebra expressions are procedural.
  - Which of the two equivalent expressions is more easily evaluated?

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Self-join Queries

Find Ids of all professors who taught at least two courses in the same semester:

SELECT T1.*ProfId*
FROM Teaching T1, Teaching T2
WHERE T1.*ProfId* = T2.*ProfId*
AND T1.*Semester* = T2.*Semester*
AND T1.*CrsCode* <> T2.*CrsCode*

Tuple variables are essential in this query!

Equivalent to:

$\pi_{ProfId}\,(\sigma_{T1.CrsCode \neq T2.CrsCode}($Teaching[*ProfId, T1.CrsCode, Semester*]
$\bowtie$ Teaching[*ProfId, T2.CrsCode, Semester*]))

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Duplicates

- Duplicate rows not allowed in a relation
- However, duplicate elimination from query result is costly and not done by default; must be explicitly requested:

SELECT DISTINCT …..
FROM …..

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Use of Expressions

Equality and comparison operators apply to strings (based on lexical ordering)

WHERE S.*Name* < 'P'

Concatenate operator applies to strings

WHERE S.*Name* || '--' || S.*Address* = ….

Expressions can also be used in SELECT clause:

SELECT S.*Name* || '--' || S.*Address* AS *NmAdd*
FROM Student S

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Set Operators

- SQL provides UNION, EXCEPT (set difference), and INTERSECT for union compatible tables
- Example: Find all professors in the CS Department and all professors that have taught CS courses

(SELECT P.*Name*
FROM Professor P, Teaching T
WHERE P.*Id*=T.*ProfId* AND T.*CrsCode* LIKE 'CS%')
UNION
(SELECT P.*Name*
FROM Professor P
WHERE P.*DeptId* = 'CS')

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Nested Queries

List all courses that were not taught in S2000

SELECT C.*CrsName*
FROM Course C
WHERE C.*CrsCode* NOT IN
(SELECT T.*CrsCode* *--subquery*
FROM Teaching T
WHERE T.*Sem* = 'S2000')

Evaluation strategy: subquery evaluated once to produces set of courses taught in S2000. Each row (as C) tested against this set.

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Correlated Nested Queries

Output a row <*prof, dept*> if *prof* has taught a course in *dept.*

```
SELECT  P.Name, D.Name                --outer query
  FROM Professor P, Department D
  WHERE  P.Id  IN
          -- set of  all ProfId's who have taught a course in D.DeptId
          (SELECT T.ProfId                   --subquery
           FROM Teaching T, Course C
           WHERE T.CrsCode=C.CrsCode  AND
                   C.DeptId=D.DeptId        --correlation
          )
```

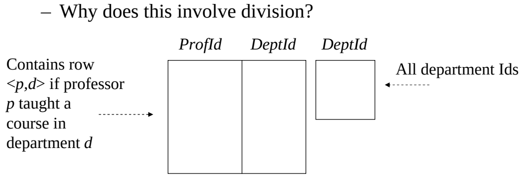

Correlated Nested Queries (con't)

- Tuple variables T and C are *local* to subquery
- Tuple variables P and D are *global* to subquery
- *Correlation*: subquery uses a global variable, D
- The value of D.*DeptId* parameterizes an evaluation of the subquery
- Subquery must (at least) be re-evaluated for each distinct value of D.*DeptId*

- *Correlated queries can be expensive to evaluate*

Division in SQL

- *Query type*: Find the subset of items in one set that are related to *all* items in another set
- *Example*: Find professors who taught courses in *all* departments
  - Why does this involve division?



$\pi_{ProfId,DeptId}(\text{Teaching} \bowtie \text{Course})\ /\ \pi_{DeptId}(\text{Department})$

Division in SQL

- *Strategy for implementing division in SQL*:
  - Find set, A, of all departments in which a particular professor, *p*, has taught a course
  - Find set, B, of all departments
  - Output *p* if A $\supseteq$ B, or, equivalently, if B–A is empty

Division – SQL Solution

```
SELECT  P.Id
FROM  Professor P
WHERE NOT EXISTS
   (SELECT  D.DeptId          -- set B of all dept Ids
    FROM  Department D
      EXCEPT
    SELECT  C.DeptId           -- set A of dept Ids of depts in
                               -- which P taught a course
    FROM  Teaching T, Course C
    WHERE  T.ProfId=P.Id     -- global variable
        AND  T.CrsCode=C.CrsCode)
```


Aggregates

- Functions that operate on sets:
  - COUNT, SUM, AVG, MAX, MIN
- Produce numbers (not tables)
- Not part of relational algebra (but not hard to add)

```
SELECT COUNT(*)            SELECT MAX (Salary)
FROM  Professor P          FROM  Employee E
```

Aggregates (cont'd)

Count the number of courses taught in S2000

SELECT COUNT (T.*CrsCode*)
FROM Teaching T
WHERE T.*Semester* = 'S2000'

But if multiple sections of same course are taught, use:

SELECT COUNT (DISTINCT T.*CrsCode*)
FROM Teaching T
WHERE T.*Semester* = 'S2000'

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Grouping

- But how do we compute the number of courses taught in S2000 *per professor*?
  - Strategy 1: Fire off a separate query for <u>each</u> professor:

    SELECT COUNT(T.*CrsCode*)
    FROM Teaching T
    WHERE T.*Semester* = 'S2000' AND T.*ProfId* = 123456789

    - Cumbersome
    - What if the number of professors changes? Add another query?
  - Strategy 2: define a special *grouping operator*:

    SELECT T.*ProfId*, COUNT(T.*CrsCode*)
    FROM Teaching T
    WHERE T.*Semester* = 'S2000'
    GROUP BY T.*ProfId*

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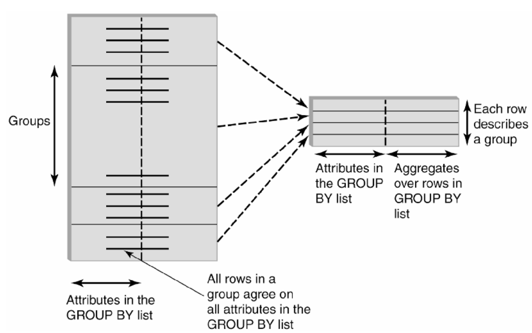
GROUP BY



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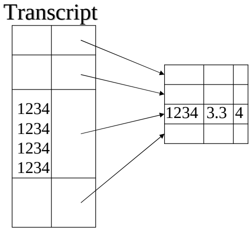
GROUP BY - Example

Transcript



Attributes:
–student's *Id*
–avg grade
–number of courses

SELECT T.*StudId*, AVG(T.*Grade*), COUNT (*)
FROM Transcript T
GROUP BY T.*StudId*

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HAVING Clause

- Eliminates unwanted groups (analogous to WHERE clause, but works on groups instead of individual tuples)
- HAVING condition is constructed from attributes of GROUP BY list and aggregates on attributes not in that list

SELECT T.*StudId*,
AVG(T.*Grade*) AS *CumGpa*,
COUNT (*) AS *NumCrs*
FROM Transcript T
WHERE T.*CrsCode* LIKE 'CS%'
GROUP BY T.*StudId*
HAVING AVG (T.*Grade*) > 3.5

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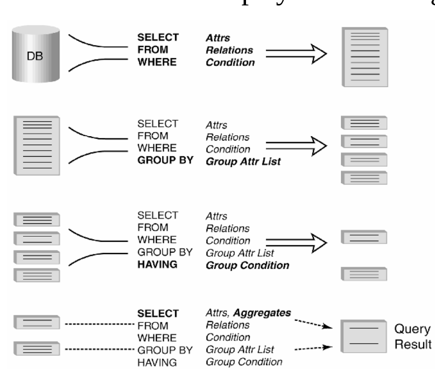
Evaluation of GroupBy with Having



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Example

- Output the name and address of all seniors on the Dean's List

```
SELECT  S.Id, S.Name
FROM    Student S, Transcript T
WHERE  S.Id = T.StudId  AND  S.Status = 'senior'

GROUP BY < S.Id              -- wrong
           S.Id, S.Name    -- right

HAVING AVG (T.Grade) > 3.5  AND  SUM (T.Credit) > 90
```

Every attribute that occurs in SELECT *clause must also occur in* GROUP BY *or it must be an aggregate. S.Name does not.*

Aggregates: Proper and Improper Usage

SELECT COUNT (T.*CrsCode*), T. *ProfId*
– *makes no sense (in the absence of* GROUP BY *clause)*

SELECT COUNT (*), AVG (T.*Grade*)
– *but this is OK*

WHERE T.*Grade* > COUNT (SELECT ….)
– *aggregate cannot be applied to result of* SELECT *statement*

ORDER BY Clause

- Causes rows to be output in a specified order

```
SELECT  T.StudId, COUNT (*) AS NumCrs,
        AVG(T.Grade) AS CumGpa
FROM    Transcript T
WHERE   T.CrsCode LIKE 'CS%'
GROUP BY  T.StudId
HAVING  AVG (T.Grade) > 3.5
ORDER BY  DESC  CumGpa,  ASC StudId
```

Descending *Ascending*

Query Evaluation with GROUP BY, HAVING, ORDER BY

As before:

1. Evaluate FROM: produces Cartesian product, A, of tables in FROM list
2. Evaluate WHERE: produces table, B, consisting of rows of A that satisfy WHERE condition
3. Evaluate GROUP BY: partitions B into groups that agree on attribute values in GROUP BY list
4. Evaluate HAVING: eliminates groups in B that do not satisfy HAVING condition
5. Evaluate SELECT: produces table C containing a row for each group. Attributes in SELECT list limited to those in GROUP BY list and aggregates over group
6. Evaluate ORDER BY: orders rows of C

Views

- Used as a relation, but rows are not physically stored.
  - The contents of a view is *computed* when it is used within an SQL statement
- View is the result of a SELECT statement over other views and base relations
- When used in an SQL statement, the view definition is substituted for the view name in the statement
  - As SELECT statement nested in FROM clause

View - Example

```
CREATE VIEW  CumGpa (StudId, Cum) AS
  SELECT  T.StudId,  AVG (T.Grade)
  FROM Transcript T
  GROUP BY T.StudId

SELECT  S.Name, C.Cum
FROM  CumGpa C,  Student S
WHERE  C.StudId = S.StudId AND C.Cum > 3.5
```

View Benefits

- *Access Control*: Users not granted access to base tables. Instead they are granted access to the view of the database appropriate to their needs.
  - *External schema* is composed of views.
  - View allows owner to provide SELECT access to a subset of columns (analogous to providing UPDATE and INSERT access to a subset of columns)

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Views – Limiting Visibility

Grade projected out

```
CREATE VIEW PartOfTranscript (StudId, CrsCode, Semester) AS
   SELECT T. StudId, T.CrsCode, T.Semester     -- limit columns
   FROM Transcript T
   WHERE T.Semester = 'S2000'                  -- limit rows
```

Give permissions to access data through view:

GRANT SELECT ON PartOfTranscript TO joe

This would have been analogous to:

GRANT SELECT (*StudId,CrsCode,Semester*) ON Transcript TO joe

on regular tables, <u>if</u> SQL allowed attribute lists in GRANT SELECT

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View Benefits (cont'd)

- *Customization*: Users need not see full complexity of database. View creates the illusion of a simpler database customized to the needs of a particular category of users
- A view is *similar in many ways to a subroutine* in standard programming
  - Can be reused in multiple queries

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Nulls

- *Conditions*: *x op y* (where *op* is <, >, <>, =, etc.) has value ***unknown*** (*U*) when either x or y is null
  - WHERE T.*cost* > T.*price*
- *Arithmetic expression*: x *op y* (where *op* is +, –, *, etc.) has value NULL if x or y is NULL
  - WHERE (T. *price*/T.*cost*) > 2
- *Aggregates*: COUNT counts NULLs like any other value; other aggregates ignore NULLs

```
SELECT COUNT (T.CrsCode), AVG (T.Grade)
FROM   Transcript T
WHERE  T.StudId = '1234'
```

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Nulls (cont'd)

- WHERE clause uses a ***three-valued logic*** – *T*, *F*, *U(ndefined)* – to filter rows. Portion of truth table:

C1	*C2*	*C1* AND *C2*	*C1* OR *C2*
T	U	U	T
F	U	F	U
U	U	U	U

- Rows are discarded if WHERE condition is *F(alse)* or U(*nknown)*
- Ex: WHERE T.*CrsCode* = 'CS305' AND T.*Grade* > 2.5

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Modifying Tables – Insert

- Inserting a single row into a table
  - Attribute list can be omitted if it is the same as in CREATE TABLE (but do not omit it)
  - NULL and DEFAULT values can be specified

```
INSERT INTO Transcript(StudId, CrsCode, Semester, Grade)
VALUES (12345, 'CSE305', 'S2000', NULL)
```

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Bulk Insertion

- Insert the rows output by a SELECT

CREATE TABLE DeansList (
StudId INTEGER,
Credits INTEGER,
CumGpa FLOAT,
PRIMARY KEY *StudId*)

INSERT INTO DeansList (*StudId*, *Credits*, *CumGpa*)
SELECT T.*StudId*, 3 * COUNT (*), AVG(T.*Grade*)
FROM Transcript T
GROUP BY T.*StudId*
HAVING AVG (T.*Grade*) > 3.5 AND COUNT(*) > 30

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Modifying Tables – Delete

- Similar to SELECT except:
  - No project list in DELETE clause
  - No Cartesian product in FROM clause (only 1 table name)
  - Rows satisfying WHERE clause (general form, including subqueries, allowed) are deleted instead of output

DELETE FROM Transcript T
WHERE T.*Grade* IS NULL AND T.*Semester* <> 'S2000'

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Modifying Data - Update

UPDATE Employee E
SET E.*Salary* = E.*Salary* * 1.05
WHERE E.*Department* = 'R&D'

- Updates rows in a single table
- All rows satisfying WHERE clause (general form, including subqueries, allowed) are updated

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Updating Views

- Question: Since views look like tables to users, can they be updated?
- Answer: Yes – a view update changes the underlying base table to produce the requested change to the view

CREATE VIEW CsReg (*StudId, CrsCode, Semester*) AS
SELECT T.*StudId*, T. *CrsCode*, T.*Semester*
FROM Transcript T
WHERE T.*CrsCode* LIKE 'CS%' AND T.*Semester*='S2000'

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Updating Views - Problem 1

INSERT INTO CsReg (*StudId, CrsCode, Semester*)
VALUES (1111, 'CSE305', 'S2000')

- **Question**: What value should be placed in attributes of underlying table that have been projected out (e.g., *Grade*)?
- **Answer**: NULL (assuming null allowed in the missing attribute) or DEFAULT

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Updating Views - Problem 2

INSERT INTO CsReg (*StudId, CrsCode, Semester*)
VALUES (1111, 'ECO105', 'S2000')

- **Problem**: New tuple not in view
- **Solution**: Allow insertion (assuming the WITH CHECK OPTION clause has not been appended to the CREATE VIEW statement)

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Updating Views - Problem 3

- Update to a view might *not* *uniquely* specify the change to the base table(s) that results in the desired modification of the view (ambiguity)

```
CREATE VIEW  ProfDept (PrName, DeName)  AS
SELECT   P.Name, D.Name
FROM     Professor P, Department D
WHERE    P.DeptId = D.DeptId
```

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Updating Views - Problem 3 (cont'd)

- Tuple <Smith, CS> can be deleted from ProfDept by:
  - Deleting row for Smith from Professor (but this is inappropriate if he is still at the University)
  - Deleting row for CS from Department (not what is intended)
  - Updating row for Smith in Professor by setting *DeptId* to null (seems like a good idea, but how would the computer know?)

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Updating Views - Restrictions

- Updatable views are restricted to those in which
  - No Cartesian product in FROM clause
  - no aggregates, GROUP BY, HAVING
  - …

For example, if we allowed:

```
CREATE VIEW AvgSalary (DeptId, Avg_Sal ) AS
   SELECT  E.DeptId, AVG(E.Salary)
   FROM    Employee E
   GROUP BY E.DeptId
```

then how do we handle:

```
UPDATE AvgSalary
   SET Avg_Sal = 1.1 * Avg_Sal
```

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