SQL – The Relational Database Standard

SQL

- Data Definition in SQL
- Retrieval Queries in SQL
- Specifying Updates in SQL
- Relational Views in SQL

Overview

- Background of SQL
- Data Definition Language (DDL) in SQL
  - Domain Types
  - Schema Definition
  - Integrity Constraints

Background

- IBM **Sequel** language, the original version of SQL. (In the early 1970s)
- Renamed to **Structured Query Language** (SQL)
- ANSI and ISO standard SQL:
  - SQL-86 (SQL1)
  - SQL-89
  - SQL-92 (SQL2)
  - SQL:1999 (SQL3)
  - SQL:2003 (2003 SQL3)
- Our description is based on
  - SQL-92 (SQL2)
  - Some extensions from SQL:1999 and SQL:2003
- **Not all** examples here may work on your particular system.

Data Definition Language (DDL)

- **Domain Types**
  - Basic Domain Types
  - Additional Domain Types
- Schema Definition
- Integrity Constraints

Basic Domain Types

- **char**(*n*): a fixed length character string
- **varchar**(*n*): a variable length character string
- **int/integer**: an integer
- **smallint**: a small integer
- **numeric**(*p*,*d*): a fixed point number with user-specified precision
- **real, double precision**: floating point and double-precision floating point numbers
- **float**(*n*): a floating point number

Additional Data Types in SQL2

- **DATE**: Made up of year-month-day in the format yyyy-mm-dd
- **TIME**: Made up of hour:minute:second in the format hh:mm:ss
- **TIME(i):**Made up of hour:minute:second plus i additional digits specifying fractions of a second; format is hh:mm:ss:ii...i
- **TIMESTAMP:**Has both **DATE** and **TIME** components ('2002-09-27 09:12:47')
- **INTERVAL:**Specifies a relative value rather than an absolute value
  - Can be DAY/TIME intervals or YEAR/MONTH intervals
  - when added to or subtracted from an absolute value, the result is an absolute value

Data Definition Language (DDL)

- Domain Types
- **Schema Definition**
  - Create Table
    - Insert
    - Delete
  - Drop Table
  - Alter Table
- Integrity Constraints

Data Definition in SQL

- Used to CREATE, DROP, and ALTER the descriptions of the tables (relations) of a database
- **CREATE TABLE:**
  - Specifies a new base relation by giving it a name, and specifying each of its attributes and their data types (INTEGER, FLOAT, DECIMAL(i,j), CHAR(n), VARCHAR(n))
  - A constraint NOT NULL may be specified on an attribute

Create Table

- An SQL relation is defined using the **create table** command:

  create table *r*
  (A_1 D_1,
  A_2 D_2,
  ...,
  A_n D_n,
  (integrity-constraint$_1$),
  ...,
  (integrity-constraint$_k$))
  - ***r*** is the name of the relation
  - each $\boldsymbol{A_i}$ is an attribute name in the schema of relation *r*
  - $\boldsymbol{D_i}$ is the data type of values in the domain of attribute A_i
- Example:

  create table *branch*
  (*branch_name* **char**(15),
  branch_city **char**(30),
  assets **integer**)

CREATE table example

```
CREATE TABLE   DEPARTMENT
  (   DNAME          VARCHAR(10)   NOT NULL,
      DNUMBER        INTEGER       NOT NULL,
      MGRSSN         CHAR(9),
      MGRSTARTDATE        CHAR(9)  );
```

Key attributes can be specified via the **PRIMARY KEY** and **UNIQUE** phrases

```
CREATE TABLE   DEPT
  (   DNAME   VARCHAR(10)      NOT NULL,
      DNUMBER   INTEGER        NOT NULL,
      MGRSSN  CHAR(9),
      MGRSTARTDATE   CHAR(9),
      PRIMARY KEY (DNUMBER),
      UNIQUE (DNAME),
      FOREIGN KEY (MGRSSN) REFERENCES EMP(SSN)  );
```

Insert

- The **insert** command inserts a tuple into a relation
  - Example:

    insert into *branch*

    values (‘Perryridge ’, ‘Dallas’, **null**)
  - Attribute list can be omitted if it is the same as in **CREATE TABLE**
  - **NULL** and **DEFAULT** values can be specified

Delete

- The **delete** command deletes tuples from a relation
  - Simple form: delete all tuples from a relation
    - Example: **delete from** *branch*
  - Other forms: allow specific tuples to be deleted (covered later)

DROP TABLE

- Used to remove a relation (base table) *and its definition*
- The relation can no longer be used in queries, updates, or any other commands since its description no longer exists
- **E.g.**
  - **DROP TABLE** DEPENDENT
  - **DROP TABLE** Branch

Alter Table

- The **alter table** command is used to add attributes to an existing relation:
  - Example**:**

    alter table *branch* **add** *phone_number* **char**(10)
  - All tuples in the relation are assigned *null* as the value for the new attribute.
- The **alter table** command can also be used to drop attributes of a relation:
  - Example:

    alter table *branch* **drop** *branch_city*
  - Dropping of attributes is not supported by many databases

ALTER TABLE

- Used to add/drop an attribute, change a column definition, add/drop table constrains
- The new attribute will have NULLs in all the tuples of the relation right after the command is executed; hence, the NOT NULL constraint is *not allowed* for such an attribute
- e.g.,
  - **ALTER TABLE** EMPLOYEE **ADD** JOB **VARCHAR(12);**
  - **Alter table** *branch* **add** *phone_number* **char**(10);
  - **Alter table** *branch* **drop** *branch_city;*

Data Definition Language (DDL)

- Domain Types
- Schema Definition
- **Integrity Constraints**
  - Constraints on a Single Relation
  - Referential Integrity
  - Assertions

Constraints on a Single Relation

- **not null**
- **primary key**
- **default**
- **unique**
- **check** (*P*), where *P* is a predicate

Not Null Constraint

- Not null constraint: null value is not permitted.
- Example:
  – Declare *branch_name* for *branch* to be **not null**

    branch_name **char**(15) **not null**

  – Declare the domain *Dollars* to be **not null**

    create domain *Dollars* **numeric**(12,2) **not null**

Primary Key

- **primary key** (A_1, ..., A_n)
- Example: Declare *branch_name* as the primary key for *branch*

  create table *branch*
  (*branch_name* **char**(15),
  branch_city **char**(30),
  assets **integer**,
  primary key (*branch_name*))

- **primary key** declaration implies **not null** and **unique**.

Default Constraint

- Specify a default value for the attribute with the **default** clause
- Example:

create table *account*

(*account_number* **char**(10),

branch_name **char**(15),

balance **integer** **default** 0,

primary key (branch_name))

Unique Constraint

- **unique** (A_1, A_2, …, A_m)
- The unique specification states that the attributes (A_1, A_2, … A_m) form a candidate key.

The check Clause

- **check** (*P*), where *P* is a predicate
- The **check** clause can be applied to relation declarations.
- Example 1: Declare *branch_name* as the primary key for *branch* and ensure that the values of *assets* are non-negative.

create table *branch*
(*branch_name* **char**(15)**,**
branch_city **char**(30),
assets **integer**,
primary key (*branch_name*),
check (*assets* >= 0))

The check Clause (Cont.)

- Example 2:

create table *student*
(*name* **char**(15) **not null**,
student_id **char**(10),
degree-level **char**(15),
primary key (*student_id*),
check (*degree_level* **in** ('Bachelors', 'Masters', 'Doctorate')))

The check Clause (Cont.)

- The **check** clause in SQL-92 permits domains to be restricted.
- Example 3: Use **check** clause to ensure that an hourly_wage domain allows only values greater than a specified value.

create domain *hourly_wage* **numeric(5,2)**
constraint *value_test* **check(value** > = 4.00)

The check Clause (Cont.)

- Example 4:

create domain *AccountType* **varchar**(10)
constraint *type_test*
check (**value in** ('Checking', 'Saving'))

Referential Integrity

- Enforce referential integrity by **foreign key** clause
- Example:

  create table *branch*
  (*branch_name* **char**(15),
  …)

  create table *account*
  (…
  branch_name **char**(15),
  foreign key (*branch_name*) **references** *branch*
  (branch_name),
  …)

- A foreign key only references the primary key attributes or the candidate key attributes of the referenced relation.

Referential Integrity (Cont.)

- When a referential integrity constraint is violated
  - Default procedure: reject the action
  - Other procedures: change the tuple in the referencing relation to restore the constraint.
    - Set to null: on delete/update set null
    - Set to default value: on delete/update set default
    - Propagate delete/update: on delete/update cascade
  - Example:

    create table *account*
    (…
    foreign key (*branch_name*) **references** *branch*
    on delete cascade
    on update cascade,
    …)

Referential Integrity (Cont.)

- Attributes of foreign keys are allowed to be null.
- What if any attribute of a foreign key is null?
- The tuple is defined to satisfy the foreign key constraint.
- Can we alter integrity constraints to an existing relation?
  - **alter table** *r* **add** *constraint*
  - **alter table** *r* **drop constraint** *constraint name*

Referential Integrity (Cont.)

- Transactions consist of several steps.
- What if intermediate steps violate referential integrity, but later steps remove the violation?
- **Initially deferred**: the constraint will be checked at the end of a transaction.
- **Deferrable**: checked immediately by default, but can be deferred when desired.
  - **set constraints** *constraint-list* **deferred**

Assertions

- An **assertion** is a predicate expressing a condition that we wish the database always to satisfy.

  create assertion <assertion-name> **check**
  <predicate>

- Assertion testing may introduce a significant amount of overhead.
- Asserting
  for all *X*, *P*(*X*)
  by using
  not exists *X* such that not *P*(*X*)

Assertions (Example 1)

- Every loan has at least one borrower who maintains an account with a minimum balance or $1000.00

```
create assertion balance_constraint check
   (not exists (select * from loan
          where not exists (select *
                 from borrower, depositor, account
                 where loan.loan_number =
                        borrower.loan_number
                     and borrower.customer_name =
                            depositor.customer_name
                     and depositor.account_number =
                        account.account_number
                     and account.balance >= 1000)))
```

Assertions (Example 2)

- The sum of all loan amounts for each branch must be less than the sum of all account balances at the branch.

create assertion *sum_constraint* **check**
(**not exists** (**select * from** *branch*
where (**select sum**(*amount*) **from** *loan*
where *loan.branch_name* = *branch.branch_name*)
>= (**select sum** (*amount*)
from *account*
where *loan.branch_name* = *branch.branch_name*)))

CREATE table example

```
CREATE TABLE   DEPARTMENT
  (   DNAME           VARCHAR(10)  NOT NULL,
      DNUMBER         INTEGER      NOT NULL,
      MGRSSN          CHAR(9),
      MGRSTARTDATE         CHAR(9)  );
```

Key attributes can be specified via the **PRIMARY KEY** and **UNIQUE** phrases

```
CREATE TABLE   DEPT
  (   DNAME   VARCHAR(10)       NOT NULL,
      DNUMBER   INTEGER         NOT NULL,
      MGRSSN  CHAR(9),
      MGRSTARTDATE   CHAR(9),
      PRIMARY KEY (DNUMBER),
      UNIQUE (DNAME),
      FOREIGN KEY (MGRSSN) REFERENCES EMP(SSN)  );
```

Features Added in SQL2

- CREATE SCHEMA
  - Specifies a new database schema by giving it a name
  - **CREATE SCHEMA** COMPANY **;**
- REFERENTIAL INTEGRITY OPTIONS
  - specify **CASCADE** or **SET NULL** or **SET DEFAULT** on referential integrity constraints (foreign keys)

```
CREATE TABLE   DEPT
    (       DNAME   VARCHAR(10)         NOT NULL,
            DNUMBER   INTEGER           NOT NULL,
            MGRSSN  CHAR(9),
            MGRSTARTDATE    CHAR(9),
            PRIMARY KEY (DNUMBER),
            UNIQUE (DNAME),
            FOREIGN KEY (MGRSSN) REFERENCES EMP
                    ON DELETE SET DEFAULT ON UPDATE CASCADE  );
CREATE TABLE   EMP
    (       ENAME   VARCHAR(30)         NOT NULL,
            ESSN    CHAR(9),
            BDATE   DATE,
            DNO     INTEGER  DEFAULT 1,
            SUPERSSN          CHAR(9),
            PRIMARY KEY (ESSN),
            FOREIGN KEY (DNO) REFERENCES DEPT
                    ON DELETE SET DEFAULT ON UPDATE CASCADE,
            FOREIGN KEY (SUPERSSN) REFERENCES EMP
                    ON DELETE SET NULL ON UPDATE CASCADE  );
```

Retrieval Queries in SQL

- Basic SQL queries correspond to using the **SELECT**, **PROJECT**, and **JOIN** operations of the relational algebra
- Basic form of the SQL SELECT statement is called a *mapping* or a *SELECT-FROM-WHERE block*

```
SELECT <attribute list>
FROM <table list>
WHERE <condition>
```

<attribute list> is a list of attribute names whose values are to be retrieved by the query

<table list> is a list of the relation names required to process the query

<condition> is a conditional (Boolean) expression that identifies the tuples to be retrieved by the query

- the SELECT basic statement for retrieving information is ***not the same*** *as* the SELECT operation of the relational algebra
- Distinction between SQL and the formal relational model:
  - SQL allows a table (relation) to have two or more tuples that are identical in all their attribute values
  - an SQL relation (table) is a *multi-set* of tuples; it *is not* a set of tuples
  - SQL relations can be constrained to be sets by specifying PRIMARY KEY or UNIQUE attributes, or by using the DISTINCT option in a query

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)

Query Example

- Select all the course names offered by Department of computer science.
  - Assume: DeptID of Computer Science =‘CS’.

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: $\pi_{CrsName}\sigma_{DeptId=\text{'CS'}}(Course)$

Join Queries

- List all courses taught in S2000 semester.

Join Queries

Rename relation tables
Course C, Teaching T

- List all courses taught in S2000

- Selection condition “ T.Semester=‘S2000’ ”
  - eliminates irrelevant rows
- Join condition “C.CrsCode=T.CrsCode”
  - eliminates garbage

- Equivalent (using natural join) to relational algebra:

$$\pi_{CrsName}(Course \quad * \quad \sigma_{Sem=\text{‘}S2000\text{’}}(Teaching)\ )$$

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”
  - eliminates garbage
- Selection condition “ T.Sem=‘S2000’ ”
  - eliminates irrelevant rows
- Equivalent (using natural join) to:

$$\pi_{CrsName}(Course \quad * \quad \sigma_{Sem=\text{‘}S2000\text{’}}(Teaching)\ )$$

Join Queries

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

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

$$\pi_{CrsName}(Course \quad * \quad \sigma_{Sem='S2000'}(Teaching))$$

$$\pi_{CrsName}(\sigma_{Sem='S2000'}(Course \; * \; Teaching))$$

Correspondence Between SQL and Relational Algebra

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

Also equivalent to:

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

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

Self-join Queries

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

Self-join Queries

Find Ids of all professors who taught at least two different 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 now essential)

Equivalent to:

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

Duplicates

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

```
SELECT DISTINCT …..
FROM …..
```

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
```

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

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')
```

Nested Queries

List all courses that were not taught in S2000

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

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.

Correlated Nested Queries

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

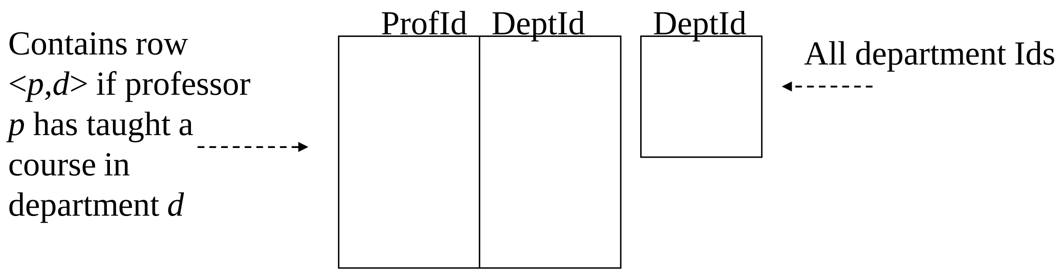
```
SELECT  P.Name, D.Name                  --outer query
  FROM Professor P, Department D
  WHERE  P.Id  IN (set of Id's of all profs who
                   have taught a course in D.DeptId)

     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

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



Division

- *Strategy for implementing division in SQL:*
  - Find set of all departments in which a particular professor, *p*, has taught a course - A
  - Find set of all departments - B
  - 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          -- B: set of all dept Ids
    FROM Department D
        EXCEPT
    SELECT C.DeptId           -- A: set of dept Ids of depts in
                              -- which P has 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

```
SELECT COUNT(*)
FROM  Professor P
```

```
SELECT MAX (Salary)
FROM  Employee E
```

Aggregates

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:

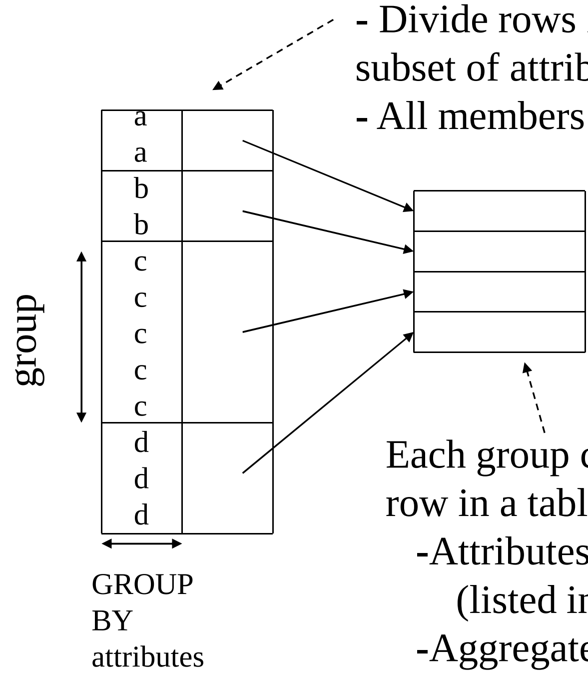
```
SELECT COUNT (DISTINCT T.CrsCode)
FROM Teaching T
WHERE  T.Semester = 'S2000'
```

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
```

GROUP BY

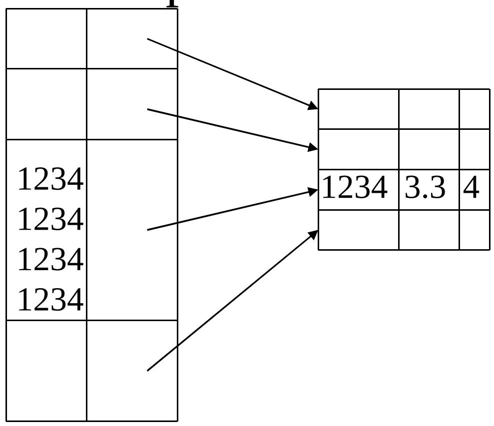
Table output by WHERE clause:
- Divide rows into groups based on subset of attributes;
- All members of a group agree on those attributes



Each group can be described by a single row in a table with attributes limited to:
- Attributes all group members share (listed in GROUP BY clause)
- Aggregates over group

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

HAVING Clause

- Eliminates unwanted groups (analogous to WHERE clause)
- HAVING condition constructed from attributes of GROUP BY list and aggregates of attributes not in 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
```

Example

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

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

           S.StudId                  -- wrong
GROUP BY
           S.Name, S.Address         -- right

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

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
```

Query Evaluation Strategy

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.
  - A view is *materialized* 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
  - SELECT statement can be 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)

Views - Limiting Visibility

```
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

GRANT SELECT ON PartOfTranscript TO joe
```

This is analogous to:

```
GRANT UPDATE (Grade) ON Transcript TO joe
```

View Benefits (con't)

- 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 used in multiple queries

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'
```

Nulls (con't)

- WHERE clause uses a three-valued logic 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 false or unknown
- Ex: WHERE T.CrsCode = 'CS305' AND T.Grade > 2.5

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)
```

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
```

Modifying Tables - Delete

- Similar to SELECT except:
  - No project list in DELETE clause
  - No Cartesian product in FROM clause
  - 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'
```

Modifying Data - Update

```
UPDATE Employee E
SET E.Salary = E.Salary * 1.05
WHERE  E.Department = ‘research’
```

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

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’
```

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

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)

Updating Views - Problem 3

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

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

Updating Views - Problem 3 (con't)

- 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)

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
```