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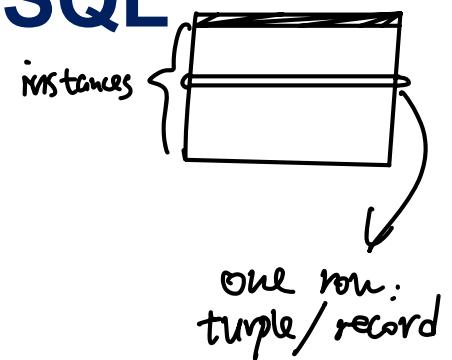
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table's structure: schema

Chapter 3: Introduction to SQL

theoretical language: relational algebra

σ
 π
 \times
 ρ
 \bowtie



SQL : User Reference Language
more closer to natural language
Database System Concepts, 7th Ed.

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Outline

- ❑ Overview of The SQL Query Language
- ❑ SQL Data Definition
- ❑ Basic Query Structure of SQL Queries
- ❑ Additional Basic Operations
- ❑ Set Operations
- ❑ Null Values
- ❑ Aggregate Functions
- ❑ Nested Subqueries
- ❑ Modification of the Database



History

first version of relational database

- ② IBM Sequel language developed as part of System R project at the IBM San Jose Research Laboratory
beginning
- ② Renamed Structured Query Language (SQL)
later on
- ② ANSI and ISO standard SQL: ~~international standard~~
 - SQL-86
 - SQL-89 *Redefined, extention*
 - SQL-92
 - SQL:1999 (language name became Y2K compliant!)
 - SQL:2003

for practice may have difference
- ② Commercial systems offer most, if not all, SQL-92 features, plus varying feature sets from later standards and special proprietary features.
 - Not all examples here may work on your particular system.



DDL Data Definition Language
DML Data Management Language
Manipulation

SQL Parts

- ❑ DML -- provides the ability to query information from the database and to insert tuples into, delete tuples from, and modify tuples in the database.
- ❑ integrity – the DDL includes commands for specifying integrity constraints.
- ❑ View definition -- The DDL includes commands for defining views.
- ❑ Transaction control –includes commands for specifying the beginning and ending of transactions.
- ❑ Embedded SQL and dynamic SQL -- define how SQL statements can be embedded within general-purpose programming languages.
- ❑ Authorization – includes commands for specifying access rights to relations and views.



Data Definition Language

Data Type , another name: domain

The SQL data-definition language (DDL) allows the specification of information about relations, including:

- ❑ The schema for each relation.
- ❑ The type of values associated with each attribute.
- ❑ The Integrity constraints
- ❑ The set of indices to be maintained for each relation.
which user can use the data
- ❑ Security and authorization information for each relation.
- ❑ The physical storage structure of each relation on disk.



Domain Types in SQL

- ❑ **char(n).** Fixed length character string, with user-specified length n .
- ❑ **varchar(n).** Variable length character strings, with user-specified maximum length n .
- ❑ **int.** Integer (a finite subset of the integers that is machine-dependent).
- ❑ **smallint.** Small integer (a machine-dependent subset of the integer domain type).
*save space of computation
important to use smallint*
- ❑ **numeric(p,d).** Fixed point number, with user-specified precision of p digits, with d digits to the right of decimal point. (ex., **numeric(3,1)**, allows 44.5 to be stored exactly, but not 444.5 or 0.32)
*p: how many digits
numeric(4,1) numeric(3,2) d: how many digits after ":"*
- ❑ **real, double precision.** Floating point and double-precision floating point numbers, with machine-dependent precision.
- ❑ **float(n).** Floating point number, with user-specified precision of at least n digits.
- ❑ More are covered in Chapter 4.
- ❑ MySQL domain type
 - <https://dev.mysql.com/doc/refman/8.0/en/data-types.html>



Create Table Construct

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

create table *r*

$(A_1 D_1, A_2 D_2, \dots, A_n D_n,$
 $\text{(integrity-constraint}_1\text{)},$
 $\dots,$
 $\text{(integrity-constraint}_k\text{)})$

- *r* is the name of the relation
- each *A_i* is an attribute name in the schema of relation *r*
- *D_i* is the data type of values in the domain of attribute *A_i*

- Example:

create table *instructor* (
 ID **char(5)**,
 name **varchar(20)**,
 dept_name **varchar(20)**,
 salary **numeric(8,2)**)



Integrity Constraints in Create Table

all the values should follow some constraints

Types of integrity constraints

- **primary key** (A_1, \dots, A_n)
- **foreign key** (A_m, \dots, A_n) **references** r
- **not null**

SQL prevents any update to the database that violates an integrity constraint.

Example:

```
create table instructor (
```

```
    ID          char(5),  
    name        varchar(20) not null,  
    dept_name   varchar(20),  
    salary      numeric(8,2),
```

primary key (ID), ID is unique . can not be reduced. already unique

foreign key ($dept_name$) **references** department;

attributes are defined in another table where they are primary keys



And a Few More Relation Definitions

② **create table student (**

ID **varchar(5),**
name **varchar(20) not null,**
dept_name **varchar(20),**
tot_cred **numeric(3,0),**

primary key (ID),

foreign key (dept_name) references department;

② **create table takes (**

ID **varchar(5),**
course_id **varchar(8),**
sec_id **varchar(8),**
semester **varchar(6),**
year **numeric(4,0),**
grade **varchar(2),**

primary key (ID, course_id, sec_id, semester, year) ,

foreign key (ID) references student,

foreign key (course_id, sec_id, semester, year) references section;

primary key for the table "section"



And more still

```
? create table course (
    course_id      varchar(8),
    title          varchar(50),
    dept_name      varchar(20),
    credits         numeric(2,0),
    primary key (course_id),
    foreign key (dept_name) references department);
    primary key for the table = department"
```



Updates to tables

e.g. create table student (

ID
name
phone
GPA;

Insert

- insert into *table name* values ('10211', 'Smith', 'Biology', 66000);

the tuple of the record

alter table *student* add

address *varchar(3)*

map: follow the standard of schema

alter table *student* drop

Phone

c: look up the dictionary to see the relation.

Delete

- Remove all tuples from the student relation

?

delete from *student*

Drop Table

- drop table *r* *in the future* you don't wanna use the table again, drop the table to save the space.

Alter

- alter table *r* add *A D*

?

where *A* is the name of the attribute to be added to relation *r* and *D* is the domain of *A*.

?

All existing tuples in the relation are assigned *null* as the value for the new attribute.

- alter table *r* drop *A*

?

where *A* is the name of an attribute of relation *r*

?

Dropping of attributes not supported by many databases.

cause a lot of complexity

may change disc's structure, may be a big problem



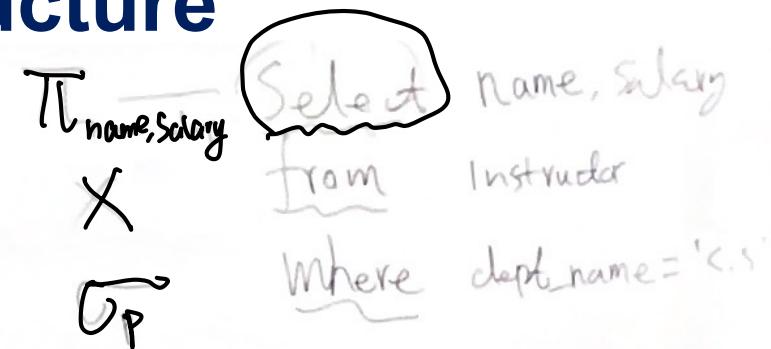
Basic Query Structure

- ② A typical SQL query has the form:

select A_1, A_2, \dots, A_n corresponding to Π
from r_1, r_2, \dots, r_m corresponding to X
where P what condition you want
corresponding to σ

- A_i represents an attribute
- R_i represents a relation
- P is a predicate.

- ② The result of an SQL query is a relation.





The select Clause

- ❑ The **select** clause lists the attributes desired in the result of a query
 - corresponds to the projection operation of the relational algebra
- ❑ Example: find the names of all instructors:

```
select name  
from instructor
```
- ❑ NOTE: SQL names are case insensitive (i.e., you may use upper- or lower-case letters.)
 - E.g., *Name* \equiv *NAME* \equiv *name*
 - Some people use upper case wherever we use bold font.



The select Clause (Cont.)

- SQL allows duplicates in relations as well as in query results.
- To force the elimination of duplicates, insert the keyword **distinct** after select.
- Find the department names of all instructors, and remove duplicates

***select distinct dept_name primary key always unique
from instructor***

- The keyword **all** specifies that duplicates should not be removed.

***select all dept_name
from instructor***

<i>dept_name</i>
Comp. Sci.
Finance
Music
Physics
History
Physics
Comp. Sci.
History
Finance
Biology
Comp. Sci.
Elec. Eng.



The select Clause (Cont.)

- ❑ An asterisk in the select clause denotes “all attributes”

```
select *  
from instructor
```

- ❑ An attribute can be a literal with no from clause

```
select '437'
```

- Results is a table with one column and a single row with value “437”
- Can give the column a name using:

```
select '437' as FOO
```

- ❑ An attribute can be a literal with from clause

```
select 'A'  
from instructor
```

- Result is a table with one column and N rows (number of tuples in the *instructors* table), each row with value “A”



The select Clause (Cont.)

- ? The **select** clause can contain arithmetic expressions involving the operation, +, -, , and /, and operating on constants or attributes of tuples.

- The query:

```
select ID, name, salary/12  
from instructor
```

would return a relation that is the same as the *instructor* relation, except that the value of the attribute *salary* is divided by 12.

- Can rename “salary/12” using the **as** clause:

```
select ID, name, salary/12 as monthly_salary
```



The where Clause

- ? The **where** clause specifies conditions that the result must satisfy
 - Corresponds to the selection predicate of the relational algebra.
 - ? To find all instructors in Comp. Sci. dept

select *name*
from *instructor* *comparison*
where *dept_name* = 'Comp. Sci.'

- SQL allows the use of the logical connectives **and, or, and not**
 - The operands of the logical connectives can be expressions involving the comparison operators <, <=, >, >=, =, and <>.
 - Comparisons can be applied to results of arithmetic expressions
 - To find all instructors in Comp. Sci. dept with salary > 70000

```
select name  
from instructor  
where dept_name = 'Comp. Sci.' and salary > 70000
```

name



The from Clause

- ❑ The **from** clause lists the relations involved in the query
 - Corresponds to the Cartesian product operation of the relational algebra.
- ❑ Find the Cartesian product *instructor X teaches*
select
from *instructor, teaches*
 - generates every possible instructor – teaches pair, with all attributes from both relations.
 - For common attributes (e.g., *ID*), the attributes in the resulting table are renamed using the relation name (e.g., *instructor.ID*)
- ❑ Cartesian product not very useful directly, but useful combined with where-clause condition (selection operation in relational algebra).



Examples

- ① *instructor(ID, name, dept_name, salary)*
teaches(ID, course_id, sec_id, semester, year)
- ② Find the names of all instructors who have taught some course and the course_id
 - **select name, course_id**
from instructor , teaches
where instructor.ID = teaches.ID
 - Find the names of all instructors in the Art department who have taught some course and the course_id
 - **select name, course_id**
from instructor , teaches
where instructor.ID = teaches.ID
and (instructor.dept_name = 'Art' OR instructor.dept_name = 'CS')
AND

<i>name</i>	<i>course_id</i>
Srinivasan	CS-101
Srinivasan	CS-315
Srinivasan	CS-347
Wu	FIN-201
Mozart	MU-199
Einstein	PHY-101
El Said	HIS-351
Katz	CS-101
Katz	CS-319
Crick	BIO-101
Crick	BIO-301
Brandt	CS-190
Brandt	CS-190
Brandt	CS-319
Kim	EE-181



The Rename Operation

- ❑ The SQL allows renaming relations and attributes using the **as** clause:
 $old-name \text{ as } new-name$
- ❑ Find the names of all instructors who have a higher salary than some instructor in 'Comp. Sci'.
 - **select distinct T.name
from instructor as T, instructor as S** *different renaming but same relation.*
where T.salary > S.salary and S.dept_name = 'Comp. Sci.'

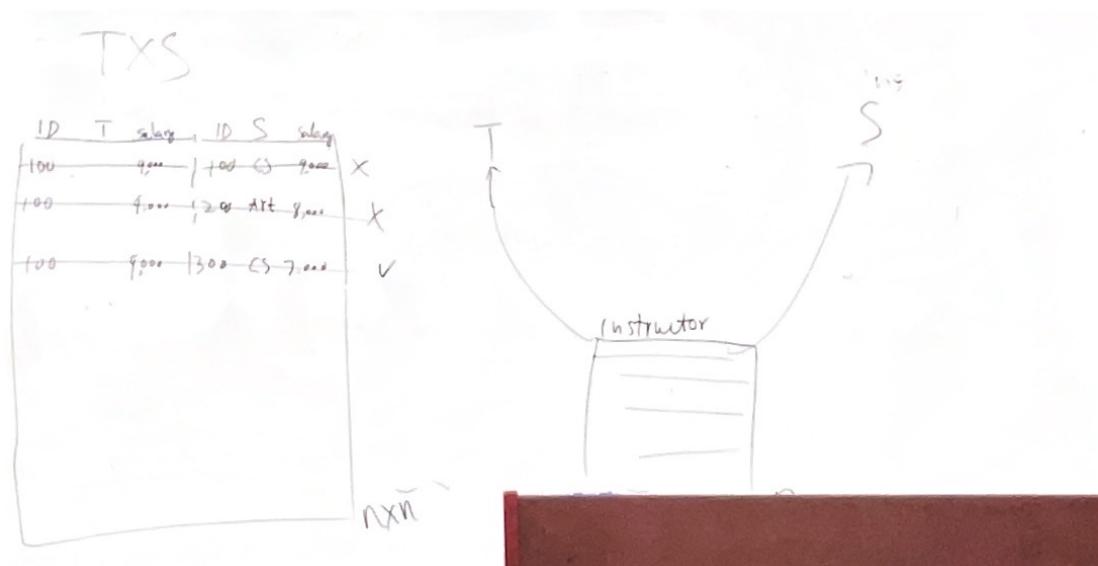
- ❑ Keyword **as** is optional and may be omitted

instructor as T \equiv instructor T

relational algebra:

$\Pi, \sigma, \times, \bowtie_\theta, \cup, \cap, -$

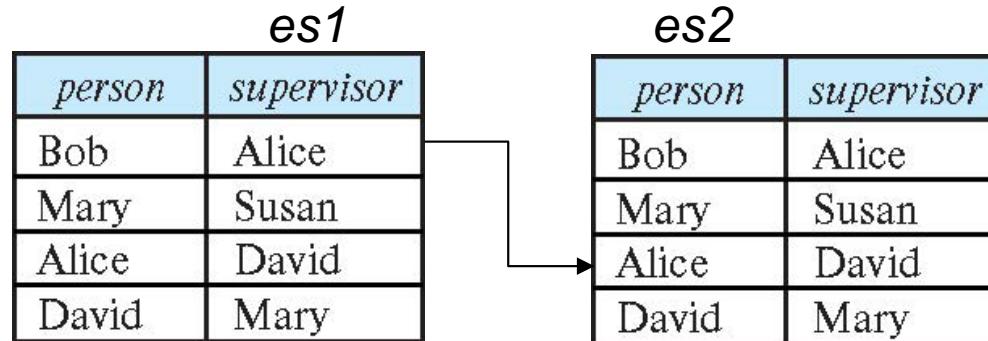
here is \bowtie_θ





Self Join Example

- Relation *emp-super*



- Find the supervisor of “Bob”
- Find the supervisor of the supervisor of “Bob”**
- Can you find ALL the supervisors (direct and indirect) of “Bob”?
- Select *es2.supervisor*
from *emp-super es1, emp-super es2*
where *es1.supervisor=es2.person*
and *es1.person='Bob'*



String Operations

- ❑ SQL includes a string-matching operator for comparisons on character strings. The operator **like** uses patterns that are described using two special characters:
 - percent (%). The % character matches any substring.
 - underscore (_). The _ character matches any character.
- ❑ Find the names of all instructors whose name includes the substring “dar”.

```
select name  
from instructor  
where name like '%dar%'
```

- ❑ Match the string “100%”

```
like '100 \%' escape '\'
```

in that above we use backslash (\) as the escape character.



String Operations (Cont.)

- ❑ Patterns are case sensitive.
- ❑ Pattern matching examples:
 - 'Intro%' matches any string beginning with “Intro”.
 - '%Comp%' matches any string containing “Comp” as a substring.
 - '___' matches any string of exactly three characters.
 - '___ %' matches any string of at least three characters.
- ❑ SQL supports a variety of string operations such as
 - concatenation (using “||”), (CONCAT('abs','def')='absdef', in MySQL)
 - converting from upper to lower case (and vice versa)
 - ❑ LOWER(), UPPER()
 - finding string length, extracting substrings, etc.
 - <https://dev.mysql.com/doc/refman/8.0/en/string-functions.html>



Ordering the Display of Tuples

- >List in alphabetic order the names of all instructors

```
select distinct name
from instructor
order by name
```

- We may specify **desc** for descending order or **asc** for ascending order, for each attribute; ascending order is the default.
 - Example: **order by name desc**
- Can sort on multiple attributes
 - Example: **order by dept_name, name**



Where Clause Predicates

- ❑ SQL includes a **between** comparison operator
- ❑ Example: Find the names of all instructors with salary between \$90,000 and \$100,000 (that is, $\geq \$90,000$ and $\leq \$100,000$)
 - **select name
from instructor
where salary between 90000 and 100000**
- ❑ Tuple comparison
 - **select name, course_id
from instructor, teaches
where (instructor.ID, dept_name) = (teaches.ID, 'Biology');**
 - equivalent
 - **select name, course_id
from instructor, teaches
where instructor.ID = teaches.ID
and instructor.dept_name='Biology';**



Set Operations

- ① Find courses that ran in Fall 2017 or in Spring 2018

```
(select course_id from section where sem = 'Fall' and year = 2017)
union
(select course_id from section where sem = 'Spring' and year = 2018)
```

- ② Find courses that ran in Fall 2017 and in Spring 2018 (MySQL not support)

```
(select course_id from section where sem = 'Fall' and year = 2017)
intersect
(select course_id from section where sem = 'Spring' and year = 2018)
```

- ③ Find courses that ran in Fall 2017 but not in Spring 2018 (MySQL not support)

```
(select course_id from section where sem = 'Fall' and year = 2017)
except
(select course_id from section where sem = 'Spring' and year = 2018)
```



Set Operations (Cont.)

- ❑ Set operations **union**, **intersect**, and **except**
 - Each of the above operations automatically eliminates duplicates
- ❑ To retain all duplicates use the
 - **union all**,
 - **intersect all**
 - **except all**.

Handwritten note: $\text{S} \cup \text{S}' = \text{S} \cup (\text{S} - \text{S}')$
 $\text{S} \cap \text{S}' = \text{S} \cap (\text{S} - \text{S}')$
 $\text{S} - \text{S}' = \text{S} \cap (\text{S}' - \text{S})$
 $\text{S} \cup \text{S}' = \text{S} \cup (\text{S} \cap \text{S}')$
 $\text{S} \cap \text{S}' = \text{S} \cup (\text{S}' - \text{S})$
 $\text{S} - \text{S}' = \text{S} \cap (\text{S}' - \text{S})$

Select Course_id

from Section

Where (Sem='Fall' And Year=2017)

S, r : sets

SUR

SNR

Or (Sem='Spring' And Year=2018) S-r:

Select Course_id

from Section

Where (Sem='Fall' And Year=2017)

Or (Sem='Spring' And Year=2018)

Intersect And "filter" for each row of section



Null Values

- ❑ It is possible for tuples to have a null value, denoted by **null**, for some of their attributes
- ❑ **null** signifies an unknown value or that a value does not exist.
- ❑ The result of any arithmetic expression involving **null** is **null**
 - Example: $5 + \text{null}$ returns **null**
- ❑ The predicate **is null** can be used to check for null values.
 - Example: Find all instructors whose salary is null.

```
select name  
from instructor  
where salary is null
```
- ❑ The predicate **is not null** succeeds if the value on which it is applied is not null.



Null Values (Cont.)

- ❑ SQL treats as **unknown** the result of any comparison involving a null value (other than predicates **is null** and **is not null**).
 - Example: $5 < \text{null}$ or $\text{null} <> \text{null}$ or $\text{null} = \text{null}$
- ❑ The predicate in a **where** clause can involve Boolean operations (**and**, **or**, **not**); thus the definitions of the Boolean operations need to be extended to deal with the value **unknown**.
 - **and** : $(\text{true and unknown}) = \text{unknown}$,
 $(\text{false and unknown}) = \text{false}$,
 $(\text{unknown and unknown}) = \text{unknown}$
 - **or**: $(\text{unknown or true}) = \text{true}$,
 $(\text{unknown or false}) = \text{unknown}$
 $(\text{unknown or unknown}) = \text{unknown}$
- ❑ Result of **where** clause predicate is treated as *false* if it evaluates to *unknown*



Aggregate Functions

- These functions operate on the multiset of values of a column of a relation, and return a value

avg: average value

min: minimum value

max: maximum value

sum: sum of values

count: number of values



Aggregate Functions Examples

- ② Find the average salary of instructors in the Computer Science department
 - **select avg (salary)
from instructor
where dept_name= 'Comp. Sci.';**
- ② Find the total number of instructors who teach a course in the Spring 2018 semester
 - **select count (distinct ID)
from teaches
where semester = 'Spring' and year = 2018;**
- ② Find the number of tuples in the course relation
 - **select count (*)
from course;**

Same as
Select count (Course
ID)
from course



Aggregate Functions – Group By

- ?
- Find the average salary of instructors in each department

- **select dept_name, avg (salary) as avg_salary
from instructor
group by dept_name;**

ID	name	dept_name	salary
76766	Crick	Biology	72000
45565	Katz	Comp. Sci.	75000
10101	Srinivasan	Comp. Sci.	65000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000
12121	Wu	Finance	90000
76543	Singh	Finance	80000
32343	El Said	History	60000
58583	Califieri	History	62000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
22222	Einstein	Physics	95000

dept_name	avg_salary
Biology	72000
Comp. Sci.	77333
Elec. Eng.	80000
Finance	85000
History	61000
Music	40000
Physics	91000



Aggregation (Cont.)

- ❑ Attributes in **select** clause outside of aggregate functions must appear in **group by** list

- /* erroneous query */
select *dept_name*, *ID*, **avg** (*salary*)
from *instructor*
group by *dept_name*;



Aggregate Functions – Having Clause

- Find the names and average salaries of all departments whose average salary is greater than 42000

```
select dept_name, avg (salary) as avg_salary  
from instructor  
group by dept_name  
having avg (salary) > 42000;
```

- Note: predicates in the **having** clause are applied after the formation of groups whereas predicates in the **where** clause are applied before forming groups

```
select dept_name, avg (salary) as avg_salary  
from instructor  
where name <> 'Eric'  
group by dept_name  
having avg(salary) > 42000;
```



Nested Subqueries

- SQL provides a mechanism for the nesting of subqueries. A **subquery** is a **select-from-where** expression that is nested within another query.
- The nesting can be done in the following SQL query

```
select A1, A2, ..., An
from r1, r2, ..., rm
where P
```

as follows:

- From clause:** r_i can be replaced by any valid subquery
- Where clause:** P can be replaced with an expression of the form:
$$B \langle\text{operation}\rangle (\text{subquery})$$

 B is an attribute and $\langle\text{operation}\rangle$ to be defined later.
- Select clause:**
 A_i can be replaced by a subquery that generates a single value.



Set Membership



Set Membership

- Find courses offered in Fall 2017

```
select distinct course_id
from section
where semester = 'Fall' and year= 2017;
```

- Find courses offered in Fall 2017 and in Spring 2018

```
select distinct course_id
from section
where semester = 'Fall' and year= 2017 and
course_id in (select course_id
from section
where semester = 'Spring' and year= 2018);
```

- Find courses offered in Fall 2017 but not in Spring 2018

```
select distinct course_id
from section
where semester = 'Fall' and year= 2017 and
course_id not in (select course_id
from section
where semester = 'Spring' and year= 2018);
```



Set Membership (Cont.)

- ② Name all instructors whose name is neither “Mozart” nor Einstein”

```
select distinct name  
from instructor  
where name not in ('Mozart', 'Einstein')
```

- ② Find the total number of (distinct) students who have taken course sections taught by the instructor with *ID* 10101

```
select count (distinct ID)  
from takes  
where (course_id, sec_id, semester, year) in  
      (select course_id, sec_id, semester, year  
       from teaches  
       where teaches.ID= 10101);
```

- ② Note: Above query can be written in a much simpler manner.
The formulation above is simply to illustrate SQL features



Set Comparison



Set Comparison – “some” Clause

- Find names of instructors with salary greater than that of some (at least one) instructor in the Biology department.

```
select distinct T.name  
from instructor as T, instructor as S  
where T.salary > S.salary and S.dept_name = 'Biology';
```

- Same query using > **some** clause

```
select name  
from instructor  
where salary > some (select salary  
                      from instructor  
                      where dept_name = 'Biology');
```



Definition of “some” Clause

□ $F <\text{comp}> \text{some } r \sqsubset t \quad \exists r \text{ such that } (F <\text{comp}> t)$

Where $<\text{comp}>$ can be:

$(5 < \text{some} \begin{array}{|c|} \hline 0 \\ \hline 5 \\ \hline 6 \\ \hline \end{array}) = \text{true}$

(read: 5 < some tuple in the relation)

$(5 < \text{some} \begin{array}{|c|} \hline 0 \\ \hline 5 \\ \hline \end{array}) = \text{false}$

$(5 = \text{some} \begin{array}{|c|} \hline 0 \\ \hline 5 \\ \hline \end{array}) = \text{true}$

$(5 \not= \text{some} \begin{array}{|c|} \hline 0 \\ \hline 5 \\ \hline \end{array}) = \text{true} \text{ (since } 0 \not= 5\text{)}$

$(= \text{some}) \not\in$

However, $(\not\text{some}) \not\in$



Set Comparison – “all” Clause

- Find the names of all instructors whose salary is greater than the salary of all instructors in the Biology department.

```
select name  
from instructor  
where salary > all (select salary  
                 from instructor  
                 where dept_name = 'Biology');
```



Definition of “all” Clause

□ $F <comp> \text{all } r \sqsubset t \quad ?r \ (F <comp> t)$

$(5 < \text{all} \quad \begin{array}{|c|} \hline 0 \\ \hline 5 \\ \hline 6 \\ \hline \end{array}) = \text{false}$

$(5 < \text{all} \quad \begin{array}{|c|} \hline 6 \\ \hline 10 \\ \hline \end{array}) = \text{true}$

$(5 = \text{all} \quad \begin{array}{|c|} \hline 4 \\ \hline 5 \\ \hline \end{array}) = \text{false}$

$(5 \ ?\text{all} \quad \begin{array}{|c|} \hline 4 \\ \hline 6 \\ \hline \end{array}) = \text{true} \ (\text{since } 5 \ ?4 \text{ and } 5 \ ?6)$

$(\ ?\text{all}) \ ?\text{not in}$
However, $(= \text{all} \ / \ ?\text{in}$



Test for Empty Relations

- ❑ The **exists** construct returns the value **true** if the argument subquery is nonempty.
- ❑ **exists** $r \neq \emptyset$
- ❑ **not exists** $r = \emptyset$



Use of “exists” Clause

- Yet another way of specifying the query “Find all courses taught in both the Fall 2017 semester and in the Spring 2018 semester”

```
select course_id  
from section as S  
where semester = 'Fall' and year = 2017 and  
exists (select *  
        from section as T  
        where semester = 'Spring' and year= 2018  
          and S.course_id = T.course_id);
```

- Correlation name** – variable S in the outer query
- Correlated subquery** – the inner query
- “Find all courses taught in the Fall 2017 semester but not in the Spring 2018 semester”
 - How to revise above query?
 - exist ? not exist



Use of “not exists” Clause

- ❑ Find all students who have taken all courses offered in the Biology department.

```
select distinct S.ID, S.name
from student as S
where not exists ( (select course_id
                     from course
                     where dept_name = 'Biology')
except
(select T.course_id
     from takes as T
     where S.ID = T.ID));
```

- First nested query lists all courses offered in Biology
- Second nested query lists all courses a particular student took

- ❑ Note that $X - Y = \emptyset$? X

- ❑ Note: Cannot write this query using = all and its variants



Test for Absence of Duplicate Tuples

- ❑ The **unique** construct tests whether a subquery has any duplicate tuples in its result.
- ❑ The **unique** construct evaluates to “true” if a given subquery contains no duplicates .
- ❑ Find all courses that were offered at most once in 2017

```
select T.course_id
  from course as T
 where unique ( select R.course_id
                  from section as R
                where T.course_id= R.course_id
                  and R.year = 2017);
```

- ❑ **Remark:** MySQL not support unique query



Subqueries in the From Clause



Subqueries in the From Clause

- ❑ SQL allows a subquery expression to be used in the **from** clause
- ❑ Find the average instructors' salaries of those departments where the average salary is greater than \$42,000.”

```
select dept_name, avg_salary
from ( select dept_name, avg (salary) as avg_salary
        from instructor
        group by dept_name) as dept_avg
where avg_salary > 42000;
```

- ❑ Note that we do not need to use the **having** clause
- ❑ Another way to write above query

```
select dept_name, avg_salary
from ( select dept_name, avg (salary)
        from instructor
        group by dept_name)
        as dept_avg (dept_name, avg_salary)
where avg_salary > 42000;
```



With Clause

- The with clause provides a way of defining a temporary relation whose definition is available only to the query in which the with clause occurs.
- Find all departments with the maximum budget

*temporary table
column called value
memory inside*

```
with max_budget (value) as
  (select max(budget)
   from department)
select department.dept_name
from department, max_budget
where department.budget = max_budget.value;
```



Complex Queries using With Clause

- ② Find all departments where the total salary is greater than the average of the total salary at all departments

```
with dept_total(dept_name, value) as  
    (select dept_name, sum(salary)  
     from instructor  
     group by dept_name),  
     dept_total_avg(value) as  
        (select avg(value)  
         from dept_total)
```

as many as temporary table
in with clause could be
extended

```
select dept_name  
from dept_total, dept_total_avg  
where dept_total.value > dept_total_avg.value;
```

only one main body



Scalar Subquery

- Scalar subquery is one which is used where a single value is expected
- List the number of instructors in 'CIS' department

```
select count(*)  
from instructor  
where instructor.dept_name='Com.Sci';
```

- List all departments along with the number of instructors in each department

main body

```
select dept_name,  
  (select count(*)) query instructor to find No. of instructors in  
  from instructor each department.  
  where instructor.dept_name= department.dept_name )  
  as num_instructors  
from department;
```

- Runtime error if subquery returns more than one result tuple



Modification of the Database

- ❑ Deletion of tuples from a given relation.
- ❑ Insertion of new tuples into a given relation
- ❑ Updating of values in some tuples in a given relation



Deletion

- ② Delete all instructors

delete from *instructor*;

- ② Delete all instructors from the Finance department

delete from *instructor*
where *dept_name*= 'Finance';

- ② *Delete all tuples in the instructor relation for those instructors associated with a department located in the Watson building.*

delete from *instructor*
where *dept_name* **in** (**select** *dept_name*
 from *department*
 where *building* = 'Watson');



Deletion (Cont.)

- ② Delete all instructors whose salary is less than the average salary of instructors

```
delete from instructor  
where salary < (select avg (salary)  
         from instructor);
```

- **Problem:** as we delete tuples from *instructor*, the average salary changes
- **Solution used in SQL:**
 1. First, compute **avg** (*salary*) and find all tuples to delete
 2. Next, delete all tuples found above (without recomputing **avg** or retesting the tuples)



Insertion

- ❑ Add a new tuple to *course*

```
insert into course      default for the insert  
    values ('CS-437', 'Database Systems', 'Comp. Sci.', 4),  
           ('CS-456', 'Data Mining', 'Comp. Sci.', 4);
```

- ❑ or equivalently

```
insert into course (course_id, title, dept_name, credits)  
    values ('CS-437', 'Database Systems', 'Comp. Sci.', 4),  
           ('CS-456', 'Data Mining', 'Comp. Sci.', 4);
```

- ❑ Add a new tuple to *student* with *tot_creds* set to null

```
insert into student  
    values ('3003', 'Green', 'Finance', null);
```



Insertion (Cont.)

- Make each student in the Music department who has earned more than 144 credit hours an instructor in the Music department with a salary of \$18,000.

```
insert into instructor addition to instructor  
select ID, name, dept_name, 18000 data tuple structure  
      from student  
      where dept_name = 'Music' and total_cred > 144;
```

- The **select from where** statement is evaluated fully before any of its results are inserted into the relation.

Otherwise queries like

```
insert into table1 select * from table1
```

would cause problem



Updates

- ② Give a 5% salary raise to all instructors

```
update instructor
    set salary = salary * 1.05
```

- ② Give a 5% salary raise to those instructors who earn less than 70000

```
update instructor
    set salary = salary * 1.05
    where salary < 70000;
```

- ② Give a 5% salary raise to instructors whose salary is less than average

```
update instructor
    set salary = salary * 1.05
    where salary < (select avg (salary)
                    from instructor);
```



Updates (Cont.)

- Increase salaries of instructors whose salary is over \$100,000 by 3%, and all others by a 5%

- Write two **update** statements:

```
update instructor  
set salary = salary * 1.03  
where salary > 100000;
```

```
update instructor  
set salary = salary * 1.05  
where salary <= 100000;
```

- The order is important
- Can be done better using the **case** statement (next slide)



Case Statement for Conditional Updates

- Same query as before but with case statement

```
update instructor      if case in Python
  set salary = case
    when salary <= 100000 then salary * 1.05
    else salary * 1.03
  end
```



Updates with Scalar Subqueries

- Recompute and update tot_creds value for all students

```
update student S
set tot_cred = (select sum(credits)
                 from takes, course
                where takes.course_id = course.course_id and
                      S.ID= takes.ID.and
                      takes.grade <> 'F' and
                      takes.grade is not null);
```

- Sets tot_creds to null for students who have not taken any course
- Instead of **sum(credits)**, use:

```
select case
      when sum(credits) is not null then sum(credits)
      else 0
    end
```



End of Chapter 3