



اصول طراحی پایگاه داده

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SEVENTH EDITION

Database System Concepts



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Chapter 3: Introduction to SQL

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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

- IBM Sequel language developed as part of System R project at the IBM San Jose Research Laboratory
- Renamed Structured Query Language (SQL)
- ANSI and ISO standard SQL:
 - SQL-86
 - SQL-89
 - SQL-92
 - SQL:1999 (language name became Y2K compliant!)
 - SQL:2003
- 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.



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

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.
- 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).
- **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)
- **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.



Create Table Construct

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

create table *r*

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

- *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: How to create the Instructor Database?

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




Integrity Constraints in Create Table

- 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),  
    foreign key (dept_name) references department);
```



And a Few More Relation Definitions

- **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*);

- **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);



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*);



Updates to tables

- **Insert**

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

- **Delete**

- Remove all tuples from the *student* relation
 - **delete from** *student*

- **Drop Table**

- **drop table** *r*

- **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.



Basic Query Structure

- A typical SQL query has the form:

select A_1, A_2, \dots, A_n
from r_1, r_2, \dots, r_m
where P

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

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

```
select all dept_name  
from instructor
```

dept_name

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.
 - What would be the result of a query that returns a relation identical to the instructor relation, except with the value of the attribute "salary" divided by 12?



The select Clause (Cont.)

- 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  
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
```

<i>name</i>
Katz
Brandt



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

- 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'

<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 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*
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*



Self Join Example

- Relation *emp-super*

<i>person</i>	<i>supervisor</i>
Bob	Alice
Mary	Susan
Alice	David
David	Mary

- Find the supervisor of “Bob”
- Find the supervisor of the supervisor of “Bob”
- Can you find ALL the supervisors (direct and indirect) of “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 “||”)
 - converting from upper to lower case (and vice versa)
 - finding string length, extracting substrings, etc.



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');



Set Operations

- 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)

- Find courses that ran in Fall 2017 and in Spring 2018

(select *course_id* from *section* where *sem* = 'Fall' and *year* = 2017)

intersect

(select *course_id* from *section* where *sem* = 'Spring' and *year* = 2018)

- Find courses that ran in Fall 2017 but not in Spring 2018

(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**.



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: $5 + \mathbf{null}$ 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

- Find the average salary of instructors in the Computer Science department
 - **select avg (*salary*)**
from *instructor*
where *dept_name*= 'Comp. Sci.';
- 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;
- Find the number of tuples in the *course* relation
 - **select count (*)**
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*;

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
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

<i>dept_name</i>	<i>avg_salary</i>
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*;



Example

■ مشخص کنید چند تهیه کننده P2 را تهیه کرده اند؟

S

S#	Sname	City
s1	Fanavaran	Tehran
s2	Iran Segment	Tabriz
s3	Pooladin	Tabriz

P

P#	Color	Type	City
P1	Red	Iron	Tehran
P2	Green	Copper	Tabriz
P3	Blue	Brass	Shiraz
P4	Red	Iron	Tehran

SP

S#	P#	Qty
s1	P1	300
s2	P2	200
s3	P3	400
s2	P1	300
s2	P2	400
s3	P2	200



Example

■ مشخص کنید چند تهیه کننده P2 را تهیه کرده اند؟

■ `Select count(*) from SP where p#='P2'`

S

S#	Sname	City
s1	Fanavaran	Tehran
s2	Iran Segment	Tabriz
s3	Pooladin	Tabriz

P

P#	Color	Type	City
P1	Red	Iron	Tehran
P2	Green	Copper	Tabriz
P3	Blue	Brass	Shiraz
P4	Red	Iron	Tehran

SP

S#	P#	Qty
s1	P1	300
s2	P2	200
s3	P3	400
s2	P1	300
s2	P2	400
s3	P2	200



Example

- کل مقدار تهیه شده از هر قطعه را در جدول جواب بدهد همراه با شماره قطعه

S

S#	Sname	City
s1	Fanavaran	Tehran
s2	Iran Segment	Tabriz
s3	Pooladin	Tabriz

P

P#	Color	Type	City
P1	Red	Iron	Tehran
P2	Green	Copper	Tabriz
P3	Blue	Brass	Shiraz
P4	Red	Iron	Tehran

SP

S#	P#	Qty
s1	P1	300
s2	P2	200
s3	P3	400
s2	P1	300
s2	P2	400
s3	P2	200



Example

- کل مقدار تهیه شده از هر قطعه را در جدول جواب بدهد همراه با شماره قطعه
- `Select P#, SUM(Qty) from SP Group By P#`

S

S#	Sname	City
s1	Fanavaran	Tehran
s2	Iran Segment	Tabriz
s3	Pooladin	Tabriz

P

P#	Color	Type	City
P1	Red	Iron	Tehran
P2	Green	Copper	Tabriz
P3	Blue	Brass	Shiraz
P4	Red	Iron	Tehran

SP

S#	P#	Qty
s1	P1	300
s2	P2	200
s3	P3	400
s2	P1	300
s2	P2	400
s3	P2	200



Example

■ برای هر قطعه تهیه شده، شماره قطعه، کل تعداد و ماکزیمم تعداد تهیه شده از آن را بدون در نظر گرفتن S1 بدهد

S

S#	Sname	City
s1	Fanavaran	Tehran
s2	Iran Segment	Tabriz
s3	Pooladin	Tabriz

P

P#	Color	Type	City
P1	Red	Iron	Tehran
P2	Green	Copper	Tabriz
P3	Blue	Brass	Shiraz
P4	Red	Iron	Tehran

SP

S#	P#	Qty
s1	P1	300
s2	P2	200
s3	P3	400
s2	P1	300
s2	P2	400
s3	P2	200



Example

■ برای هر قطعه تهیه شده، شماره قطعه، کل تعداد و ماکزیمم تعداد تهیه شده از آن را بدون در نظر گرفتن S1 بدهد

- Select P#, SUM(Qty),MAX(Qty)
- From SP
- Where S# !='S1'
- Group By P#

S

S#	Sname	City
s1	Fanavaran	Tehran
s2	Iran Segment	Tabriz
s3	Pooladin	Tabriz

P

P#	Color	Type	City
P1	Red	Iron	Tehran
P2	Green	Copper	Tabriz
P3	Blue	Brass	Shiraz
P4	Red	Iron	Tehran

SP

S#	P#	Qty
s1	P1	300
s2	P2	200
s3	P3	400
s2	P1	300
s2	P2	400
s3	P2	200



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



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  $A_1, A_2, \dots, A_n$   
from  $r_1, r_2, \dots, r_m$   
where  $P$ 
```

as follows:

- **From clause:** r_j can be replaced by any valid subquery
- **Where clause:** P can be replaced with an expression of the form:

B <operation> (subquery)

B is an attribute and <operation> to be defined later.

- **Select clause:**

A_j can be replaced by a subquery that generates a single value.



Set Membership



Set Membership

- 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.)

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

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

- 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);
```

- 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

- $F <\text{comp}> \text{some } r \Leftrightarrow \exists t \in r \text{ such that } (F <\text{comp}> t)$
Where $<\text{comp}>$ can be: $<, \leq, >, =, \neq$

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

(read: 5 < some tuple in the relation)

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

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

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

$(= \text{some}) \equiv \text{in}$

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



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

- $F \text{ <comp> all } r \Leftrightarrow \forall t \in r (F \text{ <comp> } t)$

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

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

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

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

$(\neq \text{all}) \equiv \text{not in}$

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



Test for Empty Relations

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



Use of “exists” Clause

```
select *  
from نام جدول as مستعار  
where [ شرط and ]  
exists (Select Op);
```

- **Correlation name** – variable S in the outer query
- **Correlated subquery** – the inner query



Use of “exists” Clause

- Yet another way of specifying the query “Find all courses taught in both the Fall 2009 semester and in the Spring 2010 semester”





Use of “exists” Clause

- Yet another way of specifying the query “Find all courses taught in both the Fall 2009 semester and in the Spring 2010 semester”

```
select course_id
from section as S
where semester = 'Fall' and year = 2009 and
exists (select *
         from section as T
         where semester = 'Spring' and year = 2010
         and S.course_id = T.course_id);
```

- **Correlation name** – variable *S* in the outer query
- **Correlated subquery** – the inner query



Use of “not exists” Clause

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

Q?

- First nested query lists all courses offered in Biology
 - Second nested query lists all courses a particular student took
-
- Note that $X - Y = \emptyset \Leftrightarrow X \subseteq Y$
 - *Note:* Cannot write this query using = **all** and its variants



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 $X - Y = \emptyset \Leftrightarrow X \subseteq Y$
 - *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 .
- **select** *
 from *مستعار* **as** *نام جدول*
 where [*شرط* **and**]
 where unique (Select Operation)
- Find all courses that were offered at most once in 2009

Q?



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);
```



Subqueries in the From Clause



Subqueries in the Form 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)
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

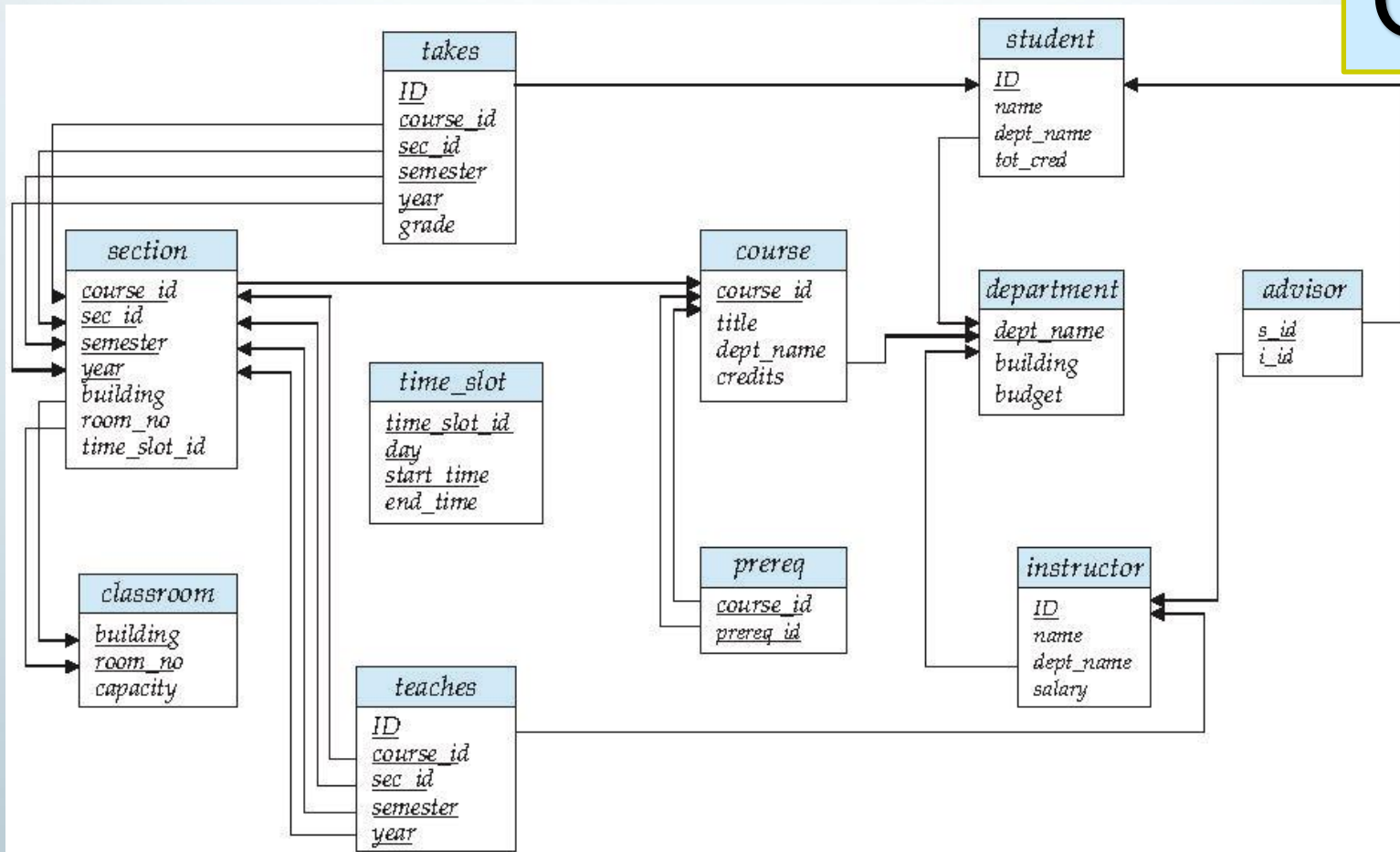
```
with max_budget (value) as  
    (select max(budget)  
     from department)  
select department.name  
from department, max_budget  
where department.budget = max_budget.value;
```



Complex Queries using With Clause

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

Q?





Complex Queries using With Clause

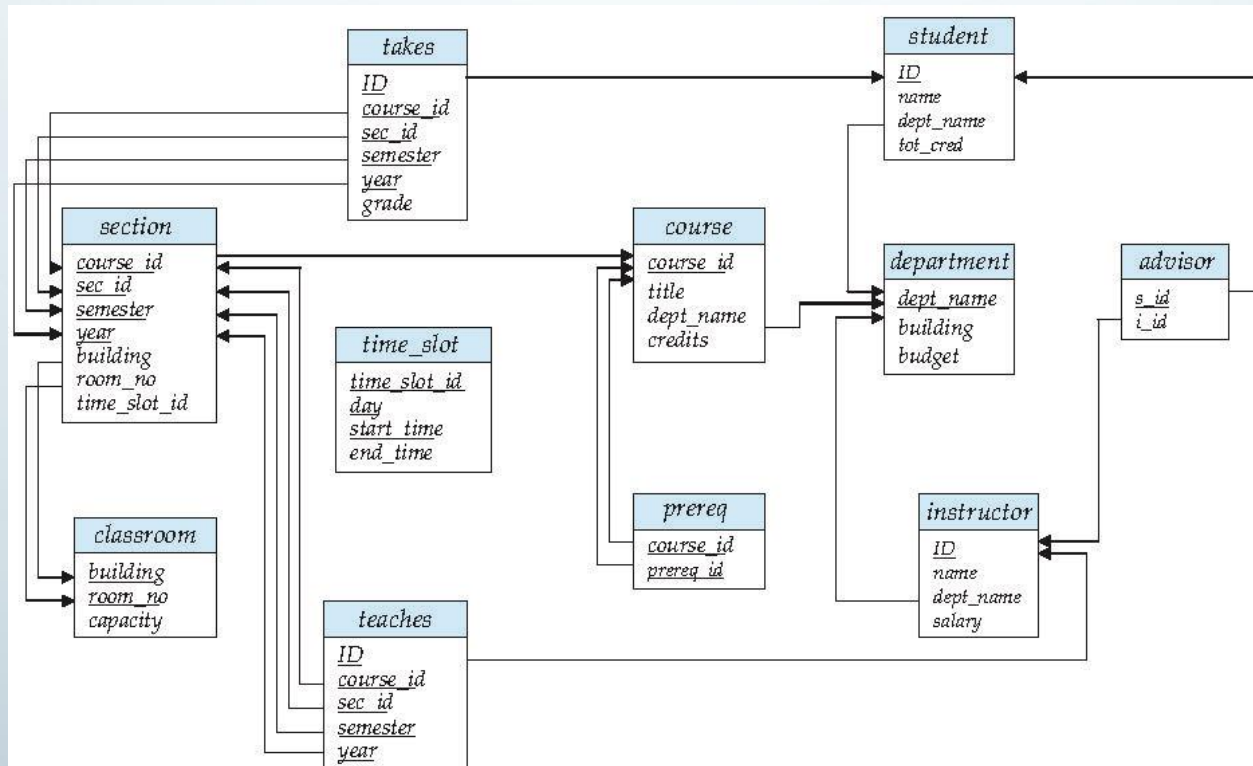
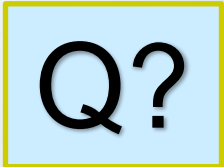
- Find all departments where the total salary is greater than the average of the total salary at all departments

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



Scalar Subquery

- Scalar subquery is one which is used where a single value is expected
- List all departments along with the number of instructors in each department





Scalar Subquery

- Scalar subquery is one which is used where a single value is expected
- List all departments along with the number of instructors in each department

```
select dept_name,  
        (select count(*)  
         from instructor  
         where department.dept_name = instructor.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

- Delete all instructors

```
delete from instructor
```

- Delete all instructors from the Finance department

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

- *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.)

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

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

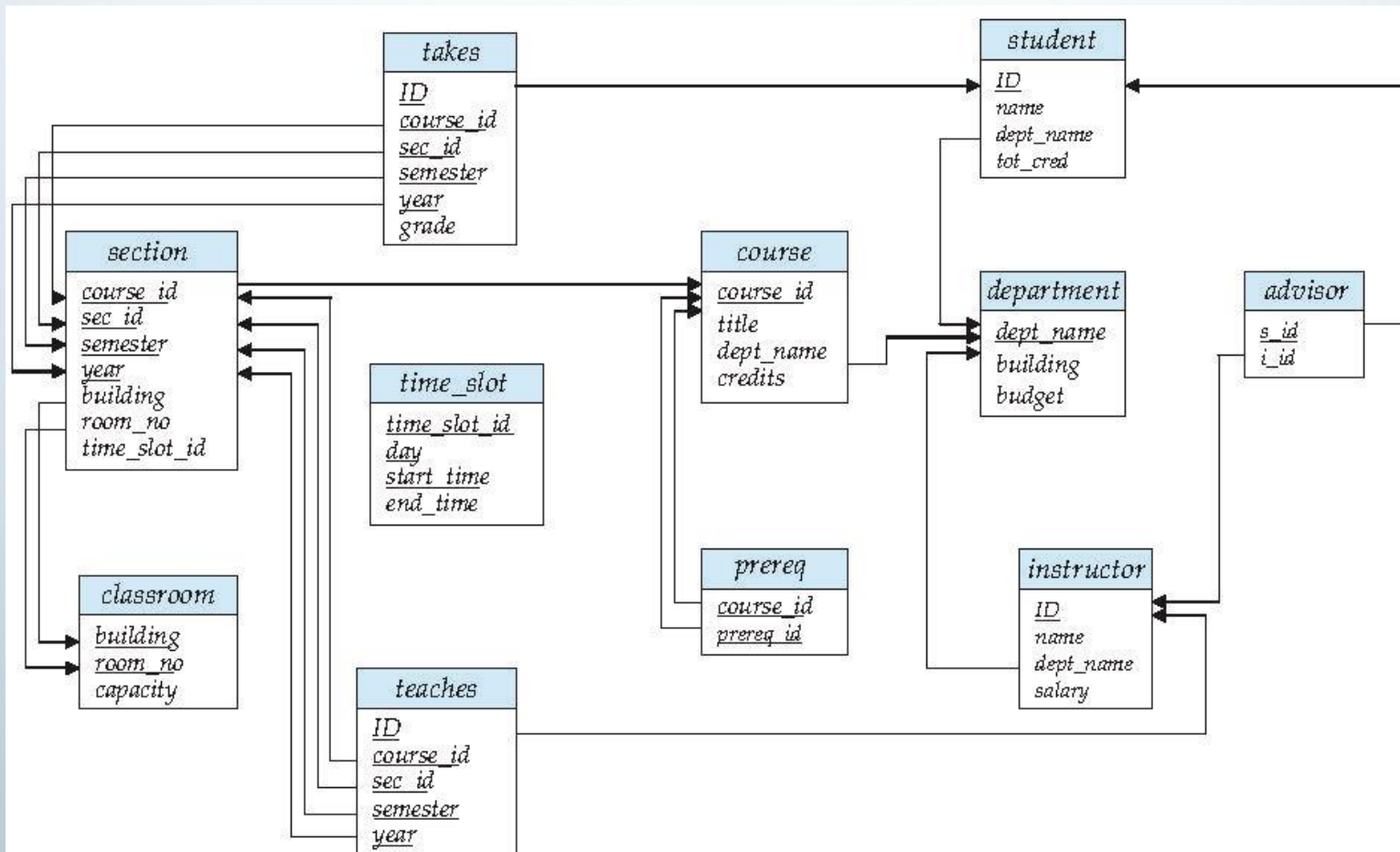
- Problem: as we delete tuples from *instructor*, the average salary changes
- Solution used in SQL:
 1. First, compute **avg** (*salary*) and find all tuples to delete
 2. Next, delete all tuples found above (without recomputing **avg** or retesting the tuples)



Deletion

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

Q?





Deletion

- 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');
```



Insertion

- Add a new tuple to *course*

```
insert into course
```

```
values ('CS-437', 'Database Systems', 'Comp. Sci.', 4);
```

- or equivalently

```
insert into course (course_id, title, dept_name, credits)
```

```
values ('CS-437', 'Database Systems', '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
```

```
  select ID, name, dept_name, 18000
```

```
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

- Give a 5% salary raise to all instructors

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

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

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

- 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  
  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:

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



End of Chapter 3