

Databases

Part 2/2 SQL

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Material adapted from: Silberschatz, Korth, Sudarshan: Database
System Concepts. 6th Edition.

Comparison Procedural vs Declarative

- Example: Find the name of the instructor with ID 22222

```
import csv

with open('instructor.csv') as file:
    reader = csv.DictReader(file)
    for row in reader:
        if row['ID'] == '2222':
            print(row['name'])
```

```
select name
from    instructor
where ID = '22222'
```

Comparison Procedural vs Declarative

- Example: Find the building of the instructor “Einstein”

```
import csv

with open('instructor.csv') as file:
    reader = csv.DictReader(file)
    for row in reader:
        if row['name'] == 'Einstein':
            dept_name = row['dept_name']

with open('department.csv') as file:
    reader = csv.DictReader(file)
    for row in reader:
        if row['dept_name'] == dept_name:
            print(row['building'])
```

```
select building
from    instructor, department
where   instructor.dept_name =
         department.dept_name
         and
         name = 'Einstein'
```

DATA DEFINITION LANGUAGE (DDL)

Data Types

Basic Data Types

- **char(*n*)** Fixed length character string, with length *n*
- **varchar(*n*)** Variable length character string, with maximum length *n*
- **integer** Integer, size is machine-dependent
- **real** Floating point number, with machine-dependent precision.
- **numeric(*p,d*)** Fixed point number, with *p* digits before and *n* digits after the decimal point.

Large-Object Data Types

- Objects that are large (several kilobytes up to several gigabytes)
 - **blob** Binary large object: uninterpreted binary data
 - ▶ a photo or video
 - **clob** Character large object: a large string.
 - ▶ some text or an XML document.
- Queries return pointers to large objects, not the objects themselves

Create Table

- Example:

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

- Example with Integrity Constraints:

```
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)
```

DATA MANIPULATION LANGUAGE (DML)

The select Clause

- By default SQL lists duplicate tuples:

```
select dept_name  
from instructor
```

- To force the elimination of duplicates:

```
select distinct dept_name  
from instructor
```

- To retain duplicates (default):

```
select all dept_name  
from instructor
```

- An asterisk denotes “all attributes”

```
select *  
from instructor
```

- Can contain arithmetic expressions:

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


Natural Join

- Natural join joins two tables in the natural way:
 - by combining all rows that have the same values on the common attributes.

- List the names of instructors along with the course ID of the courses that they taught:
 - **select** *name, course_id*
from *instructor, teaches*
where *instructor.ID = teaches.ID;*

 - **select** *name, course_id*
from *instructor* **natural join** *teaches;*

Natural Join Example

- **select *** from *instructor* natural join *teaches*;

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

ID	course_id	sec_id	semester	year
10101	CS-101	1	Fall	2009
10101	CS-315	1	Spring	2010
10101	CS-347	1	Fall	2009
12121	FIN-201	1	Spring	2010
15151	MU-199	1	Spring	2010
22222	PHY-101	1	Fall	2009
32343	HIS-351	1	Spring	2010
45565	CS-101	1	Spring	2010
45565	CS-319	1	Spring	2010
76766	BIO-101	1	Summer	2009
76766	BIO-301	1	Summer	2010
83821	CS-190	1	Spring	2009
83821	CS-190	2	Spring	2009
83821	CS-319	2	Spring	2010
98345	EE-181	1	Spring	2009

ID	name	dept_name	salary	course_id	sec_id	semester	year
10101	Srinivasan	Comp. Sci.	65000	CS-101	1	Fall	2009
10101	Srinivasan	Comp. Sci.	65000	CS-315	1	Spring	2010
10101	Srinivasan	Comp. Sci.	65000	CS-347	1	Fall	2009
12121	Wu	Finance	90000	FIN-201	1	Spring	2010
15151	Mozart	Music	40000	MU-199	1	Spring	2010
22222	Einstein	Physics	95000	PHY-101	1	Fall	2009
32343	El Said	History	60000	HIS-351	1	Spring	2010
45565	Katz	Comp. Sci.	75000	CS-101	1	Spring	2010
45565	Katz	Comp. Sci.	75000	CS-319	1	Spring	2010
76766	Crick	Biology	72000	BIO-101	1	Summer	2009
76766	Crick	Biology	72000	BIO-301	1	Summer	2010
83821	Brandt	Comp. Sci.	92000	CS-190	1	Spring	2009
83821	Brandt	Comp. Sci.	92000	CS-190	2	Spring	2009
83821	Brandt	Comp. Sci.	92000	CS-319	2	Spring	2010
98345	Kim	Elec. Eng.	80000	EE-181	1	Spring	2009

The Rename Operation – as clause

- Renaming attributes:

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

- Renaming relations:

- Find all pairs of instructors who have the same name:

```
select T.ID, S.ID  
from instructor as T, instructor as S  
where T.name = S.name
```

String Matching – like clause

- Patterns are strings containing:
 - percent (%). Matches any substring.
 - underscore (_). Matches any character.

- Example:

```
select name  
from instructor  
where name like ' _ _ _%stein%'
```

Ordering – order by clause

- List names in alphabetic order:

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

- Specify **desc**ending order, **asc**ending order is default:

```
order by name desc
```

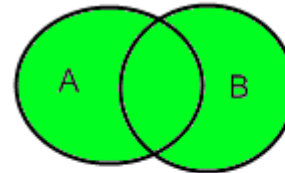
- Sort on multiple attributes:

```
order by dept_name asc, name desc
```

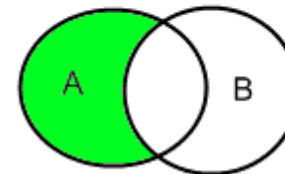
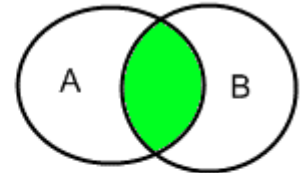
Set Operations: union, intersect, except

Keyword in SQL	Set Operation
union	union
intersect	intersection
except	difference

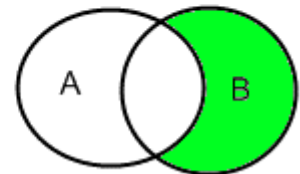
Union of A and B



Intersection of A and B



Difference A minus B



Difference B minus A

- Find courses that ran in 2009 or in 2010 or both:

```
select course_id from section where year = 2009
union
select course_id from section where year = 2010
```

- Set operations eliminate duplicates
- To retain duplicates use **union all**, **intersect all** and **except all**

Null Values

- Null values are unknown or non-existent values
 - The result of any arithmetic expression involving *null* is *null*
 - A comparison with *null* returns the special boolean value *unknown*
 - The **where** clause treats *unknown* as *false*

- What's the result of this? 

```
select name  
from instructor  
where salary = null
```

name	salary
Einstein	80000
Katz	null
Mozart	0

- Null values are very problematic.
 - Check for null with **is null**
 - Always consider the possibility that a value is null.

Aggregate Functions

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

- Find the number of tuples in the *course* relation
 - **select count** (*)
from *course*;

- Find the number of instructors who taught a course in 2010
 - **select count** (**distinct** *ID*)
from *teaches*
where *year* = 2010;

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

Nested Queries

- A **subquery** is a query inside another query.
- There are three kinds of subqueries:
 - in the where-clause,
 - in the from-clause,
 - scalar subqueries (that can occur anywhere).

Subquery in the Where-Clause – in

- Find courses offered in 2009 and in 2010

```
select distinct course_id
from section
where year = 2009 and
course_id in ( select course_id
                  from section
                  where year = 2010 );
```

Subquery in the Where-Clause – exists

- **exists** *r* returns **true** iff *r* is nonempty.
- Find all courses taught in both 2009 and 2010



```
select course_id
from section as S
where year = 2009 and
      exists (select *
               from section as T
               where year = 2010 and S.course_id = T.course_id);
```

- *S* is a **correlation variable**
- the inner query is a **correlated subquery**

Scalar Subqueries

- A **scalar subquery** is a subquery which is used where a single value is expected
 - If it returns more than one tuple it causes a runtime error
- Find the instructors that cost more than 10% of their departments budget:

```
select name
from instructor
where salary * 10 >
      (select budget from department
       where department.dept_name = instructor.dept_name)
```

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

- 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, the average salary changes
- Solution used in SQL:
 - First, compute avg salary and find all tuples to delete
 - Only then delete all those tuples



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 unknown *tot_creds*:

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


Insertion

- Add all instructors to the *student* relation with *tot_creds* set to 0

```
insert into student  
  select ID, name, dept_name, 0  
  from instructor
```

- The **select** statement is evaluated fully before any of its results are inserted, the following is possible:

```
insert into student  
  select *  
  from student,
```



Updates

- Increase salaries of instructors by 5%:
update *instructor*
set *salary* = *salary* * 1.05;
- Problem: How to increase salaries of instructors whose salary is over \$100,000 by 3%, and all others by 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;
```



Updates – case statement

- Problem as before, solution with case statement:

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