Database Management Systems
INFO 210

SQL – Part I
Lecture 8

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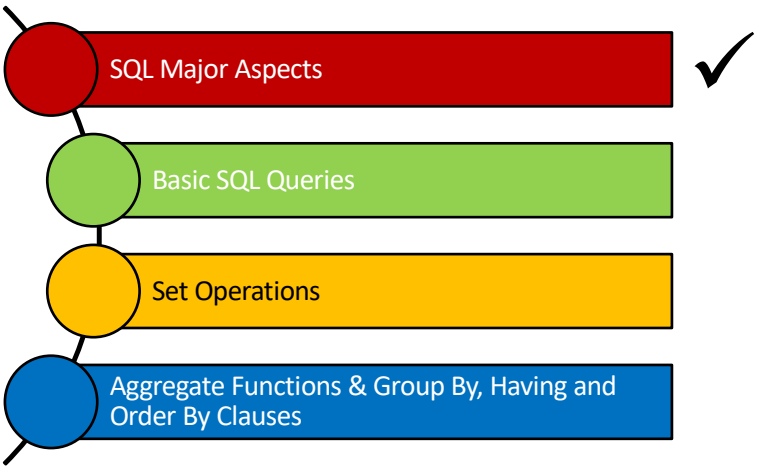
Today…

- Last Session:
  - Relational Calculus
- Today's Session:
  - Standard Query Language (SQL)- Part I

Outline



SQL Major Aspects

- A major strength of the relational model is that it supports simple and powerful *querying* of data
- Structured Query Language (SQL) is the most widely used commercial relational database language
- SQL has several aspects to it:
  1. Data Manipulation Language (DML)
     - It allows users to pose queries and insert, delete and modify rows
  2. Data Definition Language (DDL)
     - It allows users to create, delete, and modify tables and views

SQL Major Aspects

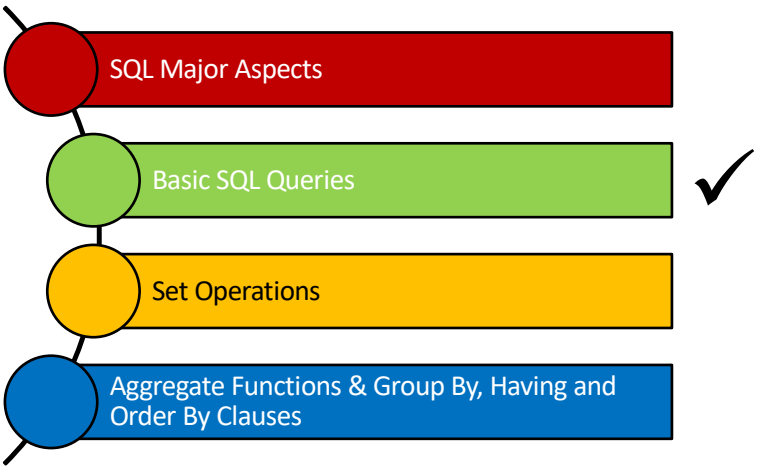
- SQL has several aspects to it:
  3. Triggers and Advanced Integrity Constraints
     - It supports "triggers", which are actions executed by the DBMS whenever changes to the database meet conditions specified in triggers
  4. Embedded and Dynamic Language
     - Embedded SQL allows SQL code to be called from a *host language* (e.g., Java)
     - Dynamic SQL allows SQL queries to be constructed and executed at run-time

SQL Major Aspects

- SQL has several aspects to it:
  5. Remote Database Access
     - It allows connecting client programs to remote database servers
  6. Transaction Management
     - It allows users to explicitly control aspects of how a transaction is to be executed (*advanced concepts!*)
  7. Security
     - It provides mechanisms to control users' accesses to data objects (e.g., tables and views)

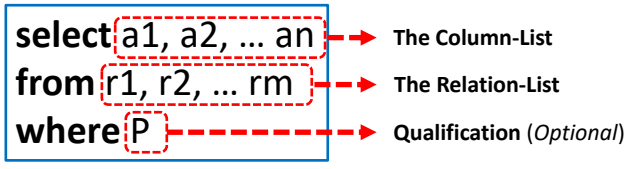
And others…

Outline



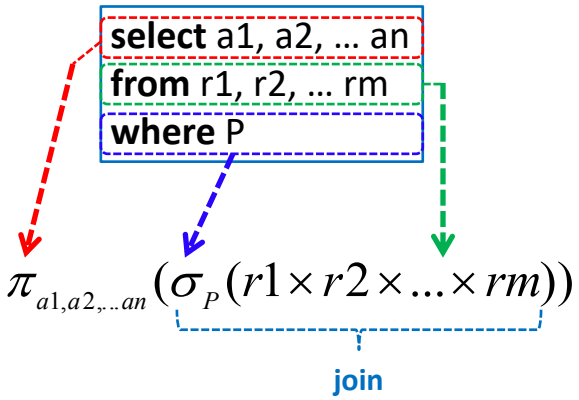
Basic SQL Queries

- The basic form of an SQL query is as follows:



Equivalence to Relational Algebra

- The basic form of an SQL query is as follows:



Reminder: Our Mini-U DB

STUDENT		
Ssn	Name	Address
123	smith	main str
234	jones	QF ave

CLASS		
c-id	c-name	units
15-413	s.e.	2
15-412	o.s.	2

TAKES		
SSN	c-id	grade
123	15-413	A
234	15-413	B

The WHERE Clause

- Find the ssn(s) of everybody called “smith”

STUDENT		
Ssn	Name	Address
123	smith	main str
234	jones	QF ave

```
select ssn
from student
where name='smith'
```

The WHERE Clause

- Find ssn(s) of all “smith”s on “main”

STUDENT		
Ssn	Name	Address
123	smith	main str
234	jones	QF ave

```
select ssn
from student
where address='main' and
   name = 'smith'
```

The WHERE Clause

- Boolean operators (**and, or, not**)
- Comparison operators (<, ≤, >, ≥, =, ≠)
- And more…

What About Strings?

- Find student ssn(s) who live on “main” (st or str or street – i.e., “main st” or “main str” or “main street”)

```
select ssn
from student
where address like 'main%'
```

%: Variable-length do not care (i.e., stands for 0 or more arbitrary characters)
_: Single-character do not care (i.e., stands for any 1 character)

Another Example on *Pattern Matching*

- Find the ages of sailors whose names begin and end with B and have at least 3 characters

Sailors			
Sid	**Sname**	**Rating**	**age**
22	Dustin	7	45.0
29	Brutus	1	33.0

```
select S.age
from Sailors S
where S.sname like 'B_%B'
```

The FROM Clause

- Find the names of students taking 15-415

STUDENT		
Ssn	**Name**	**Address**
123	smith	main str
234	jones	QF ave

CLASS		
c-id	**c-name**	**units**
15-413	s.e.	2
15-412	o.s.	2

TAKES		
SSN	**c-id**	**grade**
123	15-413	A
234	15-413	B

2-way Join!

The FROM Clause

- Find the names of students taking 15-415

```
select Name
from STUDENT, TAKES
where  ???
```

The FROM Clause

- Find the names of students taking 15-415

```
select Name
from STUDENT, TAKES
where  STUDENT.ssn = TAKES.ssn
       and TAKES.c-id = '15-415'
```

Renaming: Tuple Variables

- Find the names of students taking 15-415

```
select Name
from STUDENT as S, TAKES as T
where   S.ssn = T.ssn
        and T.c-id = "15-415"
```

Optional!

Renaming: Self-Joins

- Find Tom's grandparent(s)

PC	
p-id	c-id
Mary	Tom
Peter	Mary
John	Tom

PC	
p-id	c-id
Mary	Tom
Peter	Mary
John	Tom

```
select gp.p-id
from PC as gp, PC
where gp.c-id= PC.p-id
  and  PC.c-id = 'Tom'
```

More on Self-Joins

- Find names and increments for the ratings of persons who have sailed two different boats on the same day

Sailors			
Sid	**Sname**	**Rating**	**age**
22	Dustin	7	45.0
29	Brutus	1	33.0

Reserves		
Sid	**Bid**	**Day**
22	101	10/10/2013
22	102	10/10/2013

More on Self-Joins

- Find names and increments for the ratings of persons who have sailed two different boats on the same day

Sailors			
Sid	**Sname**	**Rating**	**age**
22	Dustin	7	45.0
29	Brutus	1	33.0

Reserves		
Sid	**Bid**	**Day**
22	101	10/10/2013
22	102	10/10/2013

```
select S.sname, S.rating+1 as rating
from Sailors S, Reserves R1, Reserves R2
where S.sid = R1.sid and S.sid = R2.sid
  and  R1.day = R2.day and R1.bid != R2.bid
```

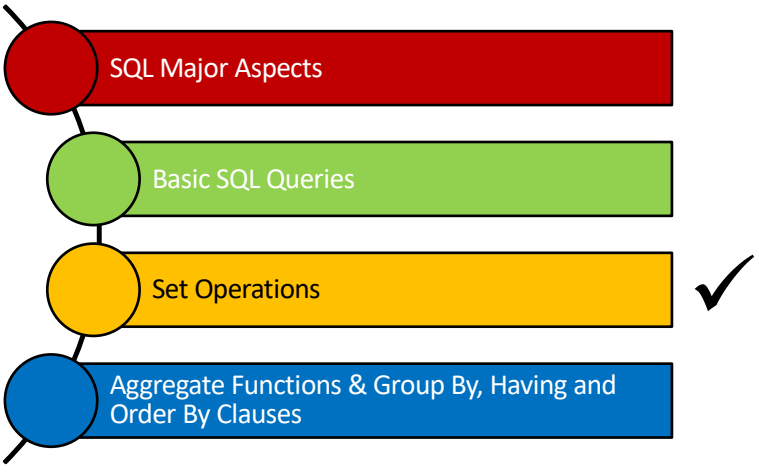
Renaming: Theta Joins

- Find course names with more units than 15-415

CLASS		
c-id	c-name	units
15-413	s.e.	2
15-412	o.s.	2

```
select c1.c-name
from class as c1, class as c2
where c1.units > c2.units
  and  c2.c-id = '15-415'
```

Outline



Set Operations

- Find ssn(s) of students taking both 15-415 and 15-413

TAKES		
SSN	c-id	grade
123	15-413	A
234	15-413	B

```
select ssn
from takes
where c-id='15-415' and
    c-id='15-413'
```

Set Operations

- Find ssn(s) of students taking both 15-415 and 15-413

TAKES		
SSN	c-id	grade
123	15-413	A
234	15-413	B

```
(select ssn from takes where c-id="15-415" )
intersect
(select ssn from takes where c-id="15-413" )
```

Other operations: **union** , **except**

Set Operations

- Find ssn(s) of students taking 15-415 or 15-413

TAKES		
SSN	c-id	grade
123	15-413	A
234	15-413	B

```
(select ssn from takes where c-id="15-415" )
union
(select ssn from takes where c-id="15-413" )
```

Set Operations

- Find ssn(s) of students taking 15-415 but not 15-413

TAKES		
SSN	c-id	grade
123	15-413	A
234	15-413	B

```
(select ssn from takes where c-id="15-415" )
except
(select ssn from takes where c-id="15-413" )
```

Another Example on Set Operations

- Find the names of sailors who have reserved both a red and a green boat

Sailors

Sid	Sname	Rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0

Reserves

Sid	Bid	Day
22	101	10/10/2013
22	102	10/11/2013

Boats

Bid	Bname	Color
101	Interlake	Red
102	Clipper	Green

Another Example on Set Operations

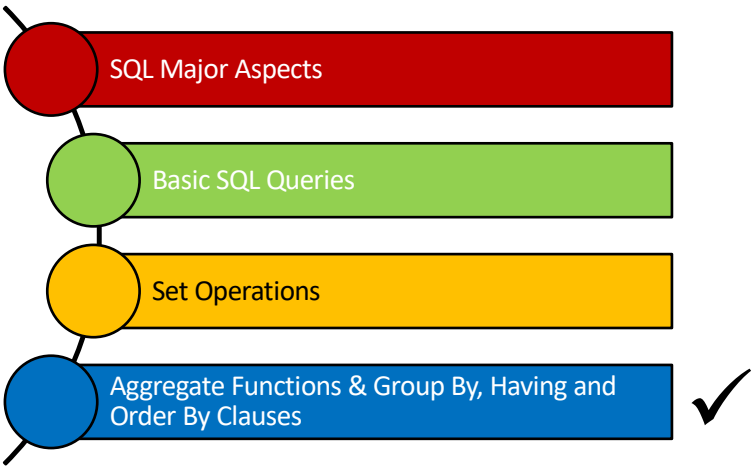
- Find the names of sailors who have reserved both a red and a green boat

```
(select S.sname from Sailors S, Reserves R, Boats B
where S.sid = R.sid and R.bid = B.bid and B.color = 'green')
intersect
(select S2.sname from Sailors S2, Reserves R2, Boats B2
where S2.sid = R2.sid and R2.bid = B2.bid and B2.color = 'red')
```

The query contains a "subtle bug" which arises because we are using *sname* to identify Sailors, and "sname" is not a key for Sailors!

We can compute the names of such Sailors using a NESTED query (*which we cover next lectures!*)

Outline



Aggregate Functions

- Find average grade, across all students

SSN	c-id	grade
123	15-413	4
234	15-413	3

select ??
from takes

Aggregate Functions

- Find average grade, across all students

SSN	c-id	grade
123	15-413	4
234	15-413	3

```
select avg(grade)
from takes
```

Other functions: Count ([Distinct] A), Sum ([Distinct] A), Max (A), Min (A), assuming column A

Aggregate Functions

- Find total number of enrollments

SSN	c-id	grade
123	15-413	4
234	15-413	3

```
select count(*)
from takes
```

Aggregate Functions

- Find total number of students in 15-415

SSN	c-id	grade
123	15-413	4
234	15-413	3

```
select count(*)
from takes
where c-id='15-415'
```

Aggregate Functions

- Find the name and age of the oldest sailor

Sailors			
Sid	Sname	Rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0

```
select S.sname, max (S.age)
from Sailors S
```

This query is illegal in SQL- If the "select" clause uses an aggregate function, it must use ONLY aggregate function unless the query contains a "group by" clause!

The GROUP BY and HAVING Clauses

- Find the age of the youngest sailor for each rating level

Sailors			
Sid	**Sname**	**Rating**	**age**
22	Dustin	7	45.0
29	Brutus	1	33.0

  - In general, we do not know how many rating levels exist, and what the rating values for these levels are!
  - Suppose we know that rating values go from 1 to 10; we can write 10 queries that look like this (!):

For $i = 1, 2, \ldots, 10$:

```
SELECT  MIN (S.age)
FROM  Sailors S
WHERE  S.rating = i
```

The GROUP BY and HAVING Clauses

- Find the age of the youngest sailor for each rating level

Sailors			
Sid	**Sname**	**Rating**	**age**
22	Dustin	7	45.0
29	Brutus	1	33.0

  - Using the GROUP BY clause, we can write this query as follows:

```
select S.rating, min (S.age)
from  Sailors S
group by S.rating
```

The Grouping-List

"*Every*" column that appears in the **Column-List**
"*must*" also appear in the **Grouping-List**

The GROUP BY and HAVING Clauses

- Find age of the youngest sailor with age ≥ 18, for each rating level with at least 2 sailors

Sailors			
Sid	**Sname**	**Rating**	**age**
22	Dustin	7	45.0
29	Brutus	1	33.0

```
SELECT  S.rating,  MIN (S.age) AS minage
FROM  Sailors S
WHERE  S.age >= 18
GROUP BY  S.rating
HAVING  COUNT (*) > 1
```

The GROUP BY and HAVING Clauses

- Find age of the youngest sailor with age ≥ 18, for each rating level with at least 2 sailors

rating	age
7	45.0
1	33.0
8	55.5
8	25.5
10	35.0
7	35.0
10	16.0
9	35.0
3	25.5
3	63.5
3	25.5

rating	age
1	33.0
3	25.5
3	63.5
3	25.5
7	45.0
7	35.0
8	55.5
8	25.5
9	35.0
10	35.0

rating	minage
3	25.5
7	35.0
8	25.5

The GROUP BY and HAVING Clauses

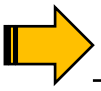
- Find age of the youngest sailor with age ≥ 18, for each rating level with at least 2 sailors, and with every sailor under 60

```
SELECT  S.rating,  MIN (S.age) AS minage
FROM  Sailors S
WHERE  S.age >= 18
GROUP BY  S.rating
HAVING  COUNT (*) > 1 AND EVERY (S.age <=60)
```

The GROUP BY and HAVING Clauses

- Find age of the youngest sailor with age ≥ 18, for each rating level with at least 2 sailors, and with every sailor under 60

rating	age
7	45.0
1	33.0
8	55.5
8	25.5
10	35.0
7	35.0
10	16.0
9	35.0
3	25.5
3	63.5
3	25.5



rating	age
1	33.0
3	25.5
3	63.5
3	25.5
7	45.0
7	35.0
8	55.5
8	25.5
9	35.0
10	35.0

rating	minage
7	35.0
8	25.5

What would be the result if we change EVERY to ANY in "HAVING COUNT (*) > 1 AND EVERY (S.age <=60)"?

The GROUP BY and HAVING Clauses

- Find age of the youngest sailor with age ≥ 18, for each rating level with at least 2 sailors between 18 and 60

```
SELECT  S.rating,  MIN (S.age) AS minage
FROM  Sailors S
WHERE  S.age >= 18 AND S.age <= 60
GROUP BY  S.rating
HAVING  COUNT (*) > 1
```

Will this give the same result as the previous query which uses the EVERY clause?

Will this give the same result as the previous query which uses the ANY clause?

The ORDER BY Clause

- Find student records, sorted in name order

```
select *
from student
where ??
```

The ORDER BY Clause

- Find student records, sorted in name order

```
select *
from student
order by name asc
```

asc is the default

The ORDER BY Clause

- Find student records, sorted in name order; break ties by reverse ssn

```
select *
from student
order by name, ssn desc
```

More Examples

- Find the total number of students in each course

SSN	c-id	grade
123	15-413	4
234	15-413	3

```
select count(*)
from takes
where ???
```

More Examples

- Find the total number of students in each course

SSN	c-id	grade
123	15-413	4
234	15-413	3

c-id	count
15-413	2

```
select c-id, count(*)
from takes
group by c-id
```

More Examples

- Find total number of students in each course, and sort by count, in decreasing order

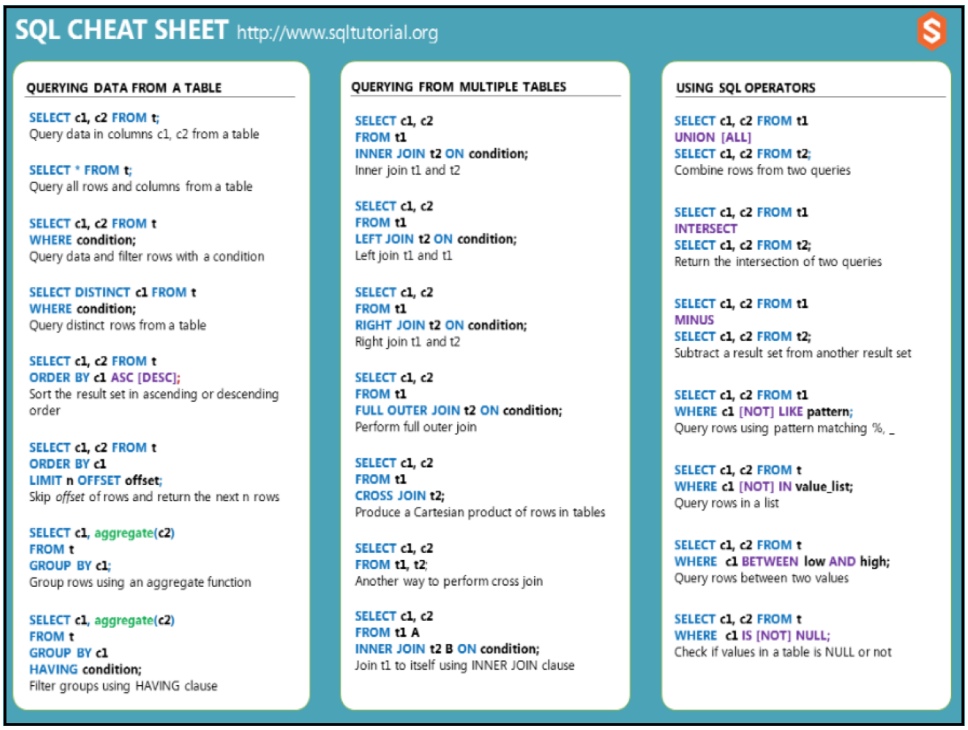
SSN	c-id	grade
123	15-413	4
234	15-413	3

c-id	pop
15-413	2

```
select c-id, count(*) as pop
from takes
group by c-id
order by pop desc
```

Concluding Remarks

- SQL was an important factor in the early acceptance of the relational model
  - It is more natural than earlier procedural query languages
- SQL is relationally complete; in fact, significantly more expressive power than relational algebra
- Even queries that can be expressed in relational algebra can often be expressed more naturally in SQL



SQL CHEAT SHEET http://www.sqltutorial.org

QUERYING DATA FROM A TABLE

SELECT c1, c2 FROM t;
Query data in columns c1, c2 from a table

SELECT * FROM t;
Query all rows and columns from a table

SELECT c1, c2 FROM t
WHERE condition;
Query data and filter rows with a condition

SELECT DISTINCT c1 FROM t
WHERE condition;
Query distinct rows from a table

SELECT c1, c2 FROM t
ORDER BY c1 ASC [DESC];
Sort the result set in ascending or descending order

SELECT c1, c2 FROM t
ORDER BY c1
LIMIT n OFFSET offset;
Skip *offset* of rows and return the next n rows

SELECT c1, aggregate(c2)
FROM t
GROUP BY c1;
Group rows using an aggregate function

SELECT c1, aggregate(c2)
FROM t
GROUP BY c1
HAVING condition;
Filter groups using HAVING clause

QUERYING FROM MULTIPLE TABLES

SELECT c1, c2
FROM t1
INNER JOIN t2 ON condition;
Inner join t1 and t2

SELECT c1, c2
FROM t1
LEFT JOIN t2 ON condition;
Left join t1 and t1

SELECT c1, c2
FROM t1
RIGHT JOIN t2 ON condition;
Right join t1 and t2

SELECT c1, c2
FROM t1
FULL OUTER JOIN t2 ON condition;
Perform full outer join

SELECT c1, c2
FROM t1
CROSS JOIN t2;
Produce a Cartesian product of rows in tables

SELECT c1, c2
FROM t1, t2;
Another way to perform cross join

SELECT c1, c2
FROM t1 A
INNER JOIN t2 B ON condition;
Join t1 to itself using INNER JOIN clause

USING SQL OPERATORS

SELECT c1, c2 FROM t1
UNION [ALL]
SELECT c1, c2 FROM t2;
Combine rows from two queries

SELECT c1, c2 FROM t1
INTERSECT
SELECT c1, c2 FROM t2;
Return the intersection of two queries

SELECT c1, c2 FROM t1
MINUS
SELECT c1, c2 FROM t2;
Subtract a result set from another result set

SELECT c1, c2 FROM t1
WHERE c1 [NOT] LIKE pattern;
Query rows using pattern matching %, _

SELECT c1, c2 FROM t
WHERE c1 [NOT] IN value_list;
Query rows in a list

SELECT c1, c2 FROM t
WHERE c1 BETWEEN low AND high;
Query rows between two values

SELECT c1, c2 FROM t
WHERE c1 IS [NOT] NULL;
Check if values in a table is NULL or not

Next Class

More SQL