# Lecture 8
# SQL part I

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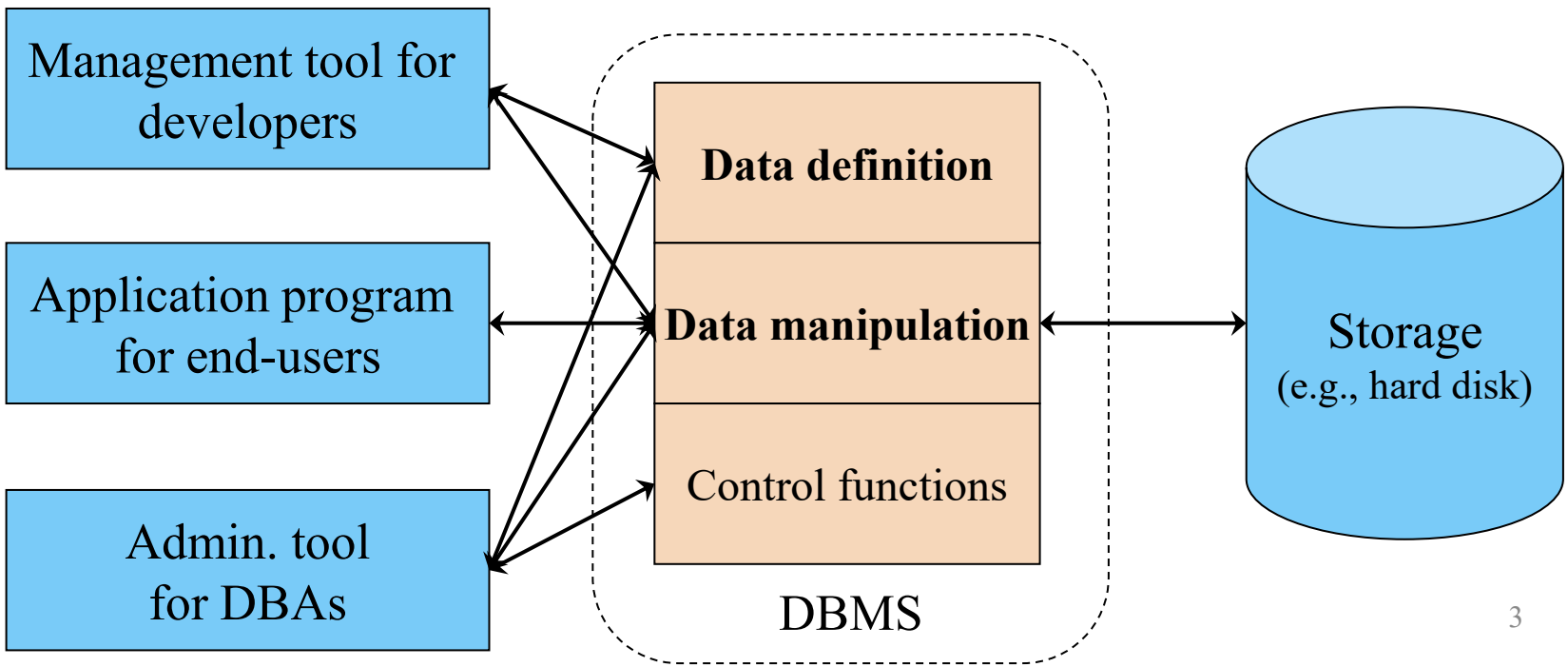
Some parts might be revised and indicated.

# Outline

- Background
- How to define a table?
- Basic SQL: select, from, where
- Order by, aggregation, group by
- Set operations
- How to insert, delete, update data?

# How to use DBMS?

- *Data Definition Language* (DDL):
  - define the database schema, i.e., the record type
- *Data Manipulation Language* (DML):
  - access / update the database content
- SQL consists of both DDL and DML



# History of SQL

- Early days (1970s)
  - Known as SEQUEL (Structured English Query Language)
  - Developed for IBM's system R
- Now called SQL (Structured Query Language)
- Standardization by ISO
  - SQL-86
  - SQL-89
    - + integrity constraints, 100 pages
  - SQL-92
    - + new DDL,DML features, 500 pages
  - SQL:1999, 2003, 2006, 2008, 2011, 2016
    - + many features, many pages

# DBMS Implementations

- DBMS implementations
  - Microsoft SQL server, Oracle, IBM DB2, ……
- Many implementations fully support "intermediate SQL" --- half of new features in SQL-92
- Some DBMS vendors have proprietary extensions to the SQL standard
  - E.g., a SQL statement used in DBMS "A" may not be directly supported in DBMS "B"

# SQL vs. relational algebra

- In SQL, **duplicates** are allowed in a table
  - In relational algebra, duplicates are not allowed
- Some functions are supported in SQL but not in relational algebra
  - Data definition language (e.g., create table, drop table)
  - Nested queries
  - Sorting a table
  - Keywords for data types
  - Conditional expressions (CASE)
  - String functions

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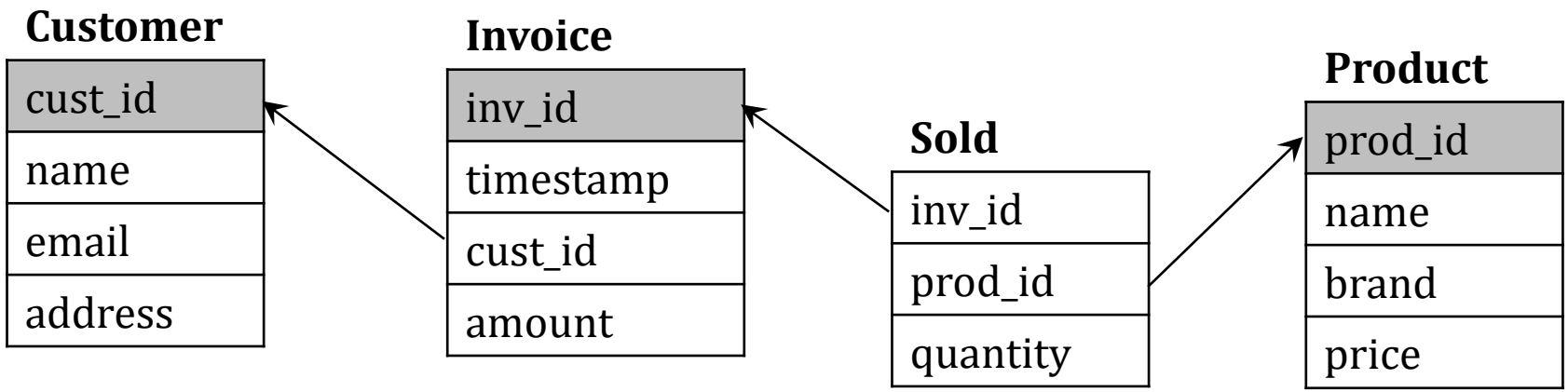
# How to create tables?

- When we create a table, we provide:
  - The table name
  - The name and type of each attribute name
    - A name may contain '_' but not '-'
  - Integrity constraints
    - E.g., primary key, foreign key, NOT NULL, unique key, CHECK
- Basic types
  - char($n$): a string with fixed length $n$
  - int: an integer
  - numeric($p$,$d$): a fixed point number with total $p$ digits and $d$ digits after the decimal point
  - real: floating-point number

**Customer**

| cust_id |
| --- |
| name |
| email |
| address |

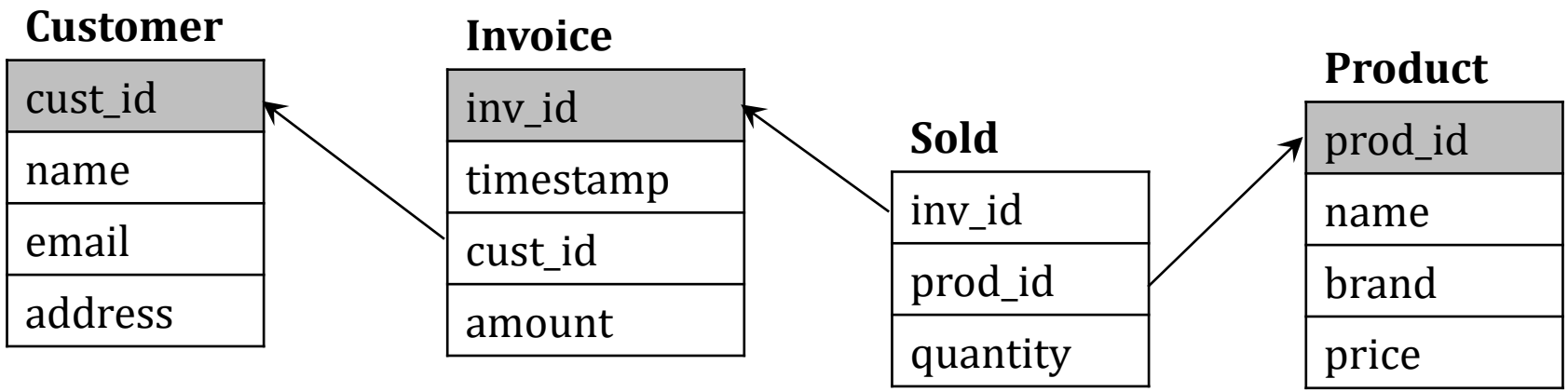
# How to create tables?




- Create the Invoice table by:

```
create table Invoice
(inv_id int,
timestamp int,
cust_id int,
amount numeric(10,2),
primary key (inv_id))
```

# How to create tables?




- Create the Sold table by:

```
create table Sold
(inv_id int,
prod_id int,
quantity int,
primary key (inv_id,prod_id))
```

# Other SQL statements for data definition

| Purpose | Example statement |
|---|---|
| Show tables in a database | `show tables` |
| Describe the schema of a table | `describe Invoice` |
| Remove a table | `drop table Invoice` |
| Add a column in a table | `alter table Invoice add staff_id int` |
| Drop a column in a table | `alter table Invoice drop staff_id` |

```
+-----------+---------------+------+-----+---------+-------+
| Field     | Type          | Null | Key | Default | Extra |
+-----------+---------------+------+-----+---------+-------+
| inv_id    | int(11)       | NO   | PRI | 0       |       |
| timestamp | int(11)       | YES  |     | NULL    |       |
| cust_id   | int(11)       | YES  |     | NULL    |       |
| amount    | decimal(10,2) | YES  |     | NULL    |       |
+-----------+---------------+------+-----+---------+-------+
4 rows in set (0.01 sec)
```

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# SQL and Relational Algebra

- A simple SQL query has the form:

**select** $A_1, A_2, ..., A_n$
**from** $r_1, r_2, ..., r_m$
**where** $P$

  - $A_i$ represents an attribute
  - $r_i$ represents a relation
  - $P$ is a predicate

- Equivalent to the relational algebra expression

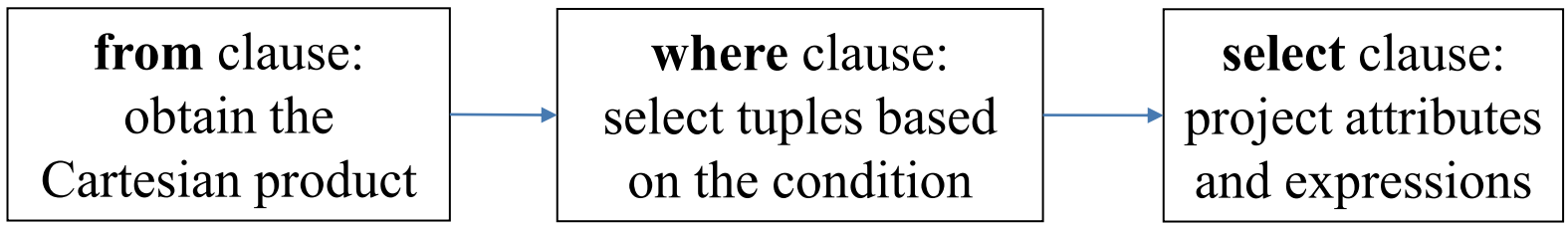
Projection Selection Cartesian product

$$\prod_{A_1, A_2, \ldots, A_n} (\sigma_P (r_1 \times r_2 \times \ldots \times r_m))$$

- The result of an SQL query is a relation
  - Note: the **select** keyword in SQL means projection (but not selection) in relational algebra!

# Flow of Clauses

**select** $A_1, A_2, \ldots, A_n$
**from** $r_1, r_2, \ldots, r_m$
**where** $P$




Cartesian product

Selection

Projection

# How to express the following queries in SQL?

- (Q1) Find products that have price > 8.0
- (Q2) Find the brands of products
- (Q3) Find the customer name and inv_id (invoice id) of each invoice
- (Q4) Find the highest price in the table *Product*
- (Q5) Find the total amount in the table *Invoice*

# SQL: where clause

- (Q1) Find products that have price > 8.0

```
select *
from Product
where price > 8.0
```

* means all attributes

Relation **Product**:

| prod_id | name | brand | price |
|---|---|---|---|
| 1 | Coca Cola | CO | 7.8 |
| 2 | Pepsi | PE | 8.9 |
| 3 | 7 Up | DP | 6.5 |
| 4 | Sprite | CO | 8.3 |

| prod_id | name | brand | price |
|---|---|---|---|
| 2 | Pepsi | PE | 8.9 |
| 4 | Sprite | CO | 8.3 |

# SQL: where clause

- In the condition, we may use
  - Comparisons: =, !=, <, >, <=, >=
  - Connectives: and, or, not, between…and…

- Examples:

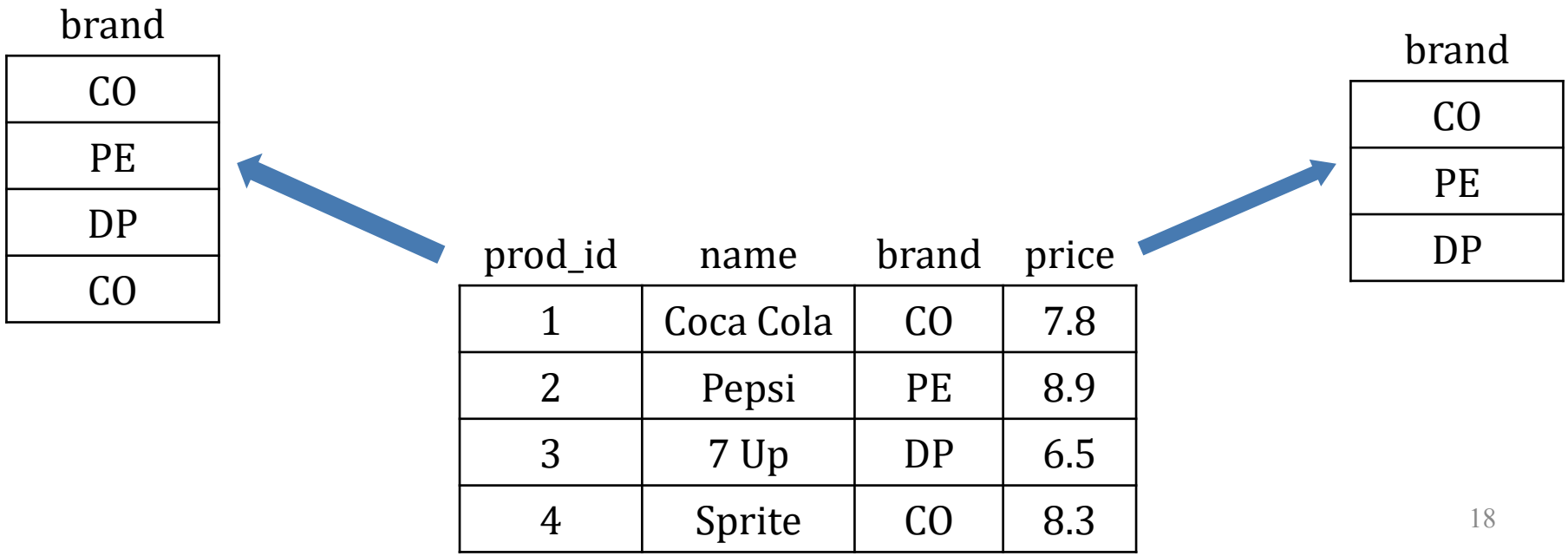
```
select *
from Product
where price>=8.0 and price<=9.0

select *
from Product
where price between 8.0 and 9.0
```

# SQL: select clause

- (Q2) Find the brands of products
  - By default, SQL allows duplicates
  - To remove duplicates, use the keyword distinct

```
select brand
from Product
```

```
select distinct brand
from Product
```



brand

| CO |
|---|
| PE |
| DP |
| CO |

| prod_id | name | brand | price |
|---|---|---|---|
| 1 | Coca Cola | CO | 7.8 |
| 2 | Pepsi | PE | 8.9 |
| 3 | 7 Up | DP | 6.5 |
| 4 | Sprite | CO | 8.3 |

brand

| CO |
|---|
| PE |
| DP |

# SQL: from clause, rename

- (Q3) "find the customer name and inv_id of each invoice"
  - Place both tables Customer and Invoice in the from clause
  - *Optional*: use the keyword as to rename a table and make the SQL statement easier to read

Remove 'as' in oracle

```
select I.inv_id, C.name
from Customer as C, Invoice as I
where C.cust_id=I.cust_id
```

| cust_id | name | email | address |
|---|---|---|---|
| 1 | James | james@yahoo.com | AB |
| 2 | Mary | mary@gmail.com | CD |
| 3 | Peter | peter@yahoo.com | EF |
| 4 | Peter | peter@gmail.com | **null** |

| inv_id | timestamp | cust_id | amount |
|---|---|---|---|
| 1 | 101 | 3 | 8.9 |
| 2 | 102 | 2 | 7.8 |

| inv_id | name |
|---|---|
| 1 | Peter |
| 2 | Mary |

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# SQL: order by

- The order by clause allows us to sort the results
  - asc: ascending order; desc: descending order

```
select *
from Product
order by price asc
```

| prod_id | name | brand | price |
|---|---|---|---|
| 3 | 7 Up | DP | 6.5 |
| 1 | Coca Cola | CO | 7.8 |
| 4 | Sprite | CO | 8.3 |
| 2 | Pepsi | PE | 8.9 |

```
select *
from Product
order by price desc
```

| prod_id | name | brand | price |
|---|---|---|---|
| 2 | Pepsi | PE | 8.9 |
| 4 | Sprite | CO | 8.3 |
| 1 | Coca Cola | CO | 7.8 |
| 3 | 7 Up | DP | 6.5 |

# SQL: aggregation

- Aggregate functions
  - sum, count, avg, min, max
- (Q4) Find the highest price in the table *Product*
- (Q5) Find the total amount in the table *Invoice*

```
select max(price)
from Product
```

```
select sum(amount)
from Invoice
```

| inv_id | timestamp | cust_id | amount |
|---|---|---|---|
| 1 | 101 | 3 | 8.9 |
| 2 | 102 | 2 | 7.8 |
| 3 | 103 | 2 | 6.5 |
| 4 | 104 | 3 | 8.3 |

| sum(amount) |
|---|
| 31.5 |

# SQL: group by

- E.g., find the total amount spent by each customer
  - First partition the table into groups (by cust_id), then use aggregate function on each group

```
select cust_id, sum(amount)
from Invoice
group by cust_id
```

| inv_id | timestamp | cust_id | amount |
|---|---|---|---|
| 1 | 101 | 3 | 8.9 |
| 2 | 102 | 2 | 7.8 |
| 3 | 103 | 2 | 6.5 |
| 4 | 104 | 3 | 8.3 |

*group by*

| inv_id | timestamp | cust_id | amount |
|---|---|---|---|
| 1 | 101 | 3 | 8.9 |
| 4 | 104 | 3 | 8.3 |
| 2 | 102 | 2 | 7.8 |
| 3 | 103 | 2 | 6.5 |

*aggregation*

| cust_id | sum(amount) |
|---|---|
| 3 | 17.2 |
| 2 | 14.3 |

# SQL: group by + having

- Keyword having: specify filter condition for groups
- E.g., find the total amount spent by each customer; display those with total amount greater than 15.0

```
select cust_id, sum(amount)
from Invoice
group by cust_id
having sum(amount)>15.0
```

| inv_id | timestamp | cust_id | amount |
|---|---|---|---|
| 1 | 101 | 3 | 8.9 |
| 2 | 102 | 2 | 7.8 |
| 3 | 103 | 2 | 6.5 |
| 4 | 104 | 3 | 8.3 |

*group by*

| inv_id | timestamp | cust_id | amount |
|---|---|---|---|
| 1 | 101 | 3 | 8.9 |
| 4 | 104 | 3 | 8.3 |
| 2 | 102 | 2 | 7.8 |
| 3 | 103 | 2 | 6.5 |

*aggregation*

| cust_id | sum(amount) |
|---|---|
| 3 | 17.2 |
| 2 | 14.3 |

*having*

| cust_id | sum(amount) |
|---|---|
| 3 | 17.2 |

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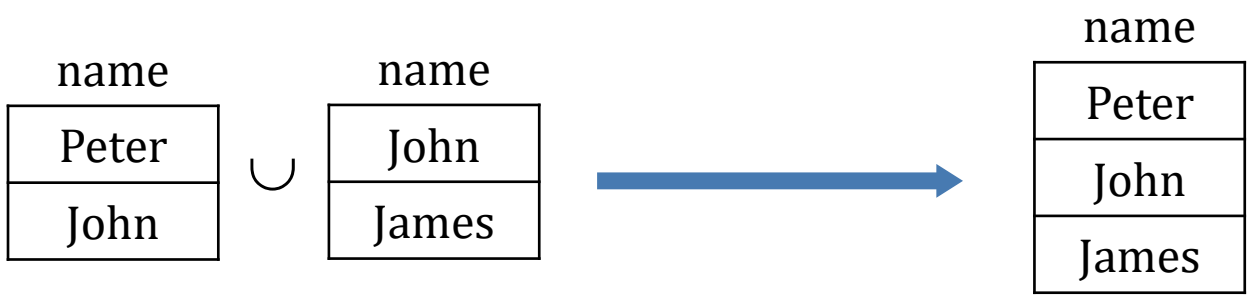
# SQL: set operations

- Set operations: union, intersect, except
  - By default, these operations **remove duplicates**

```
(select name from A)
union
(select name from B)
```



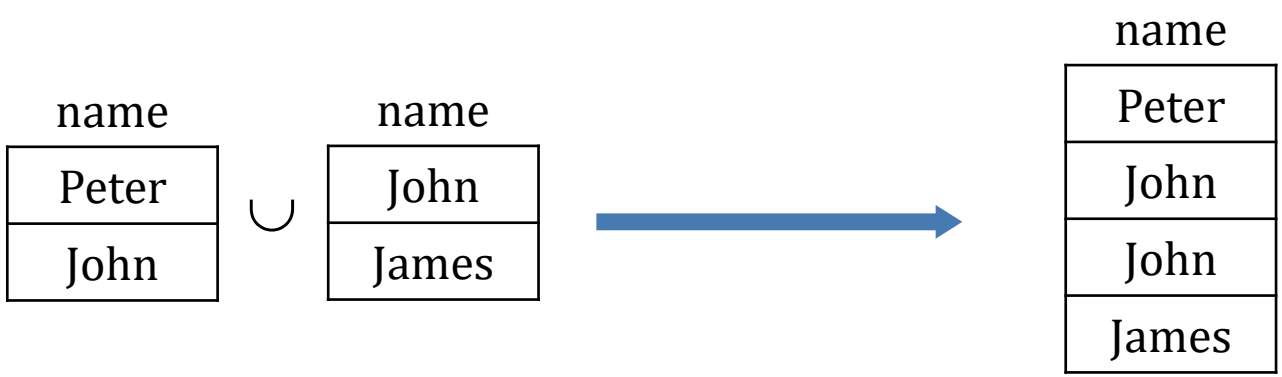
# SQL: set operations

Minus in Oracle

MS SQL

- Set operations: union, intersect, except
  - To allow duplicates, use the keyword **all**

```
(select name from A)
union all
(select name from B)
```




Oracle MINUS is an operator; it's equivalent to EXCEPT in SQL Server.
https://stackoverflow.com/questions/5557991/minus-vs-except-difference-in-oracle-sql-server

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# Insertion

- **Insertion**: insert tuple(s) into a relation
  - Example 1: insert a tuple

```
insert into Product
values (5,'Soda','AB',7.5)
```

| prod_id | name | brand | price |
|---|---|---|---|
| 1 | Coca Cola | CO | 7.8 |
| 2 | Pepsi | PE | 8.9 |
| 4 | Sprite | CO | 8.3 |
| 5 | Soda | AB | 7.5 |

  - Example 2: insert tuples obtained by select statement

```
insert into Product
   select ...
   from ...
   where ...
```

# Deletion

- **Deletion**: delete tuple(s) from a relation
  - Example: remove the product that has id=3

```
delete from Product
where prod_id=3
```

| prod_id | name | brand | price |
|---|---|---|---|
| 1 | Coca Cola | CO | 7.8 |
| 2 | Pepsi | PE | 8.9 |
| ~~3~~ | ~~7 Up~~ | ~~DP~~ | ~~6.5~~ |
| 4 | Sprite | CO | 8.3 |

# Update

- Update tuple(s) based on a condition
  - Example: double the price of each product of the brand 'AB'

```
update Product
set price=price*2
where brand='AB'
```

| prod_id | name | brand | price |
|---|---|---|---|
| 1 | Coca Cola | CO | 7.8 |
| 2 | Pepsi | PE | 8.9 |
| 4 | Sprite | CO | 8.3 |
| 5 | Soda | AB | ~~7.5~~ 15 |

# Summary

- After this lecture, you should be able to:
  1) Apply SQL to define tables
  2) Apply SQL to express simple queries

- Please read Chapter 3 in the book "*Database System Concepts*", 7th Edition

- Next lecture: advanced features of SQL