ECE30030/ITP30010 Database Systems

Advanced SQL

Reading: Chapters 4-5

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Agenda

- Join
- Views
- Window functions
- Keys

Join Operations

- Join operations take two relations and return another relation
  - A join is a Cartesian product that requires tuples in the two relations match
    - It also specifies the attributes that are present in the result of the join (project)
  - Typically used as subquery expressions in the **FROM** clause

  - Join types
    - **INNER JOIN**
    - **OUTER JOIN**

  - Join conditions
    - **NATURAL**
    - **ON** <predicate>
    - **USING** (A_1, A_2, …, A_n)

Running Example

- Relations: student, takes

ID	name	dept_name	tot_cred
00128	Zhang	Comp. Sci.	102
12345	Shankar	Comp. Sci.	32
19991	Brandt	History	80
23121	Chavez	Finance	110
44553	Peltier	Physics	56
45678	Levy	Physics	46
54321	Williams	Comp. Sci.	54
55739	Sanchez	Music	38
70557	Snow	Physics	0
76543	Brown	Comp. Sci.	58
76653	Aoi	Elec. Eng.	60
98765	Bourikas	Elec. Eng.	98
98988	Tanaka	Biology	120

ID	course_id	sec_id	semester	year	grade
00128	CS-101	1	Fall	2017	A
00128	CS-347	1	Fall	2017	A-
12345	CS-101	1	Fall	2017	C
12345	CS-190	2	Spring	2017	A
12345	CS-315	1	Spring	2018	A
12345	CS-347	1	Fall	2017	A
19991	HIS-351	1	Spring	2018	B
23121	FIN-201	1	Spring	2018	C+
44553	PHY-101	1	Fall	2017	B-
45678	CS-101	1	Fall	2017	F
45678	CS-101	1	Spring	2018	B+
45678	CS-319	1	Spring	2018	B
54321	CS-101	1	Fall	2017	A-
54321	CS-190	2	Spring	2017	B+
55739	MU-199	1	Spring	2018	A-
76543	CS-101	1	Fall	2017	A
76543	CS-319	2	Spring	2018	A
76653	EE-181	1	Spring	2017	C
98765	CS-101	1	Fall	2017	C-
98765	CS-315	1	Spring	2018	B
98988	BIO-101	1	Summer	2017	A
98988	BIO-301	1	Summer	2018	<null>

Running Example

- Relations: course, instructor

course_id	title	dept_name	credits
BIO-101	Intro. to Biology	Biology	4
BIO-301	Genetics	Biology	4
BIO-399	Computational Biology	Biology	3
CS-101	Intro. to Computer Science	Comp. Sci.	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3
CS-319	Image Processing	Comp. Sci.	3
CS-347	Database System Concepts	Comp. Sci.	3
EE-181	Intro. to Digital Systems	Elec. Eng.	3
FIN-201	Investment Banking	Finance	3
HIS-351	World History	History	3
MU-199	Music Video Production	Music	3
PHY-101	Physical Principles	Physics	4

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000.00
12121	Wu	Finance	90000.00
15151	Mozart	Music	40000.00
22222	Einstein	Physics	95000.00
32343	El Said	History	60000.00
33456	Gold	Physics	87000.00
45565	Katz	Comp. Sci.	75000.00
58583	Califieri	History	62000.00
76543	Singh	Finance	80000.00
76766	Crick	Biology	72000.00
83821	Brandt	Comp. Sci.	92000.00
98345	Kim	Elec. Eng.	80000.00

Natural Join

- Natural join matches tuples with the same values for all common attributes, and retains only one copy of each common column
  - *E.g.*, List the names of students along with the course ID of the courses that they took
    - **SELECT** *name*, *course_id*
      FROM *student*, *takes*
      WHERE *student.ID* = *takes.ID*;
  - Same query in SQL with natural join:
    - **SELECT** *name*, *course_id*
      FROM *student* **NATURAL JOIN** *takes*;

name	course_id
Zhang	CS-101
Zhang	CS-347
Shankar	CS-101
Shankar	CS-190
Shankar	CS-315
Shankar	CS-347
Brandt	HIS-351
Chavez	FIN-201
Peltier	PHY-101
Levy	CS-101
Levy	CS-101
Levy	CS-319
Williams	CS-101
Williams	CS-190
Sanchez	MU-199
Brown	CS-101
Brown	CS-319
Aoi	EE-181
Bourikas	CS-101
Bourikas	CS-315
Tanaka	BIO-101
Tanaka	BIO-301

Natural Join

- The **FROM** clause can have multiple relations combined using natural join:
  - **SELECT** $A_1, A_2, \ldots A_n$
    FROM r_1 **NATURAL JOIN** r_2 **NATURAL JOIN** … **NATURAL JOIN** r_n
    WHERE P ;

Caveat

- *E.g.*, **(Incorrect)**
  SELECT *dept_name, course_id, name, title, credits*
  FROM *student* **NATURAL JOIN** *takes* **NATURAL JOIN** *course*;

dept_name	course_id	name	title	credits
Biology	BIO-101	Tanaka	Intro. to Biology	4
Biology	BIO-301	Tanaka	Genetics	4
Comp. Sci.	CS-101	Zhang	Intro. to Computer Science	4
Comp. Sci.	CS-101	Shankar	Intro. to Computer Science	4
Comp. Sci.	CS-101	Williams	Intro. to Computer Science	4
Comp. Sci.	CS-101	Brown	Intro. to Computer Science	4
Comp. Sci.	CS-190	Shankar	Game Design	4
Comp. Sci.	CS-190	Williams	Game Design	4
Comp. Sci.	CS-315	Shankar	Robotics	3
Comp. Sci.	CS-319	Brown	Image Processing	3
Comp. Sci.	CS-347	Zhang	Database System Concepts	3
Comp. Sci.	CS-347	Shankar	Database System Concepts	3
Elec. Eng.	EE-181	Aoi	Intro. to Digital Systems	3
Finance	FIN-201	Chavez	Investment Banking	3
History	HIS-351	Brandt	World History	3
Music	MU-199	Sanchez	Music Video Production	3
Physics	PHY-101	Peltier	Physical Principles	4

Caveat

- Beware of unrelated attributes with same name getting equated incorrectly
  - *E.g.*, List the names of students along with the titles of courses that they have taken
    - Correct

      SELECT *name*, *title*
      FROM *student* **NATURAL JOIN** *takes*, *course*
      WHERE *takes*.*course_id* = *course*.*course_id*;

    - Incorrect

      SELECT *name*, *title*
      FROM *student* **NATURAL JOIN** *takes* **NATURAL JOIN** *course*;

      - This query omits all (student name, course title) pairs where the student takes a course in a department other than the student's own department

Natural Join with USING Clause

- To avoid the danger of equating attributes erroneously, use the **USING** construct
  - USING: allows us to specify exactly which columns should be equated
  - *E.g.*, **SELECT** *name*, *title*
    FROM (*student* **NATURAL JOIN** *takes*) **JOIN** *course* **USING** (*course_id*)

name	title
Tanaka	Intro. to Biology
Tanaka	Genetics
Zhang	Intro. to Computer Science
Shankar	Intro. to Computer Science
Levy	Intro. to Computer Science
Williams	Intro. to Computer Science
Brown	Intro. to Computer Science
Bourikas	Intro. to Computer Science
Levy	Intro. to Computer Science
Shankar	Game Design
Williams	Game Design
Shankar	Robotics
Bourikas	Robotics
Levy	Image Processing
Brown	Image Processing
Zhang	Database System Concepts
Shankar	Database System Concepts
Aoi	Intro. to Digital Systems
Chavez	Investment Banking
Brandt	World History
Sanchez	Music Video Production
Peltier	Physical Principles

JOIN … ON

- The **ON** condition allows a general predicate over the relations being joined
  - Written like a **WHERE** clause predicate

  - *E.g.*, **SELECT** *
    FROM *student* **JOIN** *takes* **ON** *student.ID* = *takes.ID*
    - The **ON** condition specifies that a tuple from *student* matches a tuple from *takes* if their *ID* values are equal

    - Equivalent to:
      SELECT *name*, *course_id*
      FROM *student, takes*
      WHERE *student.ID* = *takes.ID*;

Inner Join

- Inner join: Does not preserve nonmatched tuples
  - Tables are joined based on common columns mentioned in the **ON** or **USING** clause
  - One can specify the condition with an **ON** or **USING** construct

- *C.f.*, Natural join: assumes the join condition to be where same-named columns in both tables match
  - One cannot use **ON** or **USING**
  - In the result of a natural join, repeated columns are avoided

Natural Join

- Natural join: Some tuples in either or both relations being joined may be lost

- **SELECT** *
  FROM *course* **NATURAL JOIN** *prereq*;

course_id	title	dept_name	credits	prereq_id
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101

Examples

- Tables

ROLL_NO	NAME
1	HARSH
2	PRATIK
3	RIYANKA
4	DEEP
5	SAPTARHI
6	DHANRAJ
7	ROHIT
8	NIRAJ

Student

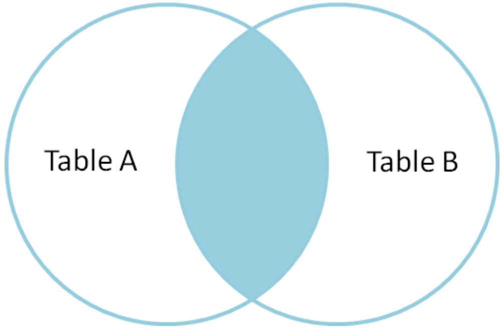
COURSE_ID	ROLL_NO
1	1
2	2
2	3
3	4
1	5
4	9
5	10
4	11

StudentCourse

Examples

- Inner join
  - **SELECT** *StudentCourse.COURSE_ID, Student.NAME*
    FROM *Student*
    INNER JOIN *StudentCourse*
    ON *Student.ROLL_NO = StudentCourse.ROLL_NO;*

COURSE_ID	NAME
1	HARSH
2	PRATIK
2	RIYANKA
3	DEEP
1	SAPTARHI



Outer Join

- An extension of the join operation that avoids loss of information
  - Outer join preserves those tuples that would be lost in a join by creating tuples in the result containing null values
  - Computes the join and then adds tuples form one relation that does not match tuples in the other relation to the result of the join

- Three forms of outer join:
  - **LEFT OUTER JOIN**
  - **RIGHT OUTER JOIN**
  - **FULL OUTER JOIN**

Running Example

- Relation *course*

course_id	title	dept_name	credits
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

- Relation *prereq*

course_id	prereq_id
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

  - *course* is missing CS-347
  - *prereq* is missing CS-315

Inner Join with NATURAL

- Natural join: Some tuples in either or both relations being joined may be lost

- **SELECT** *
  FROM *course* **NATURAL JOIN** *prereq*;

course_id	title	dept_name	credits	prereq_id
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101

Left Outer Join with NATURAL

- Left outer join: Preserves tuples only in the relation named before (to the left of) the operation

- **SELECT** *
  FROM *course* **NATURAL LEFT OUTER JOIN** *prereq*;

course_id	title	dept_name	credits	prereq_id
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	<null>

Right Outer Join with NATURAL

- Right outer join: Preserves tuples only in the relation named after (to the right of) the operation

- **SELECT** *
  FROM *course* **NATURAL RIGHT OUTER JOIN** *prereq*;

course_id	prereq_id	title	dept_name	credits
BIO-301	BIO-101	Genetics	Biology	4
CS-190	CS-101	Game Design	Comp. Sci.	4
CS-347	CS-101	<null>	<null>	<null>

Full Outer Join with NATURAL

- **SELECT** *
  FROM *course* **NATURAL FULL OUTER JOIN** *prereq*;

course_id	title	dept_name	credits	prereq_id
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	<null>
CS-347	<null>	<null>	<null>	CS-101

- MySQL does NOT support FULL join
  - Alternative: use the **UNION** of left and right joins
    SELECT course_id, title, dept_name, credits, prereq_id
    FROM course **NATURAL LEFT OUTER JOIN** prereq
    UNION
    SELECT course_id, title, dept_name, credits, prereq_id
    FROM course **NATURAL RIGHT OUTER JOIN** prereq;
    - In order to perform UNION properly, the attributes of both join queries must be aligned

Examples

- Tables

ROLL_NO	NAME
1	HARSH
2	PRATIK
3	RIYANKA
4	DEEP
5	SAPTARHI
6	DHANRAJ
7	ROHIT
8	NIRAJ

Student

COURSE_ID	ROLL_NO
1	1
2	2
2	3
3	4
1	5
4	9
5	10
4	11

StudentCourse

Examples

- Left join
  - **SELECT** *Student.NAME, StudentCourse.COURSE_ID*
    FROM *Student*
    LEFT JOIN *StudentCourse*
    ON *StudentCourse.ROLL_NO = Student.ROLL_NO;*

NAME	COURSE_ID
HARSH	1
PRATIK	2
RIYANKA	2
DEEP	3
SAPTARHI	1
DHANRAJ	*NULL*
ROHIT	*NULL*
NIRAJ	*NULL*

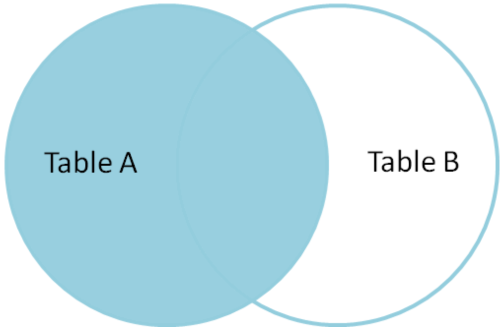
- Right join
  - **SELECT** *Student.NAME, StudentCourse.COURSE_ID*
    FROM *Student*
    RIGHT JOIN *StudentCourse*
    ON *StudentCourse.ROLL_NO = Student.ROLL_NO;*

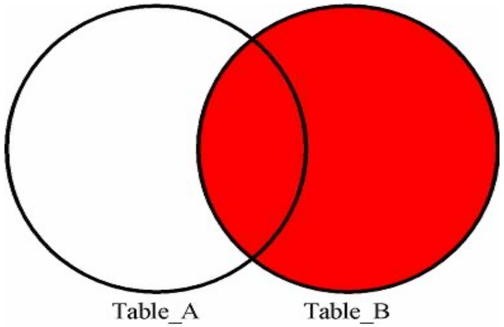
NAME	COURSE_ID
HARSH	1
PRATIK	2
RIYANKA	2
DEEP	3
SAPTARHI	1
NULL	4
NULL	5
NULL	4

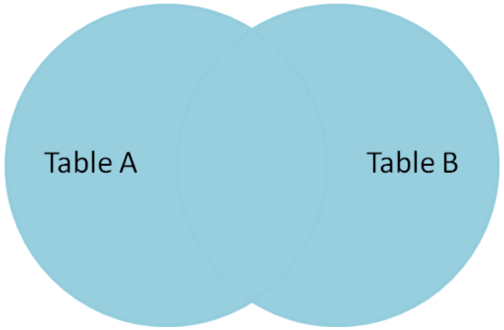
Examples

- Full join
  - **SELECT** *Student.NAME, StudentCourse.COURSE_ID*
    FROM *Student*
    FULL JOIN *StudentCourse*
    ON *StudentCourse.ROLL_NO = Student.ROLL_NO;*

NAME	COURSE_ID
HARSH	1
PRATIK	2
RIYANKA	2
DEEP	3
SAPTARHI	1
DHANRAJ	*NULL*
ROHIT	*NULL*
NIRAJ	*NULL*
NULL	9
NULL	10
NULL	11





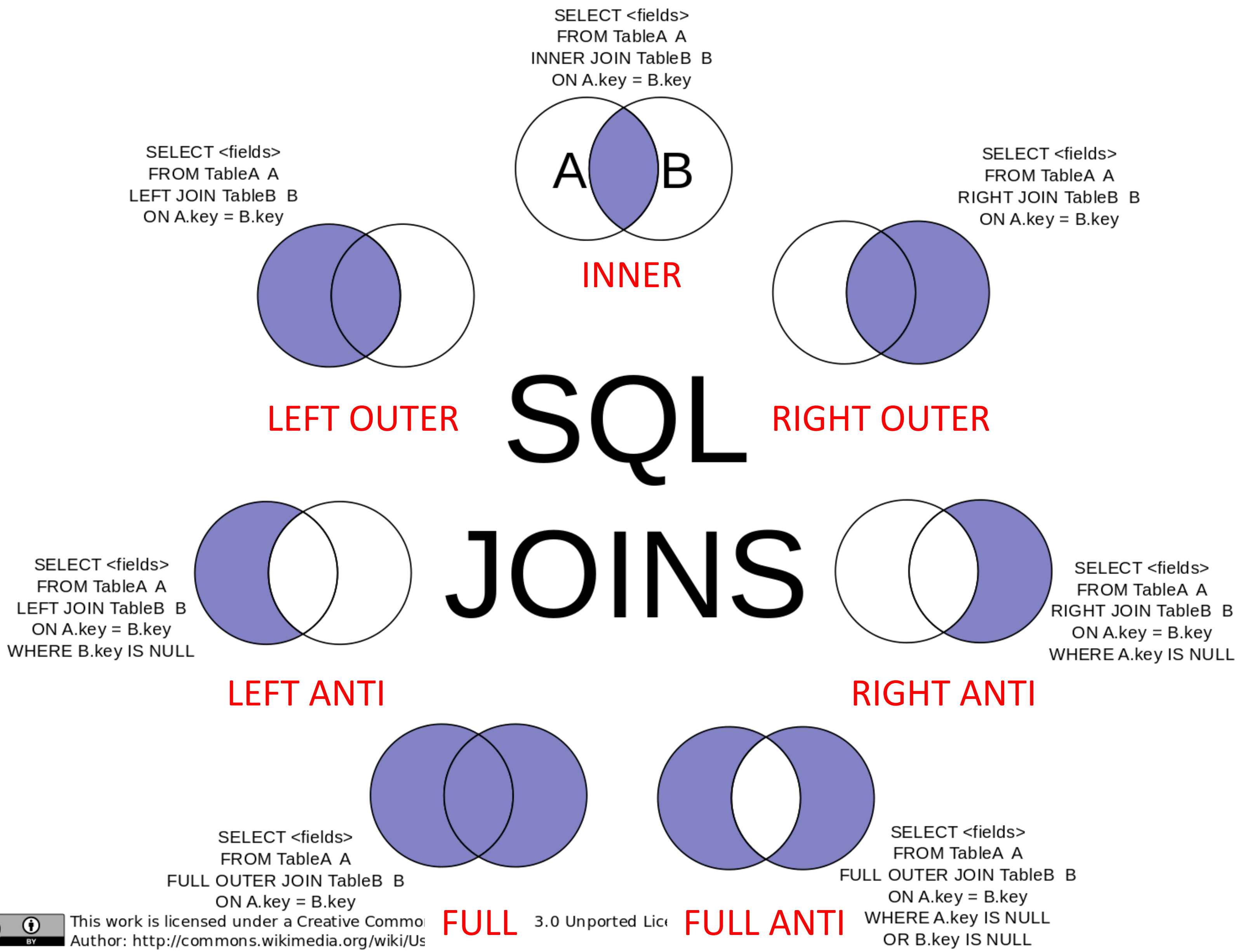


Join Types and Conditions

- Join type: Defines how tuples in each relation that do not match any tuples in the other relation are treated
  - **INNER JOIN**
  - **LEFT OUTER JOIN**
  - **RIGHT OUTER JOIN**
  - **FULL OUTER JOIN**

- Join condition: Defines which tuples in the two relations match
  - **NATURAL**
  - **ON** <predicate>
  - **USING** (A_1, A_2, …, A_n)

Join Types


SELECT <fields>
FROM TableA A
INNER JOIN TableB B
ON A.key = B.key
A
B
INNER
SELECT <fields>
FROM TableA A
LEFT JOIN TableB B
ON A.key = B.key
LEFT OUTER
SELECT <fields>
FROM TableA A
RIGHT JOIN TableB B
ON A.key = B.key
RIGHT OUTER
SQL
JOINS
SELECT <fields>
FROM TableA A
LEFT JOIN TableB B
ON A.key = B.key
WHERE B.key IS NULL
LEFT ANTI
SELECT <fields>
FROM TableA A
RIGHT JOIN TableB B
ON A.key = B.key
WHERE A.key IS NULL
RIGHT ANTI
SELECT <fields>
FROM TableA A
FULL OUTER JOIN TableB B
ON A.key = B.key
FULL
SELECT <fields>
FROM TableA A
FULL OUTER JOIN TableB B
ON A.key = B.key
WHERE A.key IS NULL
OR B.key IS NULL
FULL ANTI

Join Condition

- Join condition
  - **NATURAL**: Joins two tables based on same attribute name and datatypes
    - **SELECT** * **FROM** *course* **NATURAL JOIN** *prereq;*
  - **ON** <predicate>: Joins two tables based on the column(s) explicitly specified in the **ON** clause
    - **SELECT** * **FROM** *course*
      JOIN *prereq* **ON** *course.course_id = prereq.prereq_id*;
  - **USING** **(**A_1, A_2, …, A_n**)**: Joins two tables based on common attribute name(s) listed next to **USING**
    - **SELECT** * **FROM** *course*
      JOIN *prereq* **USING (***course_id***)**

Inner Join vs. Natural Join

INNER JOIN	NATURAL JOIN
Joins two tables on the basis of the column which is explicitly specified in the ON clause	Joins two tables based on same attribute name and datatypes
The resulting table will contain all the attribute of both the tables (including duplicate columns)	The resulting table will contain all the attribute of both the tables but keep only one copy of each common column
Only those records will return which exists in both tables	If there is no indication of LEFT, RIGHT, or FULL, it returns the rows based on the common column

* Source: https://www.geeksforgeeks.org/difference-between-natural-join-and-inner-join-in-sql/

Inner Join vs. Natural Join

- Inner join
  - **SELECT** * **FROM** *course*
    INNER JOIN *prereq* **ON** *course.course_id = prereq.prereq_id*;

- Natural join
  - **SELECT** *
    FROM *course* **NATURAL JOIN** *prereq*
    ON *course.course_id = prereq.prereq_id*; ← NOT VALID!

Inner Join vs. Natural Join

- Inner join
  - **SELECT** * **FROM** *course*
    INNER JOIN *prereq* **ON** *course.course_id = prereq.course_id*;
    - Equivalent to:
      SELECT * **FROM** *course*
      JOIN *prereq* **ON** *course.course_id = prereq.course_id*;

course.course_id	title	dept_name	credits	prereq.course_id	prereq_id
BIO-301	Genetics	Biology	4	BIO-301	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-190	CS-101

- Natural join
  - **SELECT** *
    FROM *course* **NATURAL JOIN** *prereq*;

course_id	title	dept_name	credits	prereq_id
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101

Outer Join vs. Natural Join

- Right outer join
  - **SELECT ***
    FROM *course* **NATURAL RIGHT OUTER JOIN** *prereq*;
    - Equivalent to:
      SELECT *
      FROM *course* **RIGHT OUTER JOIN** *prereq*
      USING (*course_id*);

course_id	prereq_id	title	dept_name	credits
BIO-301	BIO-101	Genetics	Biology	4
CS-190	CS-101	Game Design	Comp. Sci.	4
CS-347	CS-101	<null>	<null>	<null>

- **SELECT ***
  FROM *course* **RIGHT OUTER JOIN** *prereq*
  ON *course.course_id = prereq.course_id*;

course.course_id	title	dept_name	credits	prereq.course_id	prereq_id
BIO-301	Genetics	Biology	4	BIO-301	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-190	CS-101
<null>	<null>	<null>	<null>	CS-347	CS-101

Outer Join vs. Natural Join

- Left outer join
  - **SELECT ***
    FROM *course* **NATURAL LEFT OUTER JOIN** *prereq*;
    - Equivalent to:
      SELECT *
      FROM *course* **LEFT OUTER JOIN** *prereq*
      USING (*course_id*);

course_id	title	dept_name	credits	prereq_id
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	<null>

    - **SELECT ***
      FROM *course* **LEFT OUTER JOIN** *prereq*
      ON *course.course_id* = *prereq.course_id*;

course.course_id	title	dept_name	credits	prereq.course_id	prereq_id
BIO-301	Genetics	Biology	4	BIO-301	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-190	CS-101
CS-315	Robotics	Comp. Sci.	3	<null>	<null>

Natural Joins Are Often Avoided

- *Natural joins are often avoided in practice*, because:
  - Natural joins are not particularly readable (by most SQL coders) and possibly not supported by various tools/libraries
  - Natural joins are not informative; you cannot tell what columns are being joined on without referring to the schema
  - Your join conditions are invisibly vulnerable to schema changes
    - Even if there are multiple natural join columns and one such column is removed from a table, the query will still execute
    - But the result may not be correct and this change in behavior will be silent
  - Hardly worth the effort; you are only saving about 10 seconds by not typing specific conditions

Agenda

- Join
- **Views**
- Window functions
- Keys

Views

- It is not always desirable for all users to see the entire logical model of data
  - *E.g.*, consider a user who needs to know an instructor name and department, but not the salary

    → This user only needs to see the following relation (in SQL):

    - **SELECT** *ID*, *name*, *dept_name*
      FROM *instructor*

- View: provides a mechanism to hide certain data from the view of certain users
  - A view is a relation defined in terms of stored tables (called *base tables*) and other views
  - Any relation that is not of the conceptual model but is made visible to a user as a "virtual relation" is called a view

Views

- Syntax:

  CREATE VIEW *v* **AS** < query expression >

  where <query expression> is any legal SQL expression, and *v* represents the view name

  - Once a view is defined, the view name can be used to refer to the virtual relation that the view generates
  - View definition is not the same as creating a new relation
  - A view definition causes the saving of an expression; the expression is substituted into queries using the view

View Examples

- A view of instructors without their salary:
  - **CREATE VIEW** *faculty* ***AS***
    SELECT *ID*, *name*, *dept_name*
    FROM *instructor*

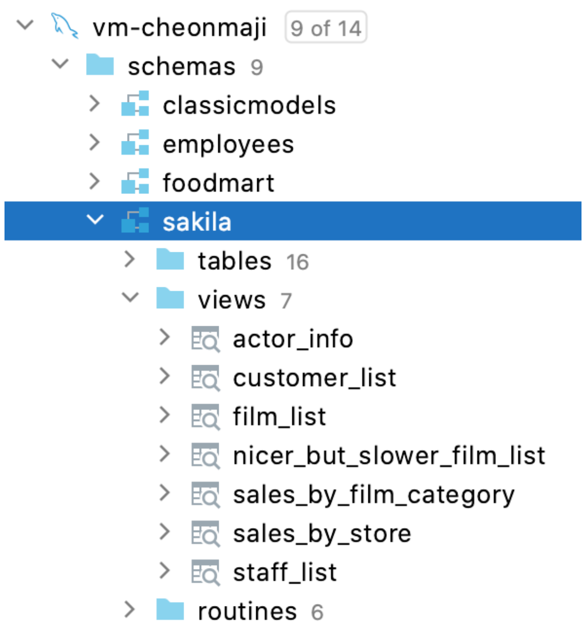
- Querying on a view is also possible:
  - **SELECT** *name*
    FROM *faculty*
    WHERE *dept_name* = 'Biology'

  - *C.f.*, find all instructors in the Biology department:
    - **SELECT** *name*
      FROM *instructor*
      WHERE *dept_name* = 'Biology'

View Examples

- The attribute names of a view can be specified explicitly
  - **CREATE VIEW** *departments_total_salary(dept_name, total_salary)* **AS**
    SELECT *dept_name*, **SUM**(*salary*)
    FROM *instructor*
    GROUP BY *dept_name*;
    - Since the expression **SUM**(*salary*) does not have a name, the attribute name is specified explicitly in the view definition

- The *sakila* database, in the Class VM image, includes 7 sample views



View Expansion

- View expansion: A way to define the meaning of views defined in terms of other views
  - Let view v_1 be defined by an expression e_1 that may itself contain uses of view relations
  - View expansion of an expression repeats the following replacement step:

    repeat

    Find any view relation v_i in e_1

    Replace the view relation v_i by the expression defining v_i

    until no more view relations are present in e_1
  - As long as the view definitions are not recursive, this loop will terminate

Views Defined Using Other Views

- One view may be used in the expression defining another view
  - A view relation v_1 is said to *depend directly* on a view relation v_2 if v_2 is used in the expression defining v_1
  - A view relation v_1 is said to *depend on* view relation v_2 if either v_1 depends directly to v_2 or there is a path of dependencies from v_1 to v_2
  - A view relation v is said to be *recursive* if it depends on itself

Views Defined Using Other Views

- Examples
  - **CREATE VIEW** *physics_fall_2017* **AS**
    SELECT *course*.*course_id*, *sec_id*, *building*, *room_number*
    FROM *course*, *section*
    WHERE *course*.*course_id* = *section*.*course_id*
    AND *course*.*dept_name* = 'Physics'
    AND *section*.*semester* = 'Fall'
    AND *section*.*year* = '2017';

  - **CREATE VIEW** *physics_fall_2017_watson* **AS**
    SELECT *course_id*, *room_number*
    FROM *physics_fall_2017*
    WHERE *building*= 'Watson';

Views Defined Using Other Views

- Both queries are equivalent (view expansion):
  - **CREATE VIEW** *physics_fall_2017_watson* **AS**
    SELECT *course_id, room_number*
    FROM *physics_fall_2017*
    WHERE *building*= 'Watson';

  - **CREATE VIEW** *physics_fall_2017_watson* **AS**
    SELECT *course_id, room_number*
    FROM (**SELECT** *course.course_id, sec_id, building, room_number*
    FROM *course, section*
    WHERE *course.course_id = section.course_id*
    AND *course.dept_name* = 'Physics'
    AND *section.semester* = 'Fall'
    AND *section.year* = '2017')
    WHERE *building*= 'Watson';

Materialized Views

- Two kinds of views
  - Virtual: not stored in the database; just a query for constructing the relation
  - Materialized: physically constructed and stored

- Materialized view: pre-calculated (materialized) result of a query
  - Unlike a simple VIEW the result of a Materialized View is stored somewhere, generally in a table
  - Used when:
    - Immediate response is needed
    - The query where the Materialized View bases on would take to long to produce a result
  - Materialized Views must be refreshed occasionally

- MySQL does NOT support materialized views

Update via a View

- Add a new tuple to *faculty* view which we defined earlier
  INSERT INTO *faculty* **VALUES** ('30765', 'Green', 'Music');
  - This insertion must be represented by the insertion into the *instructor* relation
    - Must have a value for salary

  - Must have a value for salary
    1) Reject the insert, OR
    2) Inset the tuple ('30765', 'Green', 'Music', null) into the *instructor* relation

Update via a View

- Some updates cannot be translated uniquely
  - *E.g.,* **CREATE VIEW** *instructor_info* **AS**
    SELECT *ID*, *name*, *building*
    FROM *instructor*, *department*
    WHERE *instructor*.*dept_name* = *department*.*dept_name*;

    then, **INSERT INTO** *instructor_info*
    VALUES ('69987', 'White', 'Taylor');

  - Issues
    - Which department, if multiple departments are in Taylor?
    - What if no department is in Taylor?
    - On MySQL, an "*SQL error (1394): Can not insert into join view without fields list*" occurs

Update via a View

- Example
  - **CREATE VIEW** *history_instructors* **AS**
    SELECT *
    FROM *instructor*
    WHERE *dept_name*='History';

view를 통해 insert 를 하면, 기존 테이블인 instructor 에 insert가 된다. 근데, view를 다시 실행 시켰을 때는 history만 가지고 오므로 결과에는 insert한 것이 보이지 않는다. 이런 오류(?)를 사전에 차단하고 싶다면, where clause다음에 with check dept_name = 'History' 조건을 추가하여 사전에 차단할 수 있다.

- What happens if one inserts ('25566', 'Brown', 'Biology', 100000) into *history_instructors*?
  - **INSERT INTO** history_instructors
    VALUES ('25566', 'Brown', 'Biology', 100000)

ID	name	dept_name	salary
32343	El Said	History	60000.00
58583	Califieri	History	62000.00

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000.00
12121	Wu	Finance	90000.00
15151	Mozart	Music	40000.00
22222	Einstein	Physics	95000.00
25566	Brown	Biology	100000.00
32343	El Said	History	60000.00
33456	Gold	Physics	87000.00
45565	Katz	Comp. Sci.	75000.00
58583	Califieri	History	62000.00
76543	Singh	Finance	80000.00
76766	Crick	Biology	72000.00
83821	Brandt	Comp. Sci.	92000.00
98345	Kim	Elec. Eng.	80000.00

Update via a View

- Most SQL implementations allow updates only on simple views
  - The **FROM** clause has only one database relation
  - The **SELECT** clause contains only attribute names of the relation, and does not have any expressions, aggregates, or **DISTINCT** specification
  - Any attribute not listed in the **SELECT** clause can be set to null
  - The query does not have a **GROUP BY** or **HAVING** clause

Agenda

- Join (cont'd)
- Views
- **Window functions**
- Keys

Window Functions in SQL

- First introduced to standard SQL in 2003
- Built-in functions that define the relationships between records
  - *"A window function performs a calculation across a set of table rows that are somehow related to the current row…Behind the scenes, the window function is able to access more than just the current row of the query result" (PostgreSQL)*
  - One can find ranks, percentiles, sums/averages, row numbers, *etc*.
- For aggregation functions, one can implement moving sums, moving averages, *etc*.
  - One can change the window sizes using the **WINDOW_FUNCTION** clause
- Cannot be used together with a **GROUP BY** clause
  - Both **PARTITION** and **GROUP BY** partition the data and compute some statistics
  - Does not reduce the number of records in the result

Window Functions in SQL

- Window function types
  - Aggregate window functions
    - **SUM**(), **MAX**(), **MIN**(), **AVG**(), **COUNT**(), …
  - Ranking window functions
    - **RANK**(), **DENSE_RANK**(), **PERCENT_RANK**(), **ROW_NUMBER**(), **NTILE**()
  - Value window functions
    - **LAG**(), **LEAD**(), **FIRST_VALUE**(), **LAST_VALUE**(), **CUME_DIST**(), **NTH_VALUE**()

Window Functions in SQL

약간 정규화가 잘되어있
는 테이블 하나 대상으로
는 partition을 쓸일
이 없을 것 같음. 근데
필요한 테이블 다 조인
해놓고 partition 을
쓰는 일이 많을 듯.

- Syntax
  - **SELECT WINDOW_FUNCTION** ([**ALL**] expression)
    OVER ([**PARTITION BY** partition_list] [**ORDER BY** order_list])
    FROM table;

    - **WINDOW_FUNCTION**: Specify the name of the window function
    - **ALL** (optional): When you will include ALL it will count all values including duplicates
      - *C.f.*, DISTINCT is not supported in window functions
    - **OVER**: Specifies the window clauses for aggregate functions
      - **PARTITION BY** partition_list: Defines the window (set of rows on which window function operates) for window functions
        - If **PARTITION BY** is not specified, grouping will be done on entire table and values will be aggregated accordingly
      - **ORDER BY** order_list: Sorts the rows within each partition
        - If **ORDER BY** is not specified, ORDER BY uses the entire table

Running Examples

- DEPT

DEPTNO	DNAME	LOC
10	ACCOUNTING	NEW YORK
20	RESEARCH	DALLAS
30	SALES	CHICAGO
40	OPERATIONS	BOSTON

- EMP

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7839	KING	PRESIDENT	NULL	1981-11-17	5000.00	NULL	10
7698	BLAKE	MANAGER	7839	1981-05-01	2850.00	NULL	30
7782	CLARK	MANAGER	7839	1981-05-09	2450.00	NULL	10
7566	JONES	MANAGER	7839	1981-04-01	2975.00	NULL	20
7654	MARTIN	SALESMAN	7698	1981-09-10	1250.00	1400.00	30
7499	ALLEN	SALESMAN	7698	1981-02-11	1600.00	300.00	30
7844	TURNER	SALESMAN	7698	1981-08-21	1500.00	0.00	30
7900	JAMES	CLERK	7698	1981-12-11	950.00	NULL	30
7521	WARD	SALESMAN	7698	1981-02-23	1250.00	500.00	30
7902	FORD	ANALYST	7566	1981-12-11	3000.00	NULL	20
7369	SMITH	CLERK	7902	1980-12-09	800.00	NULL	20
7788	SCOTT	ANALYST	7566	1982-12-22	3000.00	NULL	20
7876	ADAMS	CLERK	7788	1983-01-15	1100.00	NULL	20
7934	MILLER	CLERK	7782	1982-01-11	1300.00	NULL	10

Running Examples

- You can DIY…

```
CREATE TABLE DEPT
       (DEPTNO INT,
        DNAME VARCHAR(14),
        LOC VARCHAR(13) );

INSERT INTO DEPT VALUES (10, 'ACCOUNTING', 'NEW YORK');
INSERT INTO DEPT VALUES (20, 'RESEARCH',   'DALLAS');
INSERT INTO DEPT VALUES (30, 'SALES',      'CHICAGO');
INSERT INTO DEPT VALUES (40, 'OPERATIONS', 'BOSTON');

CREATE TABLE EMP (
 EMPNO                INT NOT NULL,
 ENAME                VARCHAR(10),
 JOB                  VARCHAR(9),
 MGR                  INT,
 HIREDATE             DATE,
 SAL                  DECIMAL(7,2),
 COMM                 DECIMAL(7,2),
 DEPTNO               INT);

INSERT INTO EMP VALUES (7839,'KING','PRESIDENT',NULL,'81-11-17',5000,NULL,10);
INSERT INTO EMP VALUES (7698,'BLAKE','MANAGER',7839,'81-05-01',2850,NULL,30);
INSERT INTO EMP VALUES (7782,'CLARK','MANAGER',7839,'81-05-09',2450,NULL,10);
INSERT INTO EMP VALUES (7566,'JONES','MANAGER',7839,'81-04-01',2975,NULL,20);
INSERT INTO EMP VALUES (7654,'MARTIN','SALESMAN',7698,'81-09-10',1250,1400,30);
INSERT INTO EMP VALUES (7499,'ALLEN','SALESMAN',7698,'81-02-11',1600,300,30);
INSERT INTO EMP VALUES (7844,'TURNER','SALESMAN',7698,'81-08-21',1500,0,30);
INSERT INTO EMP VALUES (7900,'JAMES','CLERK',7698,'81-12-11',950,NULL,30);
INSERT INTO EMP VALUES (7521,'WARD','SALESMAN',7698,'81-02-23',1250,500,30);
INSERT INTO EMP VALUES (7902,'FORD','ANALYST',7566,'81-12-11',3000,NULL,20);
INSERT INTO EMP VALUES (7369,'SMITH','CLERK',7902,'80-12-09',800,NULL,20);
INSERT INTO EMP VALUES (7788,'SCOTT','ANALYST',7566,'82-12-22',3000,NULL,20);
INSERT INTO EMP VALUES (7876,'ADAMS','CLERK',7788,'83-01-15',1100,NULL,20);
INSERT INTO EMP VALUES (7934,'MILLER','CLERK',7782,'82-01-11',1300,NULL,10);
```

Aggregation Example

- Sum over each manager
  - **SELECT** ENAME, SAL, MGR,
    SUM(SAL) **OVER** (**PARTITION BY** MGR) SUM_MGR
    FROM EMP;

ENAME	SAL	MGR	SUM_MGR
KING	5000.00	NULL	5000.00
FORD	3000.00	7566	6000.00
SCOTT	3000.00	7566	6000.00
MARTIN	1250.00	7698	6550.00
ALLEN	1600.00	7698	6550.00
TURNER	1500.00	7698	6550.00
JAMES	950.00	7698	6550.00
WARD	1250.00	7698	6550.00
MILLER	1300.00	7782	1300.00
ADAMS	1100.00	7788	1100.00
BLAKE	2850.00	7839	8275.00
CLARK	2450.00	7839	8275.00
JONES	2975.00	7839	8275.00
SMITH	800.00	7902	800.00

Ranking Example

- The base query:
  - **SELECT** EMPNO, ENAME, SAL,
    SUM(SAL) **OVER(ORDER BY** SAL
    ROWS BETWEEN UNBOUNDED PRECEDING
    AND UNBOUNDED FOLLOWING) TOTSAL
    FROM EMP;

```
unbounded preceding means
everything above me

unbounded following means
everything below me
```

EMPNO	ENAME	SAL	TOTSAL
7369	SMITH	800.00	29025.00
7900	JAMES	950.00	29025.00
7876	ADAMS	1100.00	29025.00
7654	MARTIN	1250.00	29025.00
7521	WARD	1250.00	29025.00
7934	MILLER	1300.00	29025.00
7844	TURNER	1500.00	29025.00
7499	ALLEN	1600.00	29025.00
7782	CLARK	2450.00	29025.00
7698	BLAKE	2850.00	29025.00
7566	JONES	2975.00	29025.00
7902	FORD	3000.00	29025.00
7788	SCOTT	3000.00	29025.00
7839	KING	5000.00	29025.00

Ranking Example

- A cumulative sum:
  - **SELECT** EMPNO, ENAME, SAL,
    SUM(SAL) **OVER**(**ORDER BY** SAL
    ROWS BETWEEN UNBOUNDED PRECEDING
    AND CURRENT ROW) TOTSAL
    FROM EMP;

EMPNO	ENAME	SAL	TOTSAL
7369	SMITH	800.00	800.00
7900	JAMES	950.00	1750.00
7876	ADAMS	1100.00	2850.00
7654	MARTIN	1250.00	4100.00
7521	WARD	1250.00	5350.00
7934	MILLER	1300.00	6650.00
7844	TURNER	1500.00	8150.00
7499	ALLEN	1600.00	9750.00
7782	CLARK	2450.00	12200.00
7698	BLAKE	2850.00	15050.00
7566	JONES	2975.00	18025.00
7902	FORD	3000.00	21025.00
7788	SCOTT	3000.00	24025.00
7839	KING	5000.00	29025.00

Ranking Example

- A table with the total rank and partitioned rank:
  - **SELECT** ENAME, SAL,
    RANK() OVER (**ORDER BY** SAL **DESC**) ALL_RANK,
    RANK() OVER (**PARTITION BY** JOB **ORDER BY** SAL **DESC**) JOB_RANK
    FROM EMP;

ENAME	SAL	ALL_RANK	JOB_RANK
FORD	3000.00	2	1
SCOTT	3000.00	2	1
MILLER	1300.00	9	1
ADAMS	1100.00	12	2
JAMES	950.00	13	3
SMITH	800.00	14	4
JONES	2975.00	4	1
BLAKE	2850.00	5	2
CLARK	2450.00	6	3
KING	5000.00	1	1
ALLEN	1600.00	7	1
TURNER	1500.00	8	2
MARTIN	1250.00	10	3
WARD	1250.00	10	3

Ranking Example

- A table with the total rank and partitioned rank:
  - **SELECT** ENAME, SAL,
    RANK() OVER (**ORDER BY** SAL **DESC**) ALL_RANK,
    DENSE_RANK() OVER (**PARTITION BY** JOB **ORDER BY** SAL **DESC**) JOB_RANK
    FROM EMP;

ENAME	SAL	ALL_RANK	JOB_RANK
FORD	3000.00	2	1
SCOTT	3000.00	2	1
MILLER	1300.00	9	1
ADAMS	1100.00	12	2
JAMES	950.00	13	3
SMITH	800.00	14	4
JONES	2975.00	4	1
BLAKE	2850.00	5	2
CLARK	2450.00	6	3
KING	5000.00	1	1
ALLEN	1600.00	7	1
TURNER	1500.00	8	2
MARTIN	1250.00	10	3
WARD	1250.00	10	3

Ranking Example

- A table with the total rank and partitioned rank:
  - **SELECT** ROW_NUMBER() **OVER** (**ORDER BY** SAL **DESC**) ROW_NUM,
    ENAME, SAL,
    RANK() **OVER** (**ORDER BY** SAL **DESC**) ALL_RANK
    FROM EMP;

ROW_NUM	ENAME	SAL	ALL_RANK
1	KING	5000.00	1
2	FORD	3000.00	2
3	SCOTT	3000.00	2
4	JONES	2975.00	4
5	BLAKE	2850.00	5
6	CLARK	2450.00	6
7	ALLEN	1600.00	7
8	TURNER	1500.00	8
9	MILLER	1300.00	9
10	MARTIN	1250.00	10
11	WARD	1250.00	10
12	ADAMS	1100.00	12
13	JAMES	950.00	13
14	SMITH	800.00	14

EOF

- Coming next:
  - Window functions

Running Examples

- DEPT

DEPTNO	DNAME	LOC
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20	RESEARCH	DALLAS
30	SALES	CHICAGO
40	OPERATIONS	BOSTON

- EMP

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7839	KING	PRESIDENT	NULL	1981-11-17	5000.00	NULL	10
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7782	CLARK	MANAGER	7839	1981-05-09	2450.00	NULL	10
7566	JONES	MANAGER	7839	1981-04-01	2975.00	NULL	20
7654	MARTIN	SALESMAN	7698	1981-09-10	1250.00	1400.00	30
7499	ALLEN	SALESMAN	7698	1981-02-11	1600.00	300.00	30
7844	TURNER	SALESMAN	7698	1981-08-21	1500.00	0.00	30
7900	JAMES	CLERK	7698	1981-12-11	950.00	NULL	30
7521	WARD	SALESMAN	7698	1981-02-23	1250.00	500.00	30
7902	FORD	ANALYST	7566	1981-12-11	3000.00	NULL	20
7369	SMITH	CLERK	7902	1980-12-09	800.00	NULL	20
7788	SCOTT	ANALYST	7566	1982-12-22	3000.00	NULL	20
7876	ADAMS	CLERK	7788	1983-01-15	1100.00	NULL	20
7934	MILLER	CLERK	7782	1982-01-11	1300.00	NULL	10

Running Examples

- You can DIY…

```
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       (DEPTNO INT,
        DNAME VARCHAR(14),
        LOC VARCHAR(13) );

INSERT INTO DEPT VALUES (10, 'ACCOUNTING', 'NEW YORK');
INSERT INTO DEPT VALUES (20, 'RESEARCH',   'DALLAS');
INSERT INTO DEPT VALUES (30, 'SALES',      'CHICAGO');
INSERT INTO DEPT VALUES (40, 'OPERATIONS', 'BOSTON');

CREATE TABLE EMP (
 EMPNO                INT NOT NULL,
 ENAME                VARCHAR(10),
 JOB                  VARCHAR(9),
 MGR                  INT,
 HIREDATE             DATE,
 SAL                  DECIMAL(7,2),
 COMM                 DECIMAL(7,2),
 DEPTNO               INT);

INSERT INTO EMP VALUES (7839,'KING','PRESIDENT',NULL,'81-11-17',5000,NULL,10);
INSERT INTO EMP VALUES (7698,'BLAKE','MANAGER',7839,'81-05-01',2850,NULL,30);
INSERT INTO EMP VALUES (7782,'CLARK','MANAGER',7839,'81-05-09',2450,NULL,10);
INSERT INTO EMP VALUES (7566,'JONES','MANAGER',7839,'81-04-01',2975,NULL,20);
INSERT INTO EMP VALUES (7654,'MARTIN','SALESMAN',7698,'81-09-10',1250,1400,30);
INSERT INTO EMP VALUES (7499,'ALLEN','SALESMAN',7698,'81-02-11',1600,300,30);
INSERT INTO EMP VALUES (7844,'TURNER','SALESMAN',7698,'81-08-21',1500,0,30);
INSERT INTO EMP VALUES (7900,'JAMES','CLERK',7698,'81-12-11',950,NULL,30);
INSERT INTO EMP VALUES (7521,'WARD','SALESMAN',7698,'81-02-23',1250,500,30);
INSERT INTO EMP VALUES (7902,'FORD','ANALYST',7566,'81-12-11',3000,NULL,20);
INSERT INTO EMP VALUES (7369,'SMITH','CLERK',7902,'80-12-09',800,NULL,20);
INSERT INTO EMP VALUES (7788,'SCOTT','ANALYST',7566,'82-12-22',3000,NULL,20);
INSERT INTO EMP VALUES (7876,'ADAMS','CLERK',7788,'83-01-15',1100,NULL,20);
INSERT INTO EMP VALUES (7934,'MILLER','CLERK',7782,'82-01-11',1300,NULL,10);
```

Aggregation Examples

- Average over each job
  - **SELECT** ENAME, SAL, JOB,
    AVG(SAL) **OVER** (**PARTITION BY** JOB) **AS** AVG_SAL_JOB
    FROM EMP;

데이터 참조 속도가 중요할 때는
partition by 를 쓰는 것이 유용할 듯.

ENAME	SAL	JOB	AVG_SAL_JOB
FORD	3000.00	ANALYST	3000.000000
SCOTT	3000.00	ANALYST	3000.000000
JAMES	950.00	CLERK	1037.500000
SMITH	800.00	CLERK	1037.500000
ADAMS	1100.00	CLERK	1037.500000
MILLER	1300.00	CLERK	1037.500000
BLAKE	2850.00	MANAGER	2758.333333
CLARK	2450.00	MANAGER	2758.333333
JONES	2975.00	MANAGER	2758.333333
KING	5000.00	PRESIDENT	5000.000000
MARTIN	1250.00	SALESMAN	1400.000000
ALLEN	1600.00	SALESMAN	1400.000000
TURNER	1500.00	SALESMAN	1400.000000
WARD	1250.00	SALESMAN	1400.000000

Aggregation Examples

- *C.f.*, Aggregation over groups
  - **SELECT** JOB, **AVG**(SAL)
    FROM EMP
    GROUP BY JOB;

데이터 정규화를 바로 하고 싶으면 group
by를 쓰는 것이 용량 절약이 될듯.

JOB	AVG(SAL)
PRESIDENT	5000.000000
MANAGER	2758.333333
SALESMAN	1400.000000
CLERK	1037.500000
ANALYST	3000.000000

Aggregation Examples

- Sum over each manager
  - **SELECT** ENAME, SAL, MGR,
    SUM(SAL) **OVER** (**PARTITION BY** MGR) **AS** SUM_MGR
    FROM EMP;

ENAME	SAL	MGR	SUM_MGR
KING	5000.00	NULL	5000.00
FORD	3000.00	7566	6000.00
SCOTT	3000.00	7566	6000.00
MARTIN	1250.00	7698	6550.00
ALLEN	1600.00	7698	6550.00
TURNER	1500.00	7698	6550.00
JAMES	950.00	7698	6550.00
WARD	1250.00	7698	6550.00
MILLER	1300.00	7782	1300.00
ADAMS	1100.00	7788	1100.00
BLAKE	2850.00	7839	8275.00
CLARK	2450.00	7839	8275.00
JONES	2975.00	7839	8275.00
SMITH	800.00	7902	800.00

Nonaggregation Examples

- Rank by salary
  - **SELECT** ENAME, SAL, JOB, HIREDATE,
    ROW_NUMBER() **OVER** (**ORDER BY** SAL) **AS** ROW_NUMBER_SAL,
    RANK() **OVER** (**ORDER BY** SAL) **AS** RANK_SAL,
    DENSE_RANK() **OVER** (**ORDER BY** SAL) **AS** DENSE_RANK_SAL
    FROM EMP;

ENAME	SAL	JOB	HIREDATE	ROW_NUMBER_SAL	RANK_SAL	DENSE_RANK_SAL
SMITH	800.00	CLERK	1980-12-09	1	1	1
JAMES	950.00	CLERK	1981-12-11	2	2	2
ADAMS	1100.00	CLERK	1983-01-15	3	3	3
MARTIN	1250.00	SALESMAN	1981-09-10	4	4	4
WARD	1250.00	SALESMAN	1981-02-23	5	4	4
MILLER	1300.00	CLERK	1982-01-11	6	6	5
TURNER	1500.00	SALESMAN	1981-08-21	7	7	6
ALLEN	1600.00	SALESMAN	1981-02-11	8	8	7
CLARK	2450.00	MANAGER	1981-05-09	9	9	8
BLAKE	2850.00	MANAGER	1981-05-01	10	10	9
JONES	2975.00	MANAGER	1981-04-01	11	11	10
FORD	3000.00	ANALYST	1981-12-11	12	12	11
SCOTT	3000.00	ANALYST	1982-12-22	13	12	11
KING	5000.00	PRESIDENT	1981-11-17	14	14	12

Nonaggregation Examples

- Rank by hiredate
  - **SELECT** ENAME, SAL, JOB, HIREDATE,
    ROW_NUMBER() **OVER** (**ORDER BY** HIREDATE) **AS** ROW_NUMBER_HIREDATE,
    RANK() **OVER** (**ORDER BY** HIREDATE) **AS** RANK_HIREDATE,
    DENSE_RANK() **OVER** (**ORDER BY** HIREDATE) **AS** DENSE_RANK_HIREDATE
    FROM EMP;

ENAME	SAL	JOB	HIREDATE	ROW_NUMBER_HIREDATE	RANK_HIREDATE	DENSE_RANK_HIREDATE
SMITH	800.00	CLERK	1980-12-09	1	1	1
ALLEN	1600.00	SALESMAN	1981-02-11	2	2	2
WARD	1250.00	SALESMAN	1981-02-23	3	3	3
JONES	2975.00	MANAGER	1981-04-01	4	4	4
BLAKE	2850.00	MANAGER	1981-05-01	5	5	5
CLARK	2450.00	MANAGER	1981-05-09	6	6	6
TURNER	1500.00	SALESMAN	1981-08-21	7	7	7
MARTIN	1250.00	SALESMAN	1981-09-10	8	8	8
KING	5000.00	PRESIDENT	1981-11-17	9	9	9
JAMES	950.00	CLERK	1981-12-11	10	10	10
FORD	3000.00	ANALYST	1981-12-11	11	10	10
MILLER	1300.00	CLERK	1982-01-11	12	12	11
SCOTT	3000.00	ANALYST	1982-12-22	13	13	12
ADAMS	1100.00	CLERK	1983-01-15	14	14	13

Nonaggregation Examples

- Rank by hiredate within each job
  - **SELECT** ENAME, SAL, JOB, HIREDATE,
    RANK() **OVER** (**PARTITION BY** JOB **ORDER BY** HIREDATE **DESC**) **AS** RANK_HIREDATE
    FROM EMP;

ENAME	SAL	JOB	HIREDATE	RANK_HIREDATE
SCOTT	3000.00	ANALYST	1982-12-22	1
FORD	3000.00	ANALYST	1981-12-11	2
ADAMS	1100.00	CLERK	1983-01-15	1
MILLER	1300.00	CLERK	1982-01-11	2
JAMES	950.00	CLERK	1981-12-11	3
SMITH	800.00	CLERK	1980-12-09	4
CLARK	2450.00	MANAGER	1981-05-09	1
BLAKE	2850.00	MANAGER	1981-05-01	2
JONES	2975.00	MANAGER	1981-04-01	3
KING	5000.00	PRESIDENT	1981-11-17	1
MARTIN	1250.00	SALESMAN	1981-09-10	1
TURNER	1500.00	SALESMAN	1981-08-21	2
WARD	1250.00	SALESMAN	1981-02-23	3
ALLEN	1600.00	SALESMAN	1981-02-11	4

Nonaggregation Examples

- Rank by hiredate within each job
  - **SELECT** ENAME, SAL, JOB, HIREDATE,
    RANK() **OVER** w **AS** RANK_HIREDATE
    FROM EMP
    WINDOW w **AS** (**PARTITION BY** JOB **ORDER BY** HIREDATE **DESC**);

ENAME	SAL	JOB	HIREDATE	RANK_HIREDATE
SCOTT	3000.00	ANALYST	1982-12-22	1
FORD	3000.00	ANALYST	1981-12-11	2
ADAMS	1100.00	CLERK	1983-01-15	1
MILLER	1300.00	CLERK	1982-01-11	2
JAMES	950.00	CLERK	1981-12-11	3
SMITH	800.00	CLERK	1980-12-09	4
CLARK	2450.00	MANAGER	1981-05-09	1
BLAKE	2850.00	MANAGER	1981-05-01	2
JONES	2975.00	MANAGER	1981-04-01	3
KING	5000.00	PRESIDENT	1981-11-17	1
MARTIN	1250.00	SALESMAN	1981-09-10	1
TURNER	1500.00	SALESMAN	1981-08-21	2
WARD	1250.00	SALESMAN	1981-02-23	3
ALLEN	1600.00	SALESMAN	1981-02-11	4

Nonaggregation Examples

- Percentile by salary within each job
  - **SELECT** ENAME, SAL, JOB, HIREDATE,
    RANK() **OVER** (**ORDER BY** SAL) **AS** RANK_SAL,
    CUME_DIST() **OVER** (**ORDER BY** SAL) **AS** CUME_DIST_SAL,
    PERCENT_RANK() **OVER** (**ORDER BY** SAL) **AS** PERCENT_RANK_SAL
    FROM EMP;

ENAME	SAL	JOB	HIREDATE	RANK_SAL	CUME_DIST_SAL	PERCENT_RANK_SAL
SMITH	800.00	CLERK	1980-12-09	1	0.07142857142857142	0
JAMES	950.00	CLERK	1981-12-11	2	0.14285714285714285	0.07692307692307693
ADAMS	1100.00	CLERK	1983-01-15	3	0.21428571428571427	0.15384615384615385
MARTIN	1250.00	SALESMAN	1981-09-10	4	0.35714285714285715	0.23076923076923078
WARD	1250.00	SALESMAN	1981-02-23	4	0.35714285714285715	0.23076923076923078
MILLER	1300.00	CLERK	1982-01-11	6	0.42857142857142855	0.38461538461538464
TURNER	1500.00	SALESMAN	1981-08-21	7	0.5	0.46153846153846156
ALLEN	1600.00	SALESMAN	1981-02-11	8	0.5714285714285714	0.5384615384615384
CLARK	2450.00	MANAGER	1981-05-09	9	0.6428571428571429	0.6153846153846154
BLAKE	2850.00	MANAGER	1981-05-01	10	0.7142857142857143	0.6923076923076923
JONES	2975.00	MANAGER	1981-04-01	11	0.7857142857142857	0.7692307692307693
FORD	3000.00	ANALYST	1981-12-11	12	0.9285714285714286	0.8461538461538461
SCOTT	3000.00	ANALYST	1982-12-22	12	0.9285714285714286	0.8461538461538461
KING	5000.00	PRESIDENT	1981-11-17	14	1	1

Nonaggregation Examples

- Percentile by salary within each job
  - **SELECT** ENAME, SAL, JOB, HIREDATE,
    RANK() **OVER** w **AS** RANK_SAL,
    CUME_DIST() **OVER** w **AS** CUME_DIST_SAL,
    PERCENT_RANK() **OVER** w **AS** PERCENT_RANK_SAL
    FROM EMP
    WINDOW w **AS** (**ORDER BY** SAL);

ENAME	SAL	JOB	HIREDATE	RANK_SAL	CUME_DIST_SAL	PERCENT_RANK_SAL
SMITH	800.00	CLERK	1980-12-09	1	0.07142857142857142	0
JAMES	950.00	CLERK	1981-12-11	2	0.14285714285714285	0.07692307692307693
ADAMS	1100.00	CLERK	1983-01-15	3	0.21428571428571427	0.15384615384615385
MARTIN	1250.00	SALESMAN	1981-09-10	4	0.35714285714285715	0.23076923076923078
WARD	1250.00	SALESMAN	1981-02-23	4	0.35714285714285715	0.23076923076923078
MILLER	1300.00	CLERK	1982-01-11	6	0.42857142857142855	0.38461538461538464
TURNER	1500.00	SALESMAN	1981-08-21	7	0.5	0.46153846153846156
ALLEN	1600.00	SALESMAN	1981-02-11	8	0.5714285714285714	0.5384615384615384
CLARK	2450.00	MANAGER	1981-05-09	9	0.6428571428571429	0.6153846153846154
BLAKE	2850.00	MANAGER	1981-05-01	10	0.7142857142857143	0.6923076923076923
JONES	2975.00	MANAGER	1981-04-01	11	0.7857142857142857	0.7692307692307693
FORD	3000.00	ANALYST	1981-12-11	12	0.9285714285714286	0.8461538461538461
SCOTT	3000.00	ANALYST	1982-12-22	12	0.9285714285714286	0.8461538461538461
KING	5000.00	PRESIDENT	1981-11-17	14	1	1

Running Examples

- Orders

ID	ORD_DATE	CUSTOMER_NAME	CITY	ORD_AMT
1001	2017-04-01	David Smith	GuildFord	10000.00
1002	2017-04-02	David Jones	Arlington	20000.00
1003	2017-04-03	John Smith	Shalford	5000.00
1004	2017-04-04	Michael Smith	GuildFord	15000.00
1005	2017-04-05	David Williams	Shalford	7000.00
1006	2017-04-06	Paum Smith	GuildFord	25000.00
1007	2017-04-10	Andrew Smith	Arlington	15000.00
1008	2017-04-11	David Brown	Arlington	2000.00
1009	2017-04-20	Robert Smith	Shalford	1000.00
1010	2017-04-25	Peter Smith	GuildFord	500.00

Running Examples

- You can DIY…

```
CREATE TABLE ORDERS
(
	ID INT,
	ORD_DATE DATE,
	CUSTOMER_NAME VARCHAR(250),
	CITY VARCHAR(100),
	ORD_AMT DECIMAL(9,2)
);

INSERT INTO ORDERS(ID, ORD_DATE, CUSTOMER_NAME, CITY, ORD_AMT)
SELECT '1001','2017-04-01','David Smith','GuildFord',10000
UNION ALL
SELECT '1002','2017-04-02','David Jones','Arlington',20000
UNION ALL
SELECT '1003','2017-04-03','John Smith','Shalford',5000
UNION ALL
SELECT '1004','2017-04-04','Michael Smith','GuildFord',15000
UNION ALL
SELECT '1005','2017-04-05','David Williams','Shalford',7000
UNION ALL
SELECT '1006','2017-04-06','Paum Smith','GuildFord',25000
UNION ALL
SELECT '1007','2017-04-10','Andrew Smith','Arlington',15000
UNION ALL
SELECT '1008','2017-04-11','David Brown','Arlington',2000
UNION ALL
SELECT '1009','2017-04-20','Robert Smith','Shalford',1000
UNION ALL
SELECT '1010','2017-04-25','Peter Smith','GuildFord',500;
```

Value Window Examples

- First and last records in each partition
  - **SELECT** ID, CITY, ORD_DATE,
    FIRST_VALUE(ORD_DATE) **OVER**(**PARTITION BY** CITY) **AS** FIRST_VAL,
    LAST_VALUE(ORD_DATE) **OVER**(**PARTITION BY** CITY) **AS** LAST_VAL
    FROM ORDERS;

ID	CITY	ORD_DATE	FIRST_VAL	LAST_VAL
1002	Arlington	2017-04-02	2017-04-02	2017-04-11
1007	Arlington	2017-04-10	2017-04-02	2017-04-11
1008	Arlington	2017-04-11	2017-04-02	2017-04-11
1001	GuildFord	2017-04-01	2017-04-01	2017-04-25
1004	GuildFord	2017-04-04	2017-04-01	2017-04-25
1006	GuildFord	2017-04-06	2017-04-01	2017-04-25
1010	GuildFord	2017-04-25	2017-04-01	2017-04-25
1003	Shalford	2017-04-03	2017-04-03	2017-04-20
1005	Shalford	2017-04-05	2017-04-03	2017-04-20
1009	Shalford	2017-04-20	2017-04-03	2017-04-20

Value Window Examples

- First and last records in each partition
  - **SELECT** ID, CUSTOMER_NAME, CITY, ORD_AMT, ORD_DATE,
    LAG(ORD_DATE,1) **OVER**(**ORDER BY** ORD_DATE) **AS** PREV_ORD_DAT,
    LEAD(ORD_DATE,1) **OVER**(**ORDER BY** ORD_DATE) **AS** NEXT_ORD_DAT
    FROM ORDERS;

ID	CUSTOMER_NAME	CITY	ORD_AMT	ORD_DATE	PREV_ORD_DAT	NEXT_ORD_DAT
1001	David Smith	GuildFord	10000.00	2017-04-01	NULL	2017-04-02
1002	David Jones	Arlington	20000.00	2017-04-02	2017-04-01	2017-04-03
1003	John Smith	Shalford	5000.00	2017-04-03	2017-04-02	2017-04-04
1004	Michael Smith	GuildFord	15000.00	2017-04-04	2017-04-03	2017-04-05
1005	David Williams	Shalford	7000.00	2017-04-05	2017-04-04	2017-04-06
1006	Paum Smith	GuildFord	25000.00	2017-04-06	2017-04-05	2017-04-10
1007	Andrew Smith	Arlington	15000.00	2017-04-10	2017-04-06	2017-04-11
1008	David Brown	Arlington	2000.00	2017-04-11	2017-04-10	2017-04-20
1009	Robert Smith	Shalford	1000.00	2017-04-20	2017-04-11	2017-04-25
1010	Peter Smith	GuildFord	500.00	2017-04-25	2017-04-20	NULL

Value Window Examples

- First and last records in each partition
  - **SELECT** ID, CUSTOMER_NAME, CITY, ORD_AMT, ORD_DATE,
    LAG(ORD_DATE,2) **OVER**(**ORDER BY** ORD_DATE) **AS** PREV_ORD_DAT,
    LEAD(ORD_DATE,2) **OVER**(**ORDER BY** ORD_DATE) **AS** NEXT_ORD_DAT
    FROM ORDERS;

ID	CUSTOMER_NAME	CITY	ORD_AMT	ORD_DATE	PREV_ORD_DAT	NEXT_ORD_DAT
1001	David Smith	GuildFord	10000.00	2017-04-01	NULL	2017-04-03
1002	David Jones	Arlington	20000.00	2017-04-02	NULL	2017-04-04
1003	John Smith	Shalford	5000.00	2017-04-03	2017-04-01	2017-04-05
1004	Michael Smith	GuildFord	15000.00	2017-04-04	2017-04-02	2017-04-06
1005	David Williams	Shalford	7000.00	2017-04-05	2017-04-03	2017-04-10
1006	Paum Smith	GuildFord	25000.00	2017-04-06	2017-04-04	2017-04-11
1007	Andrew Smith	Arlington	15000.00	2017-04-10	2017-04-05	2017-04-20
1008	David Brown	Arlington	2000.00	2017-04-11	2017-04-06	2017-04-25
1009	Robert Smith	Shalford	1000.00	2017-04-20	2017-04-10	NULL
1010	Peter Smith	GuildFord	500.00	2017-04-25	2017-04-11	NULL

Frame Specification

- A frame is a subset of the current partition, and the frame clause specifies how to define the subset
  - Frames are determined with respect to the current row
    - By defining a frame to be all rows from the partition start to the current row, one can compute running totals for each row
    - By defining a frame as extending *N* rows on either side of the current row, one can compute rolling averages

    - **ROWS**: The frame is defined by beginning and ending row positions (physical window)
    - **RANGE**: The frame is defined by rows within a value range (logical window)
    - **BETWEEN … AND …**: Specify both frame endpoints
      - **UNBOUNDED PRECEDING**: The bound is the first partition row
      - **UNBOUNDED FOLLOWING**: The bound is the last partition row
    - **CURRENT ROW**: For **ROWS**, the bound is the current row; For **RANGE**, the bound is the peers of the current row

Frame Specification Examples

- Sum over each partition
  - **SELECT** ID, CITY, ORD_AMT, ORD_DATE,
    AVG(ORD_AMT) **OVER**(**PARTITION BY** CITY **ORDER BY** ORD_DATE
    ROWS BETWEEN UNBOUNDED PRECEDING
    AND UNBOUNDED FOLLOWING
) **AS** AVG_AMT
    FROM ORDERS;

ID	CITY	ORD_AMT	ORD_DATE	AVG_AMT
1002	Arlington	20000.00	2017-04-02	12333.333333
1007	Arlington	15000.00	2017-04-10	12333.333333
1008	Arlington	2000.00	2017-04-11	12333.333333
1001	GuildFord	10000.00	2017-04-01	12625.000000
1004	GuildFord	15000.00	2017-04-04	12625.000000
1006	GuildFord	25000.00	2017-04-06	12625.000000
1010	GuildFord	500.00	2017-04-25	12625.000000
1003	Shalford	5000.00	2017-04-03	4333.333333
1005	Shalford	7000.00	2017-04-05	4333.333333
1009	Shalford	1000.00	2017-04-20	4333.333333

Frame Specification Examples

- A 2-record moving average
  - **SELECT** ID, CITY, ORD_AMT, ORD_DATE,
    AVG(ORD_AMT) **OVER**(**PARTITION BY** CITY **ORDER BY** ORD_DATE
    ROWS BETWEEN 1 **PRECEDING**
    AND 0 **FOLLOWING**
) **AS** AVG_AMT
    FROM ORDERS;

ID	CITY	ORD_AMT	ORD_DATE	AVG_AMT
1002	Arlington	20000.00	2017-04-02	20000.000000
1007	Arlington	15000.00	2017-04-10	17500.000000
1008	Arlington	2000.00	2017-04-11	8500.000000
1001	GuildFord	10000.00	2017-04-01	10000.000000
1004	GuildFord	15000.00	2017-04-04	12500.000000
1006	GuildFord	25000.00	2017-04-06	20000.000000
1010	GuildFord	500.00	2017-04-25	12750.000000
1003	Shalford	5000.00	2017-04-03	5000.000000
1005	Shalford	7000.00	2017-04-05	6000.000000
1009	Shalford	1000.00	2017-04-20	4000.000000

Frame Specification Examples

- A 2-record moving average
  - **SELECT** ID, CITY, ORD_AMT, ORD_DATE,
    AVG(ORD_AMT) **OVER**(**PARTITION BY** CITY **ORDER BY** ORD_DATE
    ROWS BETWEEN 1 **PRECEDING**
    AND CURRENT ROW
) **AS** AVG_AMT
    FROM ORDERS;

ID	CITY	ORD_AMT	ORD_DATE	AVG_AMT
1002	Arlington	20000.00	2017-04-02	20000.000000
1007	Arlington	15000.00	2017-04-10	17500.000000
1008	Arlington	2000.00	2017-04-11	8500.000000
1001	GuildFord	10000.00	2017-04-01	10000.000000
1004	GuildFord	15000.00	2017-04-04	12500.000000
1006	GuildFord	25000.00	2017-04-06	20000.000000
1010	GuildFord	500.00	2017-04-25	12750.000000
1003	Shalford	5000.00	2017-04-03	5000.000000
1005	Shalford	7000.00	2017-04-05	6000.000000
1009	Shalford	1000.00	2017-04-20	4000.000000

Frame Specification Examples

- A 3-day moving average
  - ```
    SELECT ID, ORD_DATE, ORD_AMT,
      AVG(ORD_AMT) OVER(ORDER BY ORD_DATE
                 RANGE BETWEEN INTERVAL 2 DAY PRECEDING
                 AND CURRENT ROW
      ) AS AVG_AMT
    FROM ORDERS;
    ```

ID	ORD_DATE	ORD_AMT	AVG_AMT
1001	2017-04-01	10000.00	10000.000000
1002	2017-04-02	20000.00	15000.000000
1003	2017-04-03	5000.00	11666.666667
1004	2017-04-04	15000.00	13333.333333
1005	2017-04-05	7000.00	9000.000000
1006	2017-04-06	25000.00	15666.666667
1007	2017-04-10	15000.00	15000.000000
1008	2017-04-11	2000.00	8500.000000
1009	2017-04-20	1000.00	1000.000000
1010	2017-04-25	500.00	500.000000
    ```

Agenda

- Join (cont’d)
- Views
- Window functions
- **Keys**

Keys

- Key: An attribute or a set of attributes, which help(s) uniquely identify a tuple of data in a relation

EmployeeID	Name	Branch	Email
10201	Cooper	DBMI	cooper@institute.edu
10203	Abraham	DBMI	laboriel@institute.edu
10204	Abraham	CS	abe@institute.edu
10207	Elly	EE	elly@institute.edu

  - Q: Which of the attributes can be a key?

Keys

- Key: An attribute or a set of attributes, which help(s) uniquely identify a tuple of data in a relation
  - Why we need keys?
    - To force identity of data and
    - To ensure integrity of data is maintained
    - To establish relationship between relations
  - Types of Keys
    - Super key
    - Candidate key
    - Primary key
    - Alternate key
    - Foreign key
    - Composite key
    - Compound key
    - Surrogate key

Super Keys

- Any possible unique identifier
- Any attribute or any set of attributes that can be used to identify tuple of data in a relation; *i.e.*, any of
  - Attributes with unique values or
  - Combinations of the attributes
  - *E.g.*,

EmployeeID	FileCD	Name	Branch	Email
10201	D-201-C	Cooper	DBMI	cooper@institute.edu
10203	D-203-A	Abraham	DBMI	laboriel@institute.edu
10204	C-204-A	Abraham	CS	abe@institute.edu
10207	E-207-E	Elly	EE	elly@institute.edu

Candidate Keys

- Minimal subset of super key
  - If any proper subset of a super key is also a super key, then that (super key) cannot be a candidate key
  - *E.g.,*

EmployeeID	FileCD	Name	Branch	Email
10201	D-201-C	Cooper	DBMI	cooper@institute.edu
10203	D-203-A	Abraham	DBMI	laboriel@institute.edu
10204	C-204-A	Abraham	CS	abe@institute.edu
10207	E-207-E	Elly	EE	elly@institute.edu

➔ *EmployeeID* *EmployeeID + FileCD* *EmployeeID + FileCD + Email*

FileCD *EmployeeID + Email*

Email *FileCD + Email*

Primary Keys (PKs)

- The candidate key chosen to uniquely identify each row of data in a relation
  - No two rows can have the same PK value
  - PK value cannot be NULL (every row must have a primary key value)

EmployeeID	FileCD	Name	Branch	Email
10201	D-201-C	Cooper	DBMI	cooper@institute.edu
10203	D-203-A	Abraham	DBMI	laboriel@institute.edu
10204	C-204-A	Abraham	CS	abe@institute.edu
10207	E-207-E	Elly	EE	elly@institute.edu

➔ *EmployeeID*

FileCD ***Pick any one as PK***

Email

Alternate Keys

- The candidate keys that are NOT chosen as PK in a relation

EmployeeID	FileCD	Name	Branch	Email
10201	D-201-C	Cooper	DBMI	cooper@institute.edu
10203	D-203-A	Abraham	DBMI	laboriel@institute.edu
10204	C-204-A	Abraham	CS	abe@institute.edu
10207	E-207-E	Elly	EE	elly@institute.edu

➔ *EmployeeID*

FileCD

Email

If we choose EmployeeID as PK,
then FileCD and Email become alternate keys

Foreign Keys

- An attribute in a relation that is used to define its relationship with another relation
  - Using foreign key helps in maintaining data integrity for tables in relationship

Employee

EmployeeID	FileCD	Name	Branch	Email
10201	D-201-C	Cooper	DBMI	cooper@institute.edu
10203	D-203-A	Abraham	DBMI	laboriel@institute.edu
10204	C-204-A	Abraham	CS	abe@institute.edu
10207	E-207-E	Elly	EE	elly@institute.edu

Branch

Branch	Address
DBMI	5607 Baum Blvd
CS	260 S Bouquet St
EE	3700 O'Hara St
BIO	4249 Fifth Ave

Composite & Compound Keys

- Composite key: Any key with more than one attribute
  - *E.g.,*

EmployeeID	FileCD	Name	Branch	Email
10201	D-201-C	Cooper	DBMI	cooper@institute.edu
10203	D-203-A	Abraham	DBMI	laboriel@institute.edu
10204	C-204-A	Abraham	CS	abe@institute.edu
10207	E-207-E	Elly	EE	elly@institute.edu

➔ *EmployeeID + FileCD,   EmployeeID + Email,   FileCD + Email*

EmployeeID + FileCD + Email

- Compound key: A composite key that has at least one attribute, which is a foreign key
  - *E.g.*, Let us assume that we have defined a composite key (FileCD, Branch), it is also a compound key (considering the Branch table)

Surrogate Keys

- If a relation has no attribute that can be used as a key, then we create an artificial attribute for this purpose
  - It adds no meaning to the data, but serves the sole purpose of identifying tuples uniquely in a table
    - ◯◯◯◯_ID with auto increment

EOF

- Coming next:
  - Transactions