LEADS 3-Day Camp
Session 3: Data Management: Relational Databases and SQL

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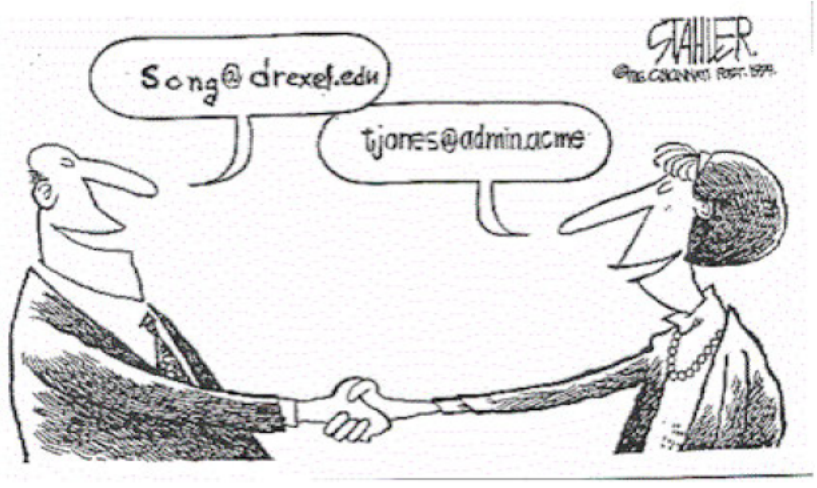
Hello!



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Instructor

- Professor, College of Computing & Informatics, Drexel University,
- PhD in CS, LSU, Baton Rouge, USA, 1988
- PhD Program Director (2010-2015)
- CVDI Deputy Director (2012-2014)
- Research Topics: *Conceptual Modeling*, *Data Warehousing*, *Big Data Management and Data Analytics*, *Smart Aging*
- Elected as an **ER Fellow,** 2012
- Named an **ACM Distinguished Scientist** in 2013
- Received **Peter Chen Award in Conceptual Modeling** in 2015
- Four teaching awards from Drexel (1991, 2000, 2001, 2011) including **Lindback Distinguished Teaching Award** (2001)
- **Co-Editor-in-Chief**, Journal of Computing Science & Engineering
- **Consulting Editor**, Data & Knowledge Engineering Journal
- **Co-Chair**, **iSchool Model Data Science Curriculum Committee**
- **Chair, IEEE Big Data and Smart Computing (BigComp) Conference**
- Published about 200+ papers

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Acknowledgement

- Materials from:
  - Drexel CCI INFO 605 and 606 Class (Il-Yeol Song)
  - Some diagrams and examples from

    Carlos Coronel and Steven Morris, Database Systems: Design, Implementation, and Management, 13th Edition, 2017. Cengage Learning.

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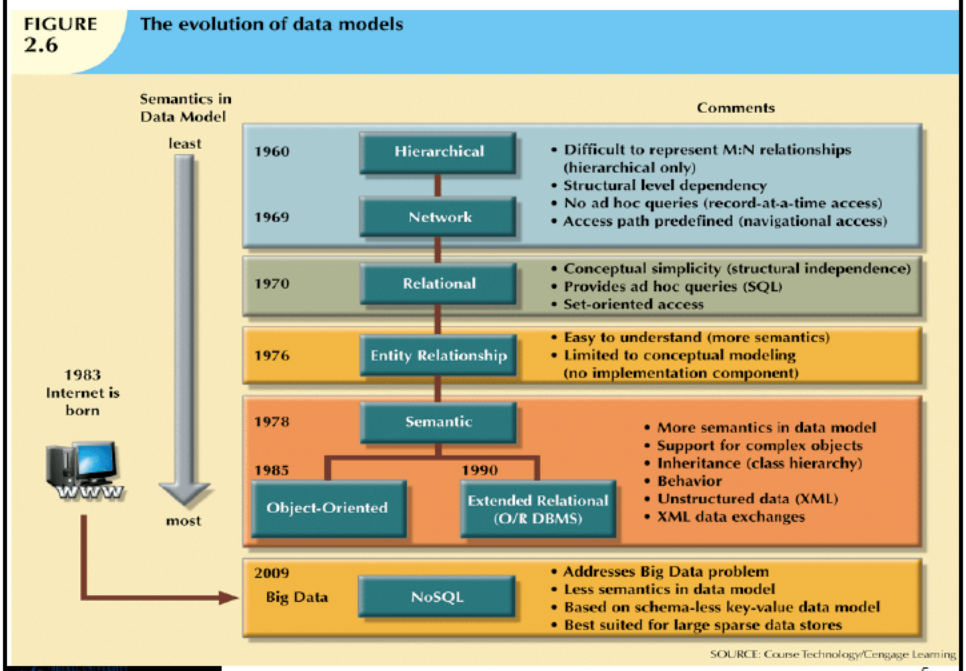

(Coronel & Morris, 2017)

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Basics in the Relational Model

- Data representation: a set of tables with structured data
- Primary keys (Candidate key, Alternate keys)
- Foreign Key
- Referential Integrity constrains
- Integrity constraints in RDBMSs
- Null values
- Metadata and Data Dictionary
- Relational schema design using ER diagrams
- Normalization (FD, MVD, JD) and Normal Forms
- SQL (*Aggregation, Subquery, JOIN*, PL/SQL functions/procedures/triggers)
- ACID property in multi-user transactions
- Why relational databases have been popular in industry?

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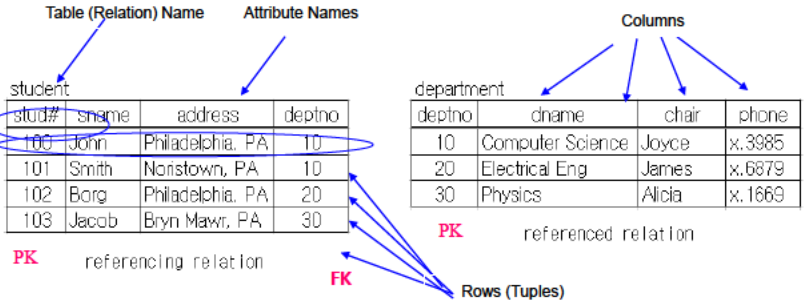
Terminology in RDB

Relational Schema

STUDENT (**stud#,** sname, address, deptno)
DEPARTMENT (**deptno,** dname, chair, phone)



A **Primary Key (PK)** uniquely identifies each row.
A **Foreign Key (FK)** is a set of attributes
that are primary key values from another table.

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Characteristics of Relational Model

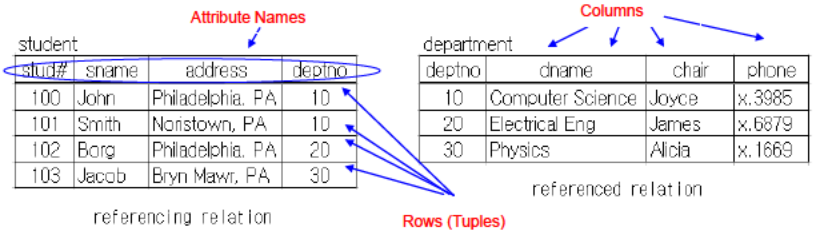

TABLE 3.1 **Characteristics of a Relational Table**

1	A table is perceived as a two-dimensional structure composed of rows and columns.
2	Each table row (**tuple**) represents a single entity occurrence within the entity set.
3	Each table column represents an attribute, and each column has a distinct name.
4	Each row/column intersection represents a single data value.
5	All values in a column must conform to the same data format.
6	Each column has a specific range of values known as the **attribute domain**.
7	The order of the rows and columns is immaterial to the DBMS.
8	Each table must have an attribute or a combination of attributes that uniquely identifies each row.

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Example of a DDL in SQL
Defining a Relational Schema

student

stud#	sname	address	deptno
100	John	Philadelphia, PA	10
101	Smith	Norristown, PA	10
102	Borg	Philadelphia, PA	20
103	Jacob	Bryn Mawr, PA	30

referencing relation

department

deptno	dname	chair	phone
10	Computer Science	Joyce	x 3985
20	Electrical Eng	James	x 6879
30	Physics	Alicia	x 1669

referenced relation

```
CREATE TABLE Department (
        DeptNo          NUMBER(5)       PRIMARY KEY,
        DName           VARCHAR2(15)    NOT NULL        ,
        Chair           VARCHAR2 (20)                   ,
        Phone           CHAR (10)                       ,
        );

CREATE TABLE Student (
        Stud#           NUMBER(8)                       ,
        SName           VARCHAR2(20)    NOT NULL        ,
        Address         VARCHAR2 (40)                   ,
        DeptNo          NUMBER (5)                      ,
        CONSTRAINT Stud_PK  PRIMARY KEY (Stud#)         ,
         CONSTRAINT Stud_FK FOREIGN KEY (DeptNo)
                REFERENCES Department (DeptNo)
        );
```


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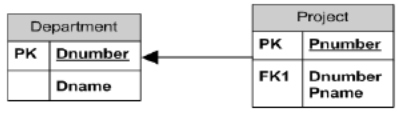
ER Model: Popular Notations

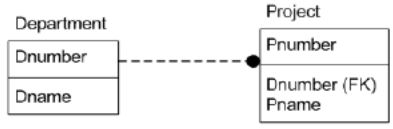
Chen

Visio 's Relational notation

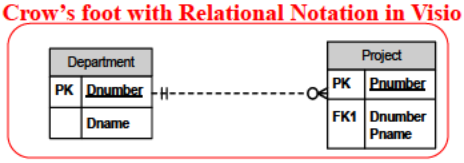


UML

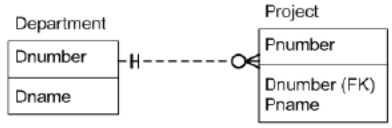
IDEF1X



Crow's foot with Relational Notation in Visio



Visio IDEF1X with Crow's foot



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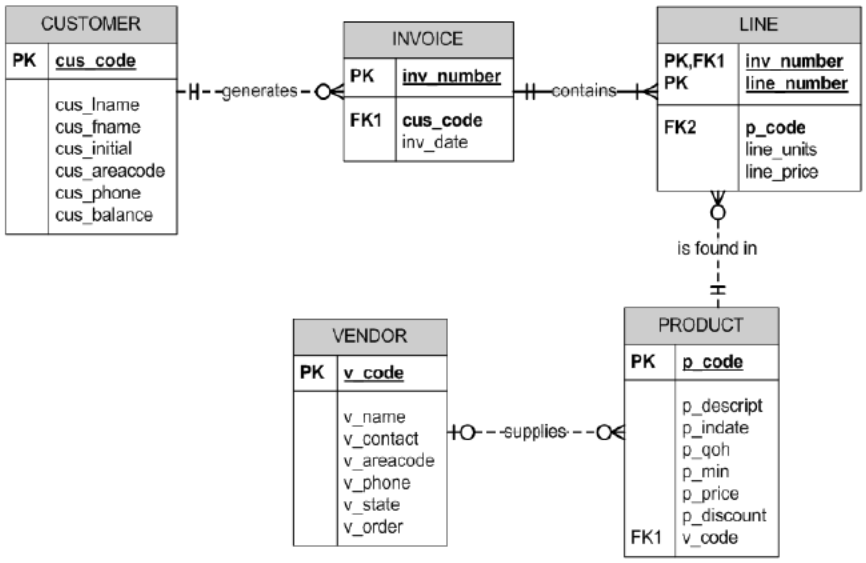
ERD for Relational DBs



(Coronel & Morris, 2016)

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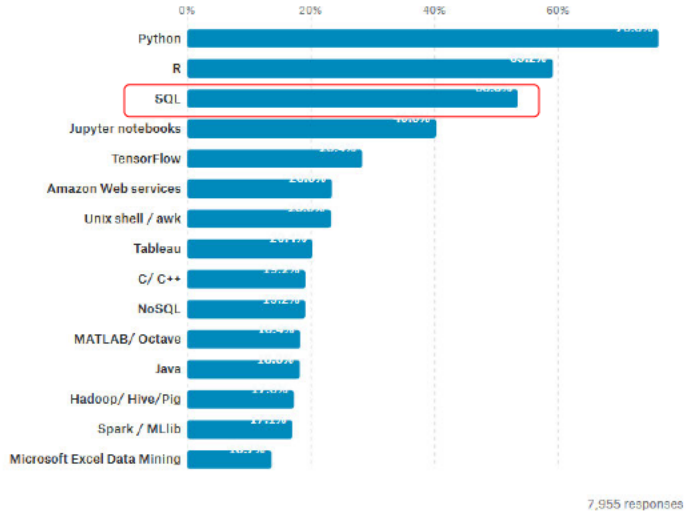
Why Relational Databases?

- Logical simplicity of the schema: Tables
- Easy, powerful, standard database language: **SQL**
- Transaction reliability: ACID property (Atomicity, Consistency, Isolation, Durability)

- Ad-hoc query processing
- Mature and reliable technologies
- Commercial investment for the last 40 years
- A large group of man-power and user bases

Top Tools used in Data Science (2017)



Source: https://www.kaggle.com/surveys/2017

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Top Desired Skills in Data Science (2021)

11 Skills Data Scientists Need

1. Data Visualization
2. Python
3. SQL/NoSQL
4. Social Media Mining
5. Fundamental Statistics
6. Natural Language Processing/Machine Learning
7. Microsoft Excel
8. High-Level Math
9. Teamwork
10. Communication
11. Business Savvy

Source: https://bootcamp.berkeley.edu/blog/data-scientist-skills/

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Two major Components of SQL

Data Definition Language (DDL)

- CREATE TABLE
- ALTER TABLE
- DROP TABLE
- CREATE/DROP VIEW
- CREATE/DROP INDEX

Data Manipulation Language(DML)

- UPDATE TABLE
- INSERT INTO
- DELETE FROM
- SELECT FROM

DDL manages metadata
DML manages data

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A Typical SQL Statement and Rules

STUDENT

ID	Name	EnrollYear

- SELECT enrollyear FROM student WHERE name ='John';
- SQL statement comprises
  - Keywords
    - Case-insensitive
    - Basic command set: fewer than 100 English words
    - Space-independent
  - User-defined word (table names, attribute names)
    - Case-insensitive
  - Data
    - **Case-sensitive** (In MS Access, case-insensitive)
  - Ends with a semi-colon

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An Overview of SQL Commands

DDL

--Changing attribute type

```
ALTER TABLE project
    MODIFY (budget
    NUMBER(9,2));
```

--Adding an attribute

```
ALTER TABLE project ADD
    (manager CHAR(10) );
```

-- Delete a column from a table

```
ALTER TABLE project
    DROP COLUMN
    manager;
```

--Removing a table from database

```
DROP TABLE project;
```

DML

--Inserting a row to a table

```
INSERT INTO project VALUES (1234,
'Perfect Project', NULL, 'John');
```

--Changing a value of attribute

```
UPDATE project SET budget =
1.1*budget WHERE projno > 1000;
```

--Deleting a row from a table

```
DELETE FROM project WHERE
manager = 'John';
```


Queries using SELECT Statement

SELECT	**Specifies which columns are to appear in output**
FROM	**Specifies table(s) to be used**
WHERE	**Filters rows with conditions**
GROUP BY	**Forms groups of rows with same column value.**
HAVING	**Filters groups subject to some condition.**
ORDER BY	**Specifies the order of the output.**

- ***Only SELECT and FROM are mandatory.***
- ***Order of the clauses cannot be changed.***

An Overview of Simple Commands

(1) **SELECT** * **FROM** Instructor;

(2) **SELECT DISTINCT** fName **FROM** Instructor;

(3) **SELECT** fName, lName, ssn **FROM** Instructor
WHERE deptCode = 'math';

(4) **SELECT** fName, lName **FROM** Instructor
WHERE bonus > 1000;

(5) **SELECT** * **FROM** Instructor
WHERE (bonus >= 500 **AND** bonus <= 1000);

(6) **SELECT** * **FROM** Instructor **WHERE** deptCode **IS NULL**;

(7) **SELECT** * **FROM** Instructor **WHERE** deptCode **IS NOT NULL**;

(8) **SELECT** * **FROM** Instructor **WHERE** bonus **BETWEEN** 500 **AND** 1000;

(9) **SELECT** * **FROM** HR **WHERE** hireDate **BETWEEN** '01-MAY-2012' **AND** '31-MAY-2012';

(10) **SELECT** * **FROM** Instructor **WHERE** bonus **IN** (100, 200, 300);

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An Overview of Simple Commands

(11) SELECT * FROM Instructor
WHERE position = 'assistant';

(12) SELECT * FROM R
WHERE lName > 'S';

(13) SELECT * FROM Instructor
WHERE fName **LIKE** 'J%';

(14) SELECT * FROM Instructor
WHERE fName **LIKE** 'J_h_';

(15) SELECT fName, lName FROM Instructor
WHERE address **LIKE** '**%**Houston,TX**%**';

(16) SELECT (salary+bonus) FROM Instructor;

(17) SELECT (salary+bonus) **AS** total_income FROM Instructor;

(18) SELECT ((A1/3.14)*2.54) **AS** A1_IN_CM FROM R;

(19)SELECT **SYSDATE** AS TODAY FROM **DUAL**;

(20) **SELECT** Fname, Lname, Bday,
TRUNC (**MONTHS_BETWEEN** (**SYSDATE**, Bday)/12) **AS** "Actual Age"
FROM Person;

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DATE Manipulation

- Show today's date in the form of MM/DD/YYYY format

```
SELECT SYSDATE, TO_CHAR(SYSDATE, 'MM/DD/YYYY') as
  CurrDate  FROM DUAL;
```

- Show today's date including time

```
SELECT SYSDATE, TO_CHAR(SYSDATE, 'yyyy-mm-dd hh24:mi:ss')
  as CurrDateTime   FROM DUAL;
```

- Find products whose INDATE is more than 90 days old

```
SELECT      P_Code, P_Desc, P_Indate
FROM        Product
WHERE       P_Indate <= SYSDATE - 90;
```

- Find all the orders received in Feb 2021.

```
SELECT Order#, Odate
FROM ORDER
WHERE Odate BETWEEN '01-Feb-21' AND '28-Feb-21';
```


STRING Manipulation

- **Concatenating strings**

```
SQL> SELECT Lname||', '||Fname  "FULL NAME"   FROM Emp;
```

will display

```
FULL NAME
Bond, James
```

- **Handling Capitalization**

```
SQL> SELECT Lname, INITCAP(Lname), UPPER(Lname), LOWER(Lname)
 FROM Emp;
```

- **Capitalization:** Show only the first letter in capital and the rest in lower

```
SQL> SELECT INITCAP(LOWER(Lname)) FROM Emp;
```

- **Padding blanks to strings**

RPAD: Pad to the right side of the column with left justification
LPAD: Pad to the left side of the column with right justification

```
SQL> SELECT RPAD(Lname, 15, '.'), Age, LPAD(Lname, 15), FROM EMP:
      Clinton.....      53              ……..Clinton
      Gore.....         52              ……….Gore
```

STRING Manipulation

/* **TRIM** function is used to remove all leading or trailing characters (or both) from a character string.*/
SQL>SELECT TRIM(“ LEADING Fellows “) FROM DUAL;

/* Use of **LTRIM**(left trim) and **RTRIM**(right trim) functions*/
SQL> SELECT Lname, **LTRIM**(Lname, 'SA'), **RTRIM**(Lname, 'S')
FROM Emp;
(LTRIM prints M from SAM, RTRIM prints WALE from WALES)

/* Remove **."** at the end and **"THE** from the front */
SQL> SELECT **LTRIM** (**RTRIM** (Title,'.'"), ‘ “THE ') FROM Magazine;
Will convert
MY DARING."
"THE GOD FATHER."
into
MY DARING
GOD FATHER

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STRING Manipulation

/* INSTR(string, set [, start [, occurrence]]) return the position number where in the ***string*** it found the “**set**”, starting ***from the start position*** */

/*Show names and the position number which have 'E' in the 5th or greater position */
SQL> SELECT Lname, **INSTR**(Lname, 'E', 5) "AFTER FIVE"
FROM Emp;

/* **SUBSTR**(String, starting_position, #chars to be returned)
Extract numeric part, add 1000, and concatenate */
SQL> SELECT Lname, E_ID,
'S' || TO_CHAR(TO_NUMBER (**SUBSTR** (E_ID,2,3)) + 1000) "NEW E_#"
FROM Emp;

Will display

LNAME	E_ID	NEW E_#
Jones	E001	S1001
Wales	E002	S1002

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Aggregation

- Example of five aggregation functions

  SELECT **MAX**(bonus), **MIN**(bonus), **AVG**(bonus), **COUNT**(bonus), **SUM**(bonus)
  FROM Instructor
  WHERE position = 'assistant';

- Note: What's wrong with the following?

  SELECT instructorID, bonus
  FROM Instructor
  WHERE bonus > **AVG**(bonus);

  We can use aggregate functions only in **SELECT** and **HAVING** clause

- How many different course titles are there?

  SELECT **COUNT**(**DISTINCT** title) AS count
  FROM Course;

Descriptive Statistics in SQL

- **SELECT** cus_fname, cus_lname, cus_balance
  AVG(cus_balance) mean,
  MEDIAN (cus_balance) median,
  STATS_MODE (cus_balance) mode,
  STDDEV (cus_balance) "Standard Deviation"
  FROM Product;

CUSTOMER	
PK	cus_code
	cus_lname cus_fname cus_initial cus_areacode cus_phone cus_balance

- Computing median over partition

SELECT cus_fname, cus_lname, cus_balance
MEDIAN (cus_balance) **OVER** (**PARTITION BY** cus_areacode) AS median
FROM Product;

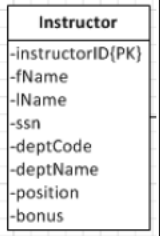
- Computing SD over unique values

SELECT cus_fname, cus_lname, cus_balance
STDDEV (**DISTINCT** cus_balance) **FROM** Product;

Aggregation with GROUP BY

Find the total number of instructors in each department and the sum of their bonus, respectively

```
SELECT    deptCode, COUNT(instructorID)  AS count, SUM(bonus) AS sum
FROM      Instructor
GROUP BY  deptCode
ORDER BY  deptCode;
```



•Result:

deptCode	count	sum
acct	2	1100
math	2	300

•***GROUP BY*** *must include* ***all non-aggregate function column names*** *in the* ***SELECT*** *list.*

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Aggregation with GROUP BY and HAVING

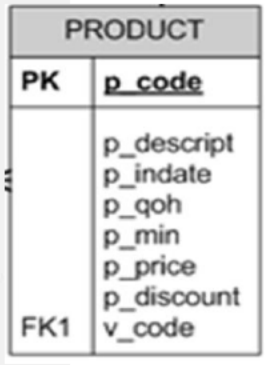
```
Oracle SQL*Plus
File  Edit  Search  Options  Help
SQL> SELECT V_CODE, COUNT(DISTINCT (P_CODE)), AVG(P_PRICE)
  2  FROM PRODUCT
  3  GROUP BY V_CODE;

    V_CODE COUNT(DISTINCT(P_CODE)) AVG(P_PRICE)
---------- ---------------------- ------------
     21225                      2         8.47
     21231                      1         8.45
     21344                      3        12.49
     23119                      2        41.97
     24288                      3   155.593333
     25595                      3        89.63
                                2       10.135

7 rows selected.

SQL> SELECT V_CODE, COUNT(DISTINCT (P_CODE)), AVG(P_PRICE)
  2  FROM PRODUCT
  3  GROUP BY V_CODE
  4  HAVING AVG(P_PRICE) < 10;

    V_CODE COUNT(DISTINCT(P_CODE)) AVG(P_PRICE)
---------- ---------------------- ------------
     21225                      2         8.47
     21231                      1         8.45
```



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Aggregation with GROUP BY and HAVING

- Find the number of invoice per year and per month for the last 3 years

```
SELECT EXTRACT(year FROM inv_date) "Year",
       EXTRACT(month FROM inv_date) "Month",
       COUNT(inv_date) "No. of Invoices"
FROM invoice
GROUP BY EXTRACT(year FROM inv_date),
       EXTRACT(month FROM inv_date)
HAVING EXTRACT(year FROM inv_date) IN (2017, 2016, 2015)
ORDER BY "No. of Invoices" DESC;
```

INVOICE	
PK	inv_number
FK1	cus_code inv_date

CASE Statement

- **Simple CASE Statements**

```
SELECT      Fname, Lname,
      (CASE DNO
            WHEN 1      THEN 'Headquarters'
            WHEN 4      THEN 'Administration'
            WHEN 5      THEN 'Research'
            ELSE         'No department'
      END)  AS Department
      FROM  Employee;
```

Output:

Fname	Lname	Department
John	Smith	Research
Franklin	Wong	Research
Alica	Zelaya	Administration

CASE Statement

- **Searched CASE Statements**

```
SELECT      Fname, Lname, Salary
      (CASE Salary
            WHEN  Salary <= 25000     THEN 1500
            WHEN  Salary > 25000 AND Salary < 50000    THEN 1000
            WHEN  Salary > 50000 AND Salary < 100000 THEN 500
            ELSE            0
      END)  "Bonus"
      FROM  Employee;
```

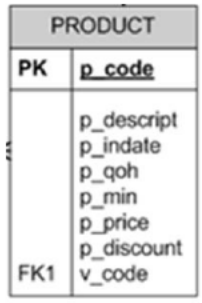
Output:

Fname	Lname	Salary	Bonus
John	Smith	30000	1000
Franklin	Wong	40000	1000
Alica	Zelaya	25000	1500

Nested Subquery and Aggregate Functions

- Find the product that has the oldest date

```
SELECT P_CODE, P_DESCRIPT
FROM   PRODUCT
WHERE  P_INDATE = (
    SELECT   MIN (P_INDATE)
    FROM     PRODUCT);
```



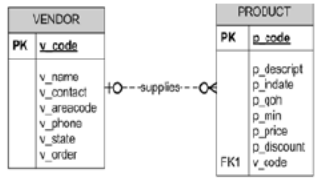
This query is in the form of a nested query.

JOIN: Two Syntax

JOIN is usually done through ***PK-FK chains***

- For each product, find their vendor code and names

```
SELECT    P.P_Code, V.V_Code, V.V_Name
FROM      Product P, Vendor V
WHERE     P.V_Code = V.V_code;
```




```
SELECT    P.P_Code, V.V_Code, V.V_Name
FROM      Product P INNER JOIN Vendor V
ON        P.V_Code = V.V_code;
```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Types of JOINs

TABLE 8.1

SQL JOIN EXPRESSION STYLES

JOIN CLASSIFICATION	JOIN TYPE	SQL SYNTAX EXAMPLE	DESCRIPTION
CROSS	CROSS JOIN	SELECT * FROM T1, T2	Returns the Cartesian product of T1 and T2 (old style)
		SELECT * FROM T1 CROSS JOIN T2	Returns the Cartesian product of T1 and T2
INNER	Old-style JOIN	SELECT * FROM T1, T2 WHERE T1.C1=T2.C1	Returns only the rows that meet the join condition in the WHERE clause (old style); only rows with matching values are selected
	NATURAL JOIN	SELECT * FROM T1 NATURAL JOIN T2	Returns only the rows with matching values in the matching columns; the matching columns must have the same names and similar data types
	JOIN USING	SELECT * FROM T1 JOIN T2 USING (C1)	Returns only the rows with matching values in the columns indicated in the USING clause
	JOIN ON	SELECT * FROM T1 JOIN T2 ON T1.C1=T2.C1	Returns only the rows that meet the join condition indicated in the ON clause
OUTER	LEFT JOIN	SELECT * FROM T1 LEFT OUTER JOIN T2 ON T1.C1=T2.C1	Returns rows with matching values and includes all rows from the left table (T1) with unmatched values
	RIGHT JOIN	SELECT * FROM T1 RIGHT OUTER JOIN T2 ON T1.C1=T2.C1	Returns rows with matching values and includes all rows from the right table (T2) with unmatched values
	FULL JOIN	SELECT * FROM T1 FULL OUTER JOIN T2 ON T1.C1=T2.C1	Returns rows with matching values and includes all rows from both tables (T1 and T2) with unmatched values

(Coronel & Morris, 2016)

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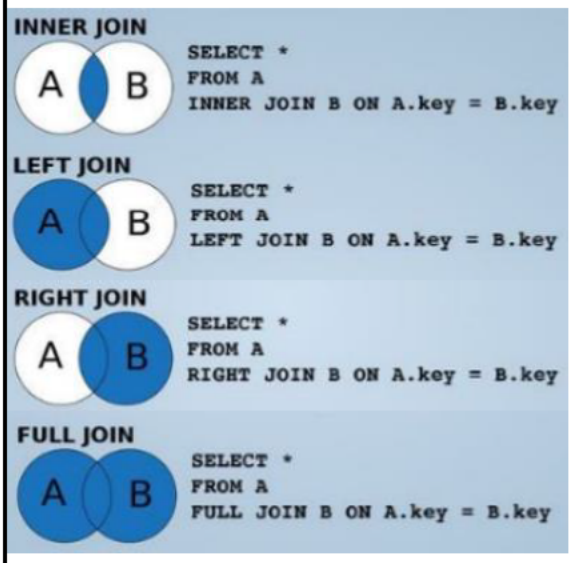
Types of JOINs



NATURAL JOIN:

SELECT *
FROM table_A
NATURAL JOIN table_B;

SELF JOIN:

SELECT *
FROM table_A X, table_A Y
WHERE X.A = Y.A;

CROSS JOIN:

SELECT *
FROM table_A
CROSS JOIN table_B;

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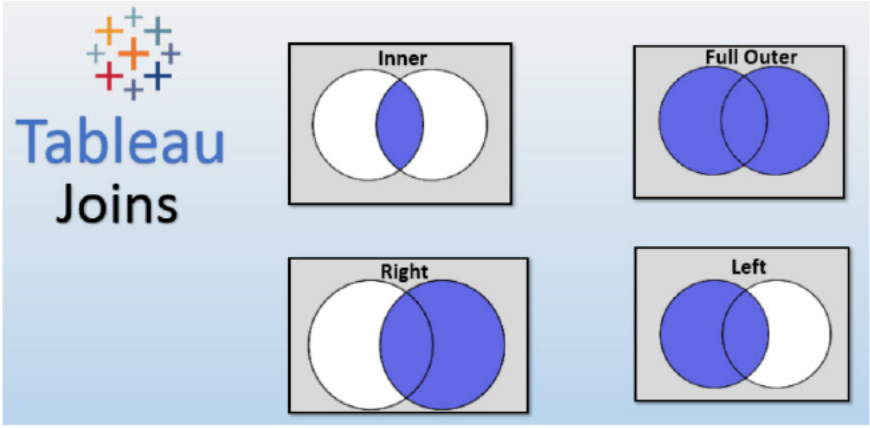
Types of JOINs in Tableau



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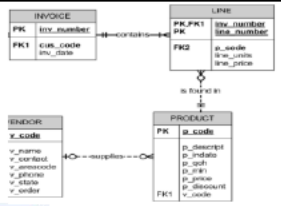
INNER JOIN



- For each invoice, find the product description, #units, and price of items in the invoice.

SQL Plus

```
SQL> SELECT INVOICE.INV_NUMBER, PRODUCT.P_CODE, P_DESCRIPT, LINE_UNITS, LINE_PRICE
  2  FROM INVOICE JOIN LINE ON INVOICE.INV_NUMBER = LINE.INV_NUMBER
  3       JOIN PRODUCT ON LINE.P_CODE = PRODUCT.P_CODE;

INV_NUMBER P_CODE     P_DESCRIPT                         LINE_UNITS LINE_PRICE
---------- ---------- ------------------------------ ---------- ----------
      1001 13-Q2/P2   7.25-in. pwr. saw blade                  1      14.99
      1001 23109-HB   Claw hammer                              1       9.95
      1002 54778-2T   Rat-tail file, 1/8-in. fine              2       4.99
      1003 2238/QPD   B&D cordless drill, 1/2-in.              1      38.95
      1003 1546-QQ2   Hrd. cloth, 1/4-in., 2x50                 1      39.95
      1003 13-Q2/P2   7.25-in. pwr. saw blade                  5      14.99
      1004 54778-2T   Rat-tail file, 1/8-in. fine              3       4.99
      1004 23109-HB   Claw hammer                              2       9.95
      1005 PVC23DRT   PVC pipe, 3.5-in., 8-ft                 12       5.87
      1006 SM-18277   1.25-in. metal screw, 25                  3       6.99
      1006 2232/QTY   B&D jigsaw, 12-in. blade                  1     109.92
      1006 23109-HB   Claw hammer                              1       9.95
      1006 89-WRE-Q   Hicut chain saw, 16 in.                   1     256.99
      1007 13-Q2/P2   7.25-in. pwr. saw blade                  2      14.99
      1007 54778-2T   Rat-tail file, 1/8-in. fine              1       4.99
      1008 PVC23DRT   PVC pipe, 3.5-in., 8-ft                  5       5.87
      1008 WR3/TT3    Steel matting, 4'x8'x1/6", .5" mesh      3     119.95
      1008 23109-HB   Claw hammer                              1       9.95

18 rows selected.

SQL> _
```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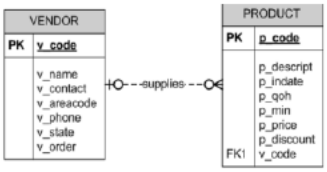
LEFT OUTER JOIN



- *For ALL the Vendors*, find all the products they provide. Include all the vendors whether or not they provide any product.

SQL Plus

```
SQL> SELECT P_CODE, VENDOR.V_CODE, V_NAME
  2  FROM VENDOR LEFT JOIN PRODUCT ON VENDOR.V_CODE = PRODUCT.V_CODE;

P_CODE     V_CODE V_NAME
---------- ------ --------------------
11QER/31    25595 Rubicon Systems
13-Q2/P2    21344 Gomez Bros.
14-Q1/L3    21344 Gomez Bros.
1546-QQ2    23119 Randsets Ltd.
1558-QW1    23119 Randsets Ltd.
2232/QTY    24288 ORDVA, Inc.
2232/QWE    24288 ORDVA, Inc.
2238/QPD    25595 Rubicon Systems
23109-HB    21225 Bryson, Inc.
54778-2T    21344 Gomez Bros.
89-WRE-Q    24288 ORDVA, Inc.
SM-18277    21225 Bryson, Inc.
SW-23116    21231 D&E Supply
WR3/TT3     25595 Rubicon Systems
            22567 Dome Supply
            21226 SuperLoo, Inc.
            24004 Brackman Bros.
            25501 Damal Supplies
            25443 B&K, Inc.

19 rows selected.

SQL> _
```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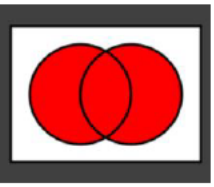
SET Operations

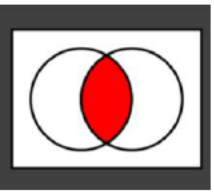
```
-- All customers and staff
SELECT first_name, last_name
FROM customer
UNION
SELECT first_name, last_name
FROM staff
```



UNION

$R \cup S$

```
-- customers that are actors
SELECT first_name, last_name
FROM customer
INTERSECT
SELECT first_name, last_name
FROM actor
```

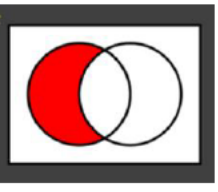


INTERSECT

$R \cap S$

MINUS

```
-- customers that are not staff
SELECT first_name, last_name
FROM customer
EXCEPT
SELECT first_name, last_name
FROM staff
```



MINUS

$R - S$

SQL Analytic Functions: ROLLUP

- Example: **GROUP BY ROLLUP** (V_Code, P_Code) produces the union of
  - GROUP BY V_Code, P_Code
  - GROUP BY V_Code
  - Grand total

```
SQL> SELECT   V_CODE, P_CODE, SUM(SALE_UNITS*SALE_PRICE) AS TOTSALES
  2  FROM     DWDAYSALESFACT NATURAL JOIN DWPRODUCT NATURAL JOIN DWVENDOR
  3  GROUP BY ROLLUP (V_CODE, P_CODE)
  4  ORDER BY V_CODE, P_CODE;
```

Oracle SQL*Plus

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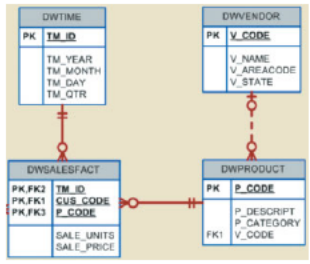
```
SQL> SELECT   V_CODE, P_CODE, SUM(SALE_UNITS*SALE_PRICE) AS TOTSALES
  2  FROM     DWDAYSALESFACT NATURAL JOIN DWPRODUCT NATURAL JOIN DWVENDOR
  3  GROUP BY ROLLUP (V_CODE, P_CODE)
  4  ORDER BY V_CODE, P_CODE;

   V_CODE P_CODE       TOTSALES
--------- ---------- ----------
    21225 23109-HB           99.5
    21225 PUC23DRT         199.58
    21225 SM-18277          41.94
    21225                  341.02
    21344 13-Q2/P2         239.84
    21344 54778-2T          59.88
    21344                  299.72
    23119 1546-QQ2          79.9
    23119                   79.9
    24288 2232/QTY         219.84
    24288 89-WRE-Q         513.98
    24288                  733.82
    25595 2238/QPD           77.9
    25595 WR3/TT3           719.7
    25595                   797.6
                           2252.06

16 rows selected.
```



Subtotals by V_CODE

Grand total for all P_CODE values

(Coronel & Morris, 2016)

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SQL Analytic Functions: Cube

- The CUBE extension
  - Enables you to get a subtotal for each column listed in the expression, in addition to a grand total for the last column listed
  - GROUP BY CUBE (TM_Month, P_CODE) is a union of:
    - GROUP BY CUBE (TM_Month, P_CODE)
    - GROUP BY CUBE (TM_Month)
    - GROUP BY CUBE (P_CODE)
    - Grand total

```
SQL> SELECT   TM_MONTH, P_CODE, SUM(SALE_UNITS*SALE_PRICE) AS TOTSALES
  2  FROM     DWDAYSALESFACT NATURAL JOIN DWPRODUCT NATURAL JOIN DWTIME
  3  GROUP BY CUBE (TM_MONTH, P_CODE)
  4  ORDER BY TM_MONTH, P_CODE;
```


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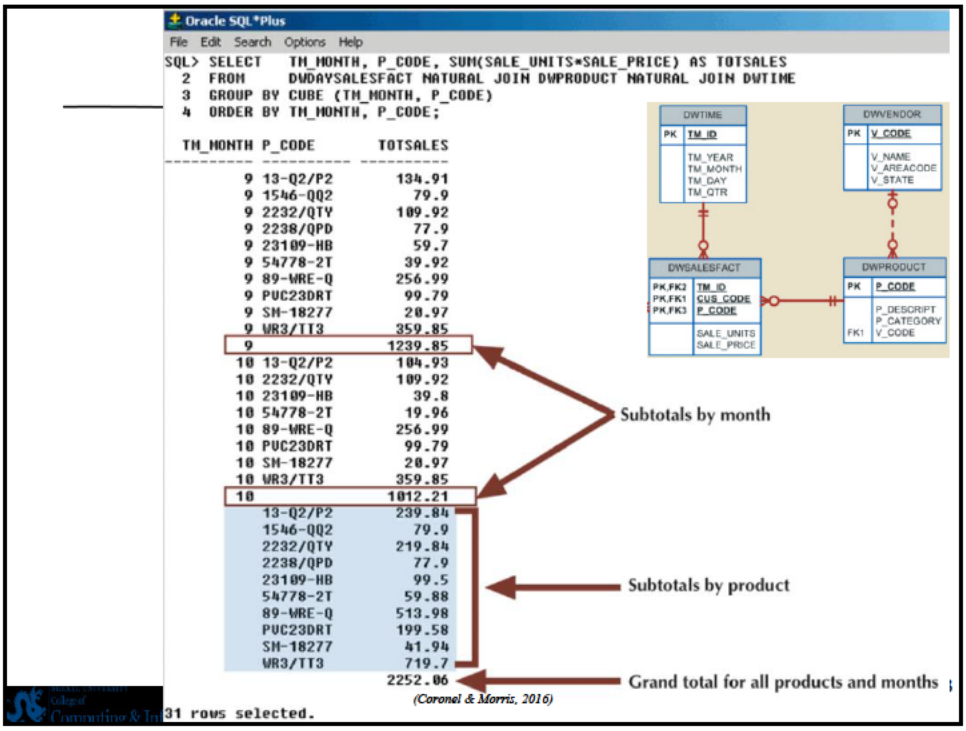

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RANK and DENSE RANK Functions

- RANK() leave ranking gaps when there multiple rows in the same rank (1, 2, 2, 4, 5…)
- DENSE_RANK() does **not** leave ranking gaps (1, 2, 2, 3, 4, 5)

```
SELECT p_code, p_descript, p_price,
        RANK() OVER
                (ORDER BY p_price NULLS LAST) AS Rank,
        DENSE_RANK ()
                (ORDER BY p_price NULLS LAST) AS Dense_rank
FROM    Product
ORDER BY p_price;
```

PRODUCT	
PK	**p_code**
	p_descript
	p_indate
	p_qoh
	p_min
	p_price
	p_discount
FK1	v_code

- DESC means descending order
- NULLS LAST means null values are smaller than non-null values
- You may use NULLS FIRST

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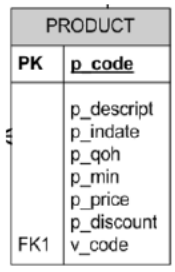
RANK and DENSE RANK Functions

- Ranking applied to dates

```
SELECT p_code, p_descript, p_indate,
        RANK() OVER
                (ORDER BY p_indate NULLS LAST) AS Rank,
        DENSE_RANK ()
                (ORDER BY p_indate NULLS LAST) AS Dense_rank
FROM    Product
ORDER BY p_indate;
```



Top-N Queries

- **Before Oracle 12c:**

```
SELECT p_code, p_descript,
        (SELECT p_price,
                RANK() OVER
                    (ORDER BY p_price NULLS LAST) AS Rank
         FROM product)
FROM    Product
WHERE  Rank <= 10
ORDER BY p_price;
```

- **In Oracle 12c:**

```
SELECT p_code, p_descript, p_price,
        RANK() OVER
                (ORDER BY p_price NULLS LAST) AS Rank,
FROM    Product
ORDER BY p_price;
FETCH FIRST 10 ROWS ONLY;
```

- Another option by percentage

```
FETCH FIRST 20 PERCENT ROWS ONLY;
```

- MySQL uses LIMIT clause

```
LIMIT 10
```

RANK with PARTITION BY

```
SELECT employee_id, first_name, department_id, salary
RANK() OVER (PARTITION BY department_id
      ORDER BY salary) rank
FROM employee;
```

	EMPLOYEE_ID	FIRST_NAME	DEPARTMENT_ID	SALARY	RANK
1	119	Karen	30	2500	1
2	118	Guy	30	2600	2
3	117	Sigal	30	2800	3
4	116	Shelli	30	2900	4
5	115	Alexander	30	3100	5
6	114	Den	30	11000	6
7	144	Peter	50	2500	1
8	143	Randall	50	2600	2
9	142	Curtis	50	3100	3
10	141	Trenna	50	3500	4
11	107	Diana	60	4200	1
12	105	David	60	4800	2

Windows Function: WIDTH_BUCKET

- This operation assigns a bucket number to the expression that it evaluates. It helps in generating equi-width histograms.
- Example: Show the last names, salaries and bucket numbers of all employees according to the following rule:
  - Salary <30,000 -> 0
  - 30,000-40,000 -> 1
  - 40,000-50,000 -> 2
  - Salary >50,000 -> 3

```
SQL> SELECT lname, salary,
WIDTH_BUCKET(salary, 30000, 50000, 2)  AS Bucket
FROM employee;
```

LNAME	SALARY	BUCKET
Smith	30000	1
Wong	40000	2
Zelaya	25000	0
Wallace	43000	2
Narayan	38000	1
English	25000	0
Jabbar	25000	0
Borg	55000	3

8 rows selected.

Other Advanced SQL

- SQL with JSON
- SQL with Python
- Views and Materialized views
- PL/SQL
  - Stored functions
  - Stored Procedures
  - Triggers
  - Packages

Question?