Unit-3

SQL and Integrity Constraints:Concept of DDL, DML and DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, Assertions, Views, Nested Sub Queries, Database Security Application development using SQL, Stored Procedures and Triggers. Relational Database Design: Functional Dependency, Different Anomalies in designing a Database.Normalization using Functional Dependencies, Decomposition, Boyce-Codd Normal Form, 3NF, Normalization using Multi-Valued Dependencies, 4NF, Join Dependency, 5NF.

SQL Introduction

Standard language for querying and manipulating data

Structured **Q**uery **L**anguage

Many standards out there:

- ANSI SQL
- SQL92 (a.k.a. SQL2)
- SQL99 (a.k.a. SQL3)
- Vendors support various subsets of these
- What we discuss is common to all of them

SQL

- Data Definition Language (DDL)
  - Create/alter/delete tables and their attributes
  - Following lectures...
- Data Manipulation Language (DML)
  - Query one or more tables – discussed next !
  - Insert/delete/modify tuples in tables
- Transact-SQL
  - Idea: package a sequence of SQL statements → server
  - Won't discuss in class

Data in SQL

1. Atomic types, a.k.a. data types
2. Tables built from atomic types

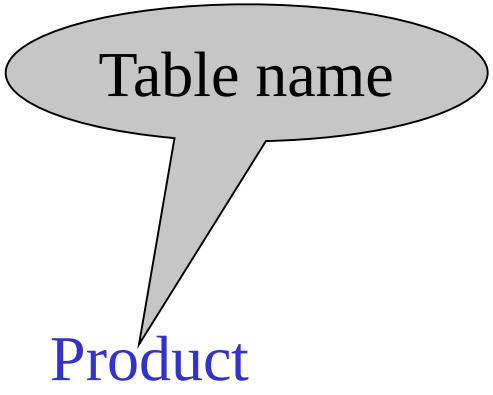
Unlike XML, no nested tables, only flat tables are allowed!

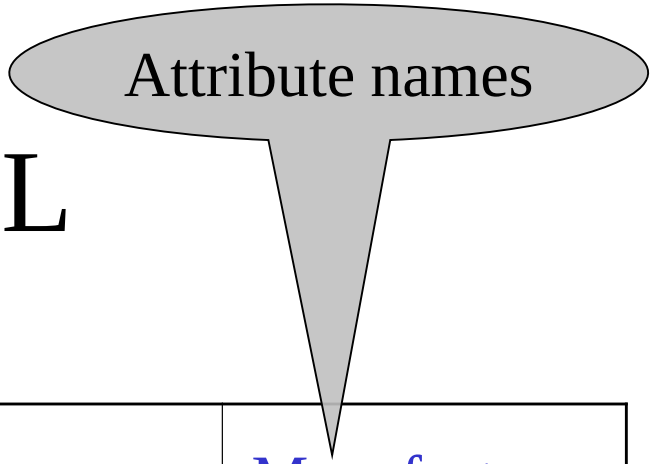
- We will see later how to decompose complex structures into multiple flat tables

Data Types in SQL

- Characters:
  - CHAR(20) -- fixed length
  - VARCHAR(40)-- variable length
- Numbers:
  - BIGINT, INT, SMALLINT, TINYINT
  - REAL, FLOAT -- differ in precision
  - MONEY
- Times and dates:
  - DATE
  - DATETIME -- SQL Server
- Others... All are simple

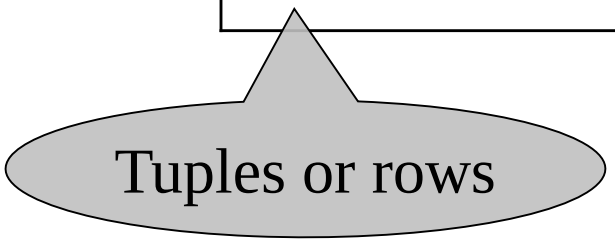
Tables in SQL





Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi



Tables Explained

- A tuple = a record
  - Restriction: all attributes are of atomic type
- A table = a set of tuples
  - Like a list…
  - …but it is unordered: no **first()**, no **next()**, no **last()**.

Tables Explained

- The *schema* of a table is the table name and its attributes:

Product(PName, Price, Category, Manfacturer)

- A *key* is an attribute whose values are unique; we underline a key

Product(PName, Price, Category, Manfacturer)

SQL Query

Basic form: (plus many many more bells and whistles)

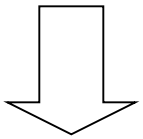
```
SELECT  attributes
FROM    relations (possibly multiple)
WHERE   conditions (selections)
```

Simple SQL Query

Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

```
SELECT  *
FROM    Product
WHERE   category='Gadgets'
```



PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks

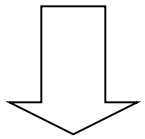
"selection"

Simple SQL Query

Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

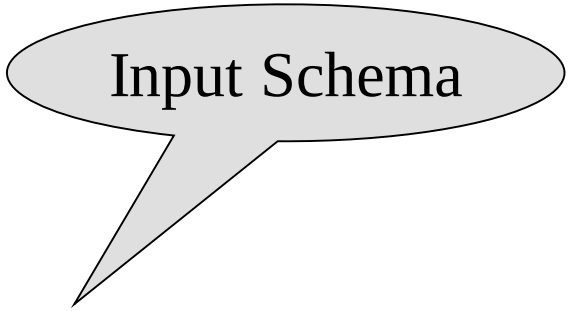
```
SELECT   PName, Price, Manufacturer
FROM     Product
WHERE    Price > 100
```



"selection" and "projection"

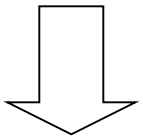
PName	Price	Manufacturer
SingleTouch	$149.99	Canon
MultiTouch	$203.99	Hitachi

A Notation for SQL Queries

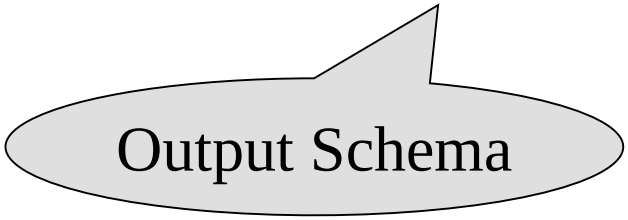


Product(PName, Price, Category, Manfacturer)

```
SELECT   PName, Price, Manufacturer
FROM     Product
WHERE    Price > 100
```



Answer(PName, Price, Manfacturer)



Selections

What goes in the WHERE clause:

- x = y, x < y, x <= y, etc
  - For number, they have the usual meanings
  - For CHAR and VARCHAR: lexicographic ordering
    - Expected conversion between CHAR and VARCHAR
  - For dates and times, what you expect...
- Pattern matching on strings...

The **LIKE** operator

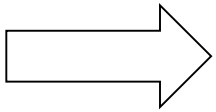
- s **LIKE** p: pattern matching on strings
- p may contain two special symbols:
  - % = any sequence of characters
  - _ = any single character

Product(PName, Price, Category, Manufacturer)
Find all products whose name mentions 'gizmo':

```
SELECT  *
FROM    Products
WHERE   PName LIKE '%gizmo%'
```

Eliminating Duplicates

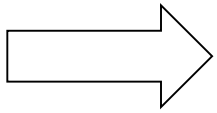
```
SELECT DISTINCT category
FROM   Product
```



Category
Gadgets
Photography
Household

Compare to:

```
SELECT category
FROM   Product
```



Category
Gadgets
Gadgets
Photography
Household

Ordering the Results

```
SELECT   pname, price, manufacturer
FROM     Product
WHERE    category='gizmo' AND price > 50
ORDER BY  price, pname
```

Ordering is ascending, unless you specify the DESC keyword.

Ties are broken by the second attribute on the ORDER BY list, etc.

Ordering the Results

```
SELECT   category
FROM     Product
ORDER BY pname
```

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
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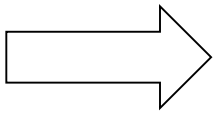

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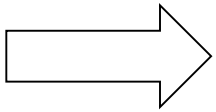
Ordering the Results

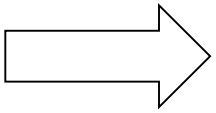
```
SELECT   DISTINCT category
FROM     Product
ORDER BY category
```



Category
Gadgets
Household
Photography

Compare to:

```
SELECT   category
FROM     Product
ORDER BY pname
```



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Joins in SQL

- Connect two or more tables:

Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

Company

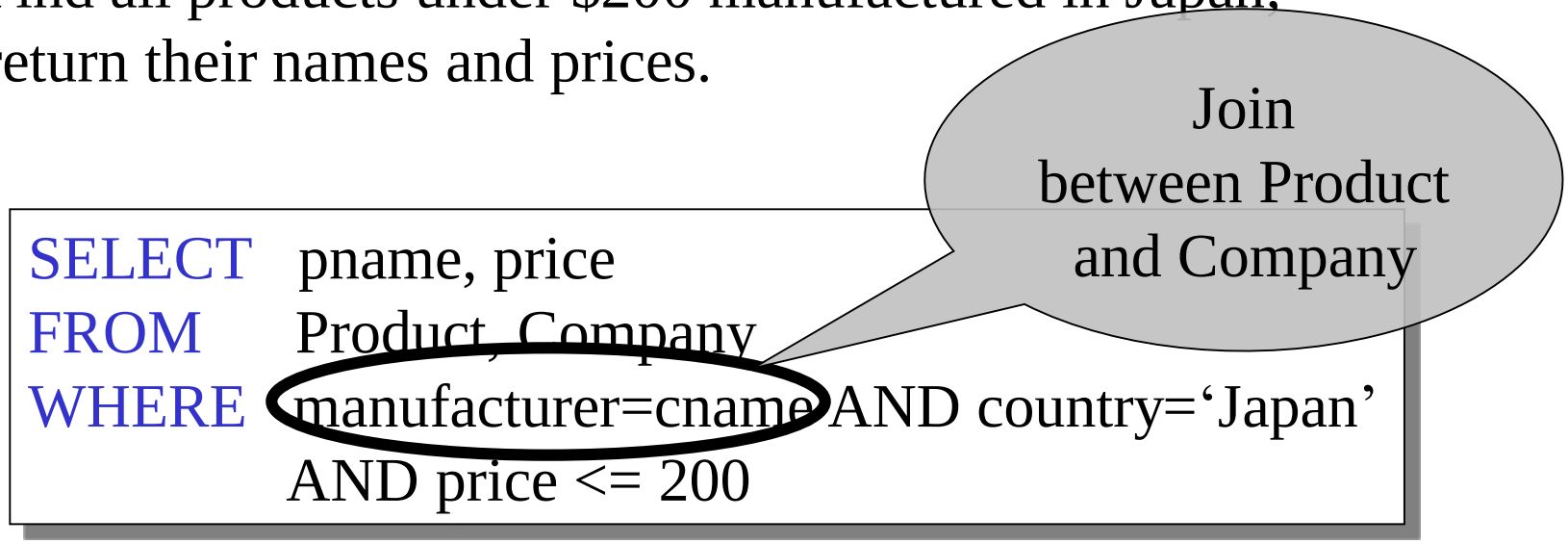
Cname	StockPrice	Country
GizmoWorks	25	USA
Canon	65	Japan
Hitachi	15	Japan

What is the connection between them ?

Joins

Product (pname, price, category, manufacturer)
Company (cname, stockPrice, country)

Find all products under $200 manufactured in Japan; return their names and prices.



Joins in SQL

Product

PName	Price	Category	Manufacturer
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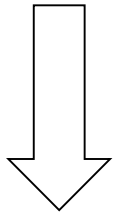
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

Company

Cname	StockPrice	Country
GizmoWorks	25	USA
Canon	65	Japan
Hitachi	15	Japan

```
SELECT   pname, price
FROM     Product, Company
WHERE    manufacturer=cname AND country='Japan'
         AND price <= 200
```



PName	Price
SingleTouch	$149.99

Joins

Product (pname, price, category, manufacturer)
Company (cname, stockPrice, country)

Find all countries that manufacture some product in the 'Gadgets' category.

```
SELECT   country
FROM     Product, Company
WHERE    manufacturer=cname AND category='Gadgets'
```

Joins in SQL

Product

Name	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
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Company

Cname	StockPrice	Country
GizmoWorks	25	USA
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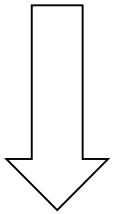
```
SELECT   country
FROM     Product, Company
WHERE    manufacturer=cname AND category='Gadgets'
```



Country
??
??

What is the problem ? What's the solution ?

Joins

Product (pname, price, category, manufacturer)
Purchase (buyer, seller, store, product)
Person(persname, phoneNumber, city)

Find names of people living in Seattle that bought some product in the 'Gadgets' category, and the names of the stores they bought such product from

```
SELECT   DISTINCT persname, store
FROM     Person, Purchase, Product
WHERE    persname=buyer AND product = pname AND
         city='Seattle'  AND category='Gadgets'
```

When are two tables related?

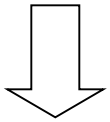
- You guess they are
- I tell you so
- Foreign keys are a method for schema designers to tell you so
  - A foreign key states that a column is a reference to the key of another table
    ex: Product.manufacturer is foreign key of Company
  - Gives information and enforces constraint

Disambiguating Attributes

- Sometimes two relations have the same attr:
  Person(pname, address, worksfor)
  Company(cname, address)

```
SELECT   DISTINCT pname, address
FROM     Person, Company
WHERE    worksfor = cname
```

Which address ?



```
SELECT   DISTINCT Person.pname, Company.address
FROM     Person, Company
WHERE    Person.worksfor = Company.cname
```

Tuple Variables

Product (pname, price, category, manufacturer)
Purchase (buyer, seller, store, product)
Person(persname, phoneNumber, city)

Find all stores that sold at least one product that the store 'BestBuy' also sold:

```
SELECT DISTINCT  x.store
FROM     Purchase AS x, Purchase AS y
WHERE   x.product = y.product AND y.store = 'BestBuy'
```

Answer (store)

Tuple Variables

General rule:
tuple variables introduced automatically by the system:

Product (name, price, category, manufacturer)

```
SELECT  name
FROM    Product
WHERE   price > 100
```

Becomes:

```
SELECT Product.name
FROM   Product AS Product
WHERE Product.price > 100
```

Doesn't work when Product occurs more than once:
In that case the user needs to define variables explicitly.

Meaning (Semantics) of SQL Queries

SELECT a1, a2, …, ak
FROM R1 AS x1, R2 AS x2, …, Rn AS xn
WHERE Conditions

1. Nested loops:

```
Answer = {}
for x1 in R1 do
    for x2 in R2 do
        …..
            for xn in Rn do
                if Conditions
                    then Answer = Answer ∪ {(a1,…,ak)}
return Answer
```

Meaning (Semantics) of SQL Queries

SELECT a1, a2, …, ak
FROM R1 AS x1, R2 AS x2, …, Rn AS xn
WHERE Conditions

2. Parallel assignment

Answer = {}
for all assignments x1 **in** R1, …, xn **in** Rn **do**
    if Conditions **then** Answer = Answer ∪ {(a1,…,ak)}
return Answer

Doesn't impose any order !

First Unintuitive SQLism

```
SELECT   R.A
FROM   R, S, T
WHERE  R.A=S.A    OR   R.A=T.A
```

Looking for $R \div (S \div T)$

But what happens if T is empty?

Exercises

Product (pname, price, category, manufacturer)
Purchase (buyer, seller, store, product)
Company (cname, stock price, country)
Person(per-name, phone number, city)

Ex #1: Find people who bought telephony products.
Ex #2: Find names of people who bought American products
Ex #3: Find names of people who bought American products and they live in Seattle.
Ex #4: Find people who have both bought and sold something.
Ex #5: Find people who bought stuff from Joe or bought products from a company whose stock prices is more than $50.