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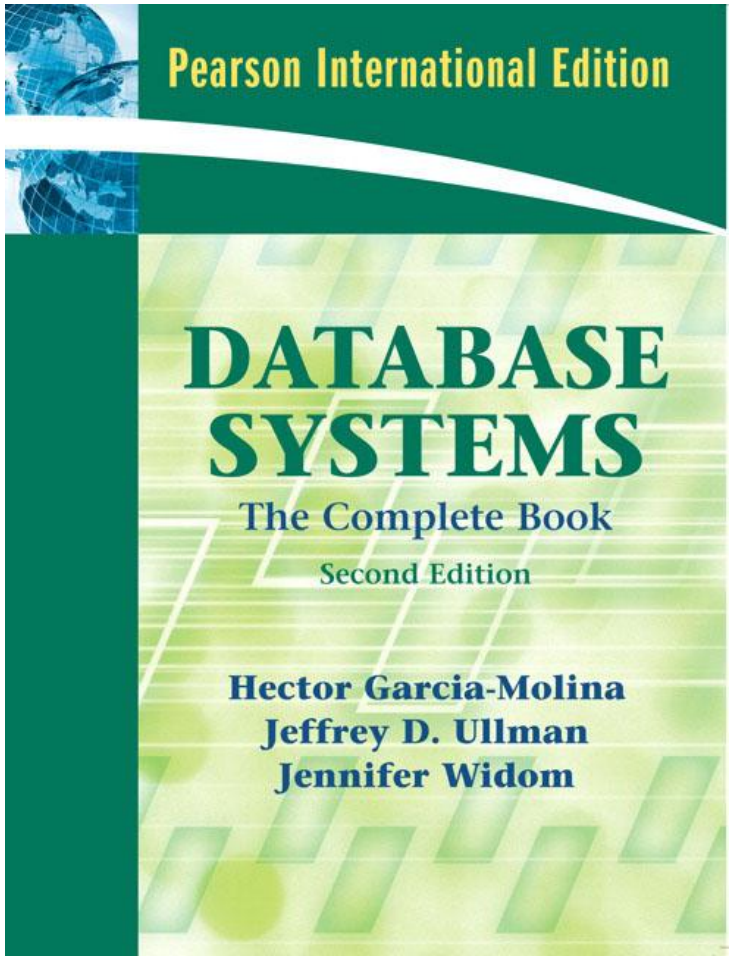
Database Management System I

Introduction to SQL

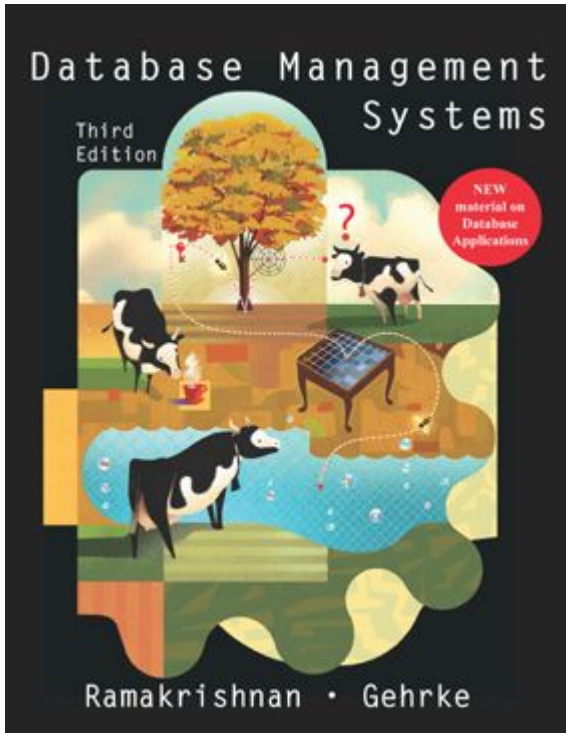
Main Textbook

- Database Systems: The Complete Book
  - Hector Garcia-Molina
  - Jeffrey D. Ullman
  - Jennifer Widom



Alternative Textbook

- Database Management Systems
  - Raghu Ramakrishnan
  - Johannes Gehrke



Goals of Course

- To obtain a firm background in database systems, e.g.,
  - how to talk to database systems in a standard language
  - how to improve the efficiency of database systems
  - the theories behind database design and some algorithms behind database implementation
- Mostly "basic stuff" about databases

What will NOT be taught

- Advanced database technologies
  - Geographical information systems
  - Data mining
  - …
  - (This is an introductory course only)
- Specific instructions on how to install and use a specific database system on a specific platform
  - Try the user manual or Google

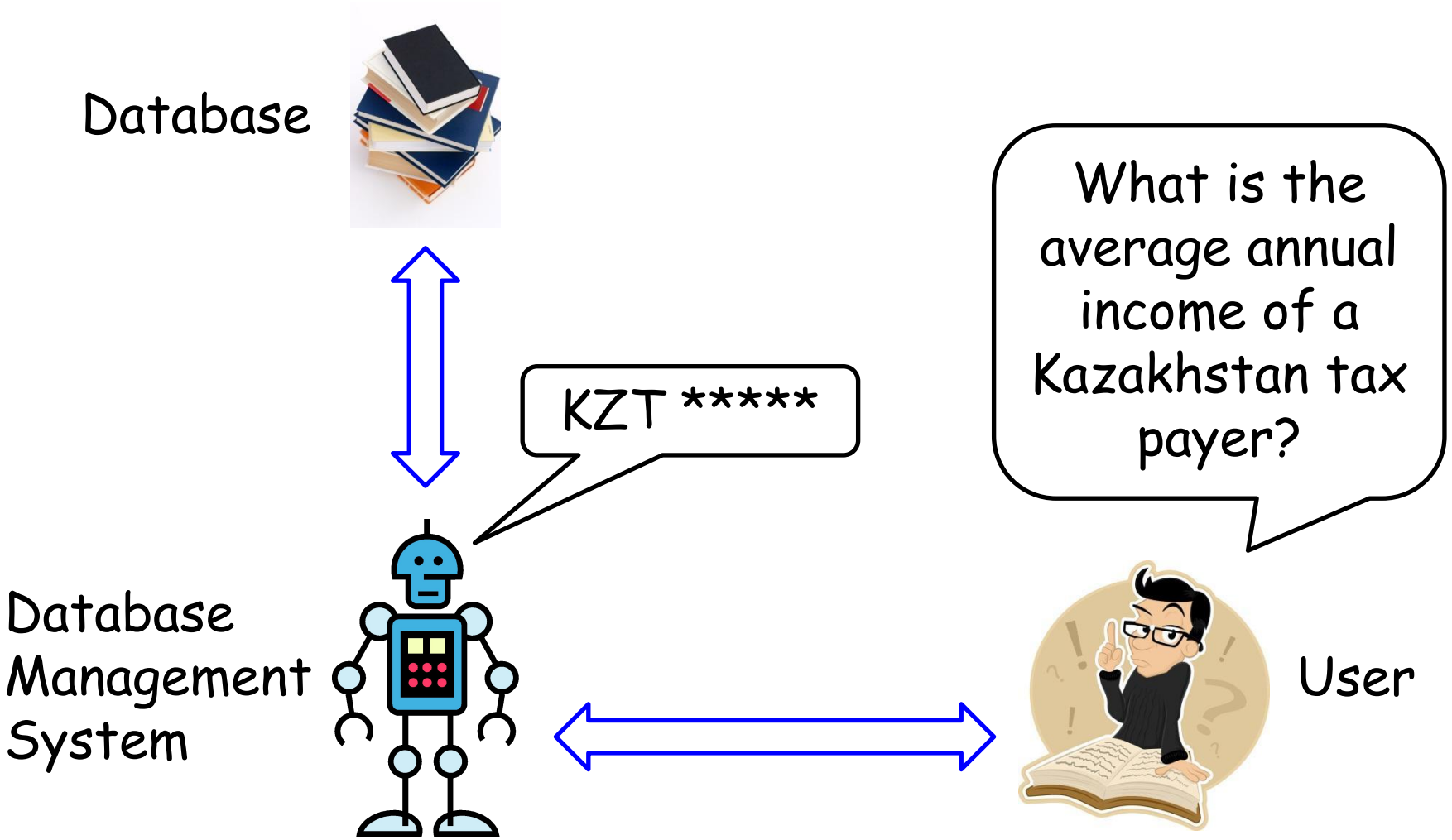
Teaching Style

- There will be a lot of in-lecture exercises
- Questions will be welcomed
- Lecture notes will be released on the Drive (at least several days before lectures)

Course Overview

- What is a database?
- A large collection of data organized especially for rapid search and retrieval (as by a computer)
- What is a database system?
  (more formally, a database management system, i.e., DBMS)
- A management system that helps us retrieve information from databases

Database and DBMS



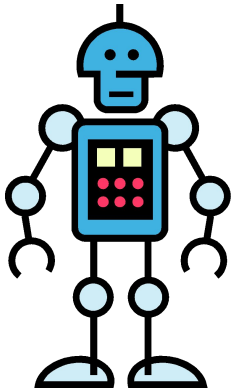
Tables, Relations, Relational Model

Database

Taxpayer_ID	Annual_Income
51248297	100000
33891634	50000
...	...

Income_Table

Database Management System



User

Tables, Relations, Relational Model

Database

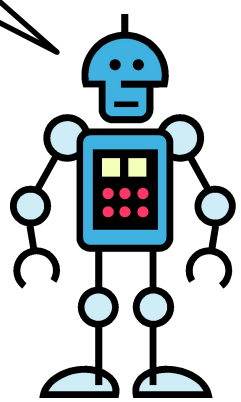
Taxpayer_ID	Annual_Income
51248297	100000
33891634	50000
...	...

Income_Table

???

What is the average annual income of a Kazakhstan tax payer?

Database Management System



User

Structured Query Language (SQL)

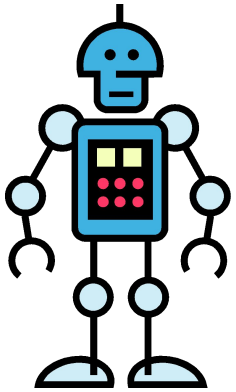
Database

Taxpayer_ID	Annual_Income
51248297	100000
33891634	50000
...	...

Income_Table

```
SELECT avg(Annual_Income)
FROM   Income_Table
```

Database Management System



User

Structured Query Language (SQL)

Database

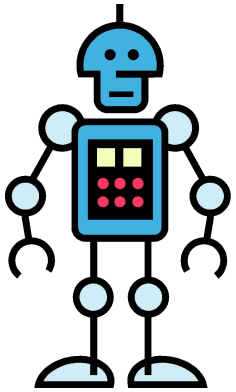
Taxpayer_ID	Annual_Income
51248297	100000
33891634	50000
...	...

Income_Table

More details about SQL will be covered later today

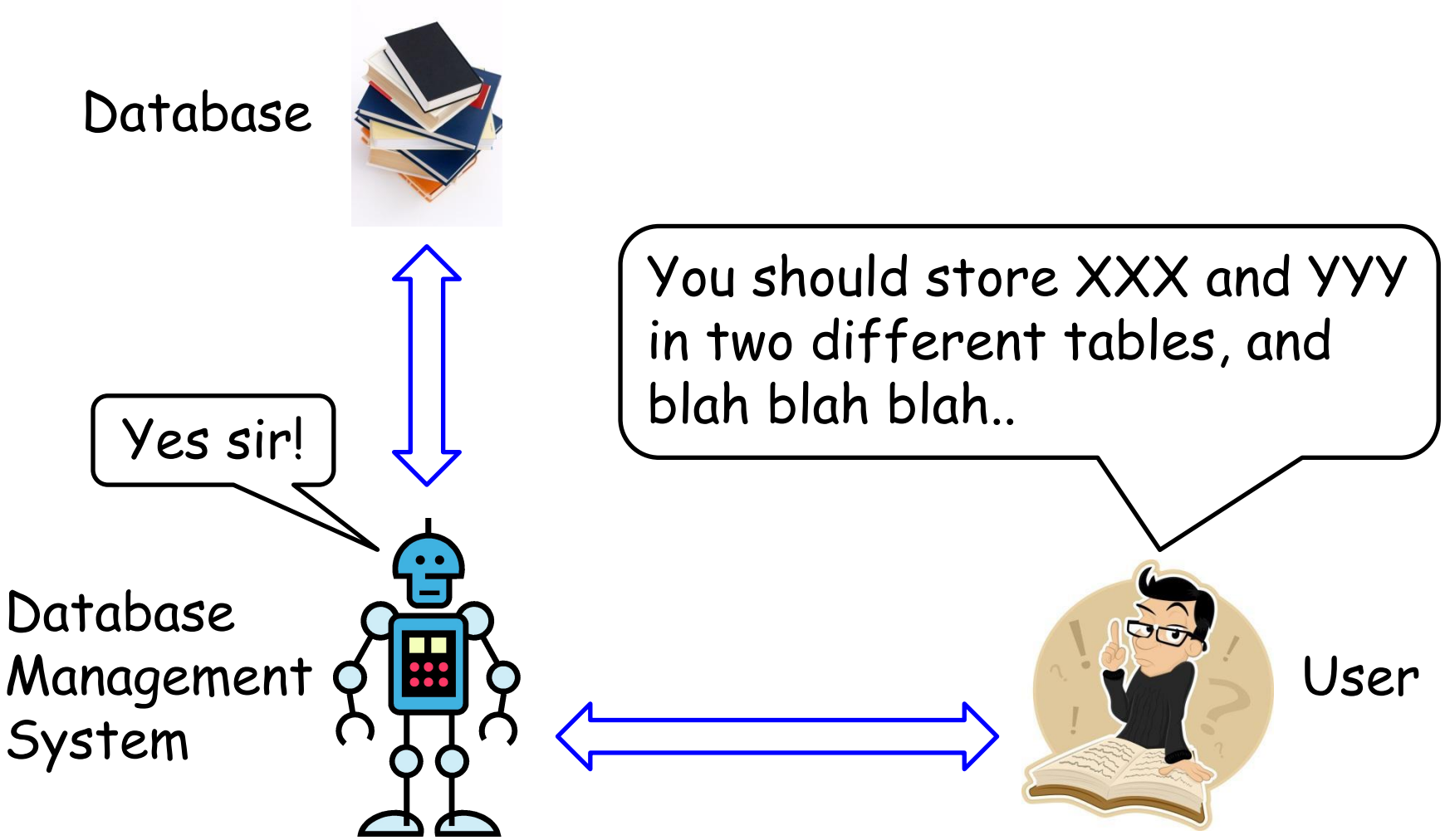
SELECT avg(Annual_Income)
FROM Income_Table

Database Management System



User

Database Schema Design



Database Schema Design

Taxpayer_ID	Annual_Income
51248297	100000
33891634	50000
67904777	70000
…	…

- Assume that we want to capture parent-child relationships

Database Schema Design

Taxpayer_ID	Annual_Income	Child_ID
51248297	100000	
33891634	50000	
67904777	70000	
…	…	

- Is one column enough?

Database Schema Design

Taxpayer_ID	Annual_Income	Child_ID1	Child_ID2
51248297	100000		
33891634	50000		
67904777	70000		
…	…		

- Are two columns enough?
- Assume that two columns are enough
- Does everyone have two children?

Schema designs based on the
Entity-Relationship model

Course Content

- SQL
- Constraints and Triggers
- Conceptual Design
- Indices
- Relation Algebra
- Query Processing/Optimization
- Concurrency Control
- Recovery
- Current trend (e.g., NOSQL)

Database Design

Database Implementation

What do you want from a DBMS?

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Why do we need it?

- Keep data around (persistent)
- Answer queries (questions) about data
- Update data

- Requirements from high-end applications
  - Massive amounts of data (terabytes ~ petabytes)
  - High throughput (thousands ~ millions transactions/min)

The Relational Revolution

The Relational Revolution (1970's)

- IBM and Univ of Berkeley
- A simple data model: Data is stored in relations (tables)
- A declarative query language: SQL
  - Programmer specifies what answers a query should return, but not how the query is executed
  - DBMS picks the best execution strategy
- Hide the physical organization of the database from applications
  - Provided only logical view of the data

Turing Award!

Edgar C Codd

- Relational model is the dominating technology today
- Graphs/Streams/Arrays are hot wanna-be!

“Relational databases are the foundation of western civilization.”

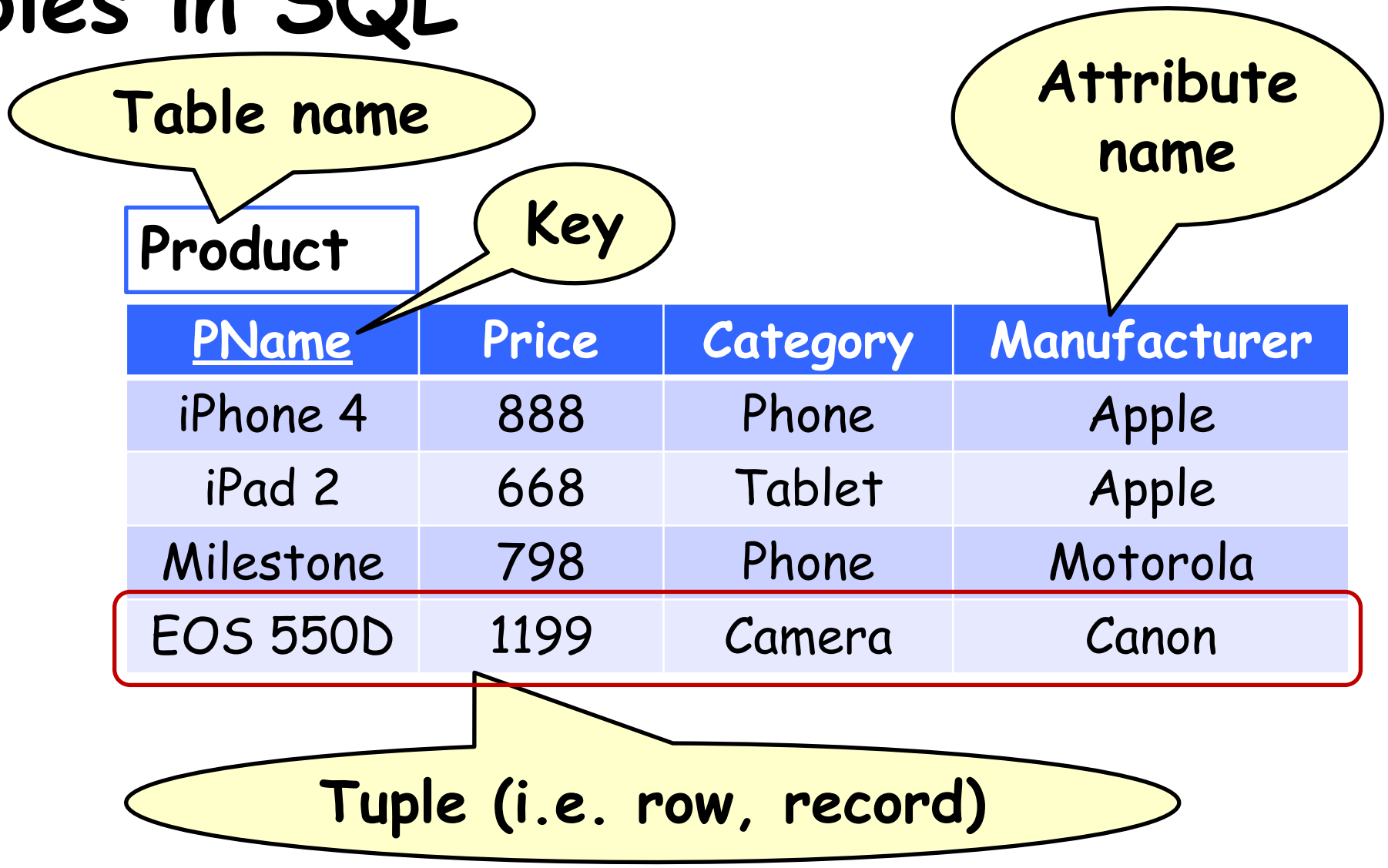
Bruce Lindsay
IBM Fellow
IBM Almaden Research Center

- Structured Query Language (SQL)

Structured Query Language (SQL)

- A declarative (computer) language for managing data in a relational database management system
- Two parts
  - Data Definition Language (DDL)
    - Create/Alter/Delete tables
    - Will be discussed in the next week
  - Data Manipulation Language (DML)
    - Query one or more tables
    - Insert/Delete/Modify tuples in tables
    - Will be discussed in the following

Tables in SQL



Data Types in SQL

- Character strings
  - CHAR(20)
  - VARCHAR(50)
  - …
- Numbers
  - INT
  - FLOAT
  - …
- Others
  - BOOLEAN
  - DATETIME
  - …

Product

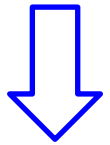
PName	Price	Category
iPhone 4	888	Phone
iPad 2	668	Tablet
Milestone	798	Phone
EOS 550D	1199	Camera

Simple SQL Query

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  Category = 'Phone'
```



"selection"

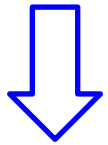
PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
Milestone	798	Phone	Motorola

Simple SQL Query

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  Category <> 'Phone'
```



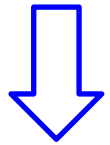
PName	Price	Category	Manufacturer
iPad 2	668	Tablet	Apple
EOS 550D	1199	Camera	Canon

Simple SQL Query

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  Category = 'Phone' AND Price > 800
```



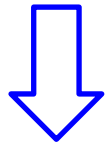
PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple

Simple SQL Query

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  Category = 'Tablet' OR Price > 1000
```



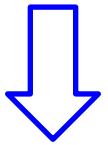
PName	Price	Category	Manufacturer
iPad 2	668	Tablet	Apple
EOS 550D	1199	Camera	Canon

Simple SQL Query (cont.)

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  PName, Price, Manufacturer
FROM    Product
WHERE   Price > 800
```



"selection and projection"

PName	Price	Manufacturer
iPhone 4	888	Apple
EOS 550D	1199	Canon

Details

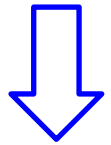
- SQL is NOT case sensitive (when it comes to keywords and names)
  - SELECT = Select = select
  - Product = product
- Constants must use single quotes
  - 'abc' – OK
  - "abc" – NOT OK

Patterns for Strings

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  PName LIKE 'iPh%'
```



PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple

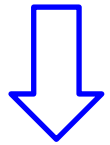
% stands for "any string"

Patterns for Strings

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  PName LIKE '%Ph%'
```



PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple

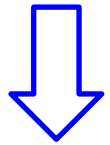
% stands for "any string"

Patterns for Strings

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  PName LIKE '%P%e%'
```



PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple

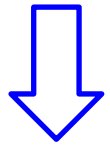
% stands for "any string"

Patterns for Strings

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  PName LIKE '_Phone 4'
```



PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple

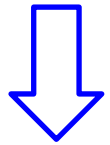
_ stands for "any character"

Patterns for Strings

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT *
FROM   Product
WHERE  PName LIKE '_Phone__'
```



PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple

_ stands for "any character"

Patterns for Strings

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

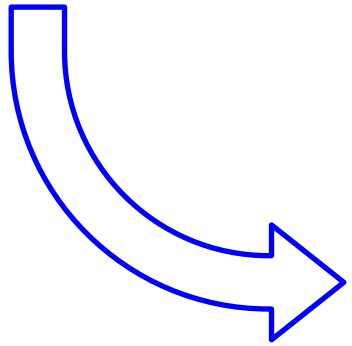
```
SELECT *
FROM   Product
WHERE  PName NOT LIKE '_Phone__'
```

Eliminating Duplicates

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  Category
FROM    Product
```



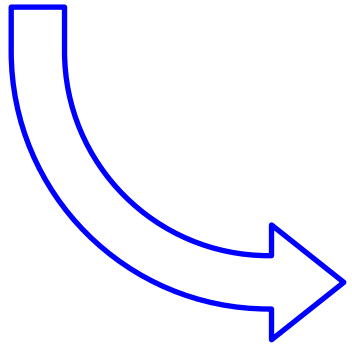
Category
Phone
Tablet
Phone
Camera

Eliminating Duplicates (cont.)

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT DISTINCT Category
FROM   Product
```



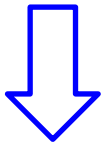
Category
Phone
Tablet
Camera

Ordering the Results

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  PName, Price
FROM    Product
WHERE   Price < 800
ORDER BY  PName
```



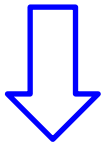
PName	Price
Milestone	798
iPad 2	668

Ordering the Results (cont.)

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  PName, Price
FROM    Product
WHERE  Price < 800
ORDER BY  PName DESC
```



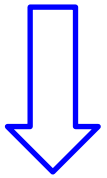
PName	Price
iPad 2	668
Milestone	798

Ordering the Results (cont.)

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  PName, Category
FROM    Product
WHERE  Price < 1000
ORDER BY  Category, PName
```



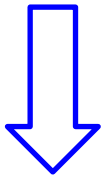
PName	Category
Milestone	Phone
iPhone 4	Phone
iPad 2	Tablet

Ordering the Results (cont.)

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  PName, Category
FROM    Product
WHERE   Price < 1000
ORDER BY  Category DESC,
                PName
```



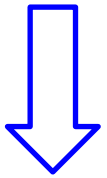
PName	Category
iPad 2	Tablet
Milestone	Phone
iPhone 4	Phone

Ordering the Results (cont.)

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  PName, Category
FROM    Product
WHERE   Price < 1000
ORDER BY  Category DESC,
                PName DESC
```



PName	Category
iPad 2	Tablet
iPhone 4	Phone
Milestone	Phone

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  DISTINCT Category
FROM    Product
ORDER BY  Category
```

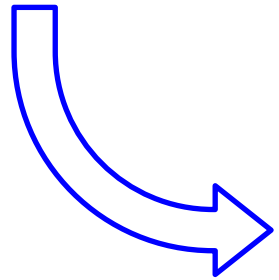
?

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  DISTINCT Category
FROM    Product
ORDER BY  Category
```



Category
Camera
Phone
Tablet

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  DISTINCT Category
FROM    Product
ORDER BY  Category
WHERE  Price < 1000
```

?

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  DISTINCT Category
FROM    Product
ORDER BY  Category
WHERE  Price < 1000
```

Error!

- "WHERE" should always proceed "ORDER BY"

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  DISTINCT Category
FROM    Product
ORDER BY  PName
```

?

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

```
SELECT  DISTINCT Category
FROM    Product
ORDER BY  PName
```

Error!

- "ORDER BY" items must appear in the select list if "SELECT DISTINCT" is specified

Joins

Company

CName	StockPrice	Country
Canon	45	Japan
Motorola	40	USA
Apple	374	USA

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

- A user wants to know the names and prices of all products by Japan companies. How?

Joins

Company

CName	StockPrice	Country
Canon	45	Japan
Motorola	40	USA
Apple	374	USA

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

- SELECT PName, Price
  FROM Product, Company
  WHERE Country = 'Japan'
  AND Manufacturer = CName

Joins

Person

PName	Address	WorksFor
…	…	…

Company

CName	Address	Country
…	…	

- Find the names of the persons who work for companies in USA
- SELECT PName
  FROM Person, Company
  WHERE Country = 'USA'
  AND WorksFor = CName

Joins

Person

PName	Address	WorksFor
...	...	...

Company

CName	Address	Country
...	...	

- Find the names the persons who work for companies in USA, as well as their company addresses
- SELECT PName, Address
  FROM Person, Company
  WHERE Country = 'USA'
  AND WorksFor = CName

Error!

Joins

Person

PName	Address	WorksFor
...	...	...

Company

CName	Address	Country
...	...	

- Find the names the persons who work for companies in USA, as well as their company addresses
- SELECT PName, Company.Address
  FROM Person, Company
  WHERE Country = 'USA'
  AND WorksFor = CName

Joins

Person

PName	Address	CName
...	...	...

Company

CName	Address	Country
...	...	

- Find the names the persons who work for companies in USA, as well as their company addresses
- SELECT PName, Company.Address
  FROM Person, Company
  WHERE Country = 'USA'
  AND CName = CName

Error!

Joins

Person

PName	Address	CName
...	...	...

Company

CName	Address	Country
...	...	

- Find the names the persons who work for companies in USA, as well as their company addresses
- SELECT PName, Company.Address
  FROM Person, Company
  WHERE Country = 'USA'
  AND Person.CName = Company.CName

Joins

Person

PName	Address	CName
…	…	…

Company

CName	Address	Country
…	…	

- Find the names the persons who work for companies in USA, as well as their company addresses
- SELECT X.PName, Y.Address
  FROM Person AS X, Company AS Y
  WHERE Y.Country = 'USA'
  AND X.CName = Y.CName

Joins

Person

PName	Address	CName
…	…	…

Company

CName	Address	Country
…	…	

- Find the names the persons who work for companies in USA, as well as their company addresses
- SELECT X.PName, Y.Address
  FROM Person X, Company Y
  WHERE Y.Country = 'USA'
  AND X.CName = Y.CName

Exercise

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	Manufacturer
...	...	...	...

- Exercise: Find the names of the companies in China that produce products in the 'tablet' category
- SELECT DISTINCT CName
  FROM Company, Product
  WHERE Manufacturer = CName
  AND Country = 'China'
  AND Category = 'Tablet'

Exercise

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	Manufacturer
...	...	...	...

- Exercise: Find the names of the companies in China that produce products in the 'tablet' or 'phone' category
- SELECT DISTINCT CName
  FROM Company, Product
  WHERE Manufacturer = CName
  AND Country = 'China'
  AND (Category = 'Tablet'
  OR Category = 'Phone')

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

- Exercise: Find the manufacturers that produce products in both the 'tablet' and 'phone' categories
- SELECT DISTINCT Manufacturer
  FROM Product
  WHERE Category = 'Tablet'
  AND Category = 'Phone'

Error!

Exercise

Product

PName	Price	Category	Manufacturer
iPhone 4	888	Phone	Apple
iPad 2	668	Tablet	Apple
Milestone	798	Phone	Motorola
EOS 550D	1199	Camera	Canon

- Exercise: Find the manufacturers that produce products in both the 'tablet' and 'phone' categories
- SELECT DISTINCT X.Manufacturer
  FROM Product AS X, Product AS Y
  WHERE X.Manufacturer = Y.Manufacturer
  AND X.Category = 'Tablet'
  AND Y.Category = 'Phone'

Subqueries

- A subquery is a SQL query nested inside a larger query
- Queries with subqueries are referred to as nested queries
- A subquery may occur in
  - SELECT
  - FROM
  - WHERE

SQL subquery

SQL subquery

A special subquery: Scalar Subquery

Scalar Subquery

- return a single value which is then used in a comparison.
- If query is written so that it expects a subquery to return a single value, and it returns multiple values or no values, a run-time error occurs.

Example Query

From Sells(bar, beer, price), find the bars that serve Heineken for the same price Ku De Ta charges for Bud.

Example Scalar Subquery

Find the price Ku De Ta charges for Bud.

Sells

Bar	Beer	Price
Clinic	Heineken	8.00
Clinic	Bud	6.60
Ku De Ta	Bud	7.90
MOS	Heineken	7.90
Ku De Ta	Heineken	8.00

```
SELECT  price
FROM    Sells
WHERE   bar = `Ku De Ta'
    AND beer = `Bud';
```

Price
7.90

Find the bars that serve Heineken at that price.

```
SELECT  bar
FROM    Sells
WHERE   beer = `Heineken'
    AND price = 7.90;
```

Bar
MOS

Example Scalar Subquery

```
SELECT   bar
FROM   Sells
WHERE  beer = 'Heineken' AND
     price = (SELECT price
              FROM   Sells
              WHERE bar = 'Ku De Ta'
                AND beer = 'Bud');
```

Subqueries in FROM

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all products in the 'phone' category with prices under 1000
- SELECT X.PName
  FROM (SELECT *
  FROM Product
  WHERE category = 'Phone') AS X
  WHERE X.Price < 1000

Subqueries in FROM (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all products in the 'phone' category with prices under 1000
- SELECT PName
  FROM Product
  WHERE Category = 'Phone'
  AND Price < 1000
- This is a much more efficient solution

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that make some products with price < 100
- SELECT DISTINCT CName
  FROM Company AS X
  WHERE X.CName IN
  (SELECT Y.CName
  FROM Product AS Y
  WHERE Y.Price < 100)

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that make some products with price < 100
-
```
SELECT DISTINCT CName
FROM   Company AS X
WHERE  EXISTS
       (SELECT * FROM Product AS Y
              WHERE X.CName = Y.Cname
                    AND Y.Price < 100)
```

•A nested query is **correlated** with the outer query if it contains a reference to an attribute in the outer query.

•A nested query is ***correlated*** with the outside query if it must be re-computed for every tuple produced by the outside query.

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that make some products with price < 100
- SELECT DISTINCT CName
  FROM Company AS X
  WHERE X.CName IN
  (SELECT *
  FROM Product AS Y
  WHERE Y.Price < 100)

Error!

•The number of attributes in the SELECT clause in the subquery must match the number of attributes compared to with the comparison operator.

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that make some products with price < 100
- SELECT DISTINCT CName
  FROM Company AS X
  WHERE 100 > ANY
  (SELECT Price FROM Product AS Y
  WHERE X.CName = Y.Cname)

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that make some products with price < 100
- SELECT DISTINCT CName
  FROM Product
  WHERE Price < 100
- This is more efficient than the previous solutions

Operators in Subqueries

IN

<tuple> IN <relation> is true if and only if the tuple is a member of the relation.

ANY

x = ANY(<relation>) is a boolean cond. meaning that *x* equals at least one tuple in the relation.

EXISTS

- EXISTS(<relation>) is true if and only if the <relation> is not empty.
- Returns true if the nested query has 1 or more tuples.

ALL

x <> ALL(<relation>) is true if and only if for every tuple *t* in the relation, *x* is not equal to *t*.

Note

The keyword NOT can proceed any of the operators (*s* NOT IN *R)*

Avoiding Nested Queries

- In general, nested queries tend to be more inefficient than un-nested queries
  - query optimizers of DBMS do not generally do a good job at optimizing queries containing subqueries
- Therefore, they should be avoided whenever possible
- But there are cases where avoiding nested queries is hard…

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that do not make any product with price < 100
- SELECT DISTINCT CName
  FROM Company AS X
  WHERE NOT EXISTS
  (SELECT * FROM Product AS Y
  WHERE X.CName = Y.Cname
  AND Y.Price < 100)

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that do not make any product with price < 100
- SELECT DISTINCT CName
  FROM Company AS X
  WHERE 100 <= ALL
  (SELECT Price FROM Product AS Y
  WHERE X.CName = Y.Cname)

Subqueries in WHERE (cont.)

Company

CName	StockPrice	Country
...	...	...

Product

PName	Price	Category	CName
...	...	...	...

- Find all companies that does not make any products with price < 100
- SELECT DISTINCT CName
  FROM Company AS X
  WHERE 100 <= ALL
  (SELECT Price FROM Product AS Y
  WHERE X.CName = Y.Cname)

Exercise

Likes

Drinker	Beer
…	…

Frequent

Drinker	Bar
…	…

Serves

Bar	Beer
…	…

- Find all drinkers that frequent some bar that serves some beer they like
- SELECT DINSTINT F.Drinker
  FROM Likes AS L, Frequent AS F,
  Serve AS S
  WHERE L.Drinker = F.Drinker
  AND F.Bar = S.Bar
  AND L.Beer = S.Beer

Exercise

Likes

Drinker	Beer
...	...

Frequent

Drinker	Bar
...	...

Serves

Bar	Beer
...	...

- Find all drinkers that frequent some bar that does not serve any beer they like
-
```
SELECT  DISTINCT F.Drinker
FROM    Frequent AS F, Serves AS S
WHERE   F.Bar = S.Bar AND NOT EXIST
        (SELECT *
          FROM   Likes as L
          WHERE  L.Beer = S.Beer
                 AND L.Drinker = F.Drinker)
```

Exercise

Likes

Drinker	Beer
…	…

Frequent

Drinker	Bar
…	…

Serves

Bar	Beer
…	…

- Find all drinkers that do not frequent any bar that serve some beer they like
-
```
SELECT  DISTINCT F.Drinker
FROM    Frequent AS F
WHERE   NOT EXIST
        (SELECT *
         FROM   Likes AS L, Serves AS S
         WHERE  L.Beer = S.Beer
                AND L.Drinker = F.Drinker
                AND S.Bar = F.Bar)
```

Roadmap --SQL

- Table
- SELECT
  FROM
  WHERE
- ORDER BY
- Joins
- Subqueries
- Aggregations
- UNION, INTERSECT, EXCEPT
- NULL
- Outerjoin
- Insert/Delete tuples
- Create/Alter/Delete tables
- View

Exercise

Likes

Drinker	Beer
John	A2

Frequent

Drinker	Bar
John	B1

Serves

Bar	Beer
B1	A1

- Find all drinkers that frequent some bar that does not serve any beer they like
-
```
SELECT  DISTINCT F.Drinker
FROM    Frequent AS F
WHERE NOT EXIST
          (SELECT *
            FROM Serves as S, Likes as L
            WHERE  L.Beer = S.Beer
                       AND L.Drinker = F.Drinker
          AND F.Bar = S.Bar)
```

Exercise

Likes

Drinker	Beer
…	…

Frequent

Drinker	Bar
…	…

Serves

Bar	Beer
…	…

- Find all drinkers that do not frequent any bar that serve some beer they like
-
```
SELECT  DISTINCT F.Drinker
FROM    Frequent AS F
WHERE   NOT EXIST
        (SELECT *
         FROM   Likes AS L, Serves AS S
         WHERE  L.Beer = S.Beer
                AND L.Drinker = F.Drinker
                AND S.Bar = F.Bar)
```