Introduction to Database Systems CSE 414

Lecture 3: SQL Basics

Review

- Relational data model
  - Schema + instance + query language
- Query language: SQL
  - Create tables
  - Retrieve records from tables
  - Declare keys and foreign keys

Discussion

- Tables are NOT ordered
  - they are sets or multisets (bags)
- Tables are FLAT
  - No nested attributes
- Tables DO NOT prescribe how they are implemented / stored on disk
  - This is called **physical data independence**

Table Implementation

- How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

Table Implementation

- How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

Row major: as an array of objects

GizmoWorks USA 20000 True	Canon Japan 50000 True	Hitachi Japan 30000 True	HappyCam Canada 500 False

Table Implementation

- How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

Column major: as one array per attribute

GizmoWorks	Canon	Hitachi	HappyCam
USA	Japan	Japan	Canada
20000	50000	30000	500
True	True	True	False

Table Implementation

- How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

Physical data independence
The logical definition of the data remains unchanged, even when we make changes to the actual implementation

First Normal Form

cname	country	no_employees	for_profit
Canon	Japan	50000	Y
Hitachi	Japan	30000	Y

- All relations must be flat: we say that the relation is in *first normal form*

First Normal Form

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- E.g., we want to add products manufactured by each company:

First Normal Form

cname	country	no_employees	for_profit
Canon	Japan	50000	Y
Hitachi	Japan	30000	Y

- All relations must be flat: we say that the relation is in *first normal form*
- E.g., we want to add products manufactured by each company:

cname	country	no_employees	for_profit	products
Canon	Japan	50000	Y	pname / price / category: SingleTouch / 149.99 / Photography; Gadget / 200 / Toy
Hitachi	Japan	30000	Y	pname / price / category: AC / 300 / Appliance

First Normal Form

cname	country	no_employees	for_profit
Canon	Japan	50000	Y
Hitachi	Japan	30000	Y

- All relations must be flat: we say that the relation is in *first normal form*
- E.g., we want to add products manufactured by each company:

Non-1NF!

cname	country	no_employees	for_profit	products
Canon	Japan	50000	Y	pname / price / category: SingleTouch / 149.99 / Photography; Gadget / 200 / Toy
Hitachi	Japan	30000	Y	pname / price / category: AC / 300 / Appliance

First Normal Form

We will learn how different languages and data models handle this aspect

Now it's in 1NF

Company

cname	country	no_employees	for_profit
Canon	Japan	50000	Y
Hitachi	Japan	30000	Y

Products

pname	price	category	manufacturer
SingleTouch	149.99	Photography	Canon
AC	300	Appliance	Hitachi
Gadget	200	Toy	Canon

SQL

- **S**tructured **Q**uery **L**anguage
- Most widely used language to query relational data
- One of the many languages for querying relational data

- A **declarative** programming language

Selections in SQL

```
SELECT *
FROM   Product
WHERE  price > 100.0
```


Demo 2


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

Joins in SQL

pname	price	category	manufacturer
MultiTouch	199.99	gadget	Canon
SingleTouch	49.99	photography	Canon
Gizom	50	gadget	GizmoWorks
SuperGizmo	250.00	gadget	GizmoWorks

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

Retrieve all Japanese products that cost < $150


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

Joins in SQL

pname	price	category	manufacturer
MultiTouch	199.99	gadget	Canon
SingleTouch	49.99	photography	Canon
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SuperGizmo	250.00	gadget	GizmoWorks

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

Retrieve all Japanese products that cost < $150

```
SELECT pname, price
FROM   Product, Company
WHERE  ...
```



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

Joins in SQL

pname	price	category	manufacturer
MultiTouch	199.99	gadget	Canon
SingleTouch	49.99	photography	Canon
Gizom	50	gadget	GizmoWorks
SuperGizmo	250.00	gadget	GizmoWorks

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

Retrieve all Japanese products that cost < $150

```
SELECT P.pname, C.price
FROM   Product as P, Company as C
WHERE  P.manufacturer=C.cname AND
       P.country='Japan' AND C.price < 150
```

Join Predicate

Selection predicates

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

Joins in SQL

pname	price	category	manufacturer
MultiTouch	199.99	gadget	Canon
SingleTouch	49.99	photography	Canon
Gizom	50	gadget	GizmoWorks
SuperGizmo	250.00	gadget	GizmoWorks

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

Retrieve all USA companies that manufacture "gadget" products

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

Joins in SQL

pname	price	category	manufacturer
MultiTouch	199.99	gadget	Canon
SingleTouch	49.99	photography	Canon
Gizom	50	gadget	GizmoWorks
SuperGizmo	250.00	gadget	GizmoWorks

cname	country
GizmoWorks	USA
Canon	Japan
Hitachi	Japan

Retrieve all USA companies that manufacture "gadget" products

```
SELECT DISTINCT cname
FROM   Product, Company
WHERE  country='USA' AND category = 'gadget'
       AND manufacturer = cname
```

Why DISTINCT?

Demo 2 – cont'd

Joins in SQL

- The standard join in SQL is sometimes called an inner join
  - Each row in the result **must come from both tables in the join**
- Sometimes we want to include rows from only one of the two table: outer join

Employee(id, name)
Sales(employeeID, productID)

Inner Join

Employee

id	name
1	Joe
2	Jack
3	Jill

Sales

employeeID	productID
1	344
1	355
2	544

Retrieve employees and their sales

Employee(id, name)
Sales(employeeID, productID)

Inner Join

Employee

id	name
1	Joe
2	Jack
3	Jill

Sales

employeeID	productID
1	344
1	355
2	544

Retrieve employees and their sales

```
SELECT *
FROM   Employee E, Sales S
WHERE  E.id = S.employeeID
```

Employee(id, name)
Sales(employeeID, productID)

Inner Join

Employee

id	name
1	Joe
2	Jack
3	Jill

Sales

employeeID	productID
1	344
1	355
2	544

Retrieve employees and their sales

```
SELECT *
FROM   Employee E, Sales S
WHERE  E.id = S.employeeID
```

id	name	empolyeeID	productID
1	Joe	1	344
1	Joe	1	355
2	Jack	2	544

Employee(id, name)
Sales(employeeID, productID)

Inner Join

Employee

id	name
1	Joe
2	Jack
3	Jill

Sales

employeeID	productID
1	344
1	355
2	544

Retrieve employees and their sales

Jill is missing

```
SELECT *
FROM   Employee E, Sales S
WHERE  E.id = S.employeeID
```

id	name	empolyeeID	productID
1	Joe	1	344
1	Joe	1	355
2	Jack	2	544

Employee(id, name)
Sales(employeeID, productID)

Inner Join

Employee

id	name
1	Joe
2	Jack
3	Jill

Sales

employeeID	productID
1	344
1	355
2	544

Retrieve employees and their sales

Jill is missing

Alternative syntax

```
SELECT *
FROM   Employee E
       INNER JOIN
       Sales S
   ON E.id = S.employeeID
```

id	name	empolyeeID	productID
1	Joe	1	344
1	Joe	1	355
2	Jack	2	544

Employee(id, name)
Sales(employeeID, productID)

Outer Join

Employee

id	name
1	Joe
2	Jack
3	Jill

Sales

employeeID	productID
1	344
1	355
2	544

Retrieve employees and their sales

Jill is present

```
SELECT *
FROM   Employee E
       LEFT OUTER JOIN
       Sales S
   ON E.id = S.employeeID
```

id	name	empolyeeID	productID
1	Joe	1	344
1	Joe	1	355
2	Jack	2	544
3	Jill	NULL	NULL