Announcements

Project 3A assigned today

Databases

Databases are collections of information; our study repeats a theme: Tell the computer the structure, and it can help you!

Why Study Databases?

Some of us want to compute, but all of us want information ...

- Much of the archived information is in tables
- Databases enhance applications, e.g. Web
- Once you know how to create databases, you can use them to personal advantage
- Databases introduce interesting ideas

How much of your information can be in a table?

Stone Age Databases

Before relational databases (the kind we study) there were only “flat files”

- Structural information was difficult to express
- All processing of information was “special cased” -- custom programs were needed
- Information repeated; difficult to combine
- Changes in format of one file means all programs that ever process that file must be changed ... adding ZIP codes

E.F. Codd of IBM invented relational databases

Relational Databases

Information is stored in tables

- Tables store information about *entities* -- things or stuff ... keep entities of one kind
- Entities have characteristics called *attributes*
- Tables are *tuples* (rows or records) of attributes (columns or fields)
- Every row must be unique, identified by a key
- Relationships -- associations among the data values are stored

Table structure = schema
Table contents = instance

A Table

Tables have names, attributes, tuples

Example : Table

ID	Last	First	Hire	Addr
1	Davolino	Nancy	01 May 1992	507 20th Ave E
2	Fuller	Andrew	14 Aug 1992	908 W. Capital Way
3	Wooster	Berton	01 Apr 1993	722 Moss Bay Blvd
4	Peacock	Margaret	03 May 1993	4110 Old Redmond Rd
5	Buchanan	Steven	17 Oct 1994	13 Garrett Hill
6	Sullimani	Okan		

Instance

Schema

Example:

ID	number	unique number(Key)
Last	text	person's last name
First	text	person's first name
Hire	date	first day on job
Addr	text	street address

Redundancy Is Very Bad

Not every assembly of tables is a good database -- repeating data is bad

- Replicated data can differ in its different locations, e.g. multiple addresses can differ
- *Inconsistent data* is worse than no data
- Keep a single copy of any data, and if it is needed in multiple places, associate it with a key, and store key rather than the data

"You can look it up"

When looking for information, a single item might be the answer, but a table is more likely

- "Who is taking FIT100"? Table of students
- "Whose mile run time ≤ 4:00?" Runner table
- "Who won 2003 Grammy for 'Best New Artist?" A table containing only a single row
- "In what years has US won the World Cup?" Empty Table

Queries to a DB (set of tables) produces tables

Tables From Tables

There are five fundamental operations on tables to create tables:

- Select -- pick rows from a table
- Project -- pick columns from a table
- Union -- combine two tables w/like columns
- Difference -- remove one table from another
- Product -- create "all pairs" from two tables

Though not primitive "Join" is usually included

Select Operation

Select creates a table from the rows of another table meeting a criterion

Select_from Example **On** Hire < 1993

Example : Table

ID	Last	First	Hire	Addr
1	Davolino	Nancy	01 May 1992	507 20th Ave E
2	Fuller	Andrew	14 Aug 1992	908 W. Capital Way
3	Wooster	Berton	01 Apr 1993	722 Moss Bay Blvd
4	Peacock	Margaret	03 May 1993	4110 Old Redmond Rd
5	Buchanan	Steven	17 Oct 1994	13 Garrett Hill
6	Sullimani	Okan	12 Dec 1994	Coventry House

Example : Table

ID	Last	First	Hire	Addr
1	Davolino	Nancy	01 May 1992	507 20th Ave E
2	Fuller	Andrew	14 Aug 1992	908 W. Capital Way

Project

Project creates a table from the columns of another table

Project Last, First **From** Example

Example : Table

ID	Last	First	Hire	Addr
1	Davolino	Nancy	01 May 1992	507 20th Ave E
2	Fuller	Andrew	14 Aug 1992	908 W. Capital Way
3	Wooster	Berton	01 A	
4	Peacock	Margaret	03 M	Rd
5	Buchanan	Steven	17 O	
6	Sullimani	Okan	12 D	

Example : Table

Last	First
Davolino	Nancy
Fuller	Andrew
Wooster	Berton
Peacock	Margaret
Buchanan	Steven
Sullimani	Okan

Union

Union (written like addition) combines two tables with same attributes

- PoliticalUnits = States + Provinces

States : Table

Name	Capitol	Sight
Washington	Olympia	Mt. Rainier
Oregon	Salem	Crater Lake
California	Sacramento	Golden G

Provinces : Table

Name	Capitol	S
British Columbia	Victoria	Stanle
Alberta	Edmonton	Banff

PoliticalUnits : Table

Name	Capitol	Sight
British Columbia	Victoria	Stanley Park
Alberta	Edmonton	Banff
Washington	Olympia	Mt. Rainier
Oregon	Salem	Crater Lake
California	Sacramento	Golden Gate

Difference

Difference (written like subtraction) removes 1 table's rows from another

- Eastern = States - WestCoast

States : Table

Name	Capitol	Sight
Washington	Olympia	Mt. Rainier
Oregon	Salem	Crater Lake
California	Sacramento	Golden Gate
Arizona	Phoenix	Grand Canyon
Nevada	Carson City	Las Vegas

WestCoast : Table

Name	Capitol	Sight
Washington	Olympia	Mt. Rainier
Oregon	Salem	Crater Lake
California	Sacramento	Golden Gate

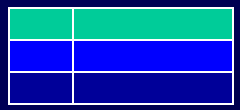
Eastern : Table

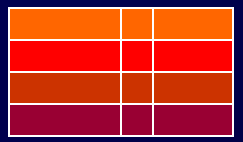
Name	Capitol	Sight
Arizona	Phoenix	Grand Canyon
Nevada	Carson City	Las Vegas

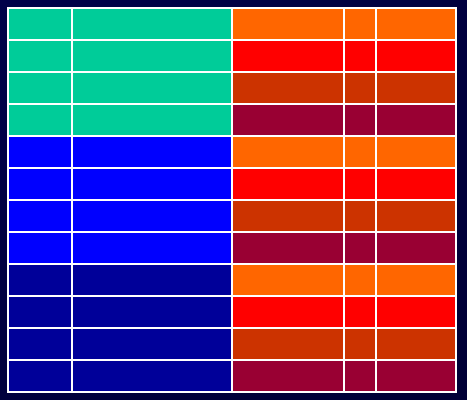
Product

Product (written like multiplication) combines columns and pairs all rows

Colors = Blues **x** Reds







Column Rule: If A has *x* columns, B has *y* columns, A **x** B has *x*+*y* columns

Row Rule: If A has *m* rows, B has *n* rows A **x** B has *mn* rows

There's divide, too, but forget it

Join

Join (written like a bow tie) combines rows (like **x**) if common field matches

Homes = States ⋈ Students

States : Table

State	Capitol	Sight
Washington	Olympia	Mt. Rainier
Oregon	Salem	Crater Lake
California	Sacramento	Golden Gate
Arizona	Phoenix	Grand Canyon
Nevada	Carson City	Las Vegas

Students : Table

First	Last	State
John	Jones	Washington
Jennifer	Smith	California
Brian	Tims	Manitoba

Homes : Table

State	Capitol	Sight	First	Last
Washington	Olympia	Mt. Rainier	John	Jones
California	Sacramento	Golden Gate	Jennifer	Smith

DB Operations

The five DB Operations can create any table from a given set of tables

- All modern database systems are built on these relational operations
- Join is not primitive, but can be built from 5
- Join, select and project are used most often
- The operations are not usually used directly, but are used indirectly from other languages

SQL, the DB language we learn, is built on basic 5