What is a DBMS?
- A Database Management System manages very large amounts of data and provides:
  - persistent storage,
  - efficient access,
  - concurrent access,
  - secure, atomic access.

Examples
- (Almost) Everything is a database!
  - Banking systems
  - Reservation systems
  - Libraries
  - The Web
  - Varying degrees of structure, organization, and efficiency.

Relational Model
- Based on tables, as:
- Today used in most DBMS's.
- Major vendors:
  - Oracle – 32%
  - IBM: DB2 – 34.6%
  - Microsoft: SQL Server, Access – 16.3%
  - Sybase – 2.6%
- IBM bought Informix for $1B in April 2001.
- Most databases are relational with growing support for XML.
- Most web sites are powered by DBMS.
Three Aspects to Studying DBMS's

1. Modeling and design
   - Allows exploration of issues before committing to an implementation.
2. Programming
   - Queries and DB operations like update; connectivity
3. DBMS implementation
   - What's under the hood.
   - CS235 = (1) + (2), while (3) will be covered in a future course.

Entity-Relationship Model

- First step of database design.
- Represent the real world with diagrams.
- Entity corresponds to an object.
- Entity set corresponds to a class.
  - Set of similar objects.
- Attribute = property of entities in entity set.
  - Similar to fields of a struct.

E/R Diagrams

- Entity set → rectangle
- Attribute → oval
- ID
- name
- email
- Students
- Other conventions also exist.

Relationships

- Connect two or more entity sets.
- Represented by diamonds.

Relationship Set

- The value of a relationship set is the set of connected entities.
- Think of the value as a table.
- One column for each connected entity set.
- One row for each connection.

<table>
<thead>
<tr>
<th>Students</th>
<th>Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jerry</td>
<td>CS 235</td>
</tr>
<tr>
<td>Cosmo</td>
<td>CS 335/10</td>
</tr>
<tr>
<td>George</td>
<td>CS 235</td>
</tr>
</tbody>
</table>

Multiway Relationships

- Binary relationships are most common.
- But, sometimes we need a relationship connecting 3 or more entity sets.
- Example: relationship among students, courses, TAs.
Multiway Relationships: Example

Is this E/R diagram correct?

Multiway Relationships

- Works in CS235, because the TA is a TA of all students. Connection student-TA is only via the course.
- But what if students were divided into sections, each headed by a TA?
  - Then, a student in CS235 would be related to only one of the TA's for CS235. Which one?
  - Need a 3-way relationship to tell.

3-Way Relationship

3-Way Relathionship

Beers-Bars-Drinkers Example

Beers-Bars-Drinkers Example

Drinks Have Favorite Beers

Multiplicity of Relationships

Representation of Many-One
- E/R: arrow pointing to "one."
- Rounded arrow = "exactly one."
- Other conventions also exist.

Students

Courses

Teaching

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs

Students

Courses

Enrolls

TAs
**One-One Relationships**

- Put arrows in both directions.

```
Manufacturer <--- Best-seller --- Beers
```

- Design issues:
  - Is the rounded arrow justified?
  - Here, manufacturer is an E.S.; in earlier diagrams it is an attribute. Which is right?

**Attributes on Relationships**

- Shorthand for 3-way relationship:

```
Bars ---- Sells ------ Beers
    
    price

Bars ---- Sells ------ Beers
```

**Attributes on Relationships**

- A true 3-way relationship.
  - Price depends jointly on beer and bar.
  - Arrow convention for multiway relationships: “all other E.S. determine one of these.”
  - Not sufficiently general to express any possibility.
  - However, if price, say, depended only on the beer, then we could use two 2-way relationships: price-beer and beer-bar.
  - Better solution?

**Converting Multiway to 2-Way**

- Necessary in some object-oriented models.

  - Create a new connecting E.S. to represent rows of a relationship set.
  - E.g., (Jimmy’s, Bud, $3.50) for the Sells relationship.
  - Many-one relationships from the connecting E.S. to the others.

**Converting Multiway to 2-Way**

- Sometimes an E.S. participates more than once in a relationship.

- Label edges with roles to distinguish.

```
Drinking  

husband  wife

husband Brad Jennifer Vanessa...

wife  

Brad Jennifer Vanessa...
```
Notice Buddies is symmetric, Married not.
• Cannot specify symmetric in E/R.
• Should we replace *husband* and *wife* by one relationship *spouse*?