What is a Database Management System?

1. Manages very large amounts of data.

2. Supports efficient access to very large amounts of data.

3. Supports concurrent access to v.l.a.d.
   ✦ Example: bank and its ATM machines.

4. Supports secure, atomic access to v.l.a.d.
   ✦ Contrast two people editing the same UNIX file — last to write “wins” — with the problem if two people deduct money from the same account via ATM machines at the same time — new balance is wrong whichever writes last.
Relational Model

- Based on tables, as:

<table>
<thead>
<tr>
<th>acct#</th>
<th>name</th>
<th>balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>12345</td>
<td>Sally</td>
<td>1000.21</td>
</tr>
<tr>
<td>34567</td>
<td>Sue</td>
<td>285.48</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>

- Today used in most DBMS’s.
The DBMS Marketplace

- Relational DBMS companies — Oracle, Informix, Sybase — are among the largest software companies in the world.

- IBM offers its relational DB2 system. With IMS, a nonrelational system, IBM is by some accounts the largest DBMS vendor in the world.

- Microsoft offers SQL-Server, plus Microsoft Access for the cheap DBMS on the desktop, answered by “lite” systems from other competitors.

- Relational companies also challenged by “object-oriented DB” companies.

- But countered with “object-relational” systems, which retain the relational core while allowing type extension as in OO systems.
Three Aspects to Studying DBMS’s

1. Modeling and design of databases.
   ✦ Allows exploration of issues before committing to an implementation.

   ✦ SQL = “intergalactic dataspeak.”

3. DBMS implementation.

CS145 = (1) + (2), while (3) is covered in CS245, CS346, CS347.
Entity/Relationship Model

Diagrams to represent designs.

- *Entity* like object, = “thing.”
- *Entity set* like class = set of “similar” entities/objects.
- *Attribute* = property of entities in an entity set, similar to fields of a struct.
- In diagrams, entity set $\rightarrow$ rectangle; attribute $\rightarrow$ oval.
Relationships

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

\[ \text{Students} \xrightarrow{\text{Taking}} \text{Courses} \]

Relationship Set

Think of the “value” of a relationship set as a table.

- One column for each of the connected entity sets.
- One row for each list of entities, one from each set, that are connected by the relationship.

<table>
<thead>
<tr>
<th>Students</th>
<th>Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sally</td>
<td>CS145</td>
</tr>
<tr>
<td>Sally</td>
<td>CS244</td>
</tr>
<tr>
<td>Joe</td>
<td>CS145</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Multiway Relationships

Usually binary relationships (connecting two E.S.) suffice.

- However, there are some cases where three or more E.S. must be connected by one relationship.

- Example: relationship among students, courses, TA’s. Possibly, this E/R diagram is OK:

```
Studen ts   Taking    Courses
           |          |
            |          |
Assisting  |          |
            |          | TAs
```


• Works in CS145, because each 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 CS145 would be related to only one of the TA’s for CS145. Which one?

• Need a 3-way relationship to tell.
<table>
<thead>
<tr>
<th>Students</th>
<th>Courses</th>
<th>TAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ann</td>
<td>CS145</td>
<td>Jim</td>
</tr>
<tr>
<td>Sue</td>
<td>CS145</td>
<td>Roy</td>
</tr>
<tr>
<td>Bob</td>
<td>CS145</td>
<td>Jim</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Beers-Bars-Drinkers Example

- Our running example for the course.
Multiplicity of Relationships

Many-many       Many-one       One-one

Representation of Many-One

- E/R: arrow pointing to “one.”
  - Rounded arrow = “exactly one.”
Example: Drinkers Have Favorite Beers
One-One Relationships

Put arrows in both directions.

Design Issue:
Is the rounded arrow justified?

Design Issue:
Here, manufacturer is an E.S.; in earlier diagrams it is an attribute. Which is right?
Attributes on Relationships

- Shorthand for 3-way relationship:
• A true 3-way relationship.
  ◆ Price depends jointly on beer and bar.

• Notice 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.

◆ Or better: just make price an attribute of beer.
Converting Multiway to 2-Way

- Baroque in E/R, but necessary in certain “object-oriented” models.
- Create a new connecting E.S. to represent rows of a relationship set.
  - E.g., (Joe’s Bar, Bud, $2.50) for the Sells relationship.
- Many-one relationships from the connecting E.S. to the others.
Roles

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

- Label edges with *roles* to distinguish.

\[
\begin{array}{c|c}
\text{Husband} & \text{Wife} \\
\hline
\d_1 & \d_2 \\
\d_3 & \d_4 \\
\ldots & \ldots \\
\end{array}
\]
Drinkers

\begin{array}{c|c}
\text{Buddy1} & \text{Buddy2} \\
\hline
\text{$d_1$} & \text{$d_2$} \\
\text{$d_1$} & \text{$d_3$} \\
\text{$d_2$} & \text{$d_1$} \\
\text{$d_2$} & \text{$d_4$} \\
\vdots & \vdots \\
\end{array}

- Notice \textit{Buddies} is symmetric, \textit{Married} not.
  
  - No way to say “symmetric” in E/R.

\textbf{Design Question}

Should we replace \texttt{husband} and \texttt{wife} by one relationship \texttt{spouse}?