Administrivia

- Three handouts today:
  - Course info, Schedule, Slides.
  - Latest info will always be online!
- Come to class!
- Ask questions!
- Give feedback!
- Have fun!

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:

<table>
<thead>
<tr>
<th>acct</th>
<th>name</th>
<th>balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>12345</td>
<td>Kate</td>
<td>100000.21</td>
</tr>
<tr>
<td>76543</td>
<td>Rick</td>
<td>89.01</td>
</tr>
<tr>
<td>23500</td>
<td>Tom</td>
<td>555999.02</td>
</tr>
<tr>
<td>34567</td>
<td>Alice</td>
<td>285.48</td>
</tr>
</tbody>
</table>

- Today used in most DBMS's.

Relational Database Marketplace

- In 2005, $13.8B (up 8.3% from 2004)
- Market shares (revenue):
  - Oracle 48.6% (48.9%)
  - IBM 22.0% (22.4%)
  - Microsoft 15.0% (13.9%)
  - Teradata 3.2% (3.3%)
  - Sybase 2.9% (3.0%)
  - Other 8.2% (8.5%)

Source: Gartner
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)

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**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.

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**E/R Diagrams**

- **Entity set** → rectangle
- **Attribute** → oval

![E/R Diagram Example]

- Other conventions also exist.

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**Relationships**

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

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**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>Alice</td>
<td>CS 235</td>
</tr>
<tr>
<td>Tom</td>
<td>CS 33510</td>
</tr>
<tr>
<td>Rick</td>
<td>CS 235</td>
</tr>
<tr>
<td>...</td>
<td>...</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, TA’s.

Multiway Relationships: Example
Is this E/R diagram correct?

3-Way Relationship

Beers-Bars-Drinkers Example

Multiplicity of Relationships
- Representation of Many-One
  - E/R: arrow pointing to “one.”
  - Rounded arrow = “exactly one.”
  - Other conventions also exist.
Drinkers Have Favorite Beers

Bars

\begin{itemize}
  \item Serves
  \item Frequents
  \item Likes
  \item Likes
\end{itemize}

Beers

\begin{itemize}
  \item name
  \item addr
  \item license
\end{itemize}

Drinks

\begin{itemize}
  \item name
  \item fav
\end{itemize}

One-One Relationships

- Put arrows in both directions.

\begin{itemize}
  \item Manfs
  \item Beers
  \item Best-sellers
\end{itemize}

\begin{itemize}
  \item Design issues:
    \begin{itemize}
      \item Is the rounded arrow justified?
      \item Here, manufacturer is an E.S.; in earlier diagrams it is an attribute. Which is right?
    \end{itemize}
\end{itemize}

Attributes on Relationships

- Shorthand for 3-way relationship:

\begin{itemize}
  \item price
  \item Sells
  \item Beers
\end{itemize}

\begin{itemize}
  \item price
  \item Prices
  \item Sells
  \item Beers
\end{itemize}

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."
    \begin{itemize}
      \item Not sufficiently general to express any possibility.
      \item However, if price, say, depended only on the beer, then we could use two 2-way relationships: price-beer and beer-bar.
      \item Better solution?
    \end{itemize}

Converting Multiway to 2-Way

- Necessary in some object-oriented models.
- Create a new connecting E.S. to represent rows of a relationship set.
  \begin{itemize}
    \item E.g., (Jimmy’s, Bud, $3.50) for the Sells relationship.
    \item Many-one relationships from the connecting E.S. to the others.
  \end{itemize}

Converting Multiway to 2-Way

- BBP
  \begin{itemize}
    \item The-Bar
    \item The-Beer
    \item The-Price
  \end{itemize}

- Bars
- Beers
- Prices
Roles

- Sometimes an E.S. participates more than once in a relationship.
- Label edges with roles to distinguish.

\[ \text{husband} \rightarrow \text{Married} \rightarrow \text{wife} \]

Drinkers

<table>
<thead>
<tr>
<th>husband</th>
<th>wife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom</td>
<td>Kate</td>
</tr>
<tr>
<td>Johnny</td>
<td>Vanessa</td>
</tr>
</tbody>
</table>

\[ \text{Buddies} \]

\[ \text{Buddy}_1 \rightarrow \text{Alice} \rightarrow \text{Kate} \rightarrow \text{Buddy}_2 \]

\[ \text{Buddy}_1 \rightarrow \text{Kate} \rightarrow \text{Alice} \rightarrow \text{Buddy}_2 \]

\[ \text{Buddy}_1 \rightarrow \text{Tom} \rightarrow \text{Rick} \rightarrow \text{Buddy}_2 \]

\[ \text{Buddy}_1 \rightarrow \text{Rick} \rightarrow \text{Tom} \rightarrow \text{Buddy}_2 \]

- Notice Buddies is symmetric, Married not.
- Cannot specify symmetric in E/R.
- Should we replace \text{husband} and \text{wife} by one relationship \text{spouse}?