In this lecture, you will learn:

- Why data models are important
- About the basic data-modeling building blocks
- What business rules are and how they affect database design
- How the major data models evolved, and their advantages and disadvantages
- How data models can be classified by level of abstraction
The Importance of Data Models

• Data model
  – Relatively simple representation, usually graphical, of complex real-world data structures
  – Communications tool to facilitate interaction among the designer, the applications programmer, and the end user

• Good database design uses an appropriate data model as its foundation

Importance of Data Modeling

• End-users have different views and needs for data

• Data model organizes data for various users
Data Model Basic Building Blocks

- Entity is anything about which data are to be collected and stored
- Attribute is a characteristic of an entity
- Relationship describes an association among (two or more) entities
  - One-to-many (1:M) relationship
  - Many-to-many (M:N or M:M) relationship
  - One-to-one (1:1) relationship

Business Rules (enforce Constraints)

- Brief, precise, and unambiguous description of a policy, procedure, or principle within a specific organization’s environment
- Apply to any organization that stores and uses data to generate information
- Description of operations that help to create and enforce actions within that organization’s environment
Business Rules

• Must be rendered in writing
• Must be kept up to date
• Sometimes are external to the organization
• Must be easy to understand and widely disseminated
• Describe characteristics of the data as viewed by the company

Sources of Business Rules

• Company managers
• Policy makers
• Department managers
• Written documentation
  – Procedures
  – Standards
  – Operations manuals
• Direct interviews with end users
Importance of Business Rules

- Promote creation of an accurate data model
- Standardize company’s view of data
- Constitute a communications tool between users and designers
- Allow designer to understand the nature, role, and scope of data
- Allow designer to understand business processes
- Allow designer to develop appropriate relationship participation rules and constraints

The Evolution of Data Models

- Hierarchical
- Network
- Relational
- Entity relationship
- Object oriented
Crucial Database Components

• Schema
  – Conceptual organization of entire database as viewed by the database administrator

• Subschema
  – Defines database portion “seen” by the application programs that actually produce the desired information from data contained within the database

• Data Management Language (DML)
  – Define data characteristics and data structure in order to manipulate the data

The Relational Model—Basic Structure

• Relational Database Management System (RDBMS)

• Performs same basic functions provided by hierarchical and network DBMS systems, plus other functions

• Most important advantage of the RDBMS is its ability to let the user/designer operate in a human logical environment
The Relational Model—
Basic Structure (continued)

• Table (relations)
  – Matrix consisting of a series of row/column intersections
  – Related to each other by sharing a common entity characteristic

• Relational schema
  – Visual representation of relational database's entities, attributes within those entities, and relationships between those entities

Relational Table

• Stores a collection of related entities
  – Resembles a file

• Relational table is purely logical structure
  – How data are physically stored in the database is of no concern to the user or the designer
  – This property became the source of a real database revolution
A Relational Schema

**FIGURE 2.5 A RELATIONAL SCHEMA**

[Diagram showing relational schema with tables and relationships]

Linking Relational Tables

**FIGURE 2.4 LINKING RELATIONAL TABLES**

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<thead>
<tr>
<th>Database name: Ch02_InsureCo</th>
<th>Table name: AGINT (first six attributes)</th>
</tr>
</thead>
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</tr>
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<td>1002 Hain</td>
<td>Lisa</td>
</tr>
<tr>
<td>1003 Irish</td>
<td>Paul</td>
</tr>
<tr>
<td>1004 Ali</td>
<td>Myron</td>
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<tr>
<td>1005 Sweeney</td>
<td>Amy</td>
</tr>
<tr>
<td>1006 Brown</td>
<td>James</td>
</tr>
<tr>
<td>1007 Williams</td>
<td>George</td>
</tr>
<tr>
<td>1008 Fantas</td>
<td>Anne</td>
</tr>
<tr>
<td>1009 Smith</td>
<td>Oselie</td>
</tr>
</tbody>
</table>

Link through AGENT_CODE

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<th>CUS_FNNAME</th>
<th>CUS_AREA</th>
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<td>503</td>
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</tbody>
</table>
The Relational Model

• Advantages
  – Structural independence
  – Improved conceptual simplicity
  – Easier database design, implementation, management, and use
  – Ad hoc query capability
  – Powerful database management system

The Relational Model (continued)

• Disadvantages
  – Substantial hardware and system software overhead
  – Can facilitate poor design and implementation
  – May promote “islands of information” problems
The Entity Relationship Model

- Widely accepted and adapted graphical tool for data modeling
- Introduced by Chen in 1976
- Graphical representation of entities and their relationships in a database structure

The Entity Relationship Model—Basic Structure

- Entity relationship diagram (ERD)
  - Uses graphic representations to model database components
  - Entity is mapped to a relational table
- Entity instance (or occurrence) is row in table
- Entity set is collection of like entities
- Connectivity labels types of relationships
  - Diamond connected to related entities through a relationship line
Relationships: The Basic Chen ERD

Figure 2.6 Relationships: The Basic Chen ERD

A One-to-Many (1:M) Relationship: a PAINTER can paint many PAINTINGS; each PAINTING is painted by one PAINTER

A Many-to-Many (M:N) Relationship: an EMPLOYEE can learn many SKILLS; each SKILL can be learned by many EMPLOYEES

A One-to-One (1:1) Relationship: an EMPLOYEE manages one STORE; each STORE is managed by one EMPLOYEE

Relationships: The Basic Crow’s Foot ERD

Figure 2.7 Relationships: The Basic Crow’s Foot ERD

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The Entity Relationship Model

• Advantages
  – Exceptional conceptual simplicity
  – Visual representation
  – Effective communication tool
  – Integrated with the relational data model

The Entity Relationship Model (continued)

• Disadvantages
  – Limited constraint representation
  – Limited relationship representation
  – No data manipulation language
  – Loss of information content
The Object Oriented Model

• Semantic data model (SDM) developed by Hammer and McLeod in 1981
• Modeled both data and their relationships in a single structure known as an object
• Basis of object oriented data model (OODM)
• OODM becomes the basis for the object oriented database management system (OODBMS)

The Object Oriented Model (continued)

• Object is described by its factual content
  – Like relational model’s entity
• Includes information about relationships between facts within object and relationships with other objects
  – Unlike relational model’s entity
• Subsequent OODM development allowed an object to also contain operations
• Object becomes basic building block for autonomous structures
Developments that Boosted OODM’s Popularity

- Growing costs put a premium on code reusability
- Complex data types and system requirements became difficult to manage with a traditional RDBMS
- Became possible to support increasingly sophisticated transaction & information requirements
- Ever-increasing computing power made it possible to support the large computing overhead required

Object Oriented Data Model—Basic Structure

- Object: abstraction of a real-world entity
- Attributes describe the properties of an object
- Objects that share similar characteristics are grouped in classes
- Classes are organized in a class hierarchy
- Inheritance is the ability of an object within the class hierarchy to inherit the attributes and methods of classes above it
A Comparison of the OO Model and the ER Model

The Object Oriented Model

• Advantages
  – Adds semantic content
  – Visual presentation includes semantic content
  – Database integrity
  – Both structural and data independence
The Object Oriented Model (continued)

• Disadvantages
  – Slow pace of OODM standards development
  – Complex navigational data access
  – Steep learning curve
  – High system overhead slows transactions
  – Lack of market penetration

Other Models

• Extended Relational Data Model (ERDM)
  – Semantic data model developed in response to increasing complexity of applications
  – DBMS based on the ERDM often described as an object/relational database management system (O/RDBMS)
  – Primarily geared to business applications
Data Models: A Summary

- Each new data model capitalized on the shortcomings of previous models
- Common characteristics:
  - Conceptual simplicity without compromising the semantic completeness of the database
  - Represent the real world as closely as possible
  - Representation of real-world transformations (behavior) must be in compliance with consistency and integrity characteristics of any data model

The Development of Data Models

![Diagram: Development of Data Models]

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Database Models and the Internet

• Characteristics of successful “Internet age” databases
  – Flexible, efficient, and secure Internet access that is easily used, developed, and supported
  – Support for complex data types and relationships
  – Seamless interfacing with multiple data sources and structures

Database Models and the Internet (continued)

  – Relative conceptual simplicity to make database design and implementation less cumbersome
  – An abundance of available database design, implementation, and application development tools
  – A powerful DBMS graphical user interface (GUI) to help make the DBA’s job easier
Degrees of Data Abstraction

• Way of classifying data models

• Many processes begin at high level of abstraction and proceed to an ever-increasing level of detail

• Designing a usable database follows the same basic process

Degrees of Data Abstraction (continued)

• American National Standards Institute/Standards Planning and Requirements Committee (ANSI/SPARC)
  – Classified data models according to their degree of abstraction (1970s):
    • Conceptual
    • External
    • Internal
The Conceptual Model

- Represents global view of the database
- Enterprise-wide representation of data as viewed by high-level managers
- Basis for identification and description of main data objects, avoiding details
- Most widely used conceptual model is the entity relationship (ER) model
Advantages of Conceptual Model

- Provides a relatively easily understood macro level view of data environment
- Independent of both software and hardware
  - Does not depend on the DBMS software used to implement the model
  - Does not depend on the hardware used in the implementation of the model
  - Changes in either the hardware or the DBMS software have no effect on the database design at the conceptual level
The Internal Model

- Representation of the database as “seen” by the DBMS
- Adapts the conceptual model to the DBMS
- Software dependent
- Hardware independent

The External Model

- End users’ view of the data environment
- Requires that the modeler subdivide set of requirements and constraints into functional modules that can be examined within the framework of their external models
- Good design should:
  - Consider such relationships between views
  - Provide programmers with a set of restrictions that govern common entities
Advantages of External Models

- Use of database subsets makes application program development much simpler
  - Facilitates designer’s task by making it easier to identify specific data required to support each business unit’s operations
  - Provides feedback about the conceptual model’s adequacy
- Creation of external models helps to ensure security constraints in the database design
The External Model

- DBMS dependent
- Hardware independent

The External Models for Tiny College
The Physical Model

- Operates at lowest level of abstraction, describing the way data are saved on storage media such as disks or tapes
- Software and hardware dependent
- Requires that database designers have a detailed knowledge of the hardware and software used to implement database design

Summary

- A good DBMS will perform poorly with a poorly designed database
- A data model is a (relatively) simple abstraction of a complex real-world data-gathering environment
- Basic data modeling components are:
  - Entities
  - Attributes
  - Relationships
Summary (continued)

• Hierarchical model
  – Based on a tree structure composed of a root segment, parent segments, and child segments
  – Depicts a set of one-to-many (1:M) relationships between a parent and its children
  – Does not include ad hoc querying capability

• Network model attempts to deal with many of the hierarchical model’s limitations

• Relational model:
  – Current database implementation standard
  – Much simpler than hierarchical or network design

• Object is basic modeling structure of object oriented model

• Data modeling requirements are a function of different data views (global vs. local) and level of data abstraction