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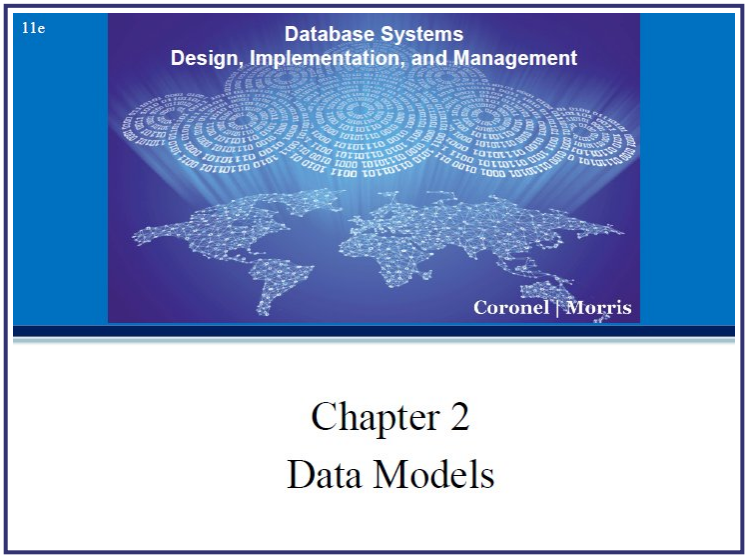
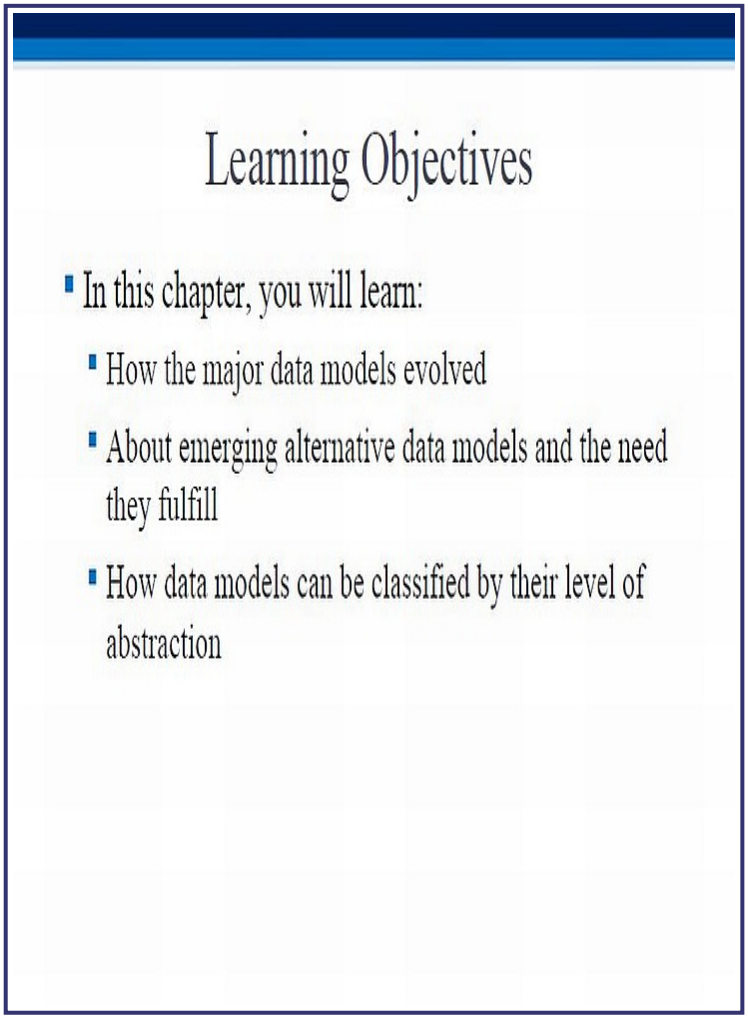
Data Modeling



Chapter 2
Data Models

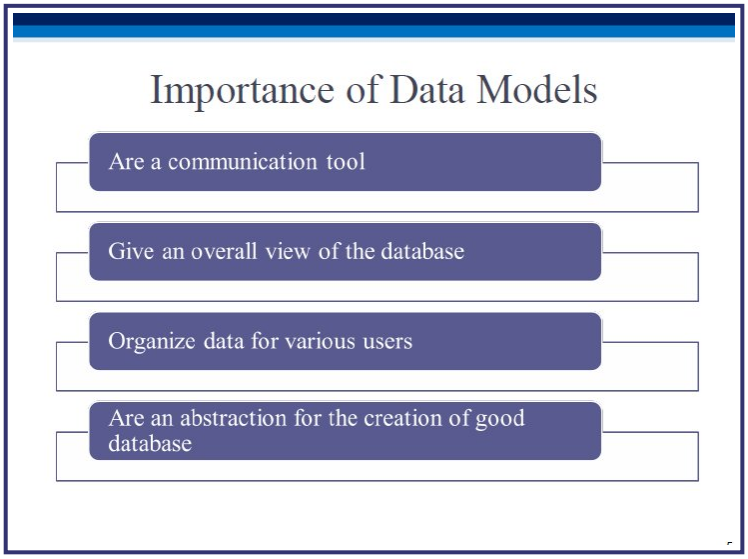
Learning Objectives

- In this chapter, you will learn:
  - About data modeling and why data models are important
  - About the basic data-modeling building blocks
  - What business rules are and how they influence database design


Learning Objectives
In this chapter, you will learn:
How the major data models evolved
About emerging alternative data models and the need they fulfill
How data models can be classified by their level of abstraction

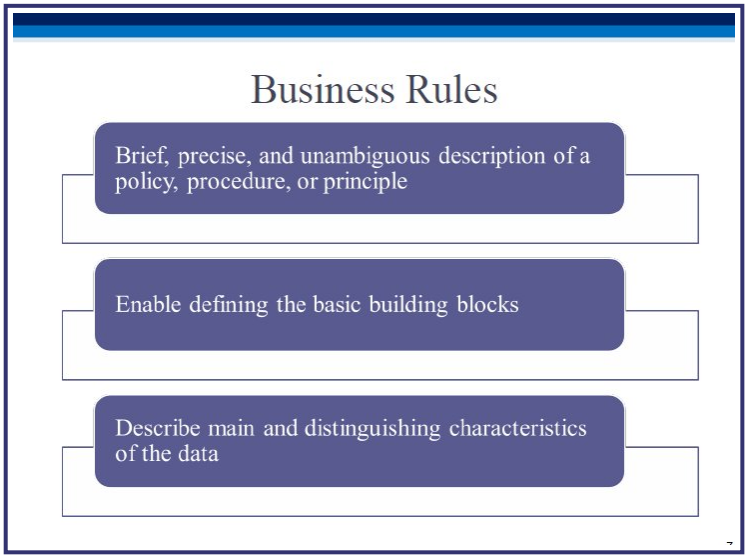
Data Modeling and Data Models

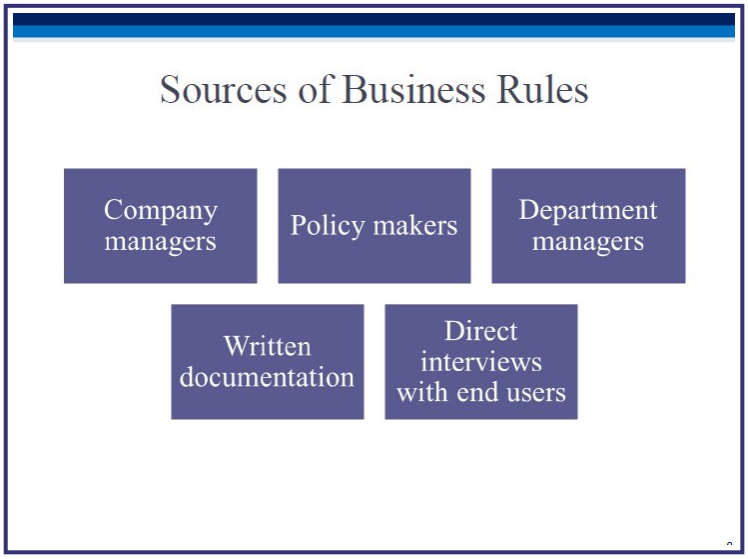
- **Data modeling**: Iterative and progressive process of creating a specific data model for a determined problem domain
  - **Data models**: Simple representations of complex real-world data structures
  - Useful for supporting a specific problem domain
  - **Model** - Abstraction of a real-world object or event


Importance of Data Models
Are a communication tool
Give an overall view of the database
Organize data for various users
Are an abstraction for the creation of good database

Data Model Basic Building Blocks

- **Entity**: Unique and distinct object used to collect and store data
  - **Attribute**: Characteristic of an entity
- **Relationship**: Describes an association among entities
  - **One-to-many (1:M)**
  - **Many-to-many (M:N or M:M)**
  - **One-to-one (1:1)**
- **Constraint**: Set of rules to ensure data integrity


Business Rules
Brief, precise, and unambiguous description of a policy, procedure, or principle
Enable defining the basic building blocks
Describe main and distinguishing characteristics of the data


Sources of Business Rules
Company managers
Policy makers
Department managers
Written documentation
Direct interviews with end users

Reasons for Identifying and Documenting Business Rules

- Help standardize company's view of data
- Communications tool between users and designers
- Allow designer to:
  - Understand the nature, role, scope of data, and business processes
  - Develop appropriate relationship participation rules and constraints
  - Create an accurate data model

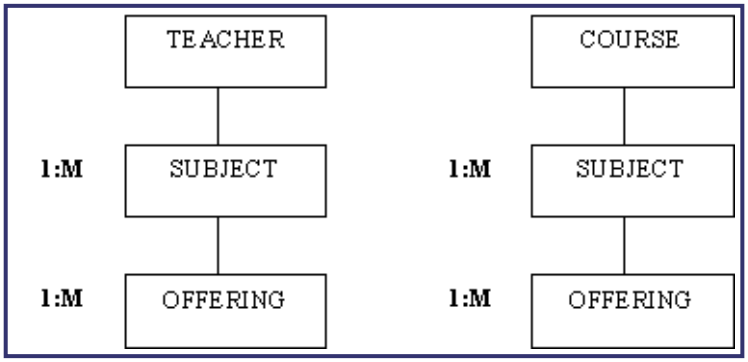
Translating Business Rules into Data Model Components

- Nouns translate into entities
- Verbs translate into relationships among entities
- Relationships are bidirectional
- Questions to identify the relationship type
  - How many instances of B are related to one instance of A?
  - How many instances of A are related to one instance of B?

Naming Conventions

- Entity names - Required to:
  - Be descriptive of the objects in the business environment
  - Use terminology that is familiar to the users
- Attribute name - Required to be descriptive of the data represented by the attribute
- Proper naming:
  - Facilitates communication between parties
  - Promotes self-documentation

Hierarchical modeling



Network modeling

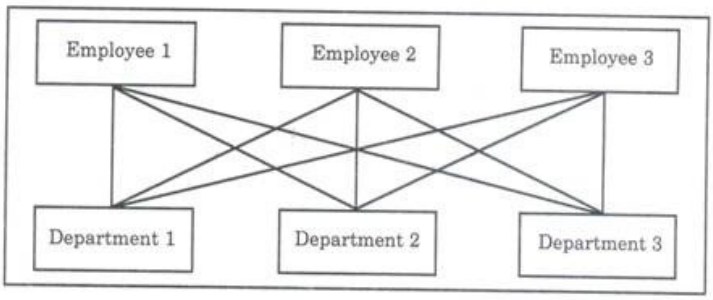
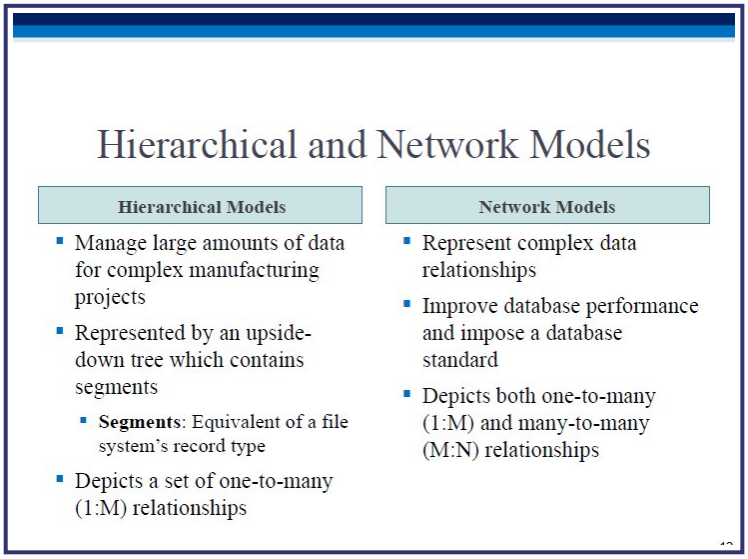
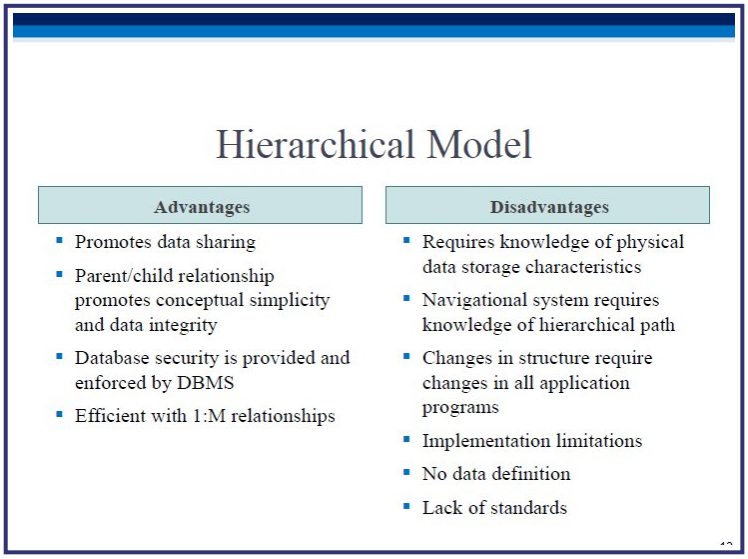


Fig. 9.5 Network model of employee information systems


Hierarchical and Network Models
Hierarchical Models
Manage large amounts of data for complex manufacturing projects
Represented by an upside-down tree which contains segments
Segments: Equivalent of a file system's record type
Depicts a set of one-to-many (1:M) relationships
Network Models
Represent complex data relationships
Improve database performance and impose a database standard
Depicts both one-to-many (1:M) and many-to-many (M:N) relationships


Hierarchical Model
Advantages
Promotes data sharing
Parent/child relationship promotes conceptual simplicity and data integrity
Database security is provided and enforced by DBMS
Efficient with 1:M relationships
Disadvantages
Requires knowledge of physical data storage characteristics
Navigational system requires knowledge of hierarchical path
Changes in structure require changes in all application programs
Implementation limitations
No data definition
Lack of standards

Network Model

Advantages	Disadvantages
▪ Conceptual simplicity ▪ Handles more relationship types ▪ Data access is flexible ▪ Data owner/member relationship promotes data integrity ▪ Conformance to standards ▪ Includes data definition language (DDL) and data manipulation language (DML)	▪ System complexity limits efficiency ▪ Navigational system yields complex implementation, application development, and management ▪ Structural changes require changes in all application programs

Standard Database Concepts

Schema

- Conceptual organization of the entire database as viewed by the database administrator

Subschema

- Portion of the database seen by the application programs that produce the desired information from the data within the database

Data creation, querying

Schema data definition language (DDL)

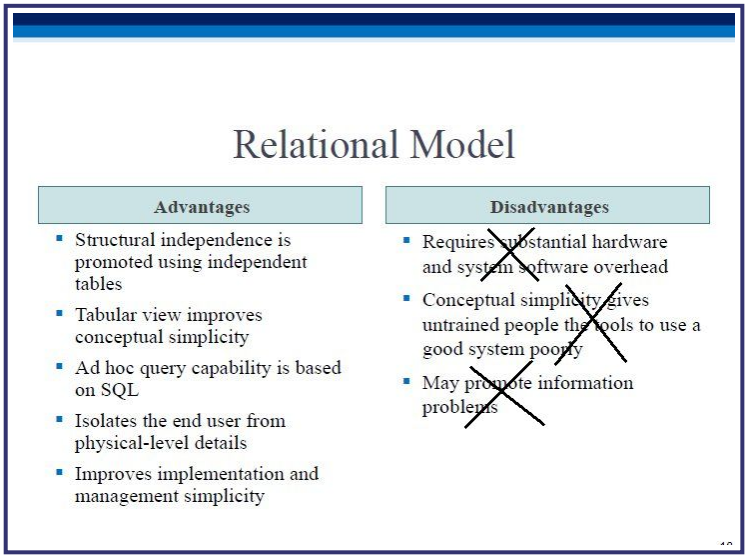
- Enables the database administrator to define the schema components

Data manipulation language (DML)

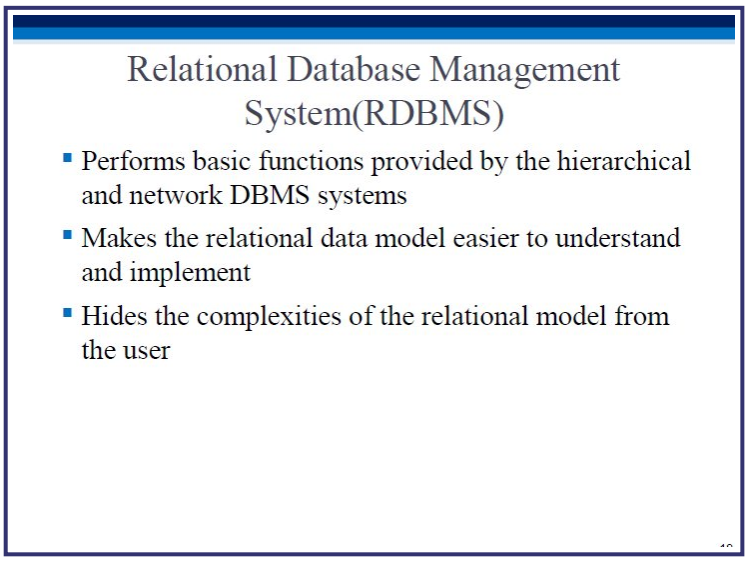
- Environment in which data can be managed and is used to work with the data in the database

The Relational Model

- Based on a relation
  - **Relation** or **table**: Matrix composed of intersecting tuple and attribute
    - **Tuple**: Rows
    - **Attribute**: Columns
- Describes a precise set of data manipulation constructs

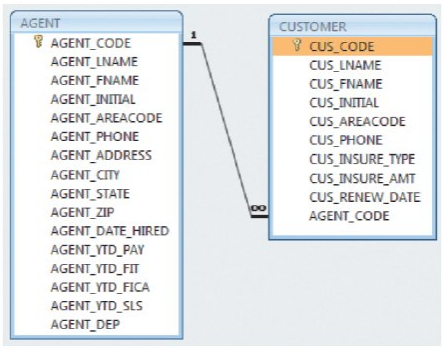

Relational Model
Advantages
Structural independence is promoted using independent tables
Tabular view improves conceptual simplicity
Ad hoc query capability is based on SQL
Isolates the end user from physical-level details
Improves implementation and management simplicity
Disadvantages
Requires substantial hardware and system software overhead
Conceptual simplicity gives untrained people the tools to use a good system poorly
May promote information problems

'Structural' dependence (not a good thing!)



Structural dependence [cont'd]

Figure 2.2 - A Relational Diagram



Redundancy of data (again, not a good thing!)

SQL-Based Relational Database Application

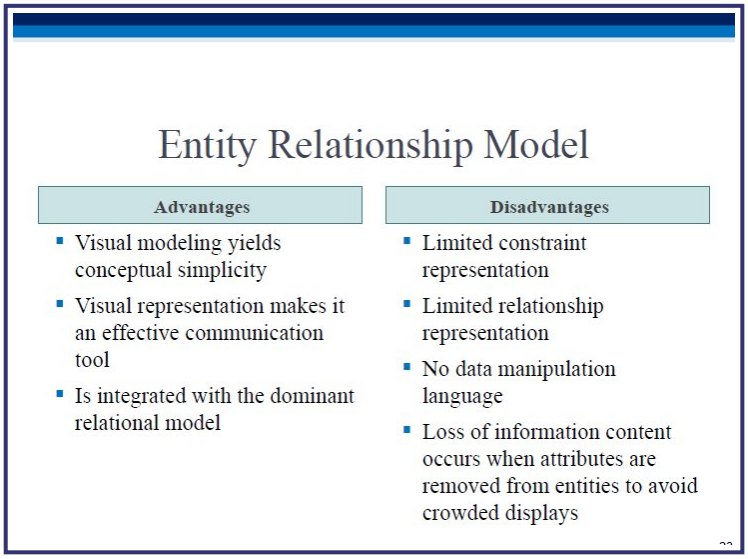
- End-user interface
  - Allows end user to interact with the data
- Collection of tables stored in the database
  - Each table is independent from another
  - Rows in different tables are related based on common values in common attributes
- SQL engine
  - Executes all queries

Why is redundancy not a good thing?

The Entity Relationship Model

- Graphical representation of entities and their relationships in a database structure
- **Entity relationship diagram (ERD)**
  - Uses graphic representations to model database components
- **Entity instance or entity occurrence**
  - Rows in the relational table
- **Connectivity**: Term used to label the relationship types

The three types of data anomalies



DB systems

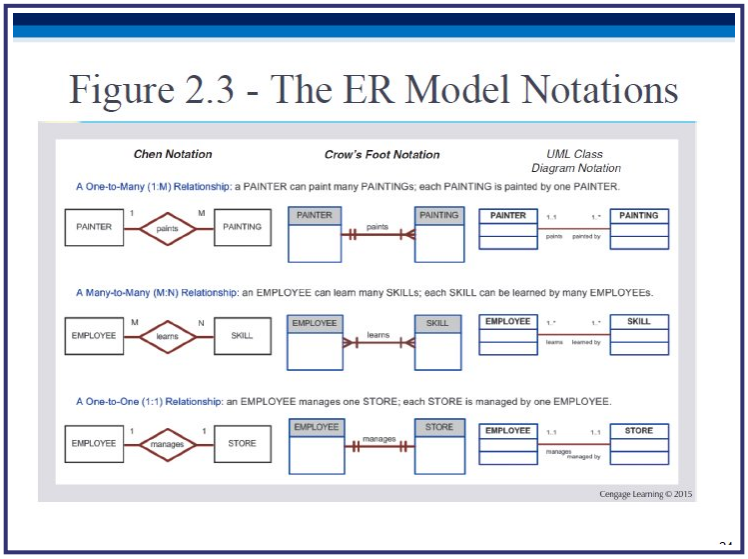


Figure 2.3 - The ER Model Notations
Chen Notation
Crow's Foot Notation
UML Class Diagram Notation
A One-to-Many (1:M) Relationship: a PAINTER can paint many PAINTINGs; each PAINTING is painted by one PAINTER.
PAINTER
paints
PAINTING
A Many-to-Many (M:N) Relationship: an EMPLOYEE can learn many SKILLs; each SKILL can be learned by many EMPLOYEEs.
EMPLOYEE
learns
SKILL
A One-to-One (1:1) Relationship: an EMPLOYEE manages one STORE; each STORE is managed by one EMPLOYEE.
manages
STORE
Cengage Learning © 2015

Notations - more..

Additional reading: here is information on, and comparison between, four ER notations: Chen, Crow, Rein85, IDEFIX.

O-O databases

Also called 'object stores', these dbs offer(ed) a way to store ("persist") objects on disk. The objects (entity instances) are instanced from classes (entities), like with standard OO programming practice.

Advantages:

- 'cleaner' design - objects mimic real-world counterparts
- inheritance and encapsulation possible
- richer datatypes (attributes) available
- good for CAD, multimedia..

Drawbacks:

- harder to query (compared to relational DBs) - no straightforward way to build and traverse relations between objects
- relations are simpler in certain situations

The RDBMS community collectively ignored this development..

O-R databases

These are a compromise between RDBs and OODBs - they feature an O-O front-end over a relational architecture. Interfacing applications do so in an O-O way, and queries/modifications are translated to/from relational form ("ORM").

Benefits:

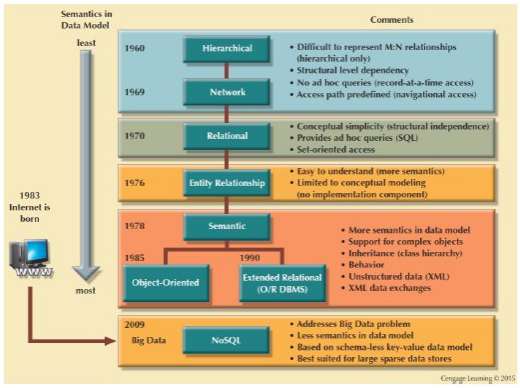
- easy to access the data from an O-O application
- queries can be simpler (can use objects' structure)

Drawback:

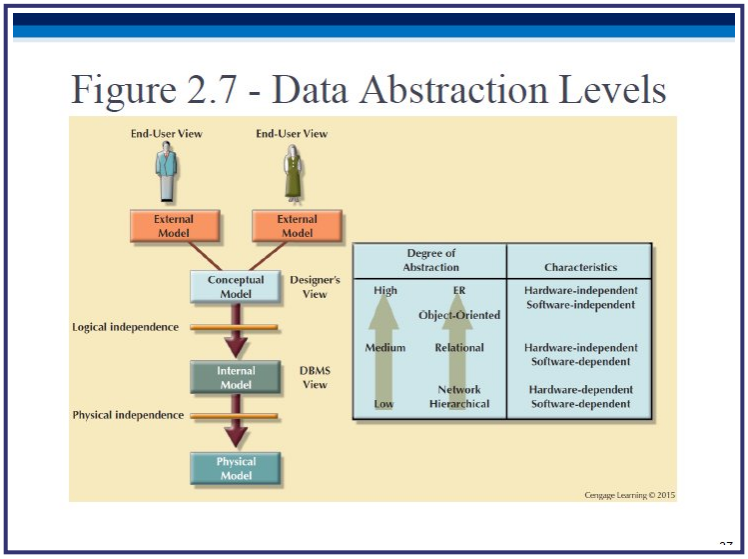
- performance can be poor on account of the two-way translation

Data models: hierarchical => => NoSQL

Figure 2.6 - The Evolution of Data Models



Layered data abstraction

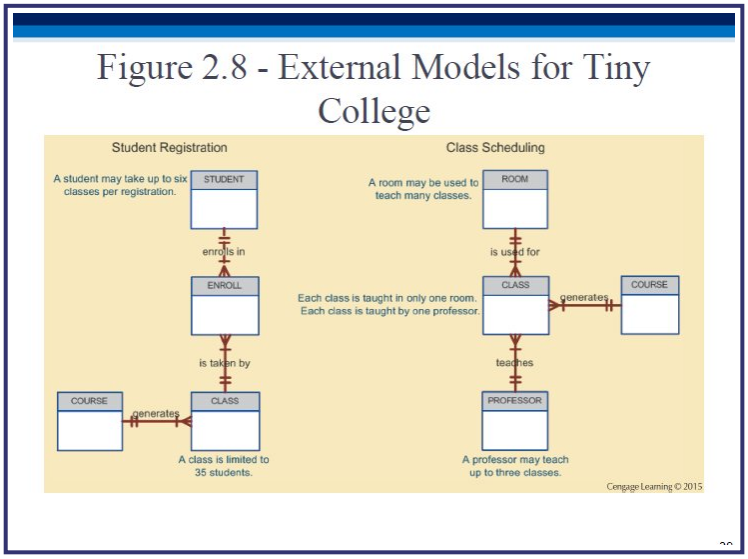


External model

The External Model

- End users' view of the data environment
- ER diagrams are used to represent the external views
- **External schema**: Specific representation of an external view

External model



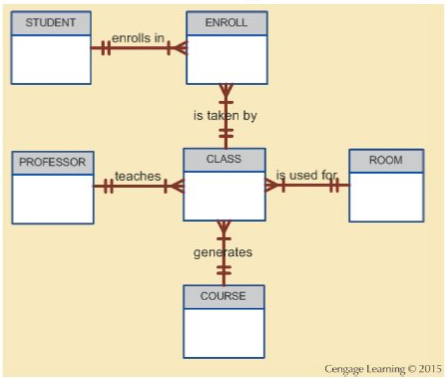
Conceptual model

The Conceptual Model

- Represents a global view of the entire database by the entire organization
- **Conceptual schema**: Basis for the identification and high-level description of the main data objects
- Has a macro-level view of data environment
- Is software and hardware independent
- **Logical design**: Task of creating a conceptual data model

Conceptual model

Figure 2.9 - Conceptual Model for Tiny College



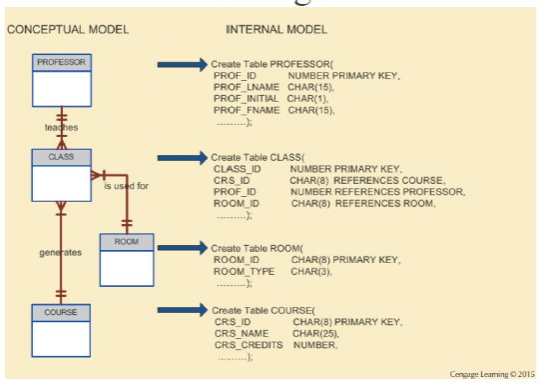
Internal model

The Internal Model

- Representing database as seen by the DBMS mapping conceptual model to the DBMS
- **Internal schema**: Specific representation of an internal model
  - Uses the database constructs supported by the chosen database
- Is software dependent and hardware independent
- **Logical independence**: Changing internal model without affecting the conceptual model

Internal model

Figure 2.10 - Internal Model for Tiny College



Physical model

The Physical Model

- Operates at lowest level of abstraction
- Describes the way data are saved on storage media such as disks or tapes
- Requires the definition of physical storage and data access methods
- Relational model aimed at logical level
  - Does not require physical-level details
- **Physical independence**: Changes in physical model do not affect internal model