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CC414- Lec 2

DataBase Models

by

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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

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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

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Importance of Data Modeling

- End-users have different views and needs for data
- Data model organizes data for various users

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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**

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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

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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*

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Sources of Business Rules

- Company managers
- Policy makers
- Department managers
- Written documentation
  - Procedures
  - Standards
  - Operations manuals
- Direct interviews with end users

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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

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The Evolution of Data Models

- Hierarchical
- Network
- Relational
- Entity relationship
- Object oriented

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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

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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

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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

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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

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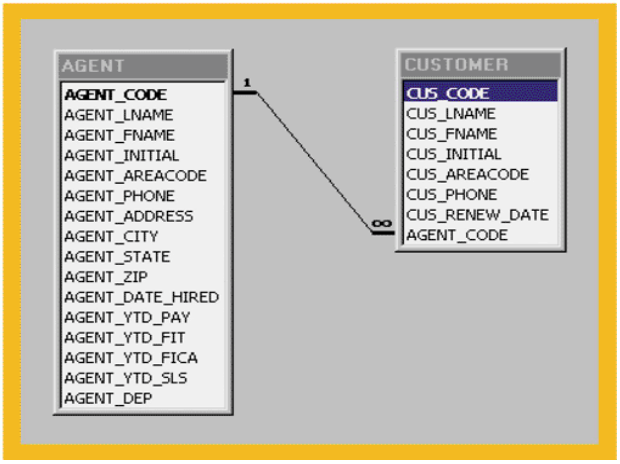
A Relational Schema

FIGURE 2.5 A RELATIONAL SCHEMA



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Linking Relational Tables

FIGURE 2.4 LINKING RELATIONAL TABLES

Database name: Ch02_InsureCo Table name: AGENT (first six attributes)

AGENT_CODE	AGENT_LNAME	AGENT_FNAME	AGENT_INITIAL	AGENT_AREACODE	AGENT_PHONE
501	Alby	Alex	B	713	228-1249
502	Hahn	Leah	F	615	882-1244
503	Okon	John	T	615	123-5589

Link through AGENT_CODE

Table name: CUSTOMER

CUS_CODE	CUS_LNAME	CUS_FNAME	CUS_INITIAL	CUS_AREACODE	CUS_PHONE	CUS_RENEW_DATE	AGENT_CODE
10010	Ramas	Alfred	A	615	844-2573	05-Apr-2004	502
10011	Dunne	Leona	K	713	894-1238	16-Jun-2004	501
10012	Smith	Kathy	W	615	894-2285	29-Jan-2005	502
10013	Olowski	Paul	F	615	894-2180	14-Oct-2004	502
10014	Orlando	Myron		615	222-1672	28-Dec-2004	501
10015	O'Brian	Amy	B	713	442-3381	22-Sep-2004	503
10016	Brown	James	G	615	297-1228	25-Mar-2004	502
10017	Williams	George		615	290-2556	17-Jul-2004	503
10018	Farriss	Anne	G	713	382-7185	03-Dec-2004	501
10019	Smith	Olette	K	615	297-3809	14-Mar-2004	503

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The Relational Model

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

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The Relational Model (continued)

- Disadvantages
  - Substantial hardware and system software overhead
  - Can facilitate poor design and implementation
  - May promote “islands of information” problems

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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

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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

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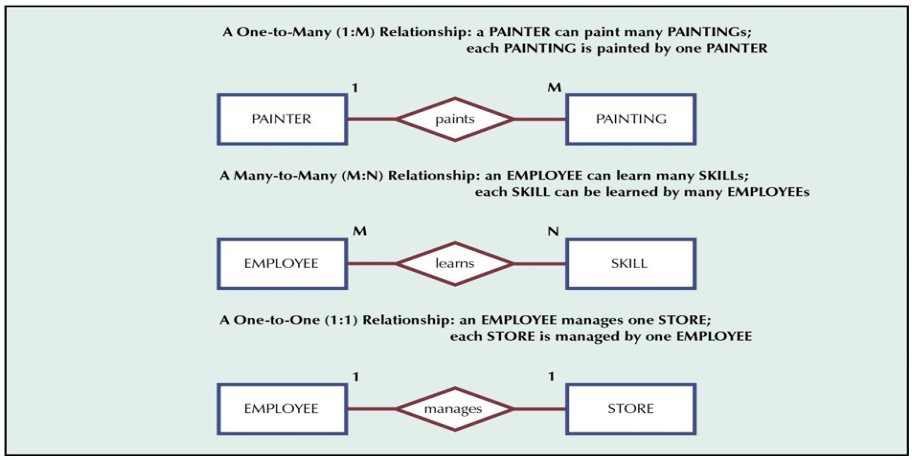
Relationships: The Basic Chen ERD

FIGURE 2.6 RELATIONSHIPS: THE BASIC CHEN ERD



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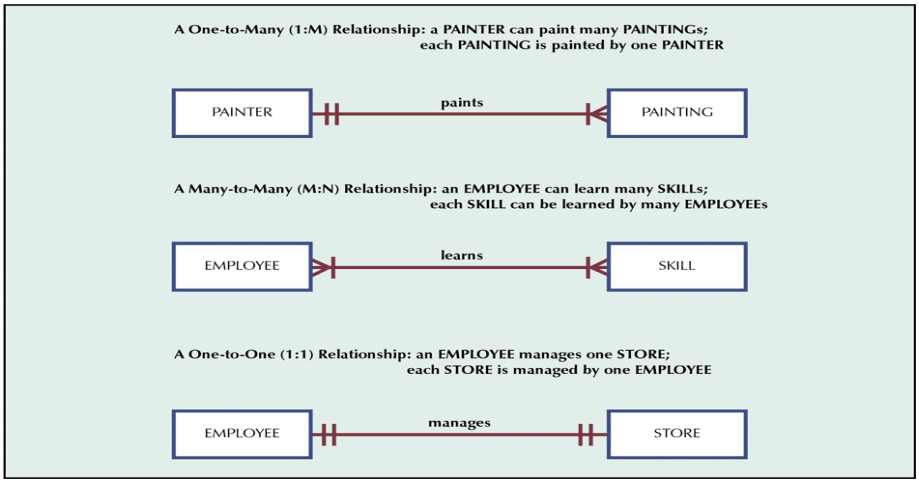
Relationships: The Basic Crow's Foot ERD

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

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The Entity Relationship Model (continued)

- Disadvantages
  - Limited constraint representation
  - Limited relationship representation
  - No data manipulation language
  - Loss of information content

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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)

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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

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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

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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

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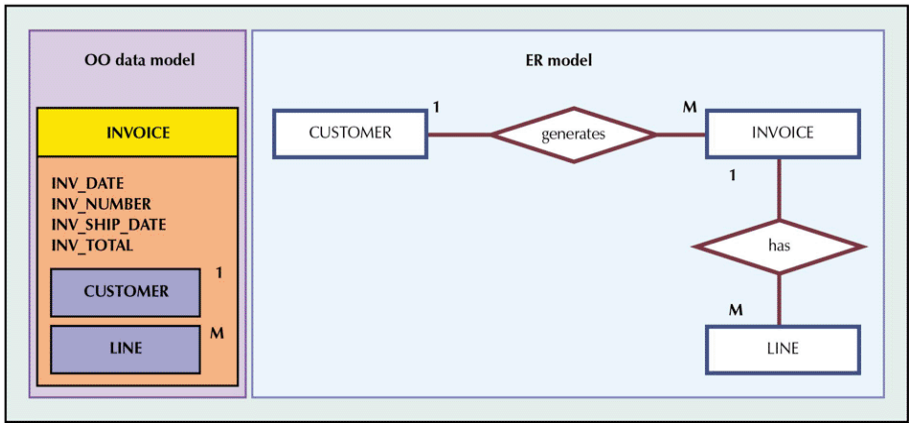
A Comparison of the OO Model and the ER Model

FIGURE 2.8 A COMPARISON OF THE OO MODEL AND THE ER MODEL



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The Object Oriented Model

- Advantages
  - Adds semantic content
  - Visual presentation includes semantic content
  - Database integrity
  - Both structural and data independence

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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

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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

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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

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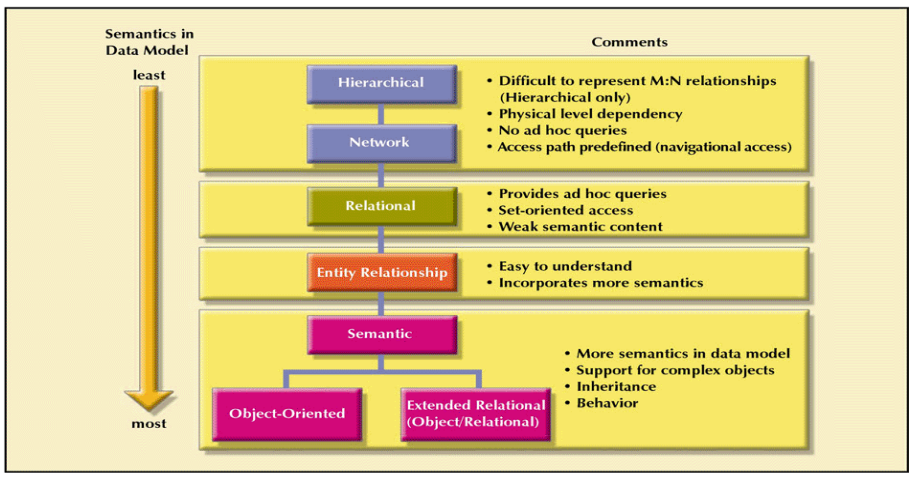
The Development of Data Models

FIGURE 2.9 THE 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

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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

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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

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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

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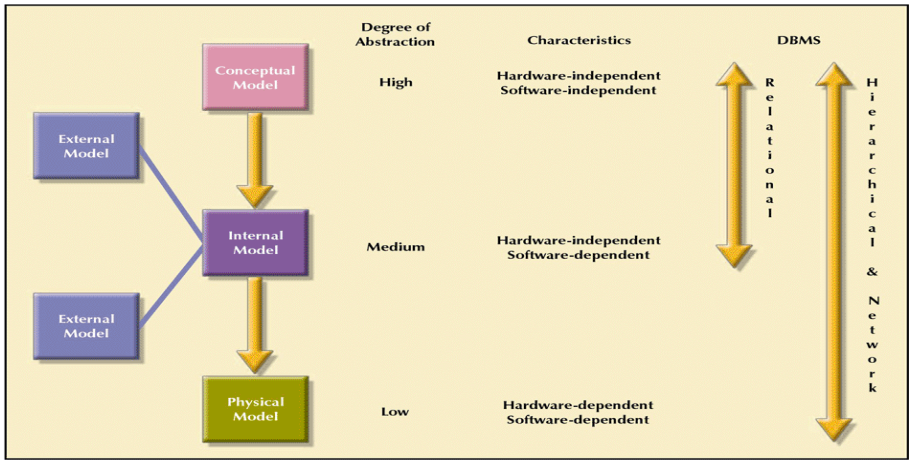
Data Abstraction Levels

FIGURE 2.10 DATA ABSTRACTION LEVELS



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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

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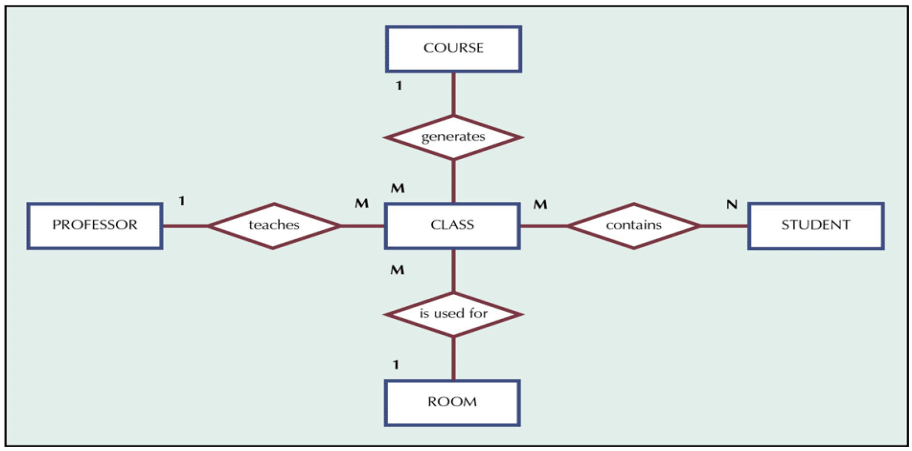
A Conceptual Model for Tiny College

FIGURE 2.12 A CONCEPTUAL MODEL FOR TINY COLLEGE



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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

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The Internal Model

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

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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

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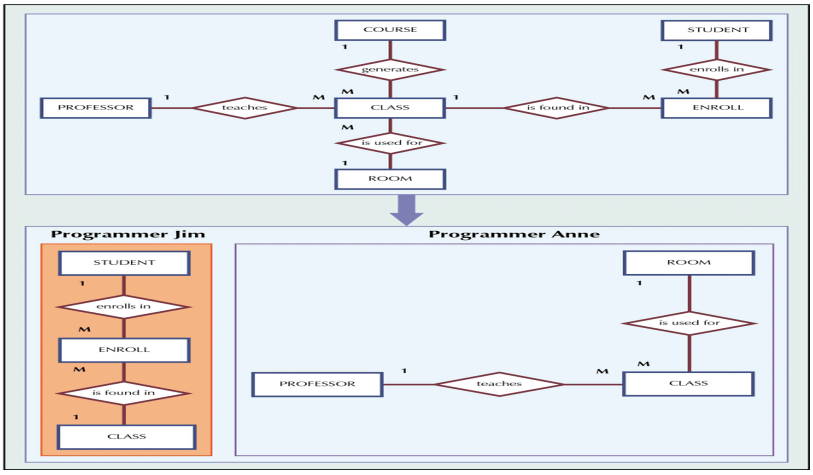
A Division of an Internal Model into External Models

FIGURE 2.13 A DIVISION OF AN INTERNAL MODEL INTO EXTERNAL MODELS



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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

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The External Model

- DBMS dependent
- Hardware independent

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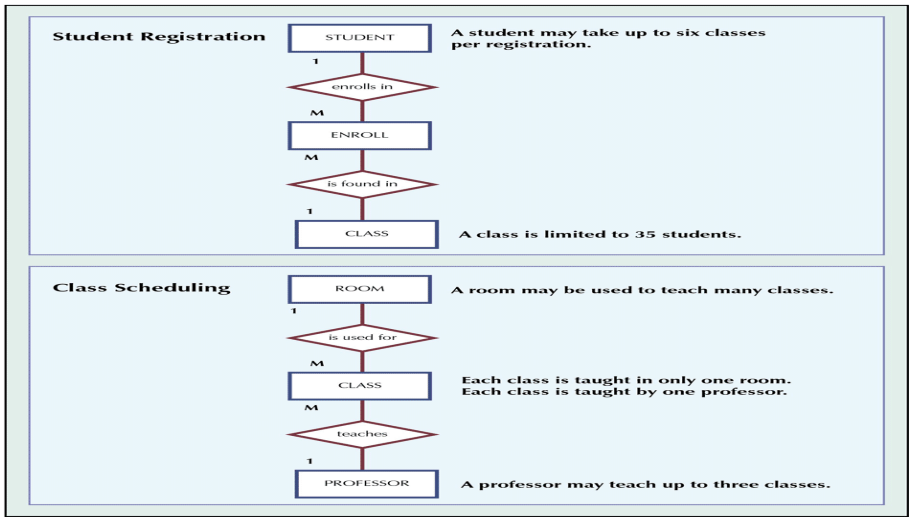
The External Models for Tiny College

FIGURE 2.14 THE EXTERNAL MODELS FOR TINY COLLEGE



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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

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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

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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 (I:M) relationships between a parent and its children
  - Does not include ad hoc querying capability

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Summary (continued)

- 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