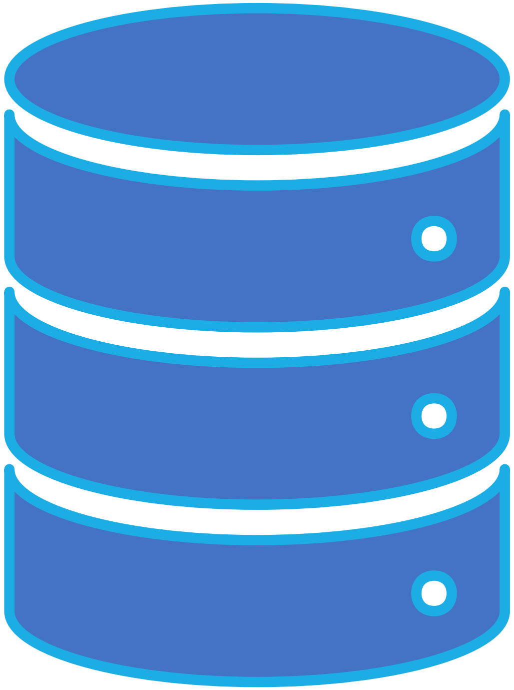
2. DATA MODELS

Database Design & Business Application Development



LEARNING OBJECTIVES

Discuss data modeling and why data models are important

Describe the basic data-modeling building blocks

Define what business rules are and how they influence database design

Understand how the major data models evolved

List emerging alternative data models and the needs they fulfill

Explain how data models can be classified by their level of abstraction

DATA MODELING AND DATA MODELS

Data modeling: creating a specific data model for a determined problem domain

- Data model: simple representation of complex real-world data structures
  - Useful for supporting a specific problem domain
- Model: abstraction of a more complex real-world object or event

THE IMPORTANCE OF DATA MODELS

The importance of data modeling cannot be overstated

- Facilitates communication
- Gives various views of the database
- Organizes data for various users
- Provides an abstraction for the creation of good a database

DATA MODEL BASIC BUILDING BLOCKS

Entity: person, place, thing, or event about which data will be collected and stored

- Attribute: characteristic of an entity
- Relationship: association among entities
  - One-to-many (1:M OR 1..*)
  - Many-to-many (M:N or *..*)
  - One-to-one (1:1 OR 1..1)
- Constraint: restriction placed on data
  - Ensures data integrity

BUSINESS RULES

Brief, precise, and unambiguous description of a policy, procedure, or principle

- Create and enforce actions within that organization's environment
- Establish entities, relationships, and constraints

DISCOVERING BUSINESS RULES

Sources of business rules

- Company managers
- Policy makers
- Department managers
- Written documentation
- Direct interviews with end users

DISCOVERING BUSINESS RULES

Reasons for identifying and documenting business rules

- Standardize company's view of data
- Facilitate communications tool between users and designers
- Assist designers
  - 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

Business rules set the stage for the proper identification of entities, attributes, relationships, and constraints

- 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 name requirements

- 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

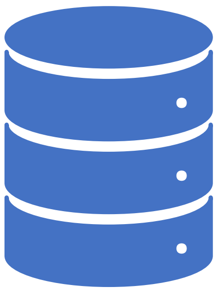
Proper naming

- Facilitates communication between parties
- Promotes self-documentation

HIERARCHICAL AND NETWORK MODELS

Hierarchical models: developed to manage large amounts of data for complex manufacturing projects

- Represented by an upside-down tree which contains segments
  - Segments are the equivalent of a file system's record type
- Depicts a set of one-to-many (1:M) relationships



HIERARCHICAL AND NETWORK MODELS

Network models: created to represent complex data relationships effectively

- Improved database performance and imposed a database standard
- Allows a record to have more than one parent

Standard database concepts that emerged with the network model are still used by modern data models

- Schema and subschema
- Data manipulation language (DML)
- Data definition language (DDL)

THE RELATIONAL MODEL

Produced an automatic transmission database that replaced standard transmission databases

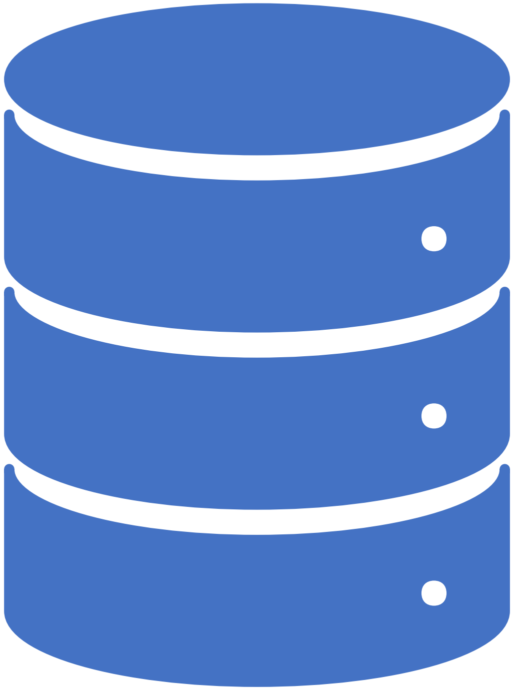
Based on a relation (i.e., table): matrix composed of intersecting tuples (rows) and attributes (columns)

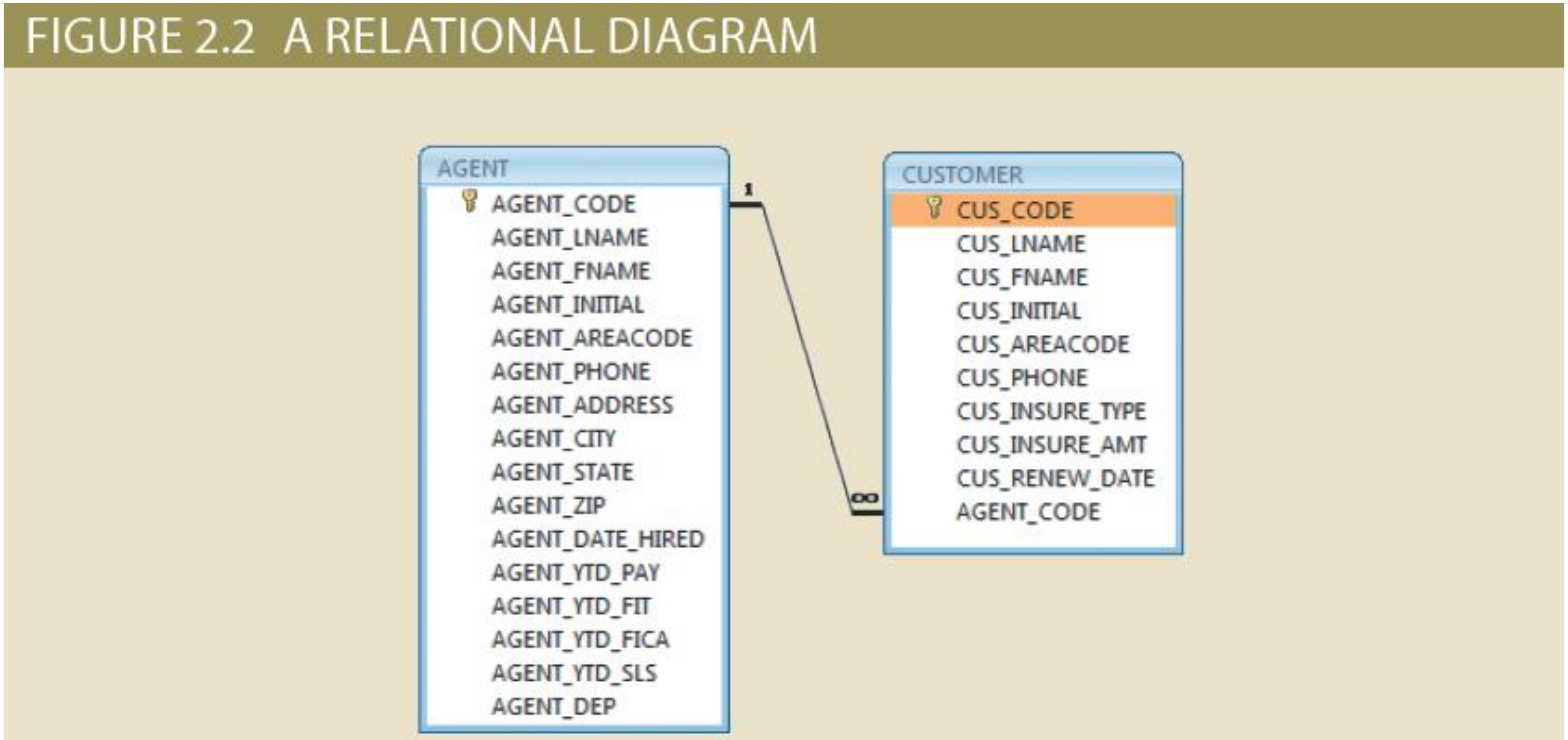
Describes a precise set of data manipulation constructs

THE RELATIONAL MODEL

Relational database management system (RDBMS)

- Performs basic functions provided by the hierarchical and network DBMS systems
- Makes the relational data model easier to understand and implement
- Hides the complexities of the relational model from the user



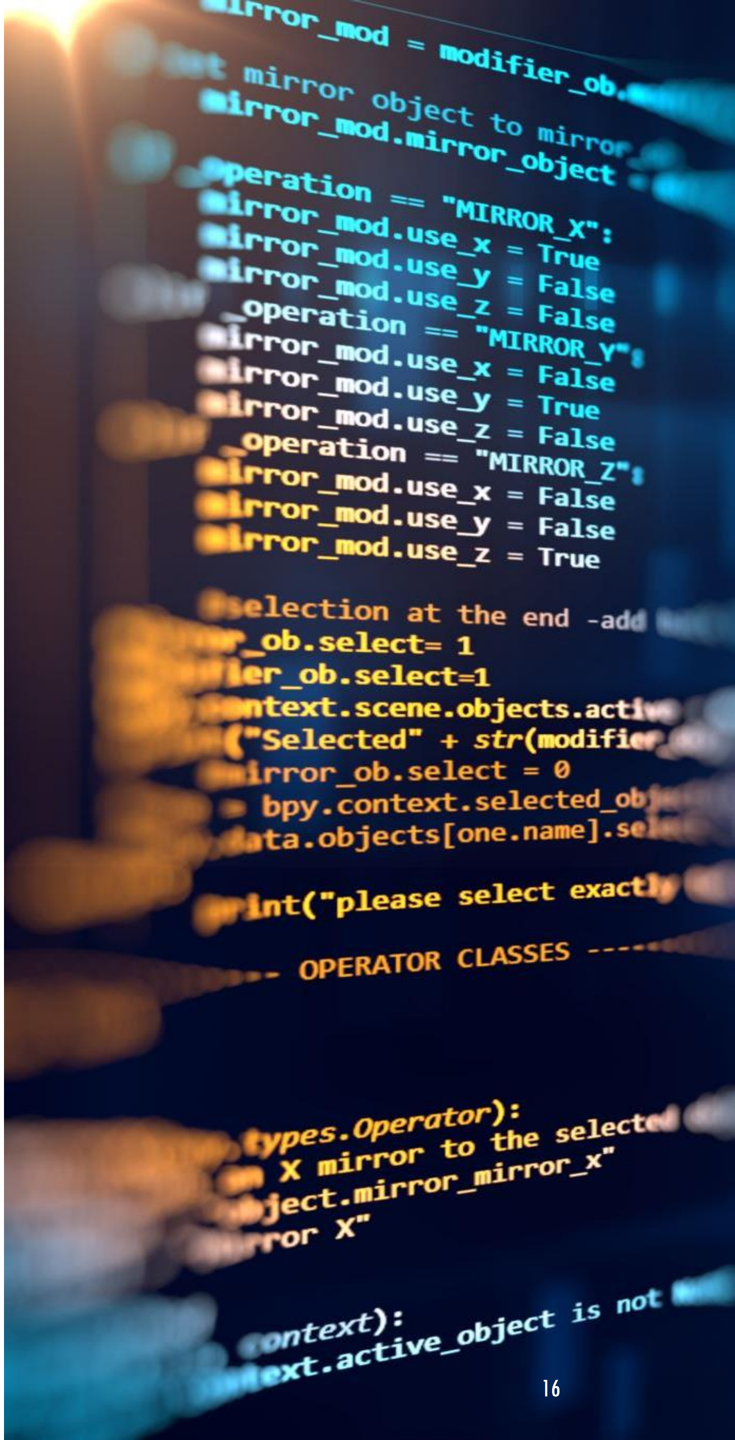


THE RELATIONAL MODEL

THE RELATIONAL MODEL

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



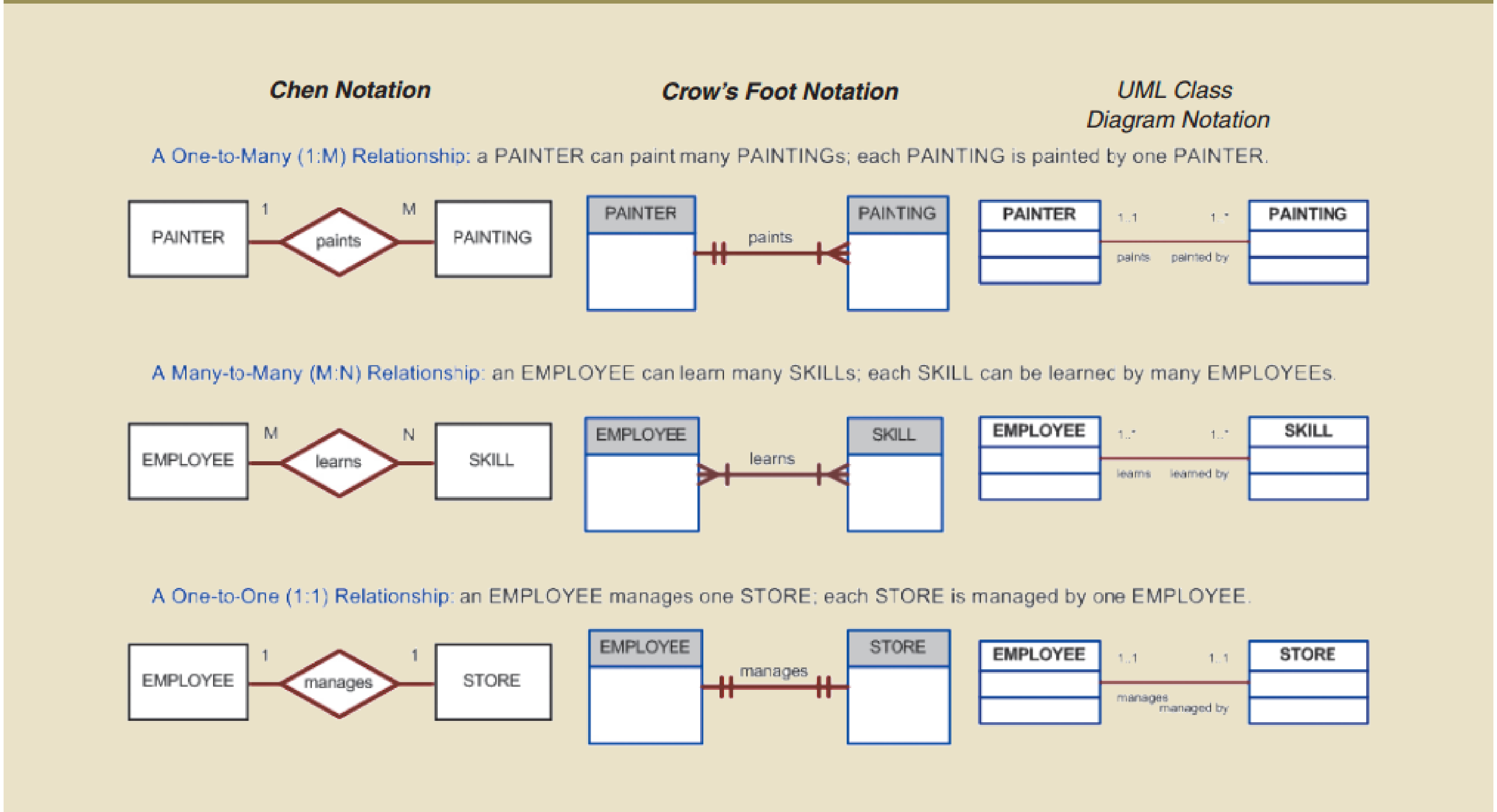
THE ENTITY RELATIONSHIP MODEL

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
- Attributes: describe particular characteristics
- Connectivity: term used to label the relationship types

THE ENTITY RELATIONSHIP MODEL

FIGURE 2.3 THE ER MODEL NOTATIONS



THE OBJECT-ORIENTED DATA MODEL

Both data and its relationships are contained in a single structure known as an object

Object-oriented database management system(OODBMS): based on OODM

Object: contains data and their relationships with operations that are performed on it

Basic building block for autonomous structures

Abstraction of real-world entity

Attribute: describes the properties of an object

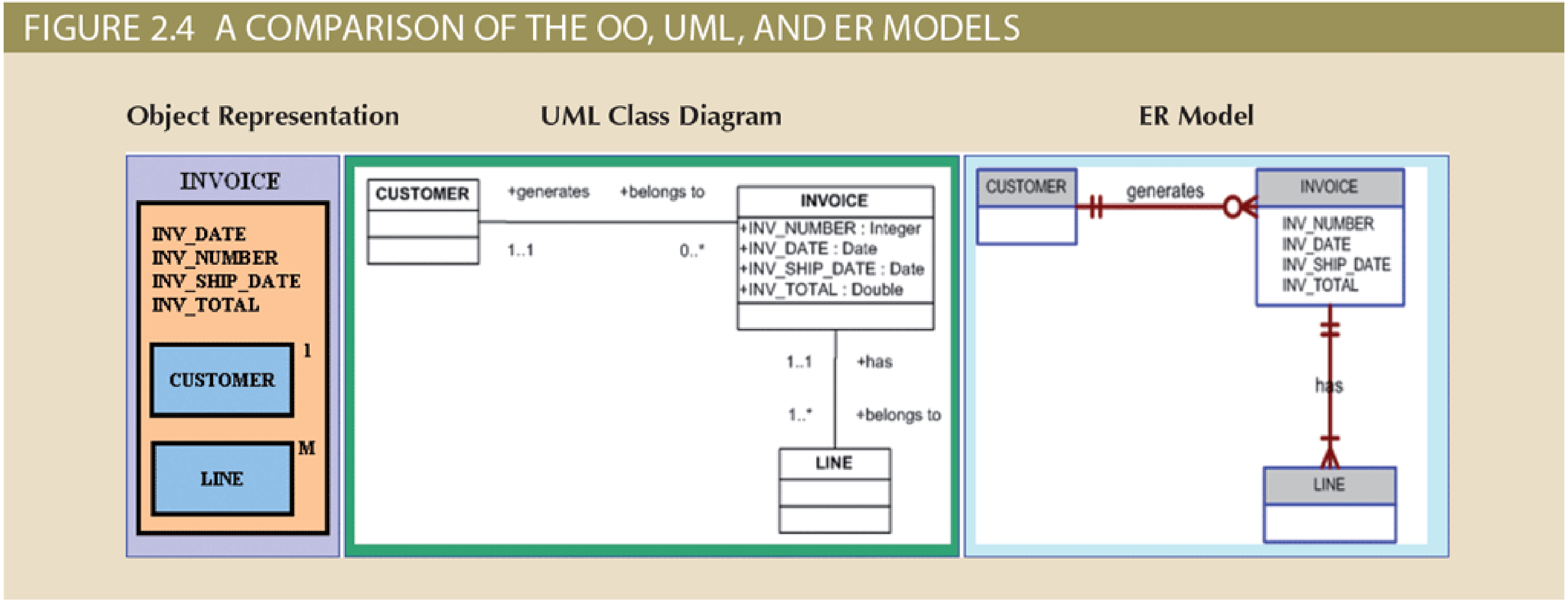
THE OBJECT-ORIENTED DATA MODEL

Class: collection of similar objects with shared structure and behavior organized in a class hierarchy

Class hierarchy: resembles an upside-down tree in which each class has only one parent

Inheritance: object inherits methods and attributes of classes above it

Unified Modeling Language (UML): describes sets of diagrams and symbols to graphically model a system



THE OBJECT-ORIENTED DATA MODEL

OBJECT/RELATIONAL AND XML

Extended relational data model (ERDM)

Supports OO features, extensible data types based on classes, and inheritance

- Object/relational database management system (O/R DBMS): based on ERDM

Extensible Markup Language (XML)

Manages unstructured data for efficient and effective exchange of structured, semistructured, and unstructured data

EMERGING DATA MODELS: BIG DATA AND NOSQL

Goals of Big Data

- Find new and better ways to manage large amounts of web and sensor-generated data
- Provide high performance at a reasonable cost

Characteristics of Big Data

- Volume
- Velocity
- Variety

EMERGING DATA MODELS: BIG DATA AND NOSQL

Challenges of Big Data

Volume doesn't allow usage of conventional structures

Expensive

OLAP tools proved inconsistent dealing with unstructured data

New technologies of Big Data

Hadoop

Hadoop Distributed File System (HDFS)

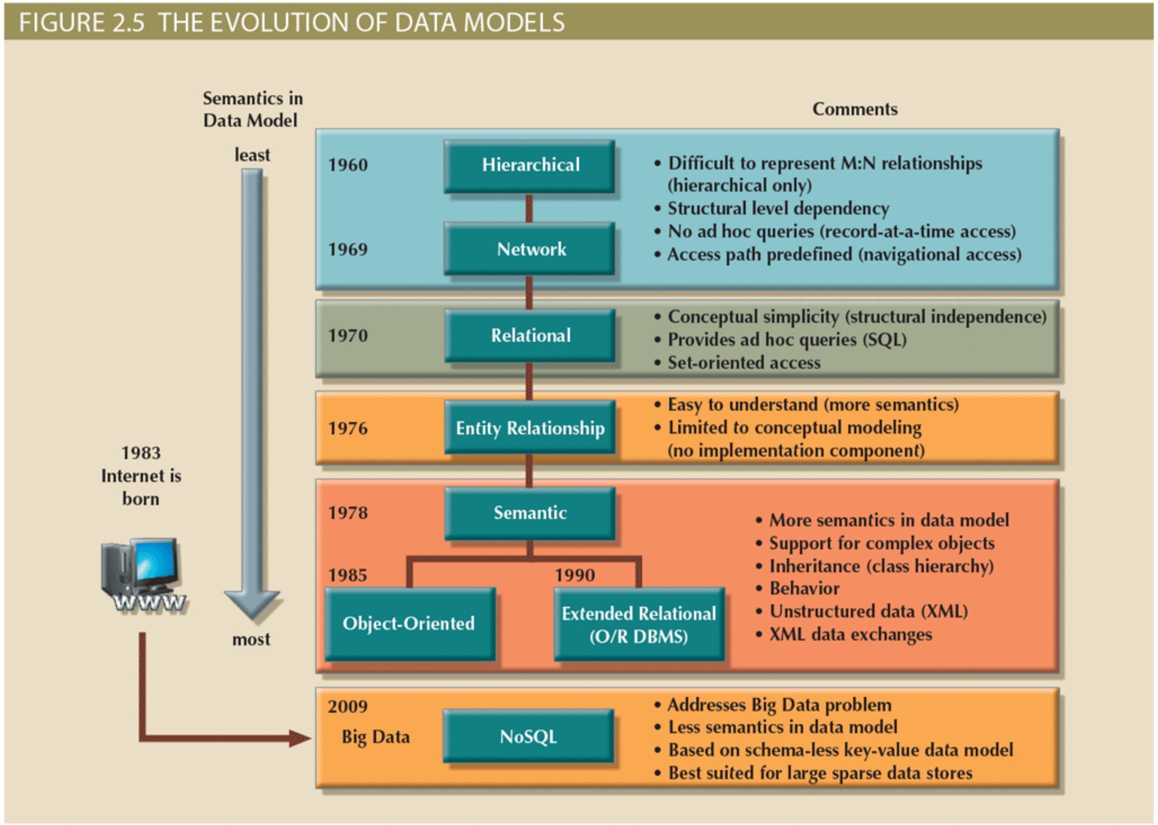
MapReduce

NoSQL

EMERGING DATA MODELS: BIG DATA AND NOSQL

NoSQL databases

- Not based on the relational model
- Support distributed database architectures
- Provide high scalability, high availability, and fault tolerance
- Support large amounts of sparse data
- Geared toward performance rather than transaction consistency
- Provides a broad umbrella for data storage and manipulation



DATA MODELS: A SUMMARY

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

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)

Disadvantages

System complexity limits efficiency

Navigational system yields complex implementation, application development, and management

Structural changes require changes in all application programs

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

ENTITY RELATIONSHIP MODEL

Advantages

Visual modeling yields conceptual simplicity

Visual representation makes it an effective communication tool

Is integrated with the dominant relational model

Disadvantages

Limited constraint representation

Limited relationship representation

No data manipulation language

Loss of information content occurs when attributes are removed from entities to avoid crowded displays

OBJECT-ORIENTED MODEL

Advantages

- Semantic content is added
- Visual representation includes semantic content
- Inheritance promotes data integrity

Disadvantages

- Slow development of standards caused vendors to supply their own enhancements
- Complex navigational system
- Learning curve is steep
- High system overhead slows transactions

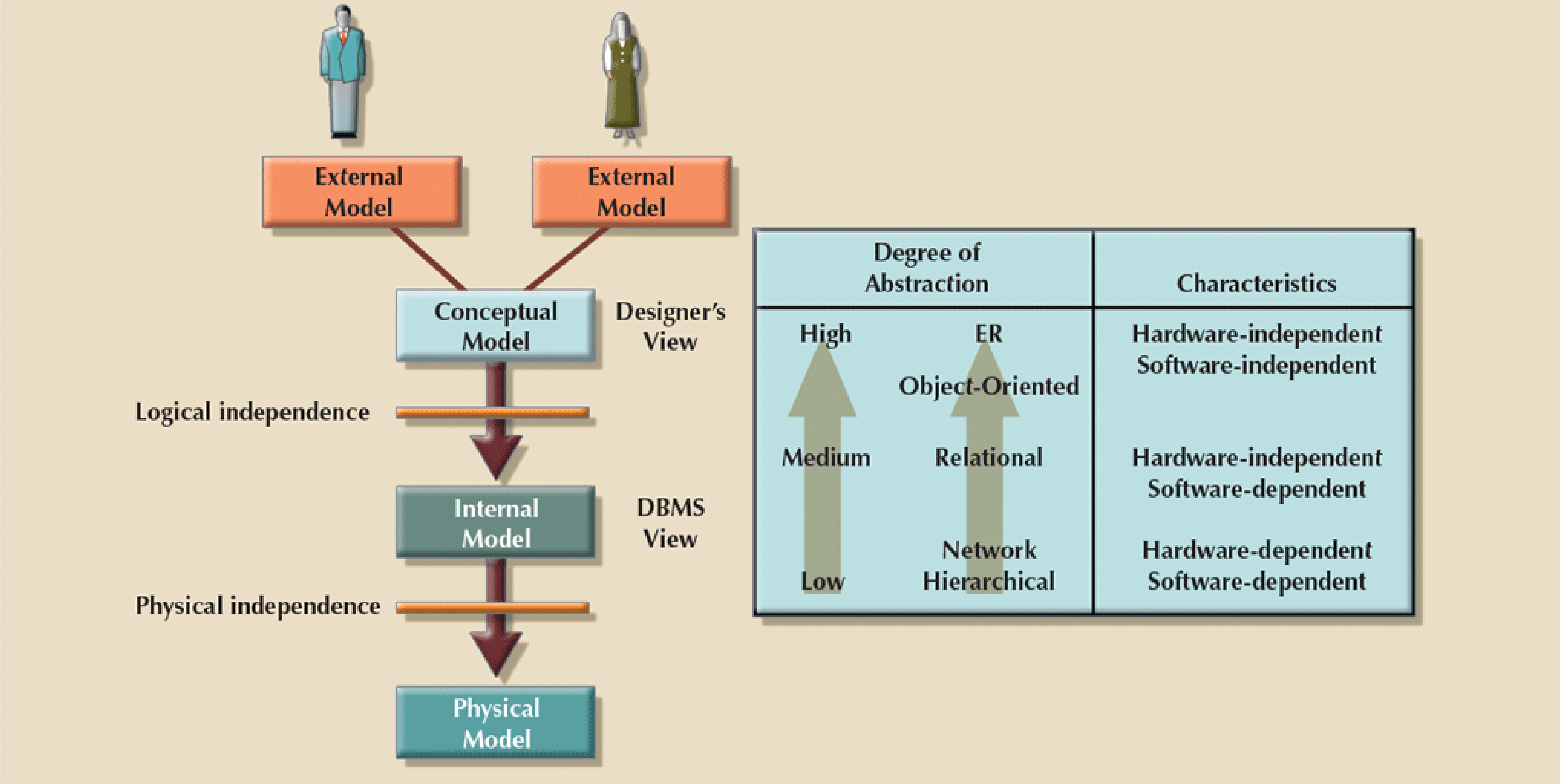
NOSQL

Advantages

- High scalability, availability, and fault tolerance are provided
- Uses low-cost commodity hardware
- Supports Big Data
- Key-value model improves storage efficiency

Disadvantages

- Complex programming is required
- There is no relationship support
- There is no transaction integrity support
- In terms of data consistency, it provides an eventually consistent model



DEGREES OF DATA ABSTRACTION

End users' view of the data environment

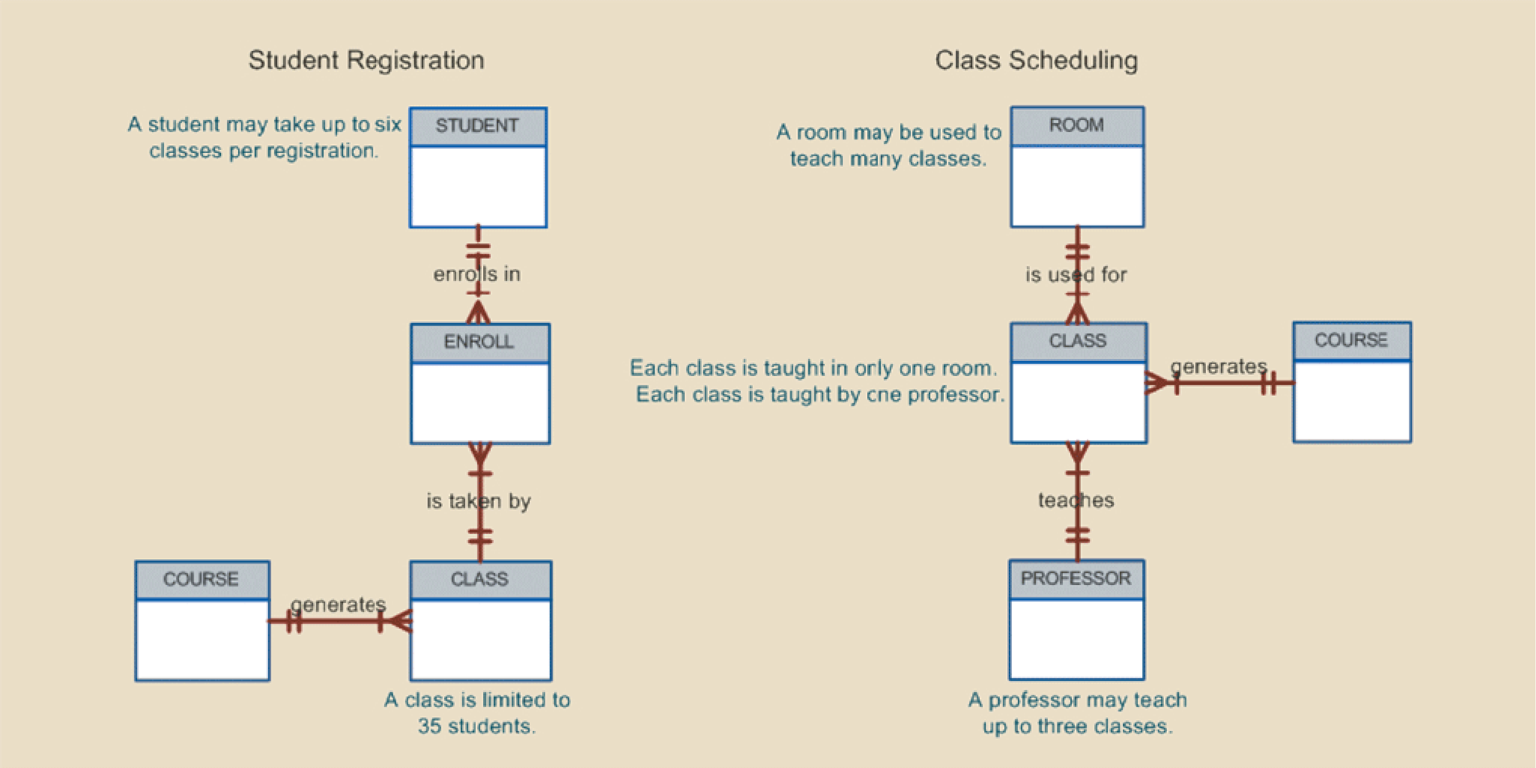
People who use the application programs to manipulate the data and generate information

ER diagrams are used to represent the external views

External schema: specific representation of an external view

THE EXTERNAL MODEL

FIGURE 2.7 EXTERNAL MODELS FOR TINY COLLEGE



THE EXTERNAL MODEL

THE CONCEPTUAL MODEL

Represents a global view of the entire database by the entire organization

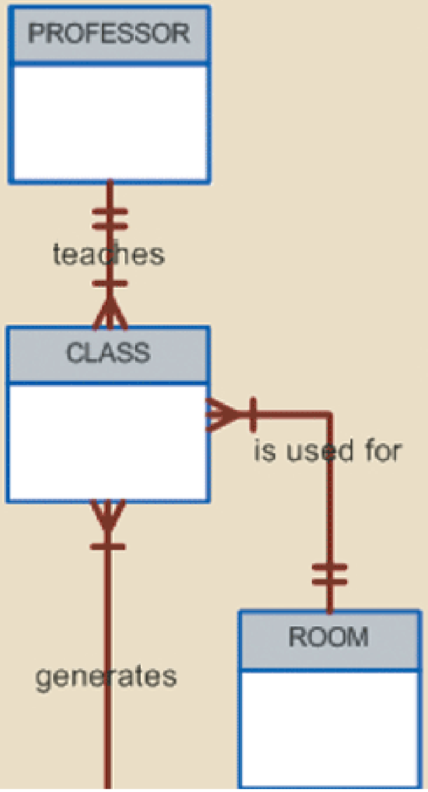
Conceptual schema: basis for the identification and high-level description of the main data objects

Logical design: task of creating a conceptual data model

Conceptual model advantages

Macro-level view of data environment

Software and hardware independent




```
Create Table PROFESSOR(
 PROF_ID        NUMBER PRIMARY KEY,
 PROF_LNAME     CHAR(15),
 PROF_INITIAL   CHAR(1),
 PROF_FNAME     CHAR(15),
 .........);

Create Table CLASS(
 CLASS_ID       NUMBER PRIMARY KEY,
 CRS_ID         CHAR(8)  REFERENCES COURSE,
 PROF_ID        NUMBER REFERENCES PROFESSOR,
 ROOM_ID        CHAR(8)  REFERENCES ROOM,
 .........);

Create Table ROOM(
 ROOM_ID        CHAR(8) PRIMARY KEY,
 ROOM_TYPE      CHAR(3),
 .........);
```

THE CONCEPTUAL 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, using the database constructs supported by the chosen database
- Logical independence: changing internal model without affecting the conceptual model
- Hardware independent: unaffected by the type of computer on which the software is installed

THE PHYSICAL MODEL

- Operates at lowest level of abstraction
  - Describes the way data are saved on storage media such as magnetic, solid state, or optical media
- Requires the definition of physical storage and data access methods
  - Software and hardware dependent
- Relational model aimed at logical level
  - Does not require physical-level details
- Physical independence: changes in physical model do not affect internal model

Table 2.4 Levels of Data Abstraction			
Model	Degree of Abstraction	Focus	Independent of
External	High	End-user views	Hardware and software
Conceptual	Medium-High	Global view of data (database model independent)	Hardware and software
Internal	Medium-Low	Specific database model	Hardware
Physical	Low	Storage and access methods	Neither hardware nor software

THE PHYSICAL MODEL

SUMMARY

A data model is an abstraction of a complex real-world data environment

There are many types of data models (e.g., hierarchical, network, relational, object-oriented, extended relational data model, etc.)

Data-modeling requirements are a function of different data views (global versus local) and the level of data abstraction

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