Database Principles: Fundamentals of Design, Implementation, and Management

Tenth Edition

Chapter 2

Database Development Process

Objectives

- In this chapter, you will learn:
  - That successful database design must reflect the information system of which the database is a part
  - That successful information systems are developed within a framework known as the Systems Development Life Cycle (SDLC)

Objectives (cont'd.)

- That within the information system, the most successful databases are subject to frequent evaluation and revision within a framework known as the Database Life Cycle (DBLC)
- How to conduct evaluation and revision within the SDLC and DBLC frameworks
- About database design strategies: top-down vs. bottom-up design and centralized vs. decentralized design

The Information System

- Provides for data collection, storage, and retrieval
- Composed of:
  - People, hardware, software
  - Database(s), application programs, procedures
- Systems analysis
  - Process that establishes need for and extent of information system
- Systems development
  - Process of creating information system

The Information System (cont'd.)

- Applications
  - Transform data into information that forms basis for decision making
  - Usually produce the following:
    - Formal report
    - Tabulations
    - Graphic displays
  - Composed of the following two parts:
    - Data
    - Code: program instructions

FIGURE 2.1 Generating information for decision making

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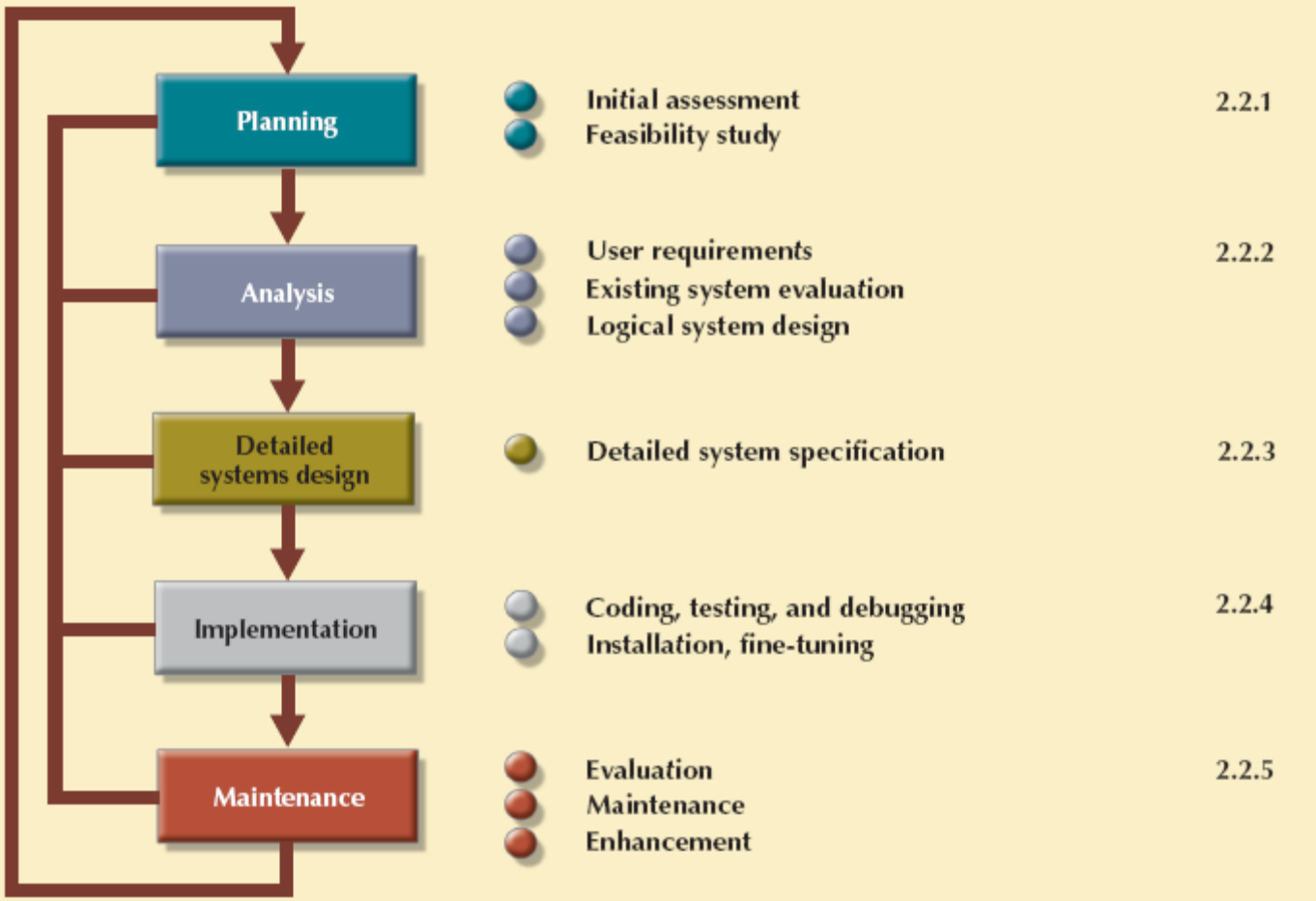
The Information System (cont'd.)

- Performance depends on three factors:
  - Database design and implementation
  - Application design and implementation
  - Administrative procedures
- Database development
  - Process of database design and implementation
  - Implementation phase includes:
    - Creating database storage structure
    - Loading data into the database
    - Providing for data management

The Systems Development Life Cycle

- Traces history (life cycle) of information system
- Database design and application development mapped out and evaluated
- Divided into following five phases:
  - Planning
  - Analysis
  - Detailed systems design
  - Implementation
  - Maintenance
- Iterative rather than sequential process

FIGURE 2.2 The Systems Development Life Cycle



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Planning

- General overview of company and objectives
- Assessment of flow-and-extent requirements
  - Should the existing system be continued?
  - Should the existing system be modified?
  - Should the existing system be replaced?
- Study and evaluate alternate solutions
  - Technical aspects of hardware and software requirements
  - System cost
  - Operational cost

Analysis

- Problems defined during planning phase are examined in greater detail during analysis
- Thorough audit of user requirements
- Existing hardware and software systems are studied
- Goal:
  - Better understanding of:
    - System's functional areas
    - Actual and potential problems
    - Opportunities

Detailed Systems Design

- Designer completes design of system's processes
- Includes all necessary technical specifications
- Steps laid out for conversion from old to new system
- Training principles and methodologies are also planned
  - Submitted for management approval

Implementation

- Hardware, DBMS software, and application programs are installed
  - Database design is implemented
- Cycle of coding, testing, and debugging continues until database is ready for delivery
- Database is created and system is customized
  - Creation of tables and views
  - User authorizations

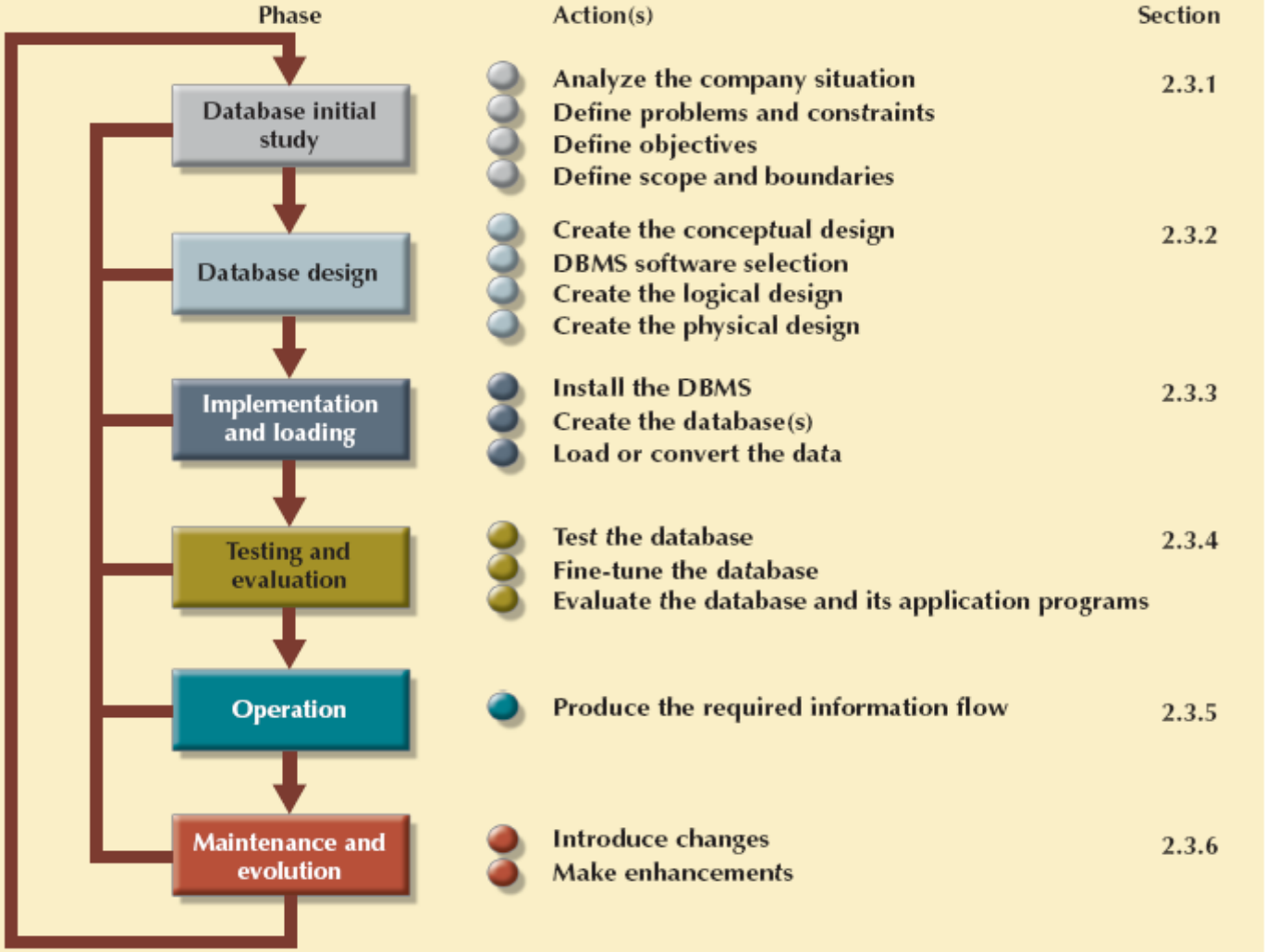
Maintenance

- Three types of maintenance activity:
  - Corrective maintenance
  - Adaptive maintenance
  - Perfective maintenance
- Computer-aided systems engineering (CASE)
  - Produce better systems within reasonable amount of time and at reasonable cost
  - CASE-produced applications are structured, documented, and standardized

The Database Life Cycle

- Six phases:
  - Database initial study
  - Database design
  - Implementation and loading
  - Testing and evaluation
  - Operation
  - Maintenance and evolution

FIGURE 2.3 The Database Life Cycle



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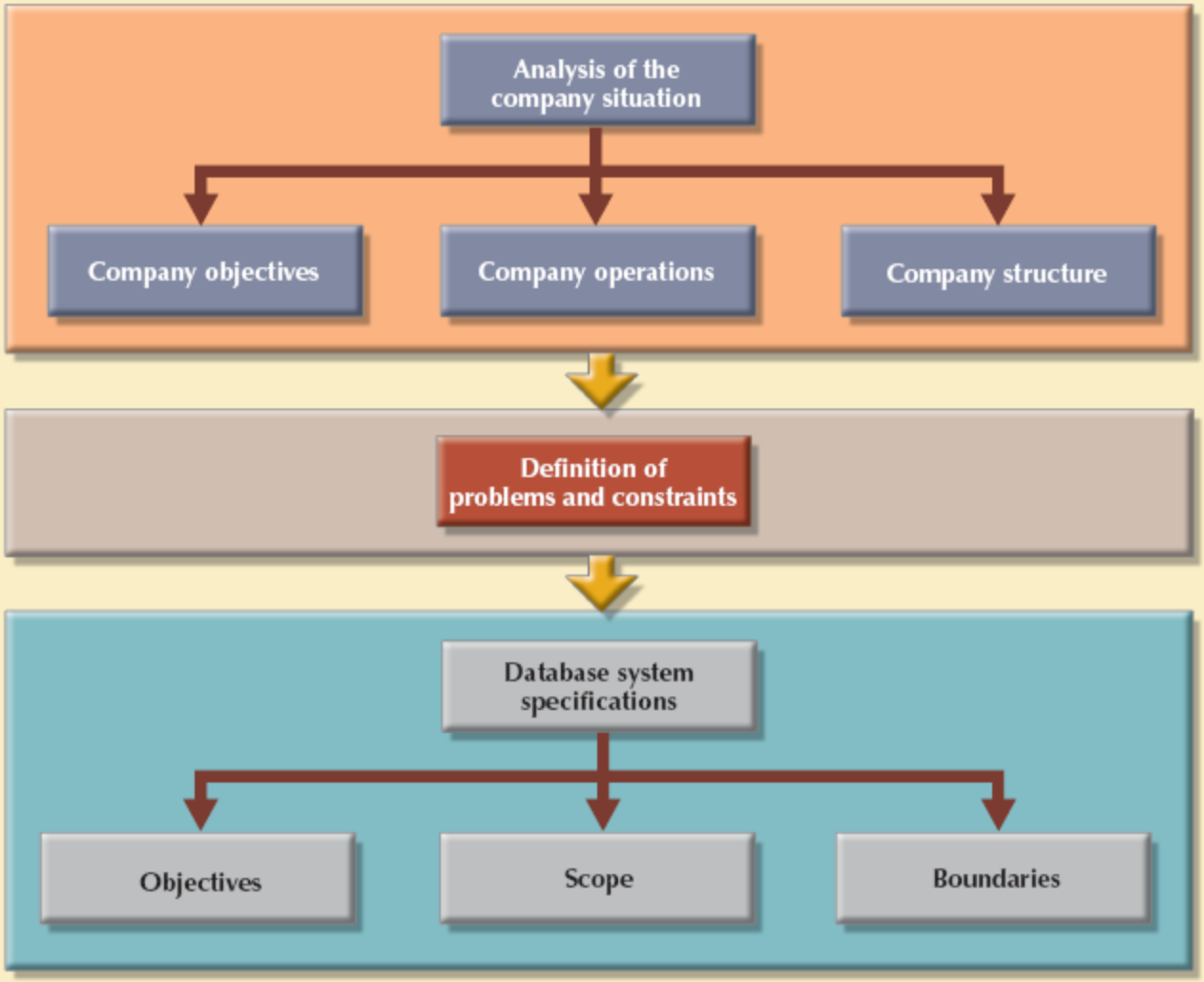
The Database Initial Study

- Overall purpose:
  - Analyze company situation
  - Define problems and constraints
  - Define objectives
  - Define scope and boundaries
- Interactive and iterative processes required to complete first phase of DBLC successfully

FIGURE 2.4 A summary of activities in the database initial study



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The Database Initial Study (cont'd.)

- Analyze the company situation
  - General conditions in which company operates, its organizational structure, and its mission
  - Discover what company's operational components are, how they function, and how they interact

The Database Initial Study (cont'd.)

- Define problems and constraints
  - Formal and informal information sources
  - Finding precise answers is important
  - Accurate problem definition does not always yield a solution

The Database Initial Study (cont'd.)

- Database system objectives must correspond to those envisioned by end users
  - What is proposed system's initial objective?
  - Will system interface with other systems in the company?
  - Will system share data with other systems or users?
- Scope: extent of design according to operational requirements
- Boundaries: limits external to system

Database Design

- Necessary to concentrate on data characteristics required to build database model
- Two views of data within system:
  - Business view
    - Data as information source
  - Designer's view
    - Data structure, access, and activities required to transform data into information

FIGURE 2.5 Two views of data: business manager and database designer

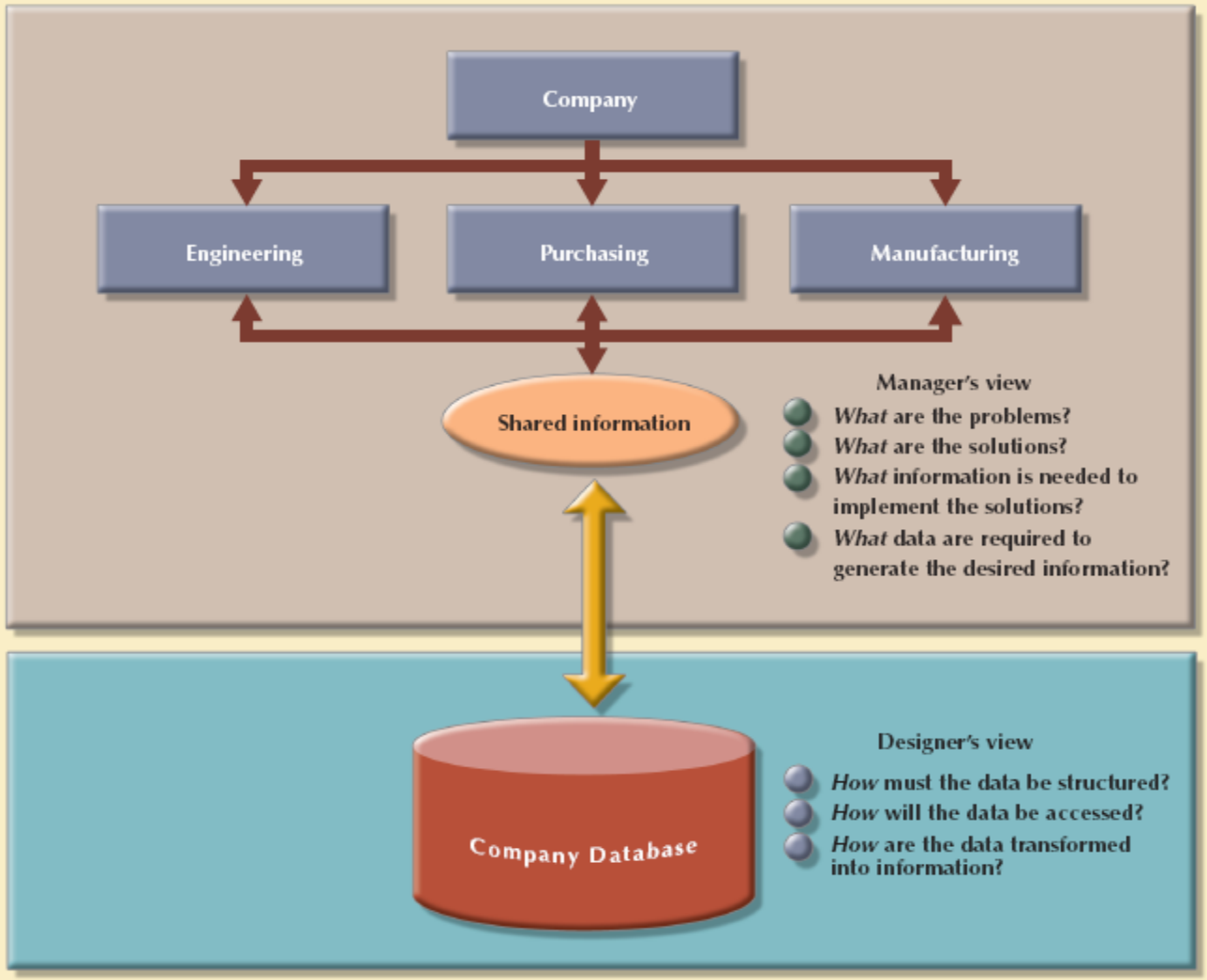

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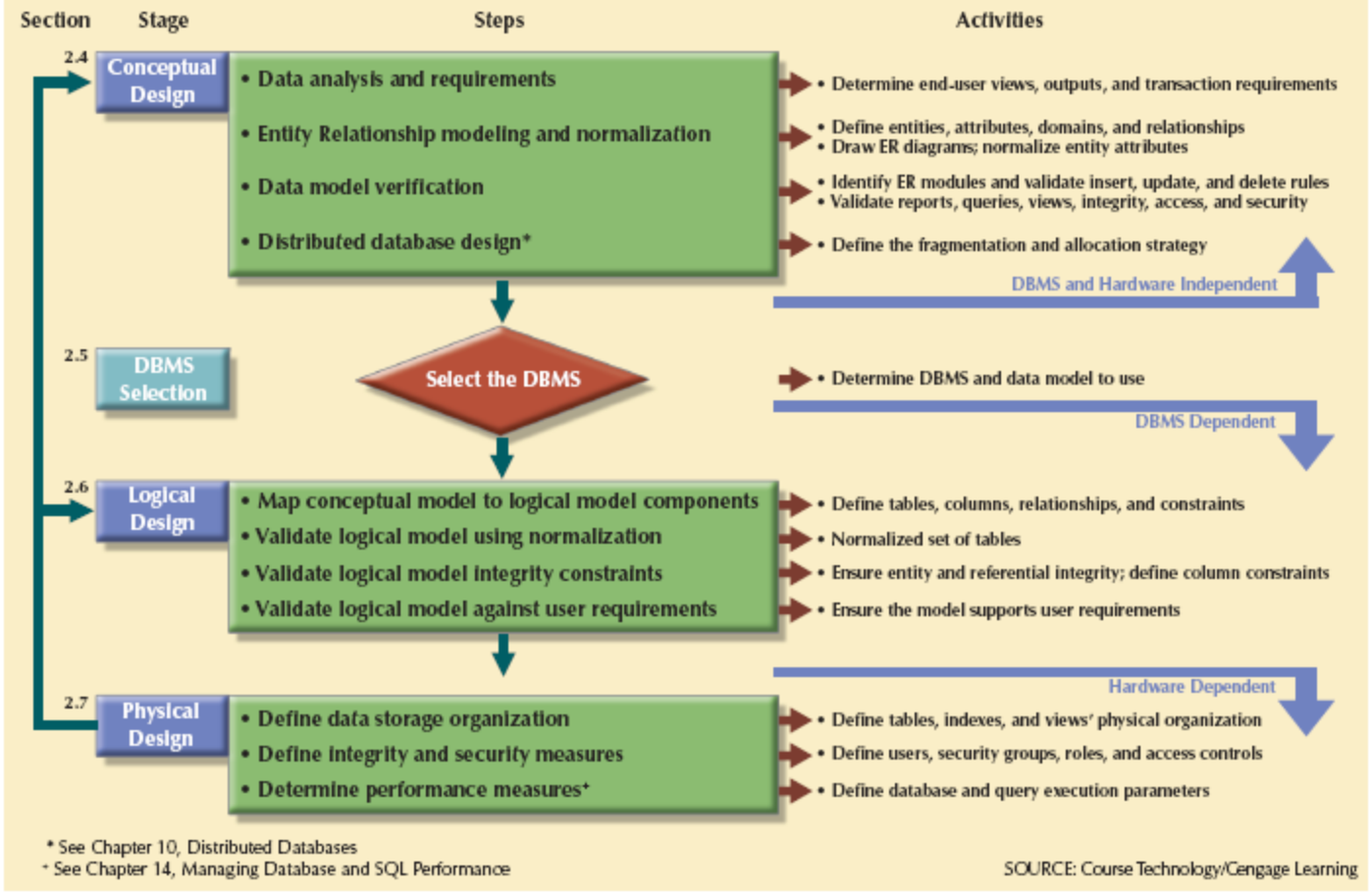
FIGURE 2.6 Database design process



Implementation and Loading

- Actually implement all design specifications from previous phase:
  - Install the DBMS
    - Virtualization: creates logical representations of computing resources independent of physical resources
  - Create the Database
  - Load or Convert the Data

Testing and Evaluation

- Occurs in parallel with applications programming
- Database tools used to prototype applications
- If implementation fails to meet some of system's evaluation criteria:
  - Fine-tune specific system and DBMS configuration parameters
  - Modify physical or logical design
  - Upgrade software and/or hardware platform

Testing and Evaluation (cont'd.)

- Integrity
  - Enforced via proper use of primary, foreign key rules
- Backup and Recovery
  - Full backup
  - Differential backup
  - Transaction log backup

Operation

- Once database has passed evaluation stage, it is considered operational
- Beginning of operational phase starts process of system evolution
- Problems not foreseen during testing surface
- Solutions may include:
  - Load-balancing software to distribute transactions among multiple computers
  - Increasing available cache

Maintenance and Evolution

- Required periodic maintenance:
  - Preventive maintenance (backup)
  - Corrective maintenance (recovery)
  - Adaptive maintenance
  - Assignment of access permissions and their maintenance for new and old users
  - Generation of database access statistics
  - Periodic security audits
  - Periodic system-usage summaries

Conceptual Design

- Data modeling creates an abstract database structure
  - Represents real-world objects
- Embodies clear understanding of business and its functional areas
- Ensure that all data needed are in model, and that all data in model are needed
- Requires four steps

Data Analysis and Requirements

- Discover data element characteristics
  - Obtains characteristics from different sources
- Requires thorough understanding of the company's data types and their extent and uses
- Take into account business rules
  - Derived from description of operations

Entity Relationship Modeling and Normalization

- Designer enforces standards in design documentation
  - Use of diagrams and symbols, documentation writing style, layout, other conventions
- Business rules must be incorporated into conceptual model
- ER model is a communications tool as well as design blueprint

TABLE 2.3

Developing the Conceptual Model Using ER Diagrams

STEP	ACTIVITY
1	Identify, analyze, and refine the business rules.
2	Identify the main entities, using the results of Step 1.
3	Define the relationships among the entities, using the results of Steps 1 and 2.
4	Define the attributes, primary keys, and foreign keys for each of the entities.
5	Normalize the entities. (Remember that entities are implemented as tables in an RDBMS.)
6	Complete the initial ER diagram.
7	Validate the ER model against the end users' information and processing requirements.
8	Modify the ER model, using the results of Step 7.

Data Model Verification

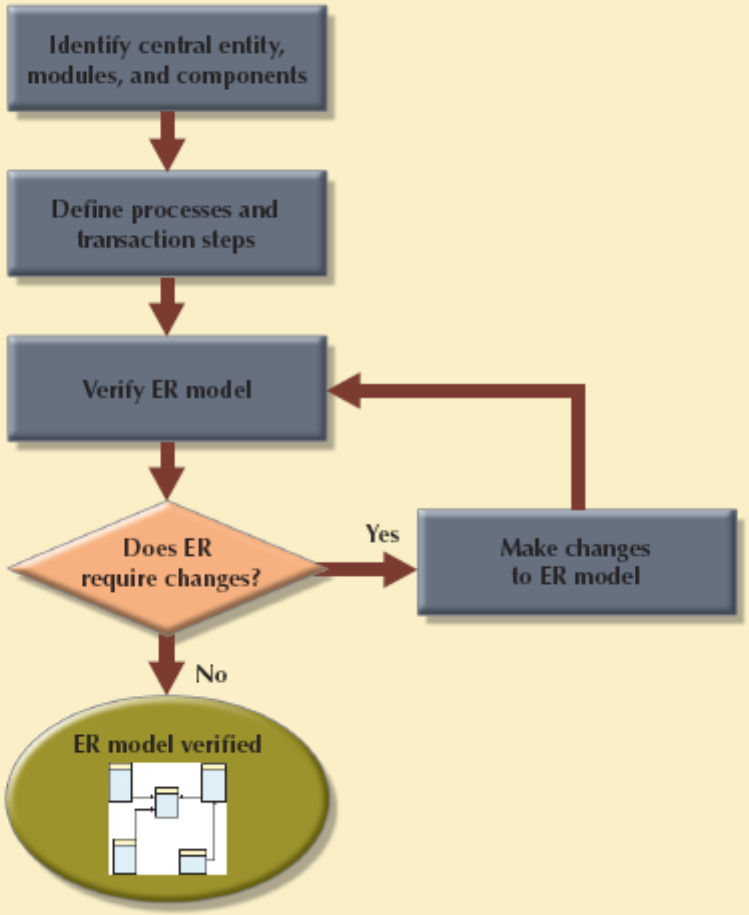
- Verified against proposed system processes
- Revision of original design
  - Careful reevaluation of entities
  - Detailed examination of attributes describing entities
- Define design's major components as modules:
  - Module: information system component that handles specific function

Data Model Verification (cont'd.)

TABLE 2.5 The ER Model Verification Process

STEP	ACTIVITY
1	Identify the ER model's central entity.
2	Identify each module and its components.
3	Identify each module's transaction requirements: Internal: updates/inserts/deletes/queries/reports External: module interfaces
4	Verify all processes against system requirements.
5	Make all necessary changes suggested in Step 4.
6	Repeat Steps 2–5 for all modules.

FIGURE 2.12 Iterative ER model verification process



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Distributed Database Design

- Portions of database may reside in different physical locations
  - Database fragment: subset of a database stored at a given location
- Processes accessing the database vary from one location to another
- Designer must also develop data distribution and allocation strategies

DBMS Software Selection

- Critical to information system's smooth operation
- Common factors affecting purchasing decisions:
  - Cost
  - DBMS features and tools
  - Underlying model
  - Portability
  - DBMS hardware requirements

Logical Design

- Map conceptual design to specific data model
- Still independent of physical-level details
- Requires all objects be mapped to specific constructs used by selected database software
  - Definition of attribute domains, design of required tables, and access restriction formats
  - Tables must correspond to entities in conceptual design
- Translates software-independent conceptual model into software-dependent model

Map the Conceptual Model to the Logical Model

- Map the conceptual model to the chosen database constructs
- Five mapping steps involved:
  - Strong entities
  - Supertype/subtype relationships
  - Weak entities
  - Binary relationships
  - Higher degree relationships

Validate the Logical Model Using Normalization

- Translation requires the definition of the attribute domains and appropriate constraints
- All defined constraints must be supported by the logical data model
- Special attention should be place at this stage to ensure security is enforced
  - May have to consider security restrictions at multiple locations

Validate Logical Model Integrity Constraints

- All defined constraints must be supported by the logical data model
- Ensure:
  - All views can be resolved
  - Security is enforced to ensure the privacy of the data

Validate the Logical Model against User Requirements

- Final step in the logical design process
- Validate all logical model definitions against all end-user data, transaction, and security requirements

Physical Design

- Process of selecting data storage and data access characteristics of database
- Storage characteristics are a function of:
  - Device types supported by hardware
  - Type of data access methods supported by system
  - DBMS
- More complex when data are distributed

Define Data Storage Organization

- Designer must determine several attributes:
  - Data volume
  - Data usage patterns
- These in turn influence:
  - Location and physical storage organization for each table
  - What indexes and the type of indexes to be used for each table
  - What views and the type of views to be used on each table

Define Integrity and Security Measures

- Define user and security groups and roles
  - Database role: set of database privileges that could be assigned as a unit to a user or group
- Assign security controls
  - Specific access rights on database objects to a user or group of users
  - Can also revoke during operation to assist with backups or maintenance events

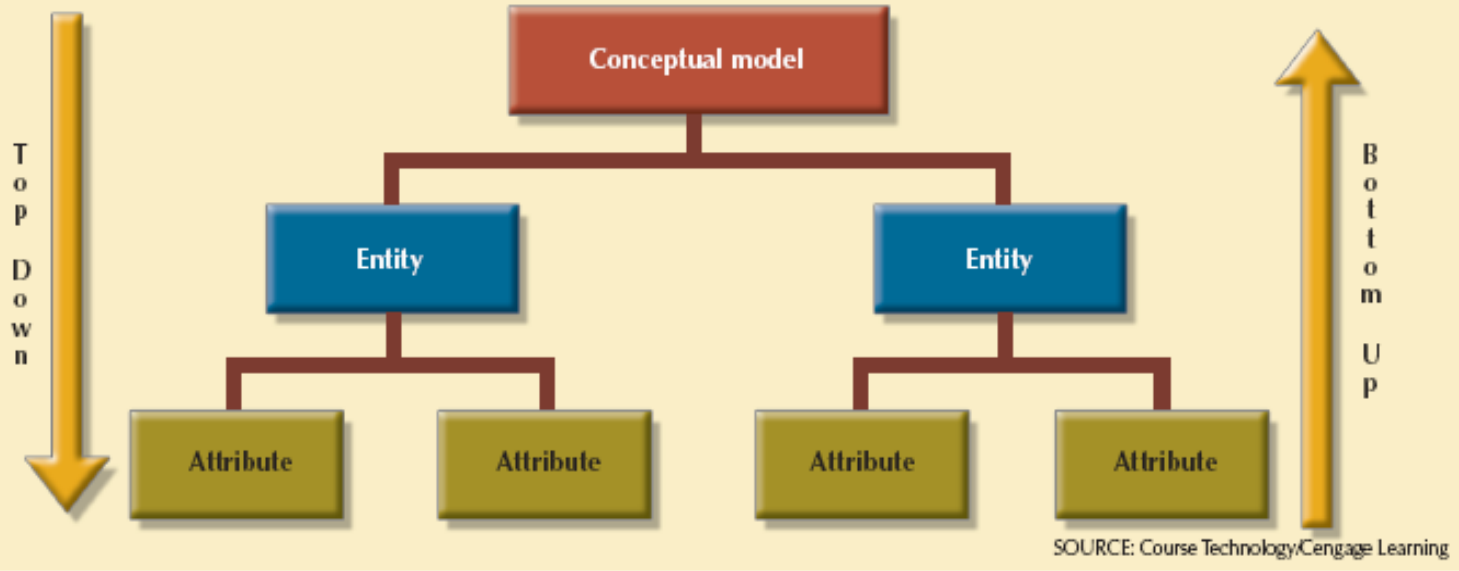
Determine Performance Measures

- Performance can be affected by characteristics:
  - Storage media
  - Seek time
  - Sector and block (page) size
  - And more…
- Fine-tuning the DBMS and queries to ensure that they will meet end-user performance requirements

Database Design Strategies

- Top-down design
  - Identifies data sets
  - Defines data elements for each of those sets
    - Definition of different entity types
    - Definition of each entity's attributes
- Bottom-up design
  - Identifies data elements (items)
  - Groups them together in data sets

FIGURE 2.14 Top-down vs. bottom-up design sequencing



Centralized vs. Decentralized Design

- Centralized design
  - When data component is composed of small number of objects and procedures
  - Typical of small systems
- Decentralized design
  - Data component has large number of entities
  - Complex relations on which complex operations are performed
  - Problem is spread across several operational sites

FIGURE 2.15 Centralized design

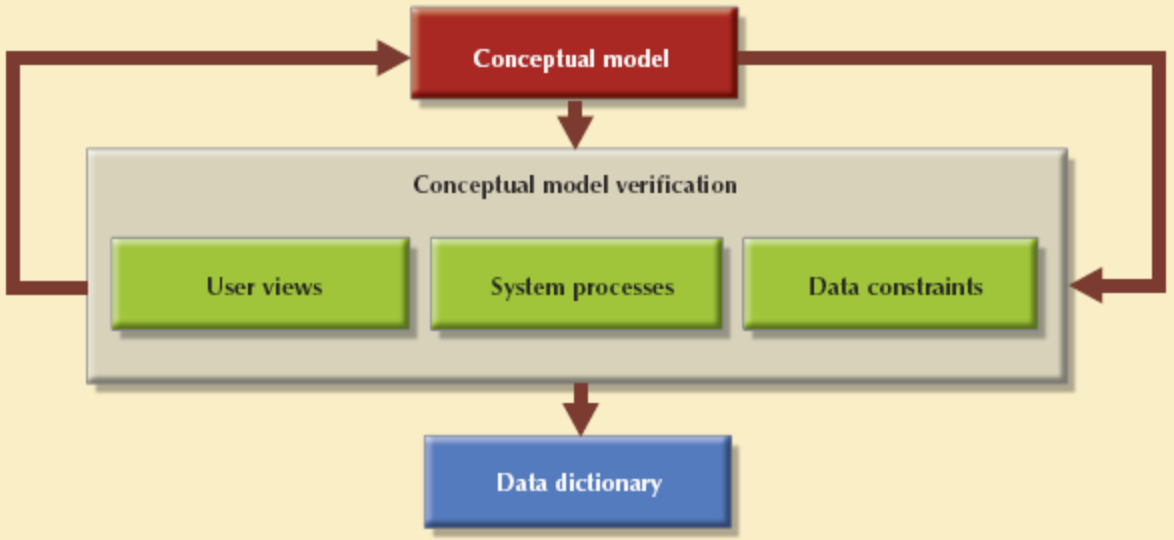


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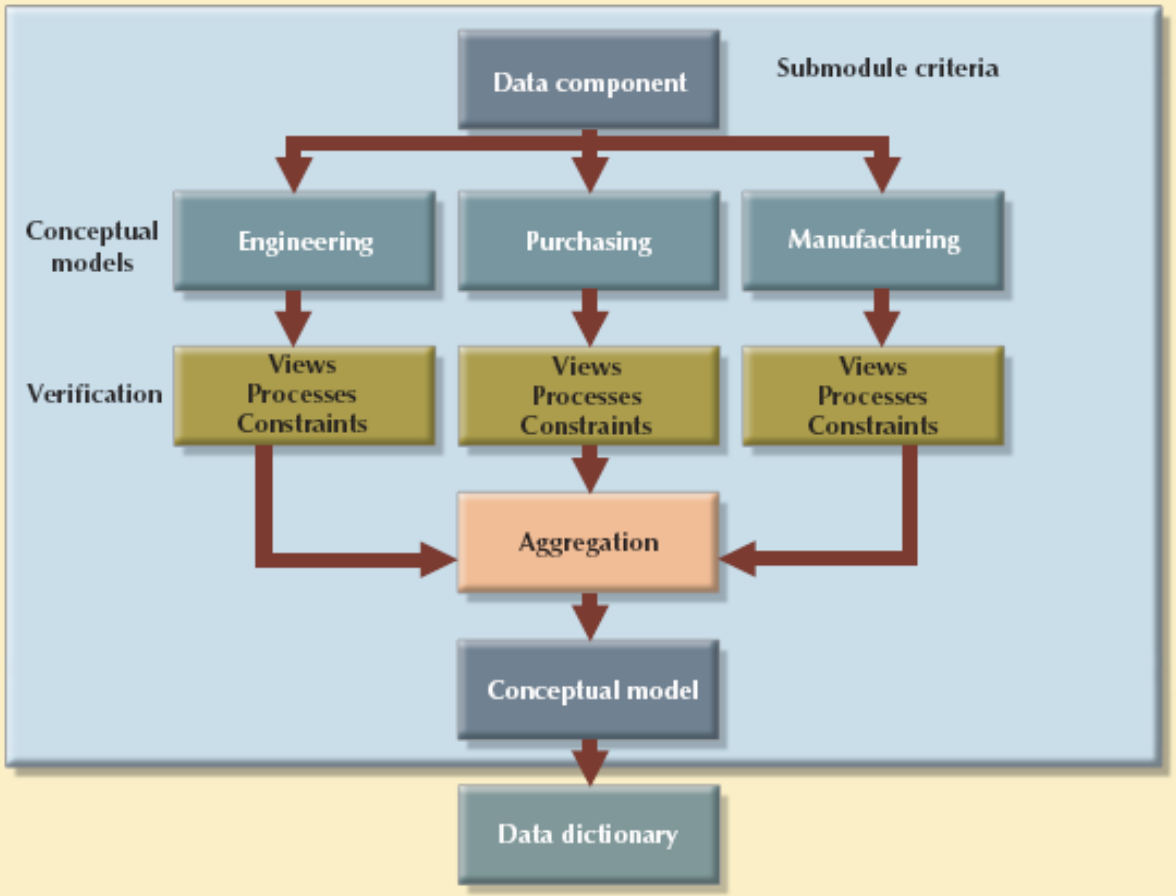
FIGURE 2.16 Decentralized design



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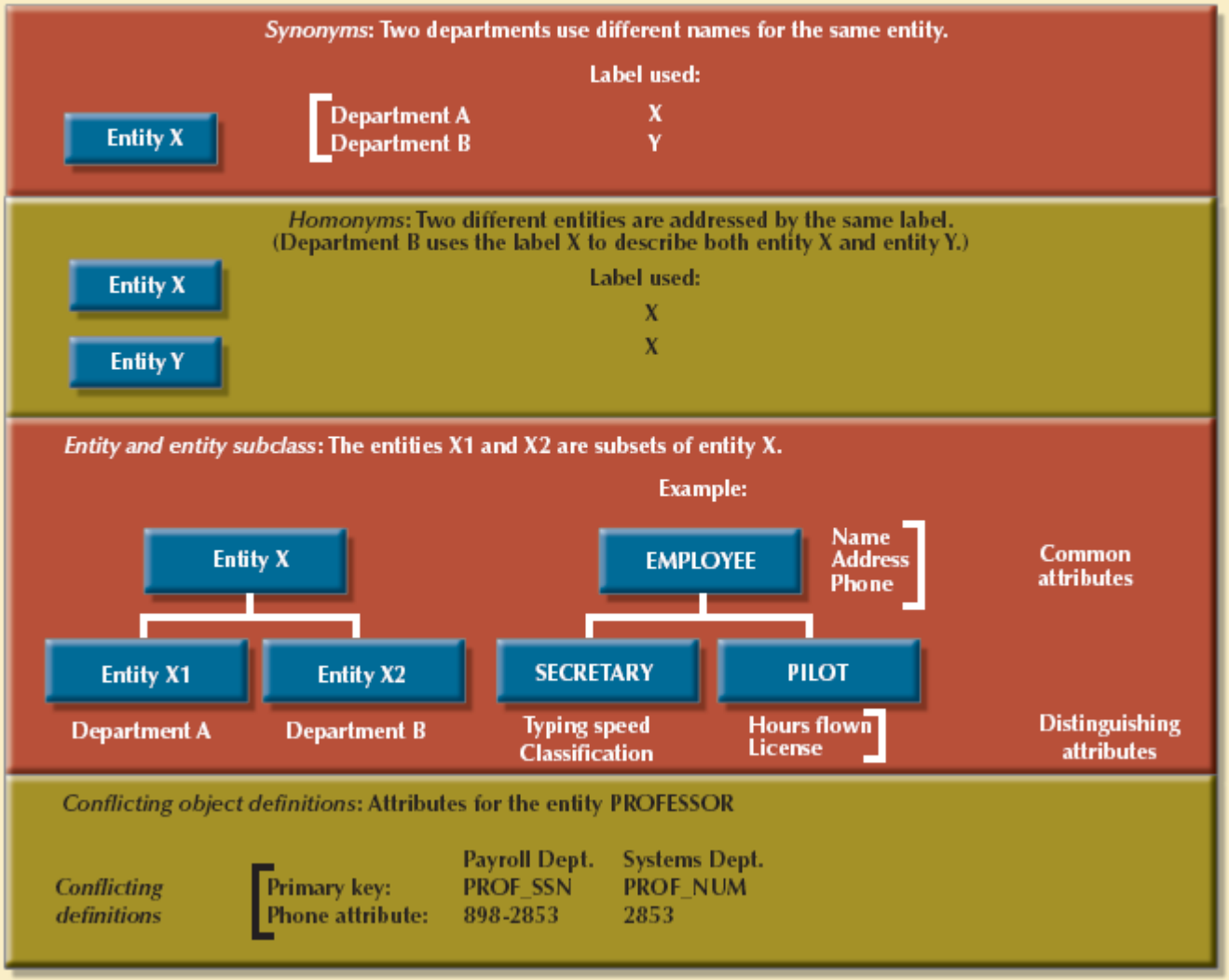
Centralized vs. Decentralized Design (cont'd.)

- All modules are integrated into one model
- Aggregation problems to be addressed:
  - Synonyms and homonyms
  - Entity and entity subtypes
  - Conflicting object definitions

FIGURE 2.17 Summary of aggregation problems



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Summary

- Information system facilitates transformation of data into information
  - Manages both data and information
- SDLC traces history (life cycle) of an application within the information system
- DBLC describes history of database within the information system

Summary (cont'd.)

- Database design and implementation process moves through series of well-defined stages
- Conceptual design subject to several variations:
  - Top-down vs. bottom-up
  - Centralized vs. decentralized