CHAPTER 1:
THE DATABASE ENVIRONMENT AND DEVELOPMENT PROCESS

Modern Database Management
12th Edition
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OBJECTIVES

- Define terms
- Name limitations of conventional file processing
- Explain advantages of databases
- Identify costs and risks of databases
- List components of database environment
- Identify categories of database applications
- Describe database system development life cycle
- Explain prototyping and agile development approaches
- Explain roles of individuals
- Explain the three-schema architecture for databases

DEFINITIONS

⚪ Databases are used to store, manipulate, and retrieve data in nearly every type of organization, including business, health care, education, government, and libraries.

⚪ Database: organized collection of logically related data

⚪ Data: stored representations of meaningful objects and events
   ⚪ Structured: numbers, text, dates
   ⚪ Unstructured: images, video, documents

⚪ Information: data processed to increase knowledge in the person using the data

⚪ Metadata: data that describes the properties and context of user data

Figure 1-1a Data in context

Class Roster

Course: MGT 500   Semester: Spring 2015
         Business Policy

Section: 2

Name	ID	Major	GPA
Baker, Kenneth D.	324917628	MGT	2.9
Doyle, Joan E.	476193248	MKT	3.4
Finkle, Clive R.	548429344	PRM	2.8
Lewis, John C.	551742186	MGT	3.7
McFerran, Debra R.	409723145	IS	2.9
Sisneros, Michael	392416582	ACCT	3.3

Context helps users understand data

# Figure 1-1b Summarized data

Percent Enrollment by Major (2015)

Enrollment Projections
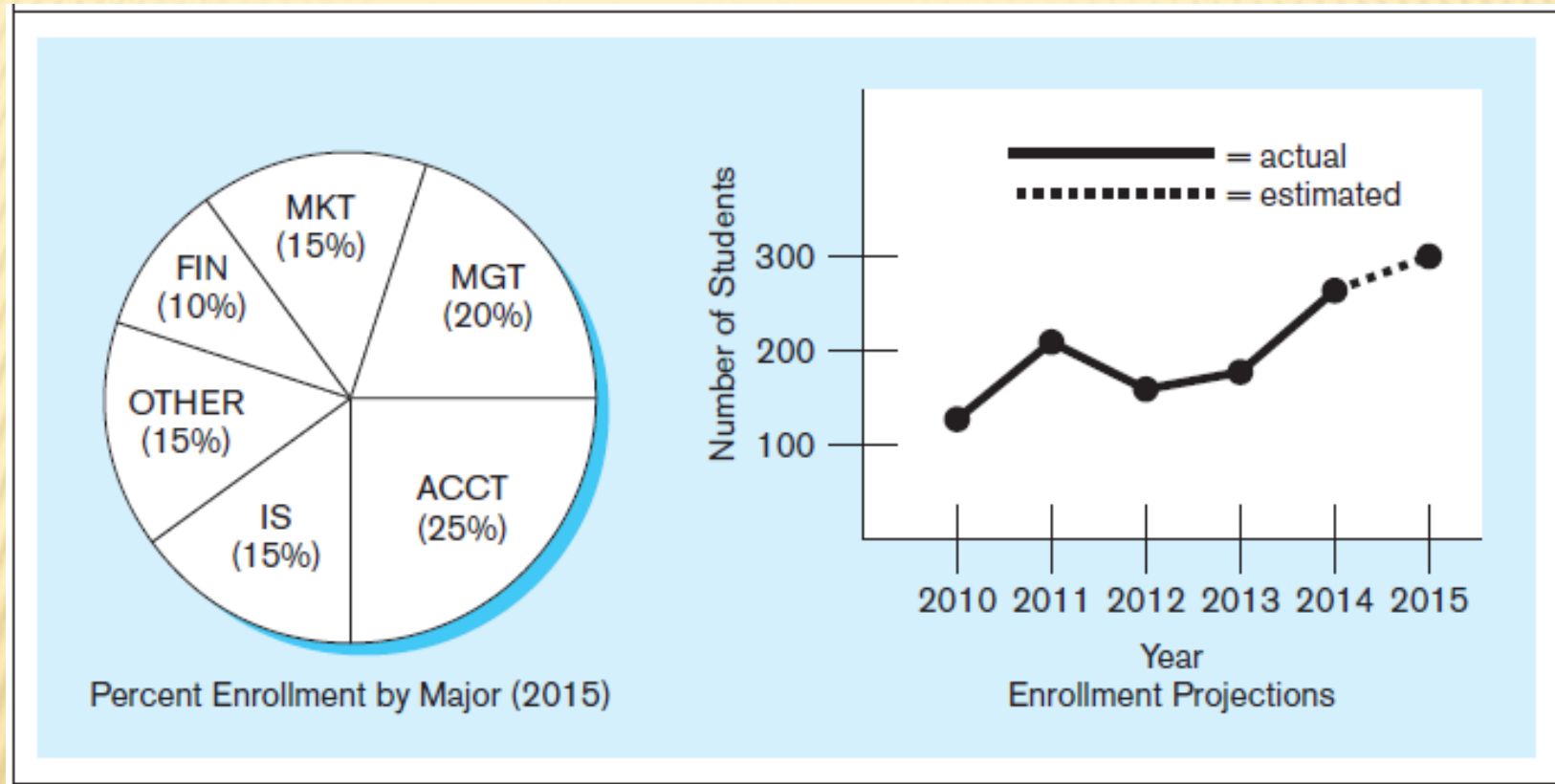
Graphical displays turn data into useful information that managers can use for decision making and interpretation

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TABLE 1-1 Example Metadata for Class Roster

Data Item			Metadata			
Name	Type	Length	Min	Max	Description	Source
Course	Alphanumeric	30			Course ID and name	Academic Unit
Section	Integer	1	1	9	Section number	Registrar
Semester	Alphanumeric	10			Semester and year	Registrar
Name	Alphanumeric	30			Student name	Student IS
ID	Integer	9			Student ID (SSN)	Student IS
Major	Alphanumeric	4			Student major	Student IS
GPA	Decimal	3	0.0	4.0	Student grade point average	Academic Unit

Descriptions of the properties or characteristics of the data, including data types, field sizes, allowable values, and data context

USING TRADITIONAL MANAGEMENT METHOD
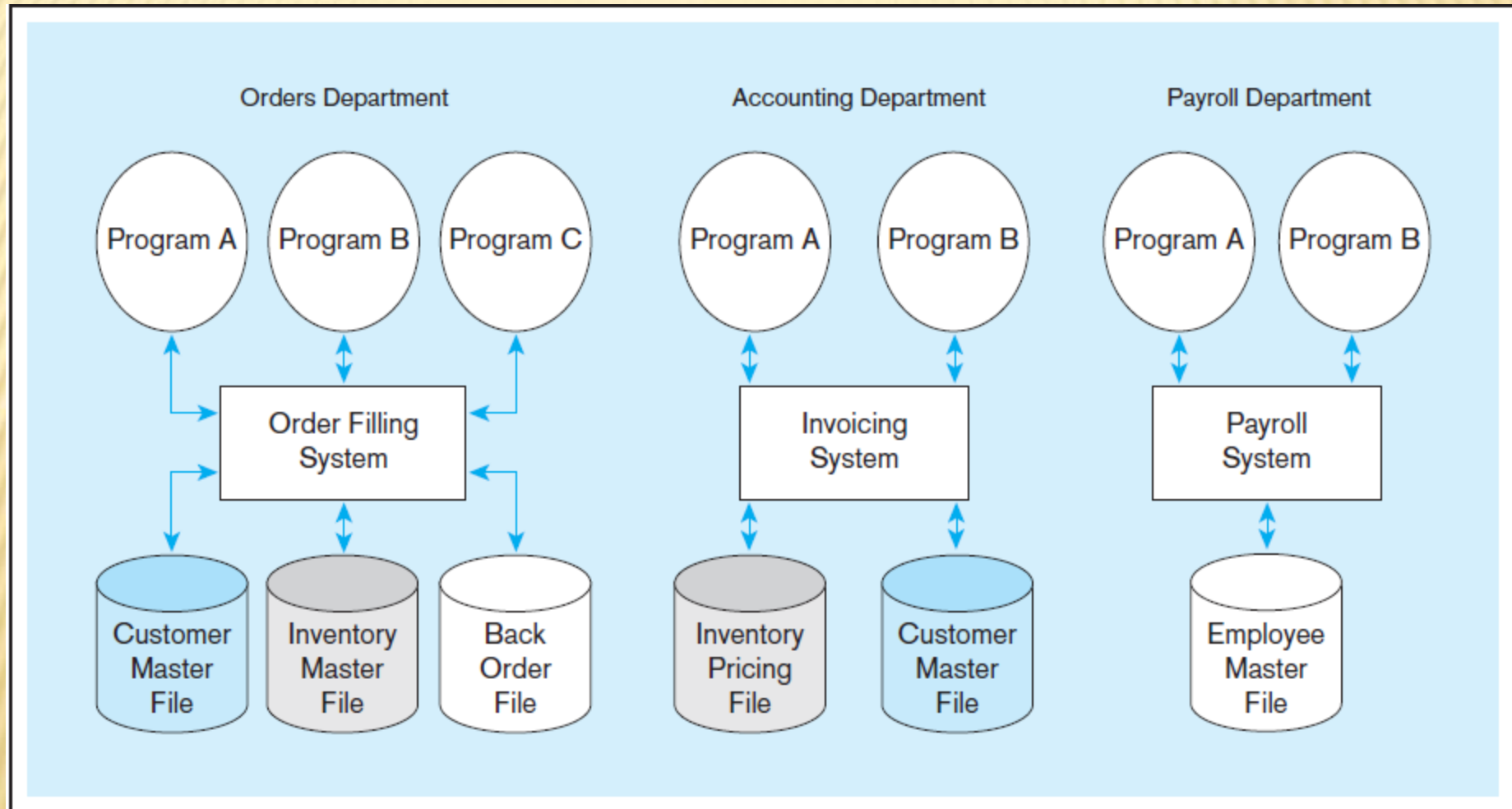
Duplicate Data
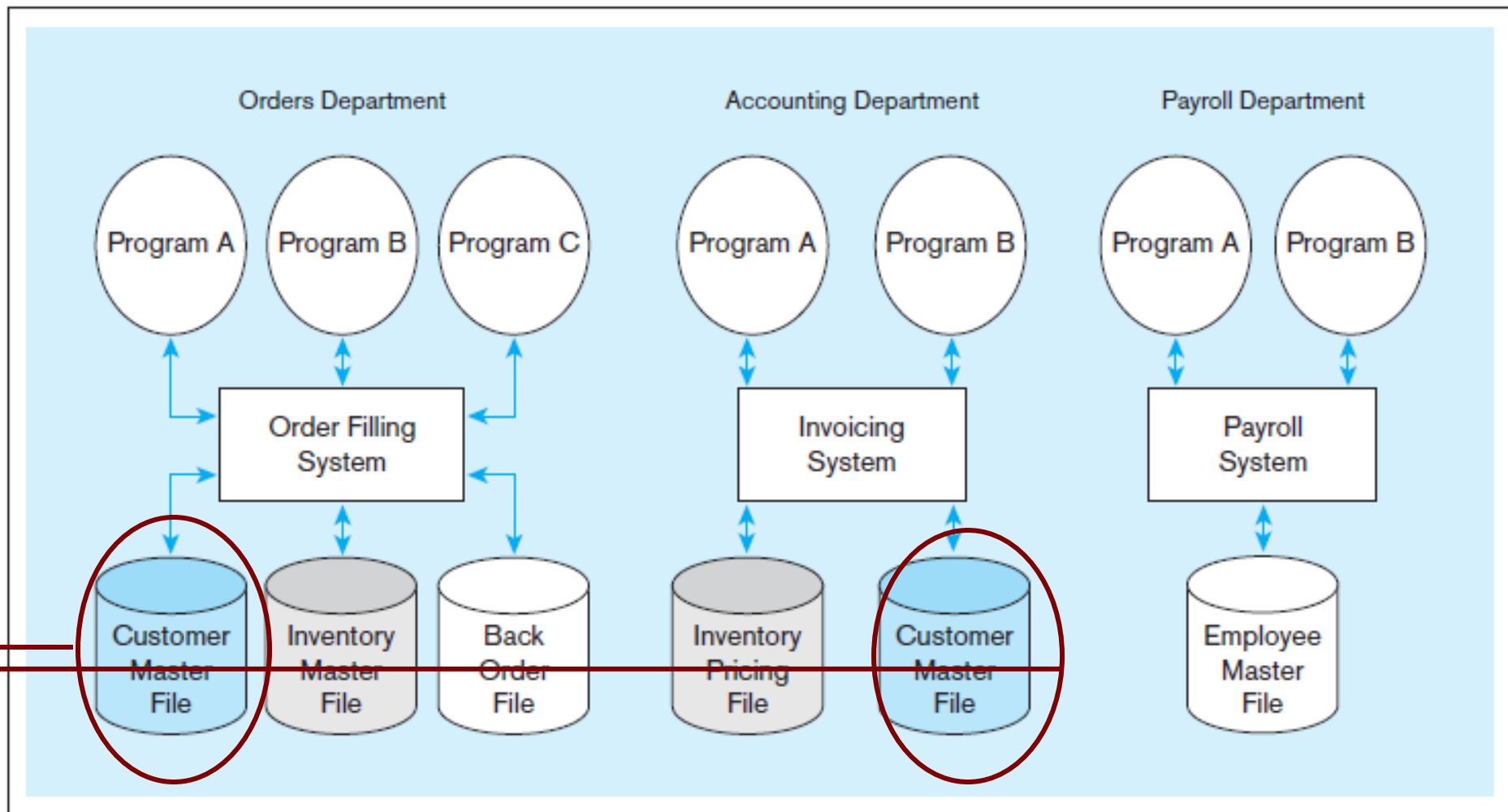
FIGURE 1-2 Old file processing systems at Pine Valley Furniture Company

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DISADVANTAGES OF FILE PROCESSING

- **Program-Data Dependence**
  - All programs maintain metadata for each file they use
- **Duplication of Data**
  - Different systems/programs have separate copies of the same data
- **Limited Data Sharing**
  - No centralized control of data
- **Lengthy Development Times**
  - Programmers must design their own file formats
- **Excessive Program Maintenance**
  - 80% of information systems budget

PROBLEMS WITH DATA DEPENDENCY

- Each application programmer must maintain his/her own data

- Each application program needs to include code for the metadata of each file

- Each application program must have its own processing routines for reading, inserting, updating, and deleting data

- Lack of coordination and central control

- Non-standard file formats

PROBLEMS WITH DATA REDUNDANCY

- Waste of space to have duplicate data
- Causes more maintenance headaches
- The biggest problem:
  - **Data changes in one file could cause inconsistencies**
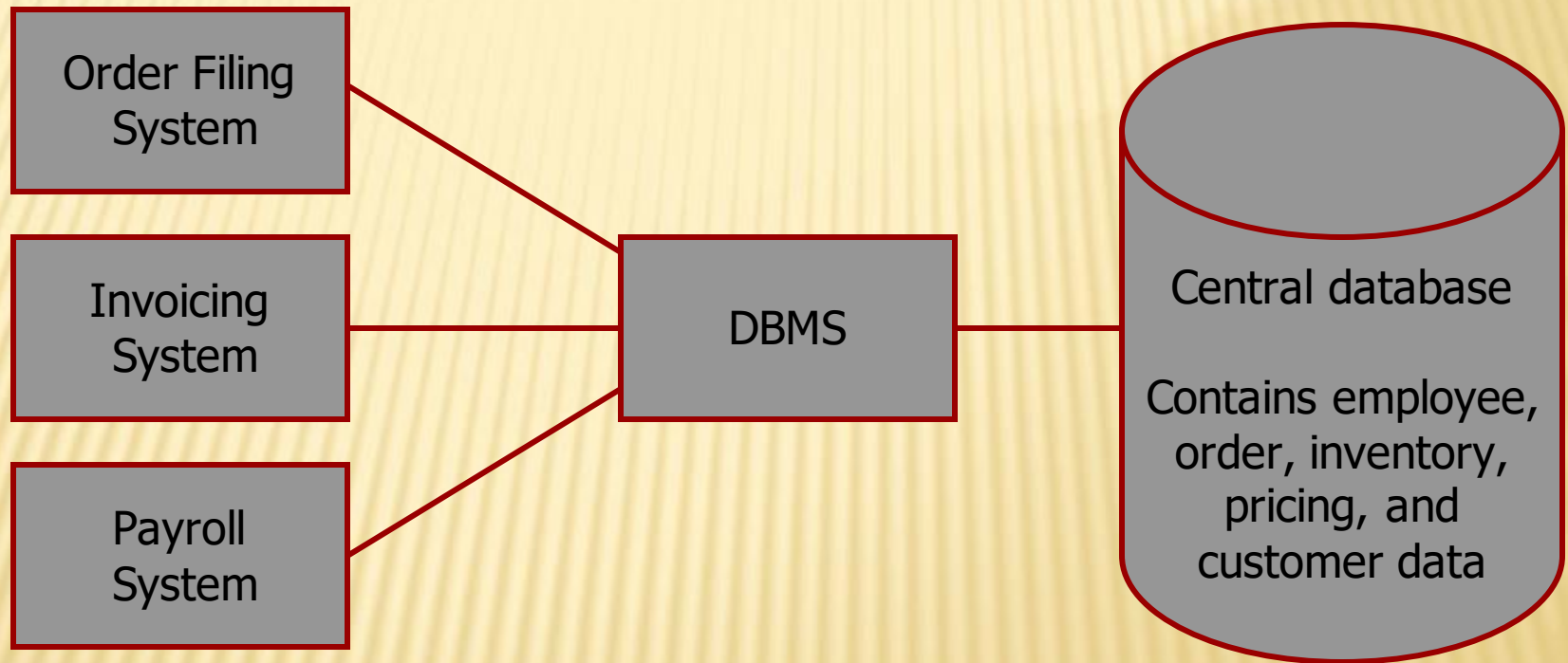 - Compromises in *data integrity*

SOLUTION: THE DATABASE APPROACH

- Central repository of shared data
- Data is managed by a controlling agent
- Stored in a standardized, convenient form

Requires a Database Management System (DBMS)

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DATABASE MANAGEMENT SYSTEM

- A software system that is used to create, maintain, and provide controlled access to user databases

```
┌──────────────┐
│ Order Filing │
│    System    │
└──────────────┘
                    ┌──────────┐         ┌─────────────────────┐
┌──────────────┐    │          │         │  Central database   │
│   Invoicing  │────│   DBMS   │─────────│                     │
│    System    │    │          │         │ Contains employee,  │
└──────────────┘    └──────────┘         │ order, inventory,   │
                                         │  pricing, and       │
┌──────────────┐                         │  customer data      │
│    Payroll   │                         └─────────────────────┘
│    System    │
└──────────────┘
```

DBMS manages data resources like an operating system manages hardware resources

ELEMENTS OF THE DATABASE APPROACH

- Data models
  - Graphical diagram capturing nature and relationship of data
  - Enterprise Data Model–high-level entities and relationships for the organization
  - Project Data Model–more detailed view, matching data structure in database or data warehouse
- Entities
  - Noun form describing a person, place, object, event, or concept
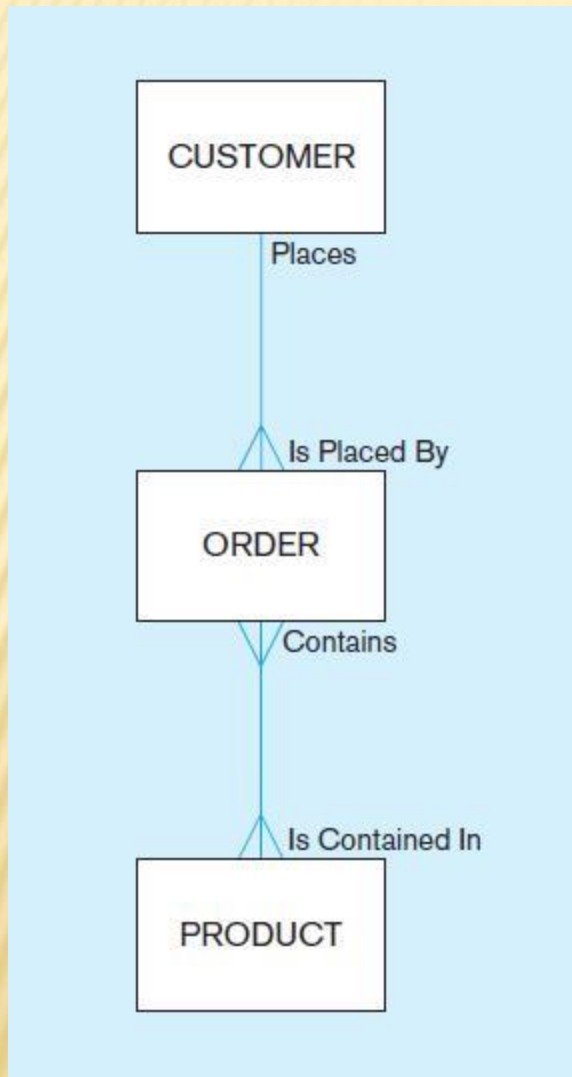 - Composed of attributes
- Relationships
  - Between entities
  - Usually one-to-many (1:M) or many-to-many (M:N), but could also be one-to-one (1:1)
- Relational Databases
  - Database technology involving tables (relations) representing entities and primary/foreign keys representing relationships

Figure 1-3 Comparison of enterprise and project level data models

Segment of an enterprise data model
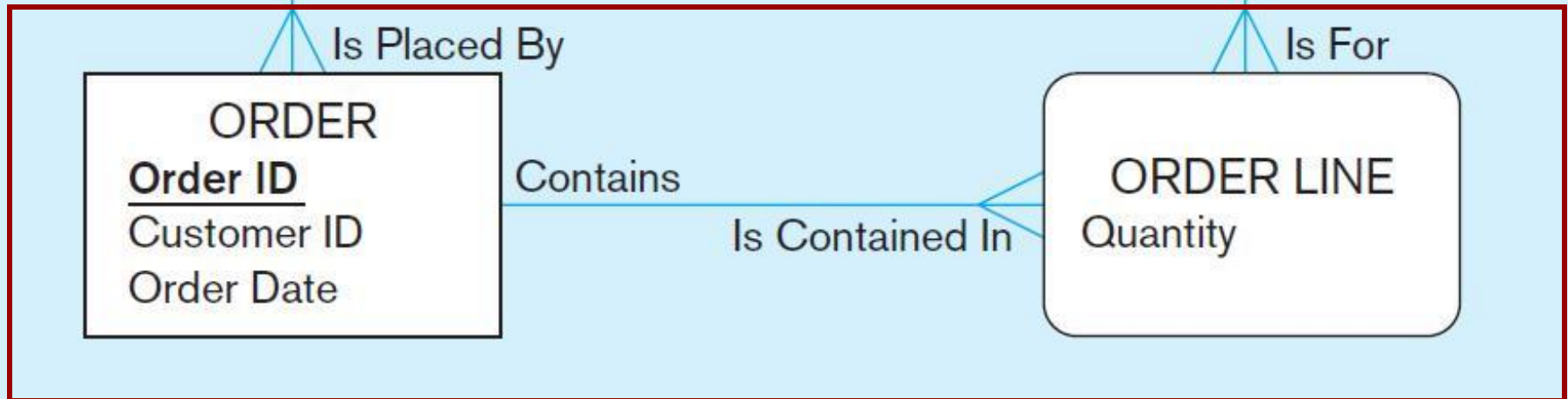

Segment of a project-level data model
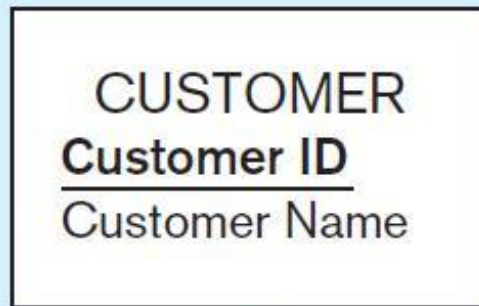
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One customer may place many orders, but each order is placed by a single customer
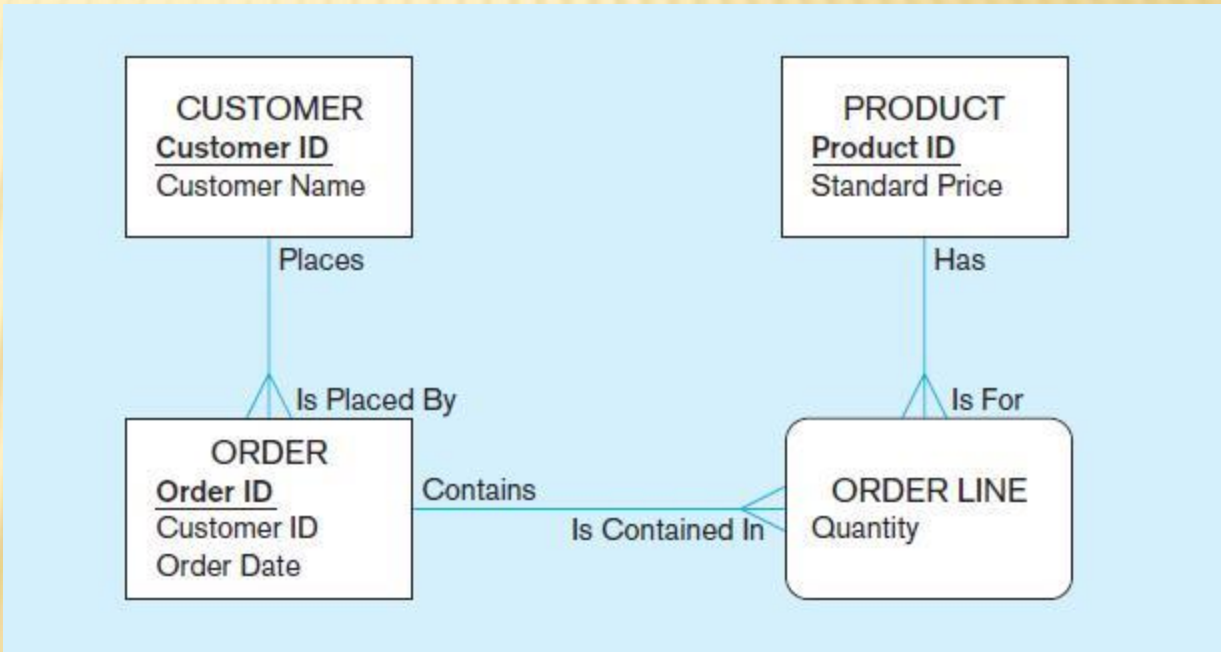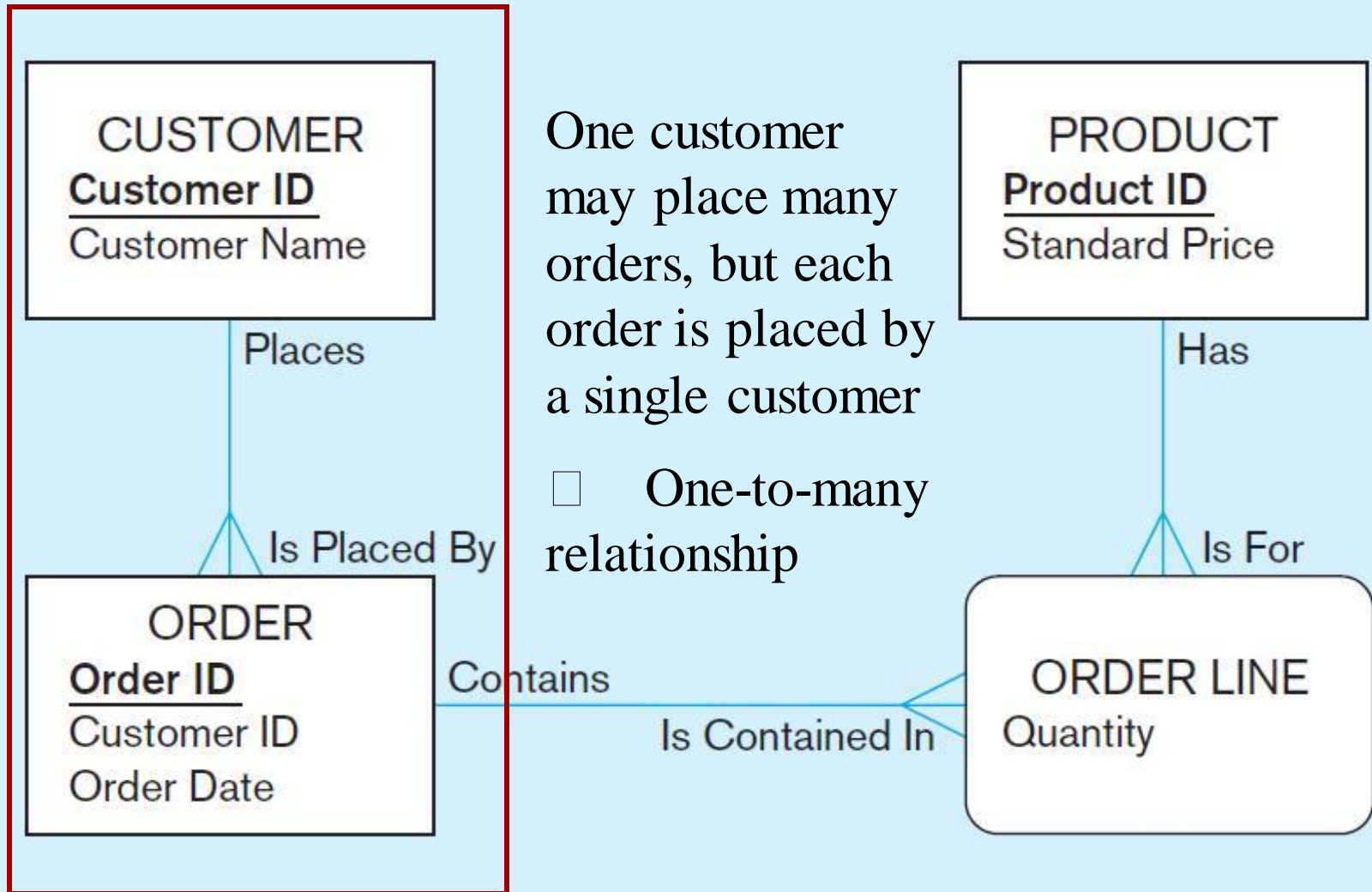
□ One-to-many relationship

One order has many order lines; each order line is associated with a single order
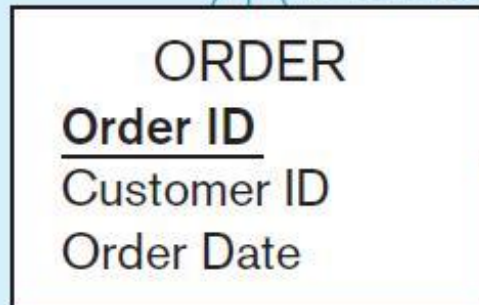
☐ One-to-many relationship

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One product can be in many order lines, each order line refers to a single product

☐ One-to-many relationship

CUSTOMER
Customer ID
Customer Name

Places

Is Placed By
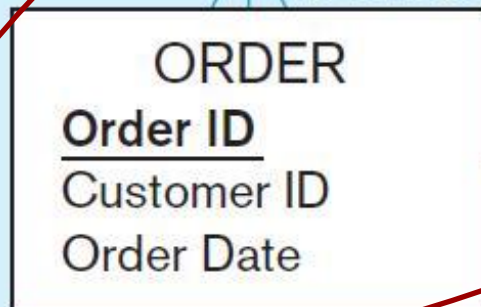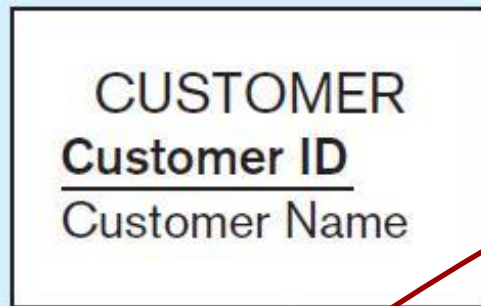
ORDER
Order ID
Customer ID
Order Date

Contains

Is Contained In

PRODUCT
Product ID
Standard Price

Has

Is For

ORDER LINE
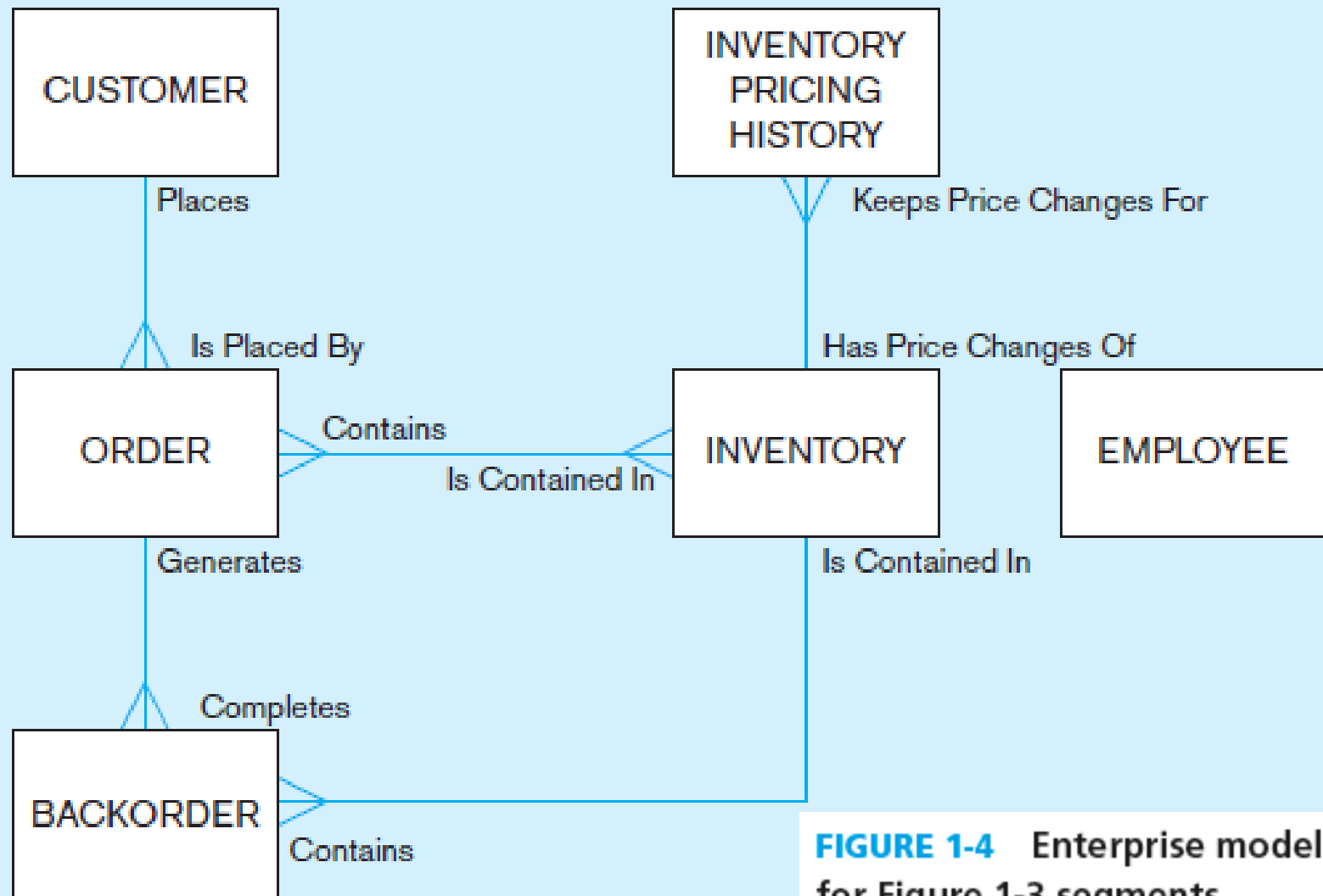Quantity

Therefore, one order involves many products and one product is involved in many orders

☐ Many-to-many relationship

FIGURE 1-4 Enterprise model for Figure 1-3 segments

DATABASE MANAGEMENT SYSTEM

- A **database management system (DBMS)** is a **software system** that enables the use of a database approach. The primary purpose of a DBMS is to provide a systematic method of creating, updating, storing, and retrieving the data stored in a database

ADVANTAGES OF THE DATABASE APPROACH

- Program-data independence
- Planned data redundancy
- Improved data consistency
- Improved data sharing
- Increased application development productivity
- Enforcement of standards
- Improved data quality
- Improved data accessibility and responsiveness
- Reduced program maintenance
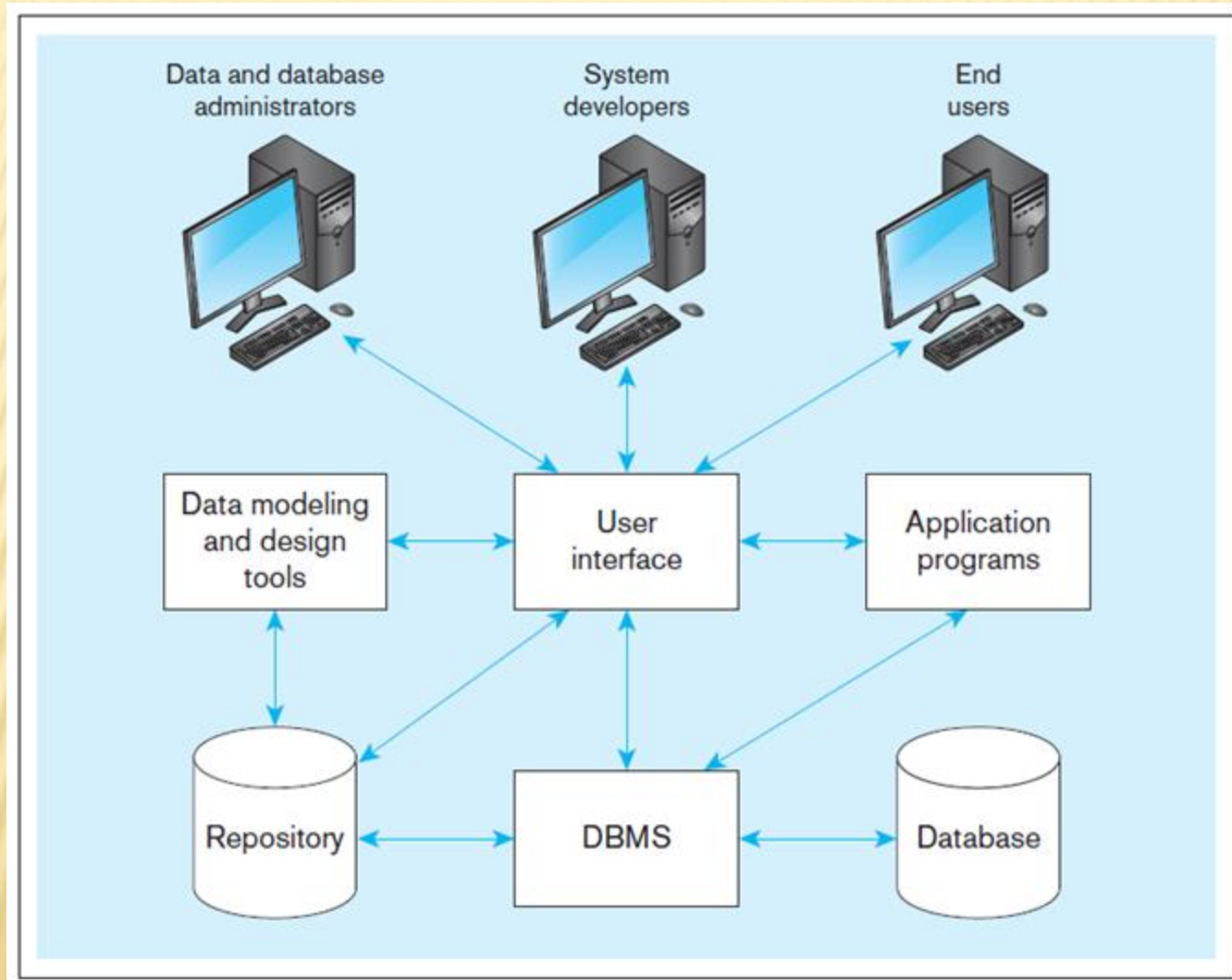- Improved decision support

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COSTS AND RISKS OF THE DATABASE APPROACH

- New, specialized personnel
- Installation and management cost and complexity (training, infrastructure)
- Conversion costs
- Need for explicit backup and recovery
- Organizational conflict

Figure 1-5 Components of the database environment

COMPONENTS OF THE DATABASE ENVIRONMENT

- **C.A.S.E. tools**-- automated tools used to design databases and application programs (even code generation).
- **Repository**–centralized storehouse of metadata
- **Database Management System (DBMS)** –software for managing the database
- **Database**–storehouse of the data
- **Application Programs**–software using the data
- **User Interface**–text, graphical displays, menus, etc. for user
- **Data/Database Administrators**–personnel responsible for maintaining the database
- **System Developers**–personnel responsible for designing databases and software
- **End Users**–people who use the applications and databases

ENTERPRISE DATA MODEL

- First step in the database development process
- Specifies scope and general content
- Overall picture of organizational data at high level of abstraction
- Entity-relationship diagram
- Descriptions of entity types
- Relationships between entities
- Business rules

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FIGURE 1-6 Example business function-to-data entity matrix

Business Functions \ Data Entity Types	Customer	Product	Raw Material	Order	Work Center	Work Order	Invoice	Equipment	Employee
Business Planning	X	X						X	X
Product Development		X	X		X			X	
Materials Management		X	X	X	X	X		X	
Order Fulfillment	X	X	X	X	X	X	X	X	X
Order Shipment	X	X		X	X		X		X
Sales Summarization	X	X		X			X		X
Production Operations		X	X	X	X	X		X	X
Finance and Accounting	X	X	X	X	X		X	X	X

X = data entity is used within business function
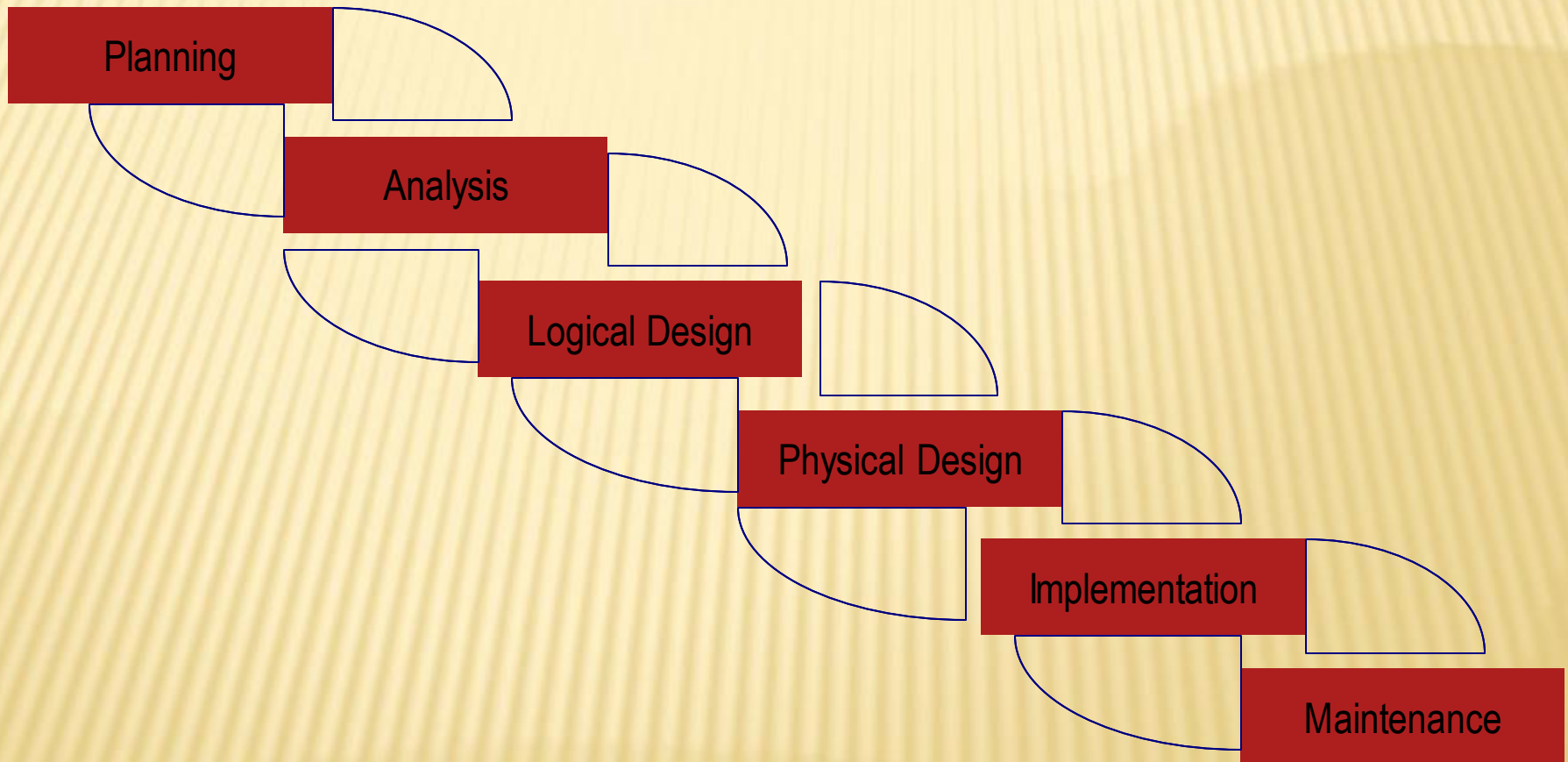
TWO APPROACHES TO DATABASE AND IS DEVELOPMENT

- SDLC
  - System Development Life Cycle
  - Detailed, well-planned development process
  - Time-consuming, but comprehensive
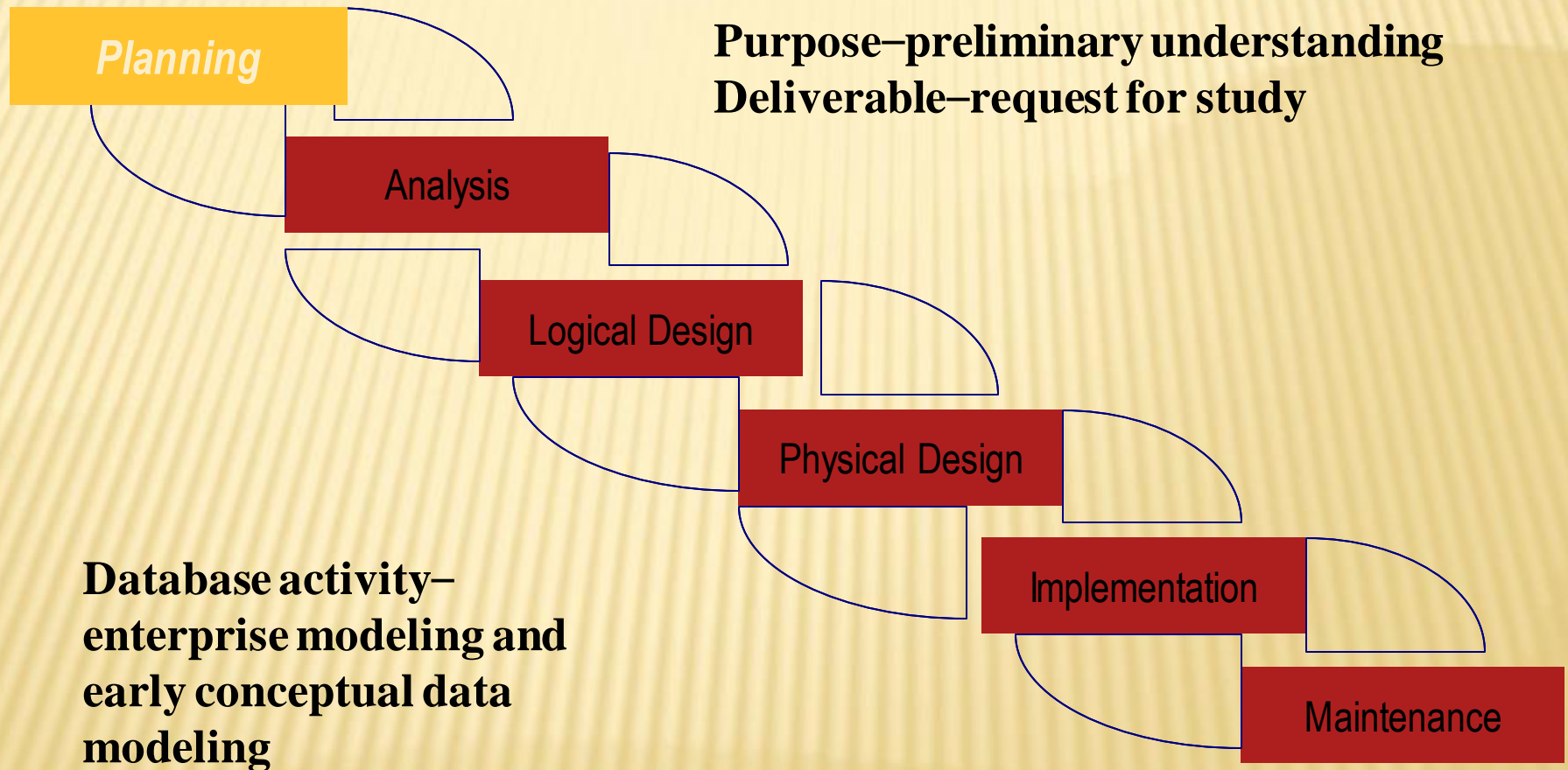 - Long development cycle
- Prototyping
  - Rapid application development (RAD)
  - Cursory attempt at conceptual data modeling
  - Define database during development of initial prototype
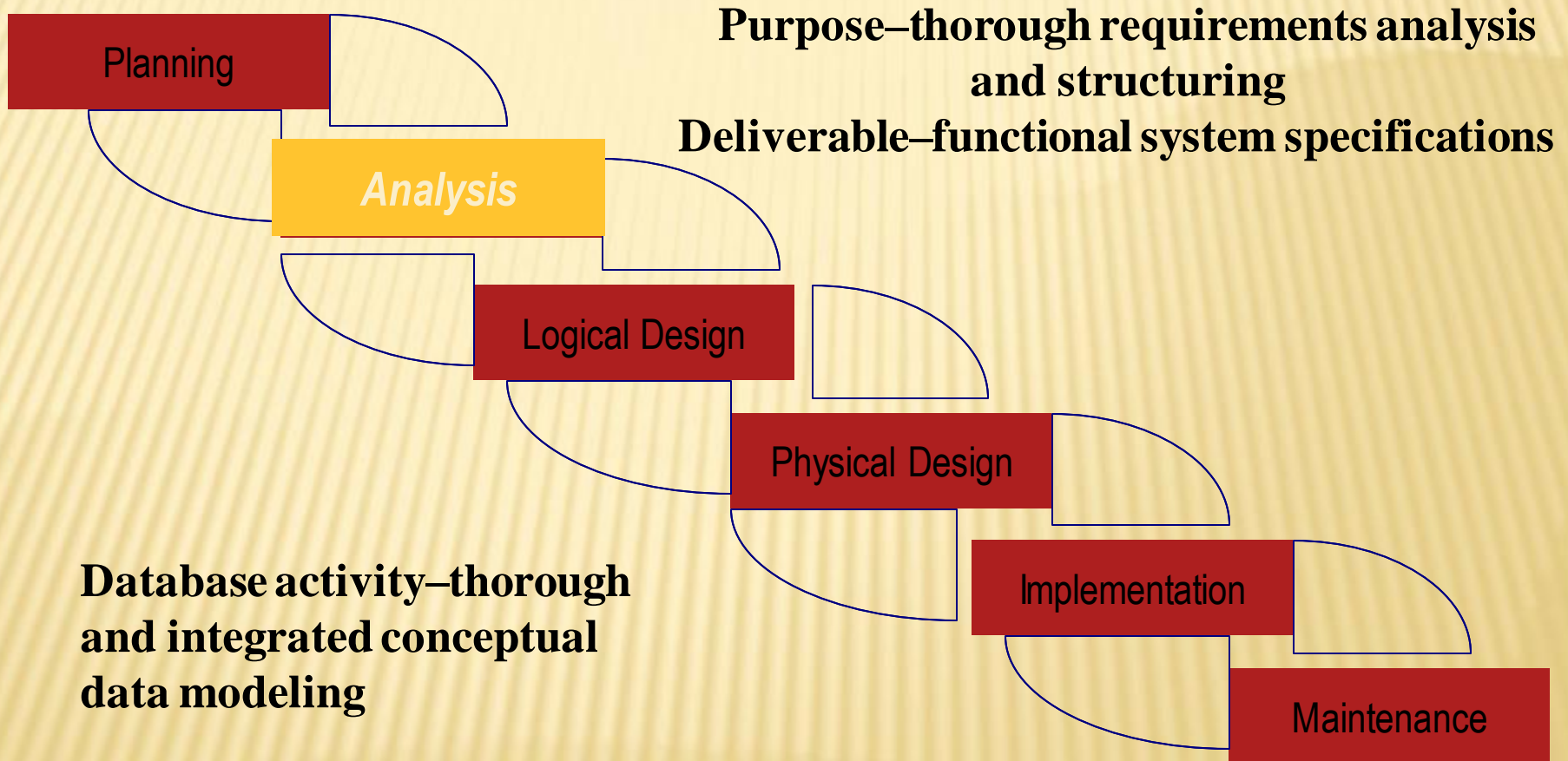 - Repeat implementation and maintenance activities with new prototype versions
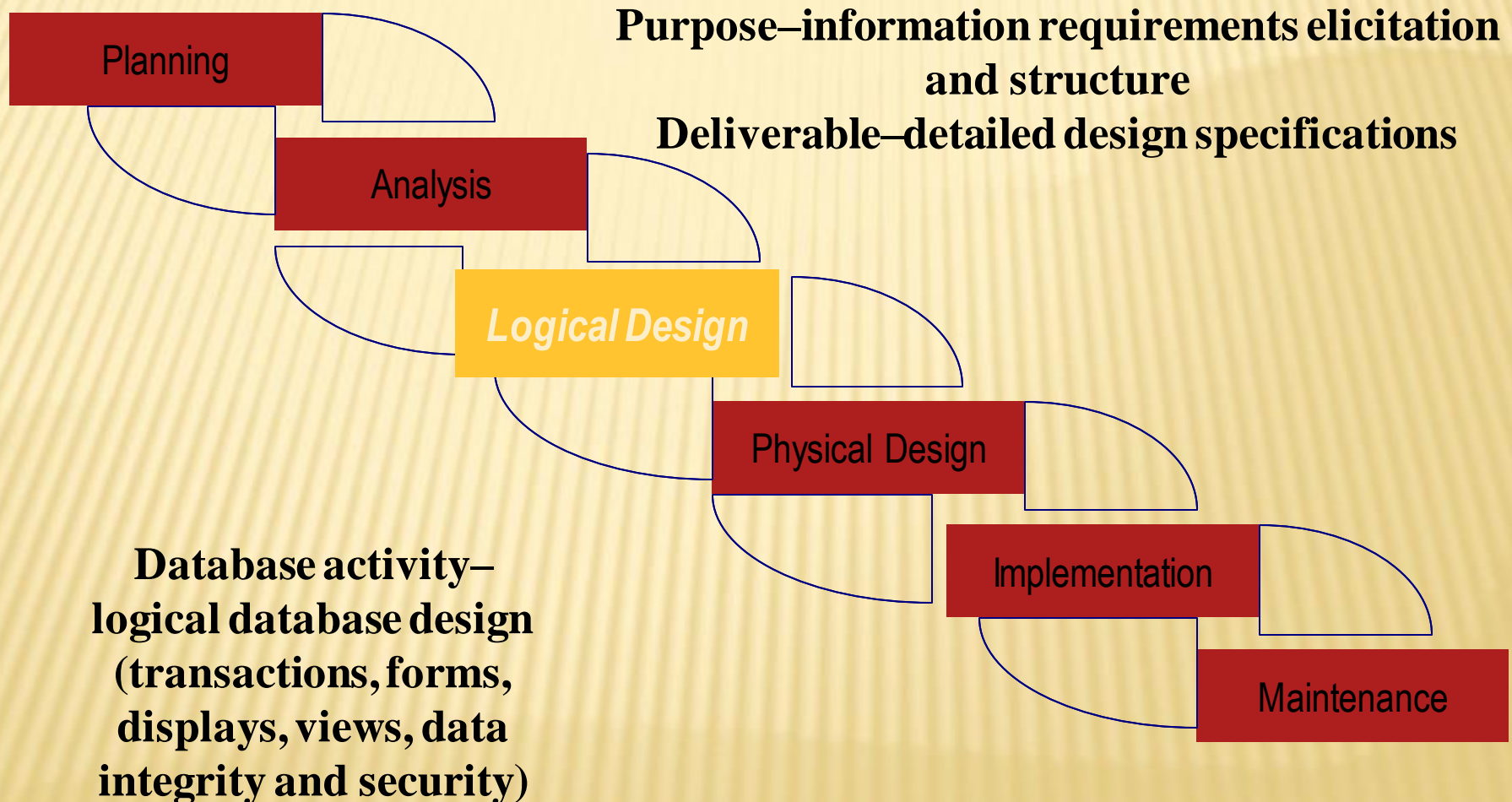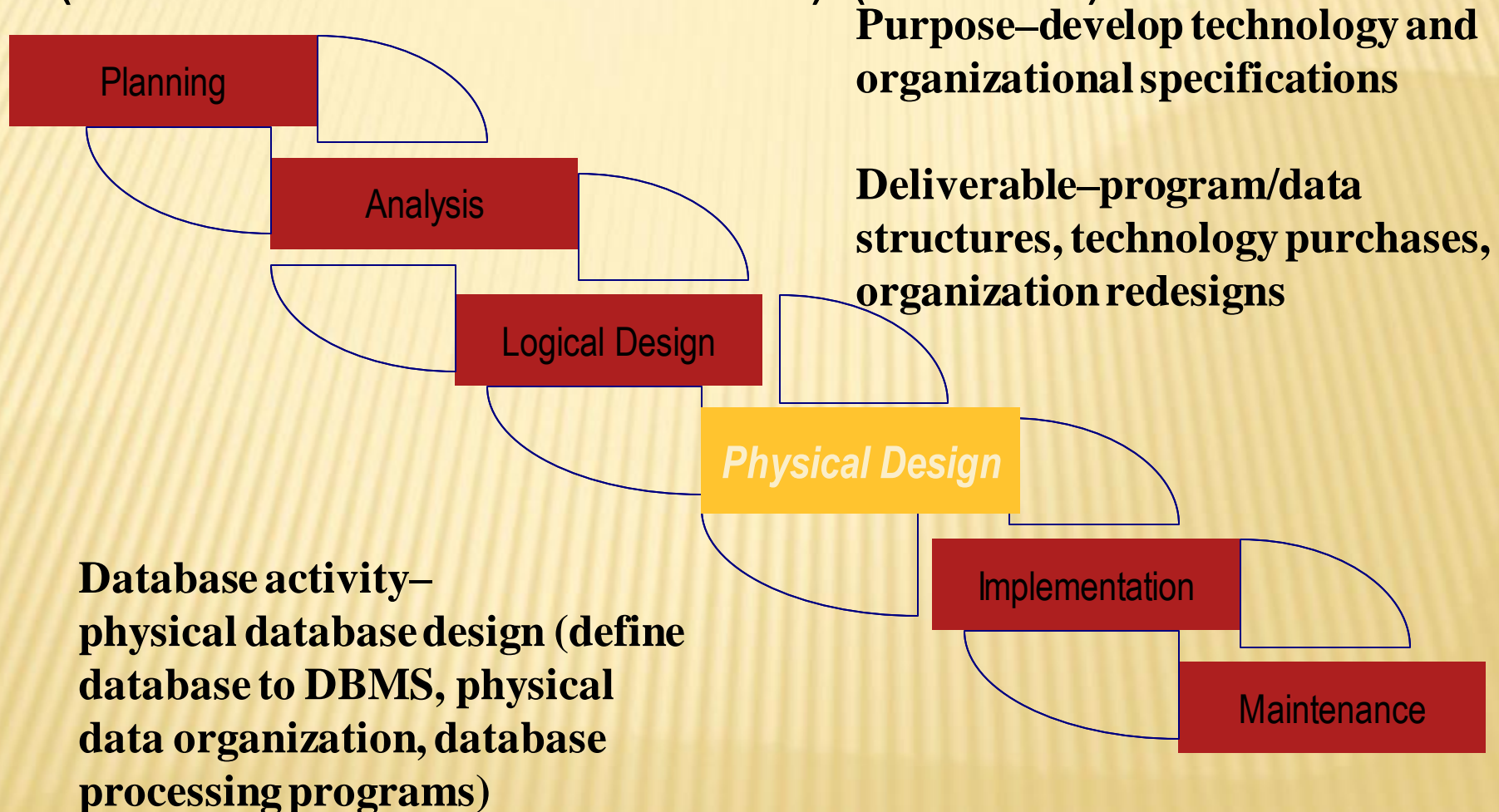
SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7)

SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7) (CONT.)

Planning

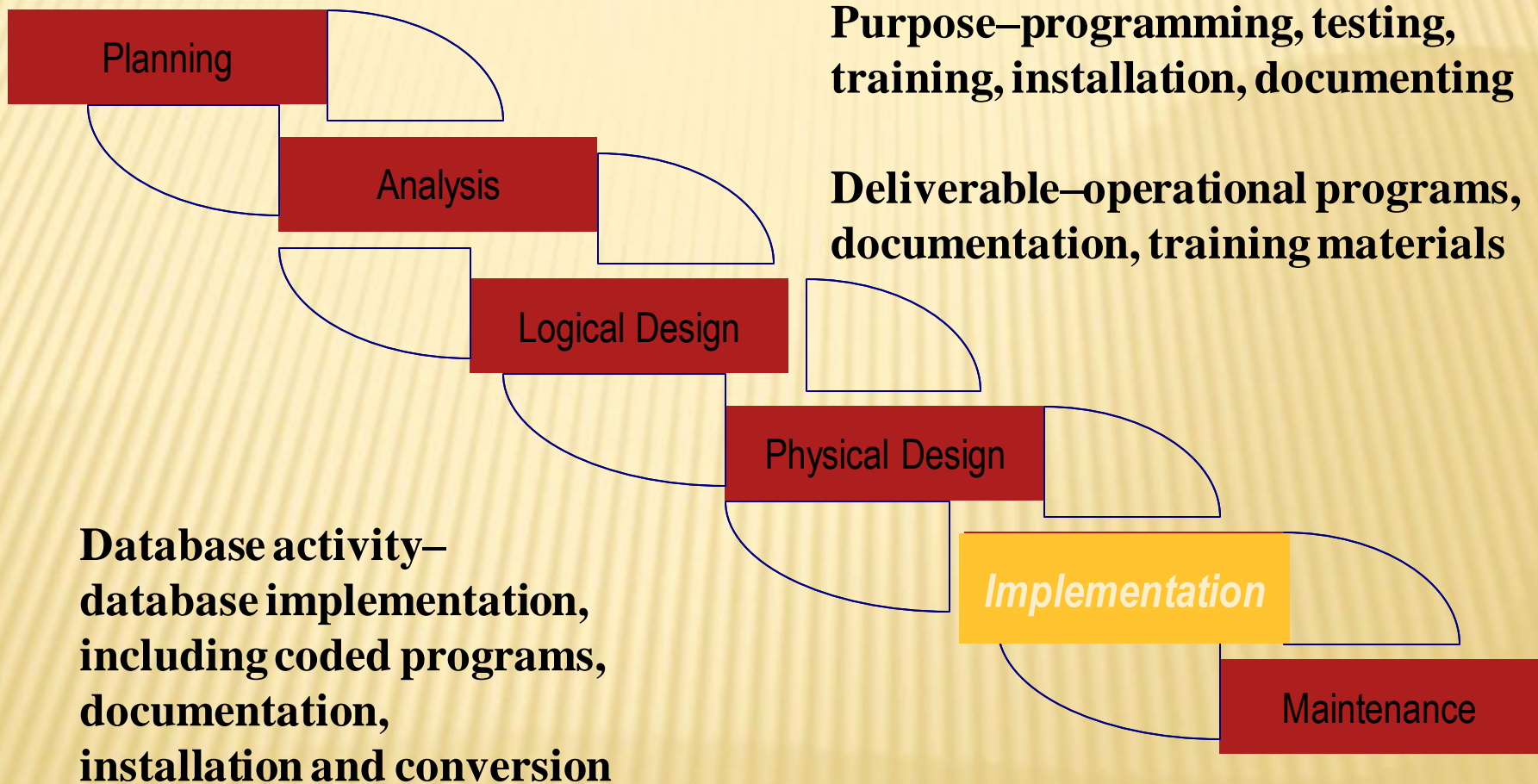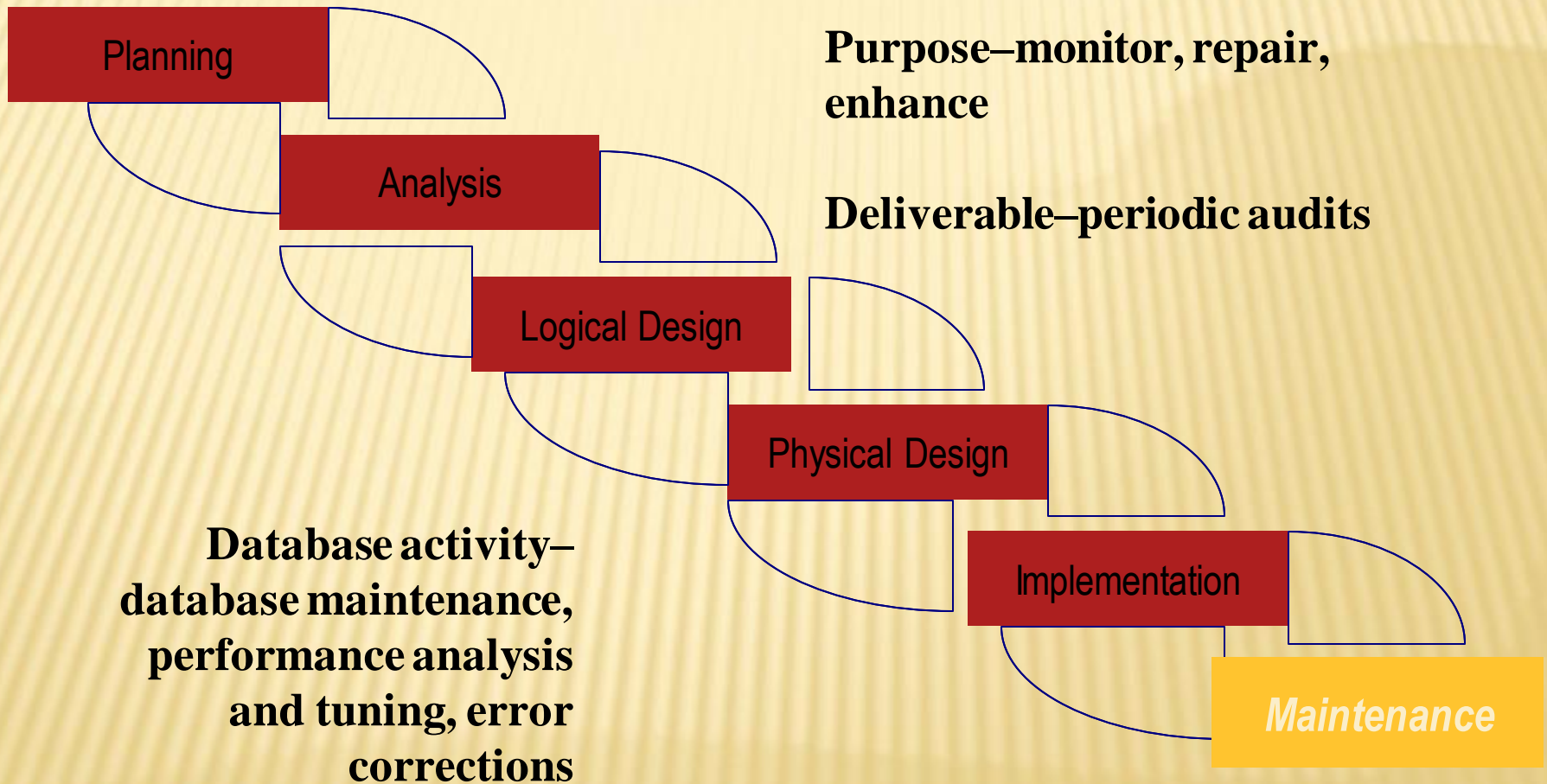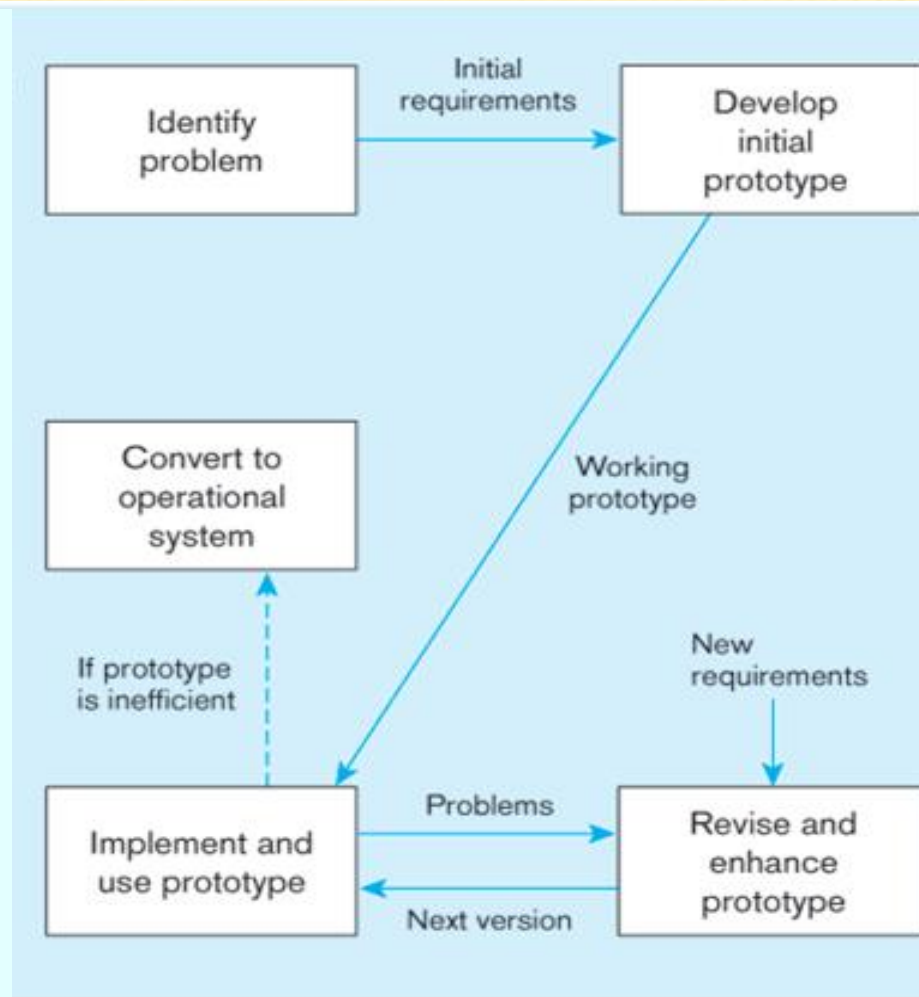**Purpose–preliminary understanding**
Deliverable–request for study

Analysis

Logical Design

Physical Design

Database activity–
enterprise modeling and
early conceptual data
modeling

Implementation

Maintenance

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SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7) (CONT.)

Planning

Analysis

Logical Design

Physical Design

Implementation

Maintenance

Purpose–thorough requirements analysis and structuring

Deliverable–functional system specifications

Database activity–thorough and integrated conceptual data modeling

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SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7) (CONT.)

Purpose–information requirements elicitation and structure
Deliverable–detailed design specifications

Planning

Analysis

Logical Design

Physical Design

Implementation

Maintenance

Database activity– logical database design (transactions, forms, displays, views, data integrity and security)

SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7) (CONT.)

Planning

Analysis

Logical Design

Physical Design

Implementation

Maintenance

Purpose–develop technology and organizational specifications

Deliverable–program/data structures, technology purchases, organization redesigns

Database activity– physical database design (define database to DBMS, physical data organization, database processing programs)

SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7) (CONT.)

Purpose–programming, testing, training, installation, documenting

Deliverable–operational programs, documentation, training materials

Database activity– database implementation, including coded programs, documentation, installation and conversion

Planning

Analysis

Logical Design

Physical Design

Implementation

Maintenance

SYSTEMS DEVELOPMENT LIFE CYCLE (SEE ALSO FIGURE 1-7) (CONT.)

Planning

Analysis

Logical Design

Physical Design

Implementation

Maintenance

Purpose–monitor, repair, enhance

Deliverable–periodic audits

Database activity– database maintenance, performance analysis and tuning, error corrections

PROTOTYPING DATABASE METHODOLOGY (FIGURE 1-8)

Prototyping is a classical Rapid Application Development (RAD) approach

PROTOTYPING DATABASE METHODOLOGY (FIGURE 1-8)

Conceptual data modeling
- Analyze requirements
- Develop preliminary data model

Identify problem → Initial requirements → Develop initial prototype

Working prototype

Convert to operational system

If prototype is inefficient

New requirements

Implement and use prototype → Problems → Revise and enhance prototype

Next version

PROTOTYPING DATABASE METHODOLOGY (FIGURE 1-8)

PROTOTYPING DATABASE METHODOLOGY (FIGURE 1-8)

PROTOTYPING DATABASE METHODOLOGY (FIGURE 1-8)

OTHER RAPID APPLICATION (RAD) APPROACHES

▢ Agile – emphasizes "individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and response to change over following a plan." (The Agile Manifesto)

▢ Examples of agile programming methodologies
  ▢ eXtreme programming
  ▢ Scrum
  ▢ DSDM Consortium
  ▢ Feature-driven development

DATABASE SCHEMA

- External Schema
  - User Views
  - Subsets of Conceptual Schema
  - Can be determined from business-function/data entity matrices
  - DBA determines schema for different users
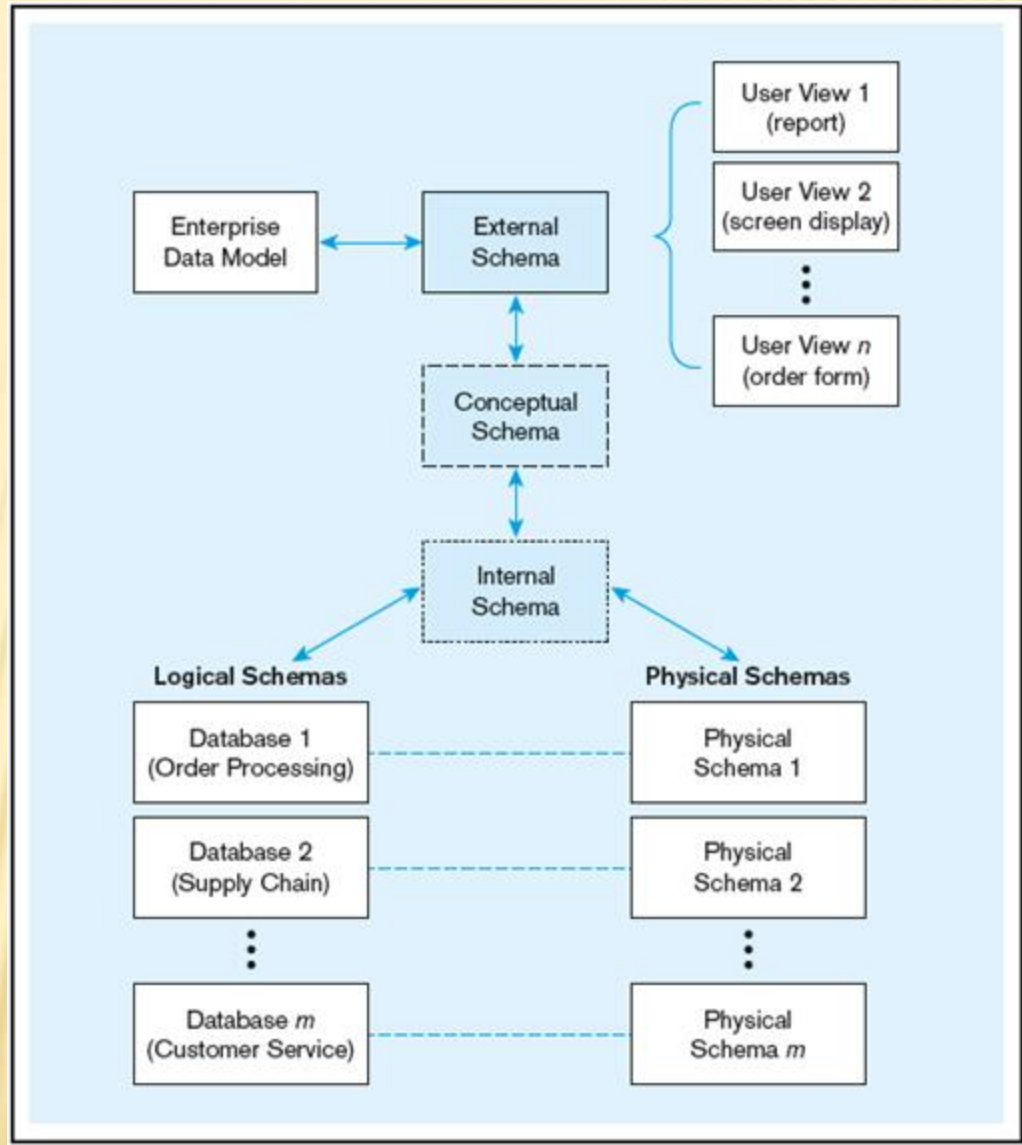- Conceptual Schema
  - E-R models–covered in Chapters 2 and 3
- Internal Schema
  - Logical structures–covered in Chapter 4
  - Physical structures–covered in Chapter 5

Figure 1-9 Three-schema architecture

Different people have different views of the database…these are the external schema

The internal schema is the underlying design and implementation

MANAGING PEOPLE AND PROJECTS

- Project–a planned undertaking of related activities to reach an objective that has a beginning and an end
- Initiated and planned in planning stage of SDLC
- Executed during analysis, design, and implementation
- Closed at the end of implementation

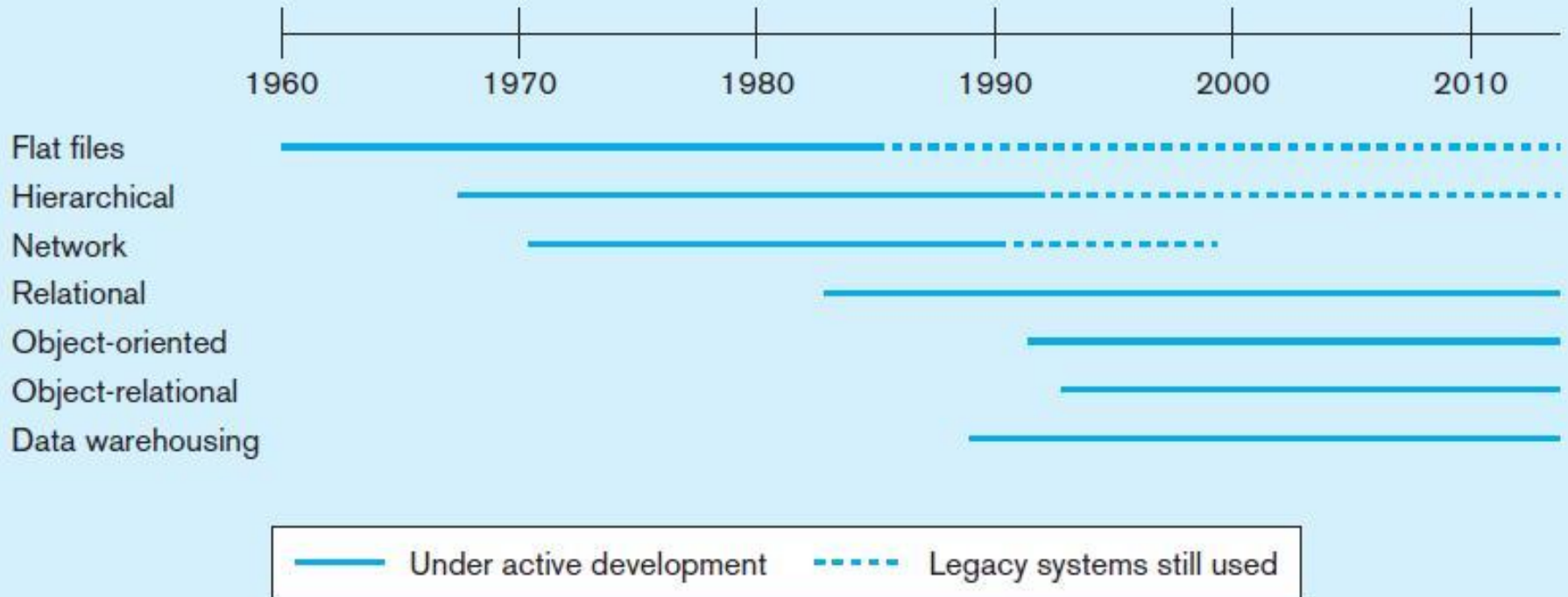# MANAGING PROJECTS: PEOPLE INVOLVED

- Business analysts
- Systems analysts
- Database analysts and data modelers
- Users
- Programmers
- Database architects
- Data administrators
- Project managers
- Other technical experts

Figure 1-10a Evolution of database technologies

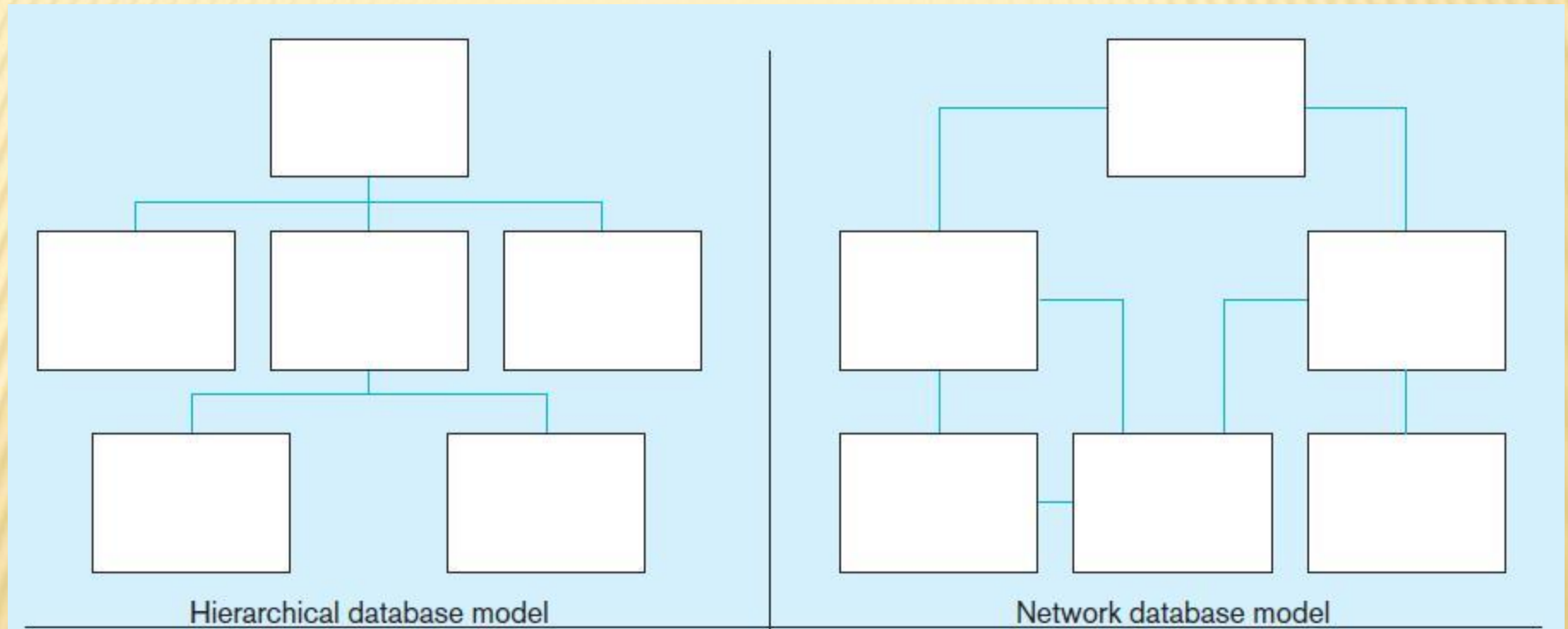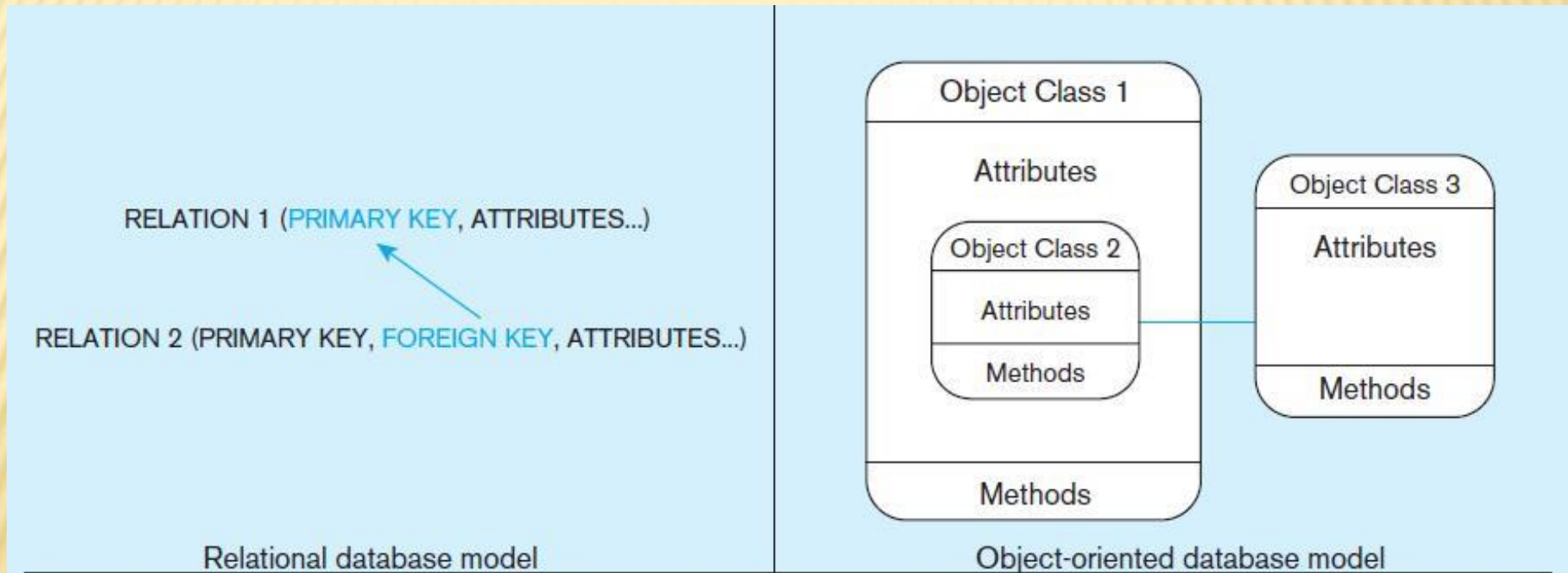Copyright © 2016 Pearson Education, Inc.

EVOLUTION OF DATABASE SYSTEMS

⬚ Driven by four main objectives:

  ⬚ Need for program-data independence reduced maintenance

  ⬚ Desire to manage more complex data types and structures

  ⬚ Ease of data access for less technical personnel

  ⬚ Need for more powerful decision support platforms

Figure 1-10b Database architectures

Hierarchical database model

Network database model

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Figure 1-10b Database architectures (cont.)

RELATION 1 (PRIMARY KEY, ATTRIBUTES...)

RELATION 2 (PRIMARY KEY, FOREIGN KEY, ATTRIBUTES...)

Relational database model

Object Class 1

Attributes

Object Class 2

Attributes

Methods

Methods

Object Class 3

Attributes

Methods

Object-oriented database model

Figure 1-10b Database architectures (cont.)

Multidimensional database model –
multidimensional cube view
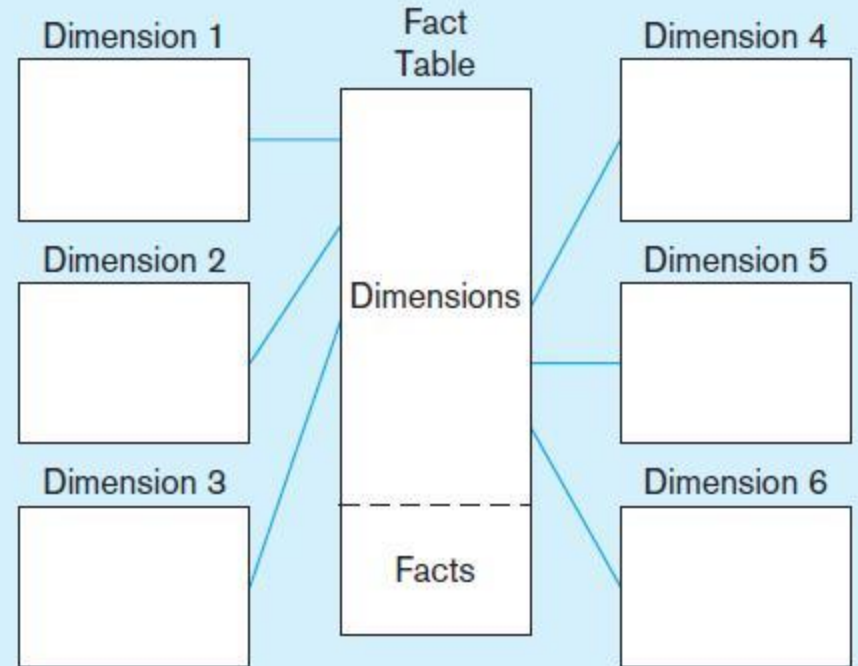
Multidimensional database model –
star-schema view

THE RANGE OF DATABASE APPLICATIONS

- ⍰ Personal databases
- ⍰ Two-tier and N-tier Client/Server databases
- ⍰ Enterprise applications
  - ⍰ Enterprise resource planning (ERP) systems
  - ⍰ Data warehousing implementations

TABLE 1-5 Summary of Database Applications

Type of Database / Application	Typical Number of Users	Typical Size of Database
Personal	1	Megabytes
Multitier Client/Server	100–1000	Gigabytes
Enterprise resource planning	>100	Gigabytes–terabytes
Data warehousing	>100	Terabytes–petabytes

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Figure 1-11 Multi-tiered client/server database architecture
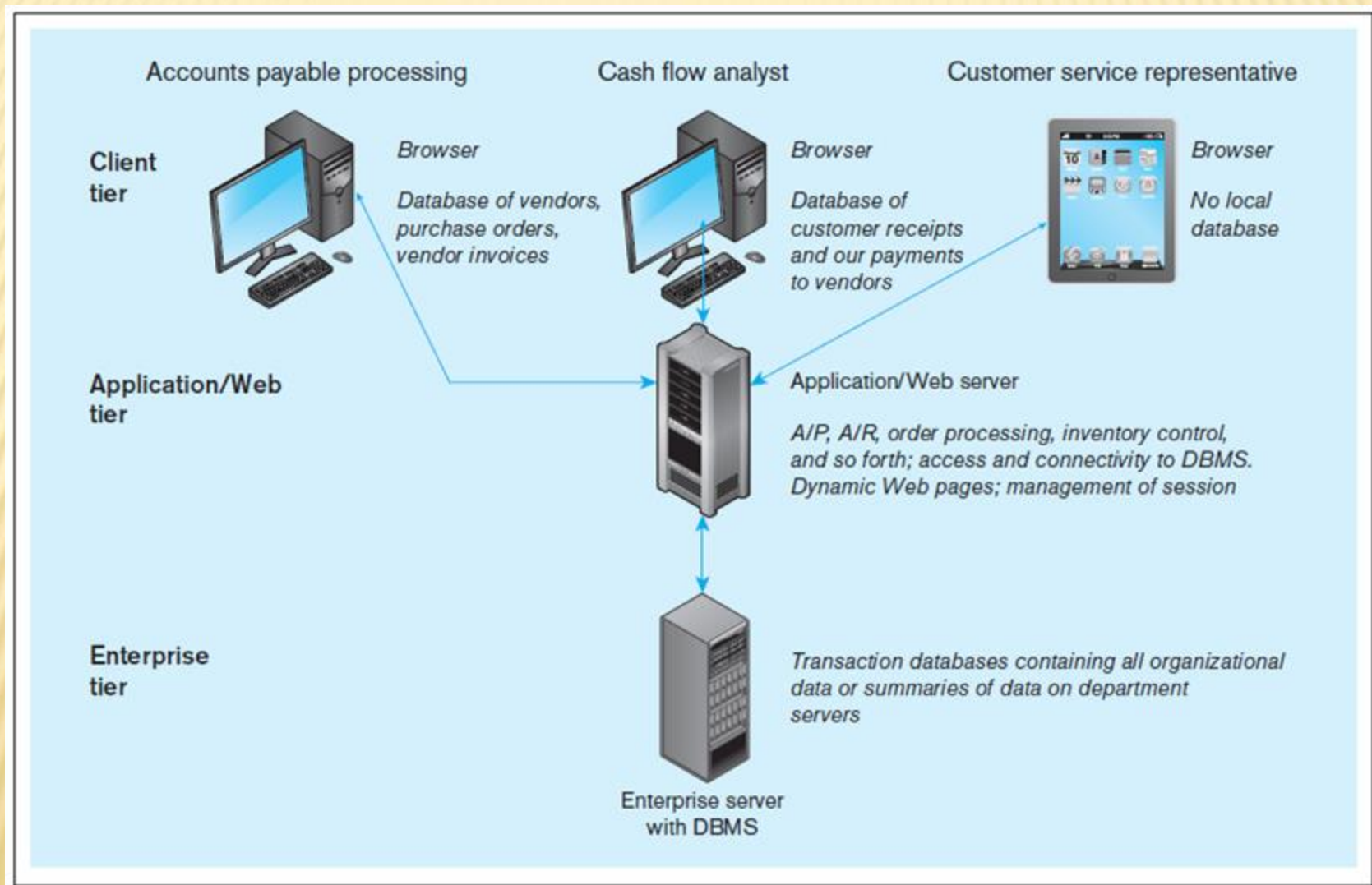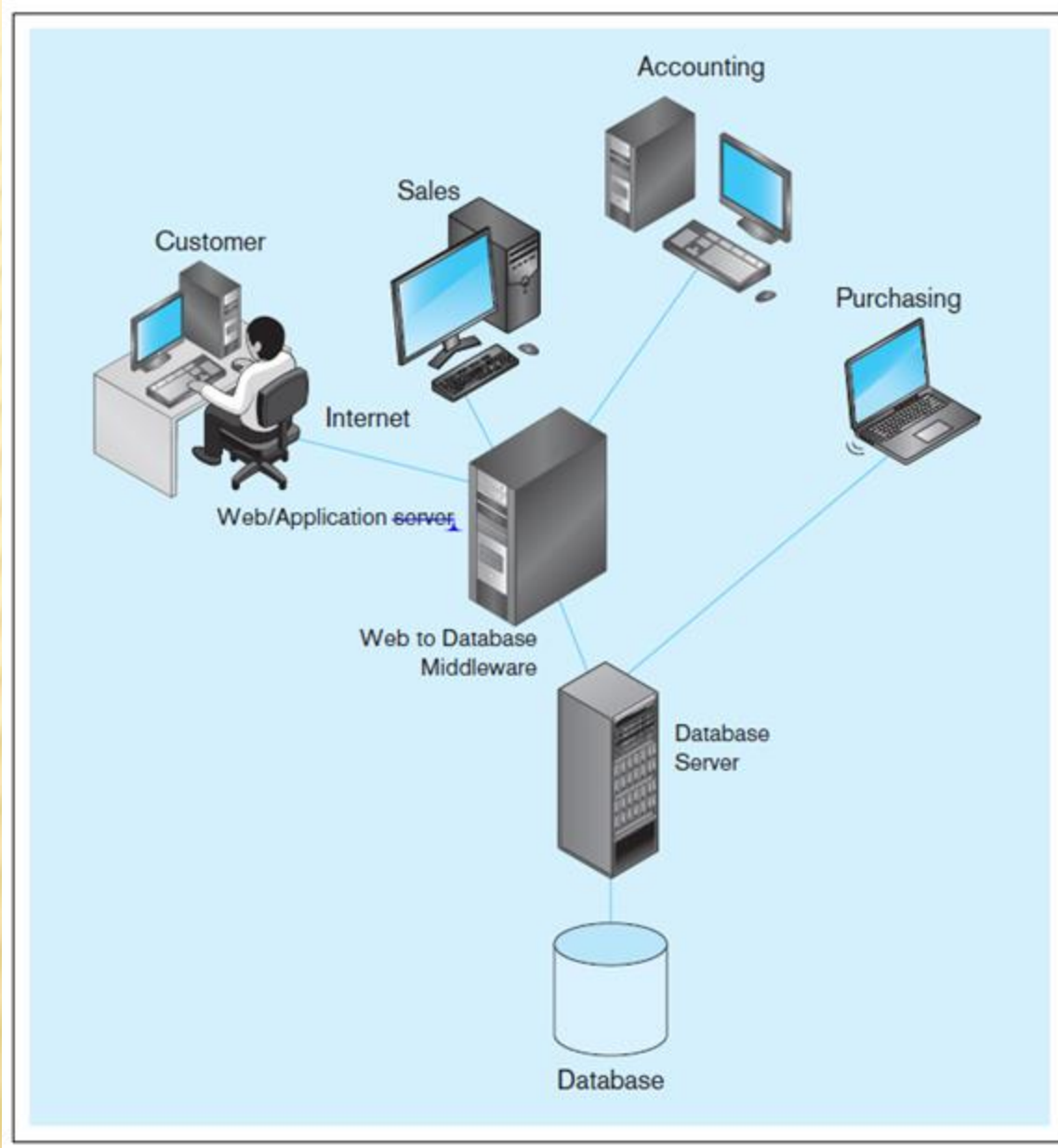
ENTERPRISE DATABASE APPLICATIONS

- Enterprise Resource Planning (ERP)
  - Integrate all enterprise functions (manufacturing, finance, sales, marketing, inventory, accounting, human resources)
- Data Warehouse
  - Integrated decision support system derived from various operational databases

FIGURE 1-13 Computer System for Pine Valley Furniture Company

FIGURE 1-15 Project data model for Home Office product line marketing support system

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