Database Systems: Design, Implementation, and Management

Eighth Edition

Chapter 1

Database Systems

Objectives

- The differences between data and information
- What a database is
- What the various types of databases are
- Why they are valuable assets for decision making
- The importance of database design

Objectives (continued)

- How modern databases evolved from file systems
- About flaws in file system data management
- What the database system's main components are
- How a database system differs from a file system
- The main functions of a database management system (DBMS)

Introduction

- Good decisions require good information derived from raw facts
- Data managed most efficiently when stored in a database
- Databases evolved from computer file systems
- Understanding file system characteristics is important

Data vs. Information

- **Data** are raw facts
- **Information** is the result of processing raw data to reveal meaning
- Information requires *context* to reveal meaning
- Raw data must be *formatted* for storage, processing, and presentation
- Data are the foundation of information, which is the bedrock of **knowledge**

Data vs. Information (continued)

- Data: building blocks of information
- Information produced by processing data
- Information used to reveal meaning in data
- Accurate, relevant, timely information is the key to good decision making
- Good decision making is the key to organizational survival

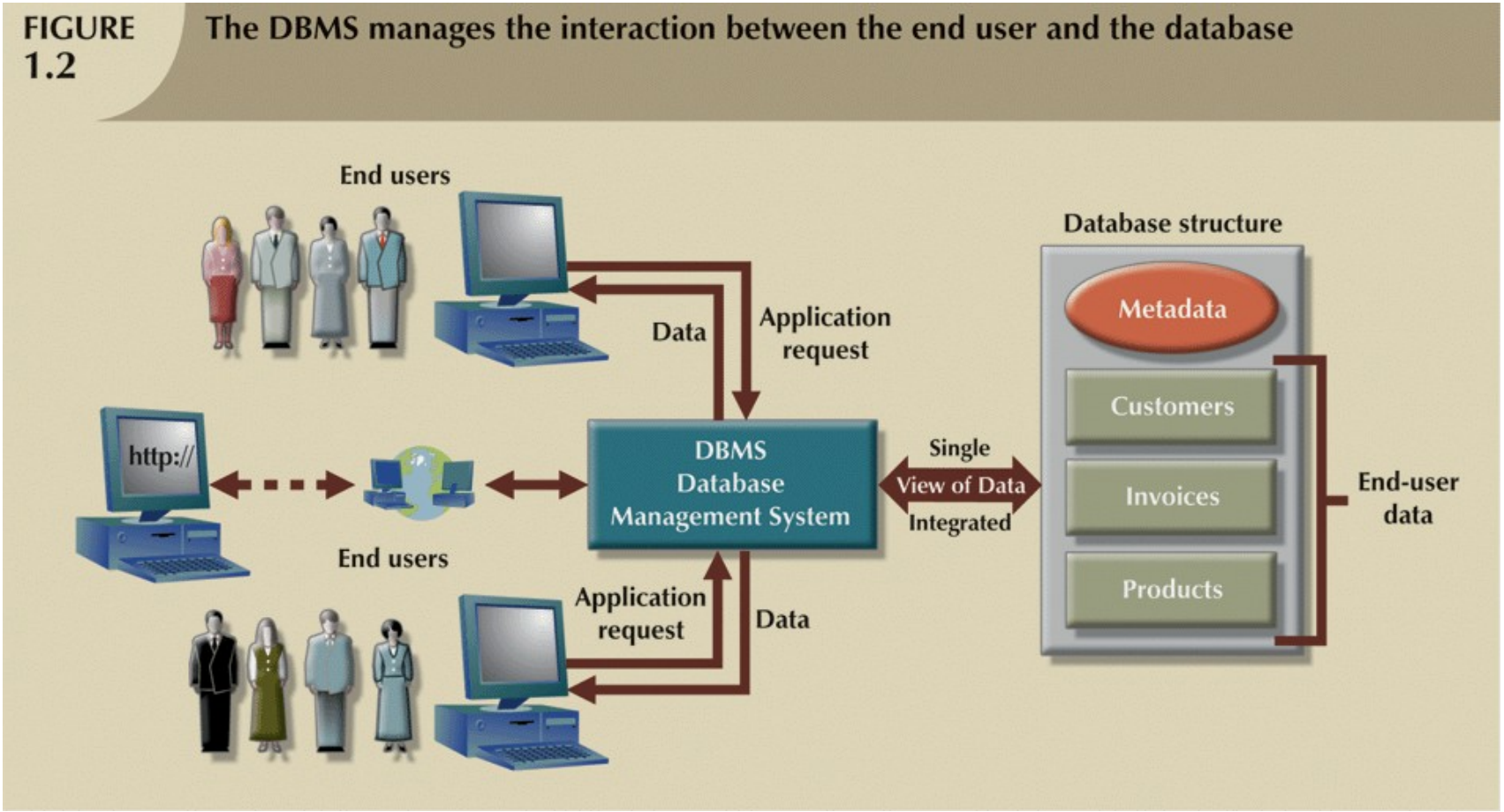
Introducing the Database and the DBMS

- Database: shared, integrated computer structure that stores a collection of data
  - End-user data: raw facts of interest to the end user
  - **Metadata**: data about data
- Metadata provides description of data characteristics and relationships in data
  - Complements and expands value of data
- **Database management system (DBMS)**: collection of programs
  - Manage structure and control access to data

Role and Advantages of the DBMS

- DBMS is the intermediary between the user and the database
- Database structure stored as file collection
- Access database through the DBMS
- DBMS enables data to be shared
- DBMS integrates many users' views of the data

FIGURE 1.2 The DBMS manages the interaction between the end user and the database



Role and Advantages of the DBMS (continued)

- Advantages of a DBMS:
  - Improved data sharing
  - Improved data security
  - Better data integration
  - Minimized **data inconsistency**
  - Improved data access
  - Improved decision making
  - Increased end-user productivity

Types of Databases

- Databases can be classified according to:
  - Number of users
  - Database location(s)
  - Expected type and extent of use
- **Single-user database** supports only one user at a time
  - **Desktop database** – single-user, runs on PC
- **Multiuser database** supports multiple users at the same time
  - **Workgroup database** supports a small number
  - **Enterprise database** supports a large number

Types of Databases (continued)

- **Centralized database**: data located at a single site
- **Distributed database**: data distributed across several different sites
- **Operational database**: supports a company's day-to-day operations
  - **Transactional** or **production database**
- **Data warehouse**: stores data used for tactical or strategic decisions

Types of Databases (continued)

- **Unstructured data** exist in their original state
- **Structured data** result from formatting
  - Structure applied based on type of processing to be performed
- **Semistructured data** have been processed to some extent
- **Extensible Markup Language (XML)** represents data elements in textual format
- **XML database** supports semistructured XML data

TABLE 1.1 Types of Databases

PRODUCT	NUMBER OF USERS			DATA LOCATION		DATA USAGE		XML
	SINGLE USER	MULTIUSER		CENTRALIZED	DISTRIBUTED	OPERATIONAL	DATA WAREHOUSE	
		WORK-GROUP	ENTER-PRISE					
MS Access	X	X		X		X		
MS SQL Server	X[2]	X	X	X	X	X	X	X
IBM DB2	X[2]	X	X	X	X	X	X	X
MySQL	X	X	X	X	X	X	X	X*
Oracle RDBMS	X[2]	X	X	X	X	X	X	X

* Supports XML functions only. XML data is stored in large text objects.

Why Database Design is Important

- **Database design** focuses on design of database structure used for end-user data
  - Designer must identify database's expected use
- Well-designed database:
  - Facilitates data management
  - Generates accurate and valuable information
- Poorly designed database:
  - Causes difficult-to-trace errors

Historical Roots: Files and File Systems

- Reasons for studying file systems:
  - Complexity of database design easier to understand
  - Understanding file system problems helps to avoid problems with DBMS systems
  - Knowledge of file system useful for converting file system to database system
- **File systems** typically composed of **collection of file folders, each tagged and kept in cabinet**
  - Organized by expected use

Historical Roots: Files and File Systems (continued)

- Contents of each file folder logically related
- Manual system served as a data repository for small data collections
  - Cumbersome for large collections
- **Data processing (DP) specialist** converted computer file structure from manual system
  - Wrote software that managed the data
  - Designed the application programs
- Initially, computer files systems resembled manual systems

Historical Roots: Files and File Systems (continued)

- As number of files increased, file systems evolved
  - Each file used its own application program to store, retrieve, modify data
  - Each file owned by individual or department that commissioned its creation
- **Data processing (DP) manager** supervised the DP department
- DP department's primary activity remained programming

FIELD

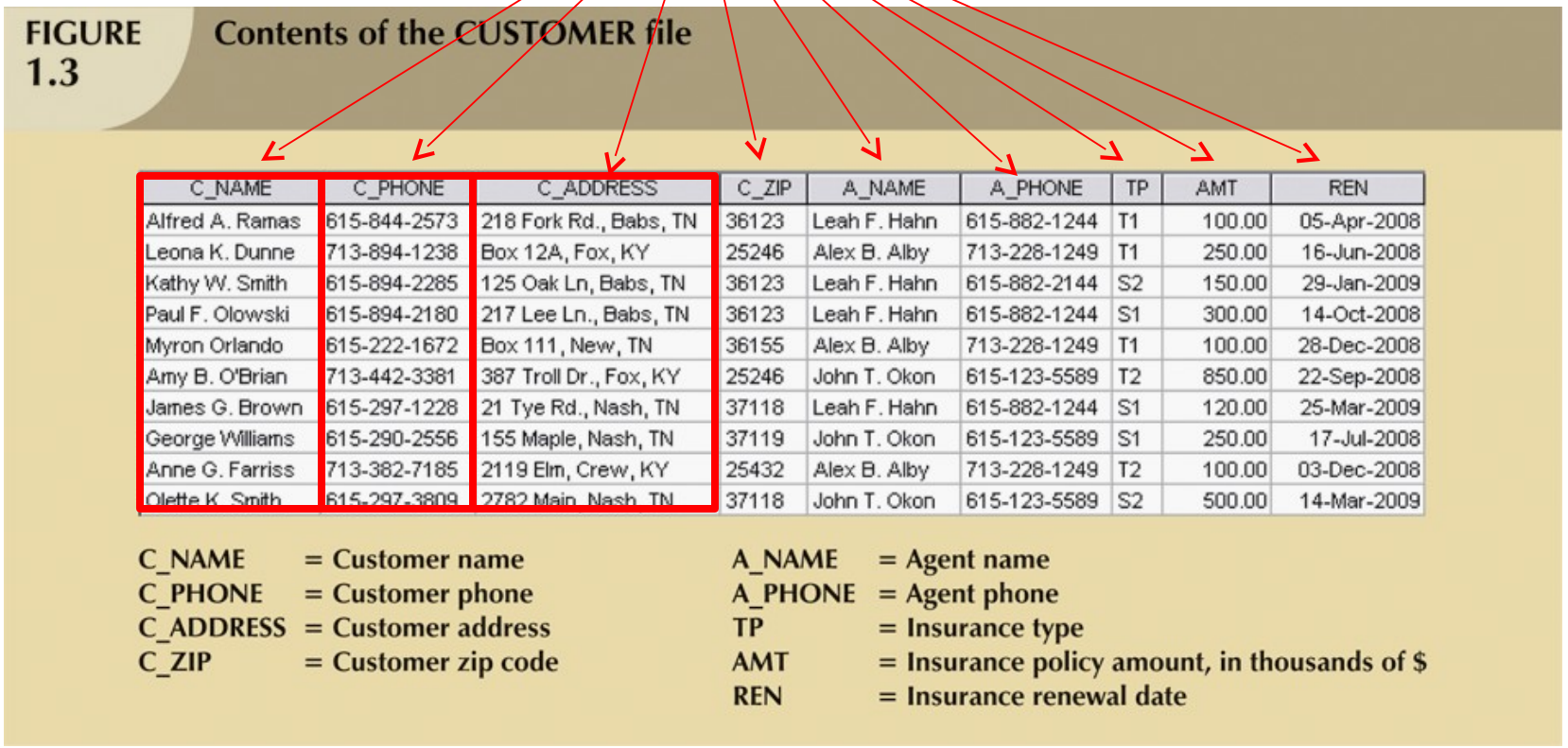


FIGURE 1.3 Contents of the CUSTOMER file

C_NAME	C_PHONE	C_ADDRESS	C_ZIP	A_NAME	A_PHONE	TP	AMT	REN
Alfred A. Ramas	615-844-2573	218 Fork Rd., Babs, TN	36123	Leah F. Hahn	615-882-1244	T1	100.00	05-Apr-2008
Leona K. Dunne	713-894-1238	Box 12A, Fox, KY	25246	Alex B. Alby	713-228-1249	T1	250.00	16-Jun-2008
Kathy W. Smith	615-894-2285	125 Oak Ln, Babs, TN	36123	Leah F. Hahn	615-882-2144	S2	150.00	29-Jan-2009
Paul F. Olowski	615-894-2180	217 Lee Ln., Babs, TN	36123	Leah F. Hahn	615-882-1244	S1	300.00	14-Oct-2008
Myron Orlando	615-222-1672	Box 111, New, TN	36155	Alex B. Alby	713-228-1249	T1	100.00	28-Dec-2008
Amy B. O'Brian	713-442-3381	387 Troll Dr., Fox, KY	25246	John T. Okon	615-123-5589	T2	850.00	22-Sep-2008
James G. Brown	615-297-1228	21 Tye Rd., Nash, TN	37118	Leah F. Hahn	615-882-1244	S1	120.00	25-Mar-2009
George Williams	615-290-2556	155 Maple, Nash, TN	37119	John T. Okon	615-123-5589	S1	250.00	17-Jul-2008
Anne G. Farriss	713-382-7185	2119 Elm, Crew, KY	25432	Alex B. Alby	713-228-1249	T2	100.00	03-Dec-2008
Olette K. Smith	615-297-3809	2782 Main, Nash, TN	37118	John T. Okon	615-123-5589	S2	500.00	14-Mar-2009

C_NAME = Customer name
C_PHONE = Customer phone
C_ADDRESS = Customer address
C_ZIP = Customer zip code

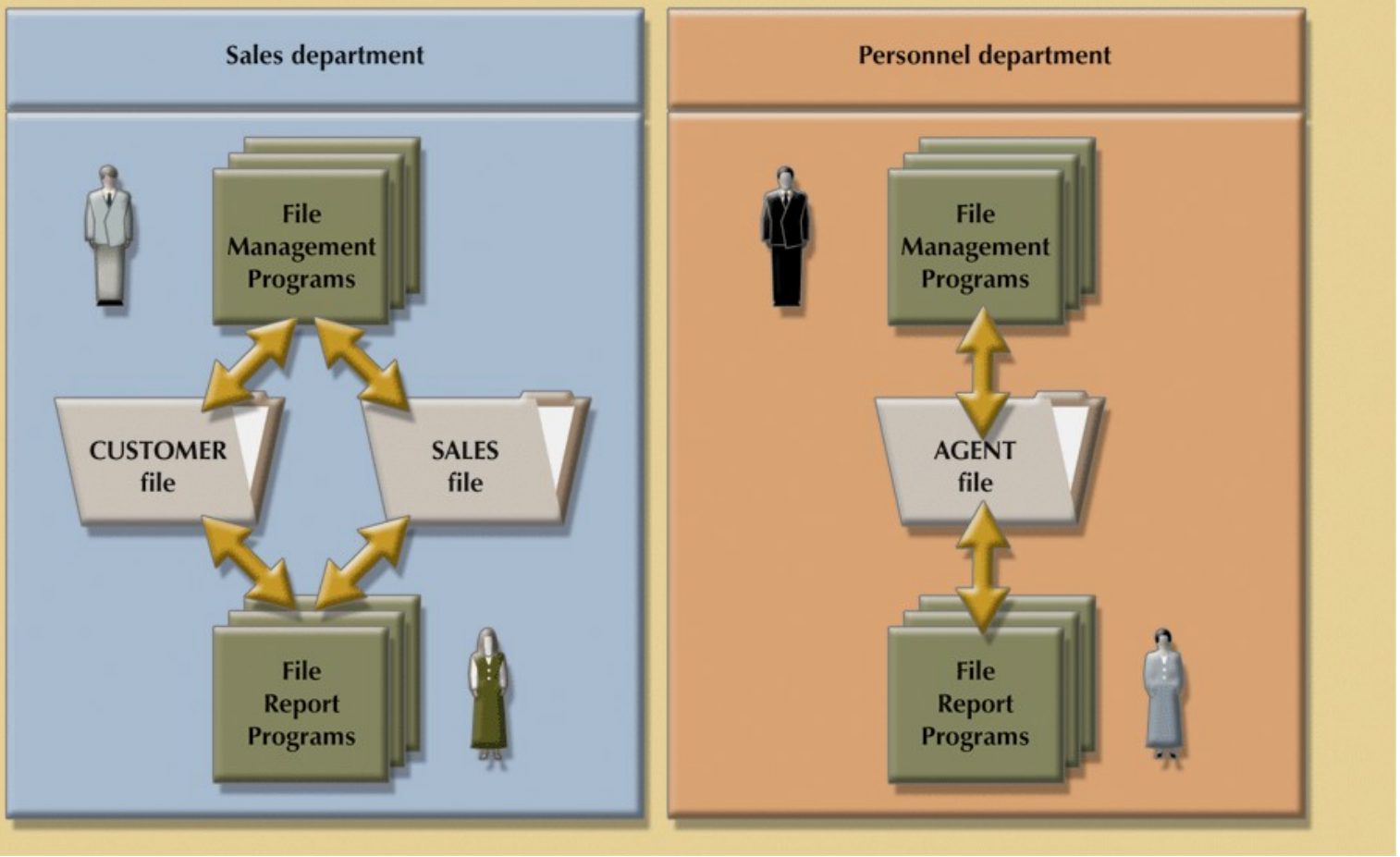
A_NAME = Agent name
A_PHONE = Agent phone
TP = Insurance type
AMT = Insurance policy amount, in thousands of $
REN = Insurance renewal date

RECORD : a logically connected set of one or more fields that describe person, place or thing

TABLE 1.2 Basic File Terminology

TERM	DEFINITION
Data	"Raw" facts, such as a telephone number, a birth date, a customer name, and a year-to-date (YTD) sales value. Data have little meaning unless they have been organized in some logical manner. The smallest piece of data that can be "recognized" by the computer is a single character, such as the letter *A*, the number 5, or a symbol such as /. A single character requires 1 byte of computer storage.
Field	A character or group of characters (alphabetic or numeric) that has a specific meaning. A field is used to define and store data.
Record	A logically connected set of one or more fields that describes a person, place, or thing. For example, the fields that constitute a record for a customer named J. D. Rudd might consist of J. D. Rudd's name, address, phone number, date of birth, credit limit, and unpaid balance.
File	A collection of related records. For example, a file might contain data about vendors of ROBCOR Company, or a file might contain the records for the students currently enrolled at Gigantic University.

FIGURE 1.5 A simple file system



Problems with File System Data Management

- File system an improvement over manual system
  - File systems used for more than two decades
  - Understanding the shortcomings of file systems aids in development of modern databases
  - Many problems not unique to file systems
- Even simple file system retrieval task required extensive programming
  - Ad hoc queries impossible
  - Changing existing structure difficult

Problems with File System Data Management (continued)

- Security features difficult to program
  - Often omitted in file system environments
- Summary of file system limitations:
  - Requires extensive programming
  - Can not perform ad hoc queries
  - System administration complex and difficult
  - Difficult to make changes to existing structures
  - Security features likely to be inadequate

Structural and Data Dependence

- **Structural dependence**: access to a file dependent on its own structure penggunaan sistem yang merubah struktur capaian data. Contoh: keluarkan duit Tabung Haji cara manual dan juga dengan menggunakan ATM.
  - All file system programs must be modified to conform to a new file structure
- **Structural independence**: change file structure without affecting data access perubahan tidak menjejaskan capaian data
- **Data dependence**: data access changes when data storage characteristics change cara capaian data berubah apabila data berubah
- **Data independence**: data storage characteristics do not affect data access perubahan data tidak menjejaskan cara capaian data

Structural and Data Dependence (continued)

- Practical significance of data dependence is difference between logical and physical format
- **Logical data format**: how **human** views the data
- **Physical data format**: how **computer** must work with data
- Each program must contain:
  - Lines specifying opening of specific file type
  - Record specification
  - Field definitions

Field Definitions and Naming Conventions

- Storing customer name as single field is a liability
  - Better record definition breaks fields into component parts
- Selecting proper field names important; field names are descriptive
  - With proper naming conventions, file structure becomes *self-documenting*
  - Some software places restrictions on length of field names
- Each record should have unique identifier

TABLE 1.3 Sample Fields in the CUSTOMER_V2 File

FIELD	CONTENTS	SAMPLE ENTRY
CUS_LNAME	Customer last name	Ramas
CUS_FNAME	Customer first name	Alfred
CUS_INITIAL	Customer initial	A
CUS_AREACODE	Customer area code	615
CUS_PHONE	Customer phone	234-5678
CUS_ADDRESS	Customer street address or box number	123 Green Meadow Lane
CUS_CITY	Customer city	Murfreesboro
CUS_STATE	Customer state	TN
CUS_ZIP	Customer zip code	37130
AGENT_CODE	Agent code	502

Data Redundancy

- File system structure makes it difficult to combine data from multiple sources
  - Vulnerable to security breaches
- Organizational structure promotes storage of same data in different locations
  - Islands of information
- Data stored in different locations unlikely to be updated consistently
- **Data redundancy**: same data stored unnecessarily in different places

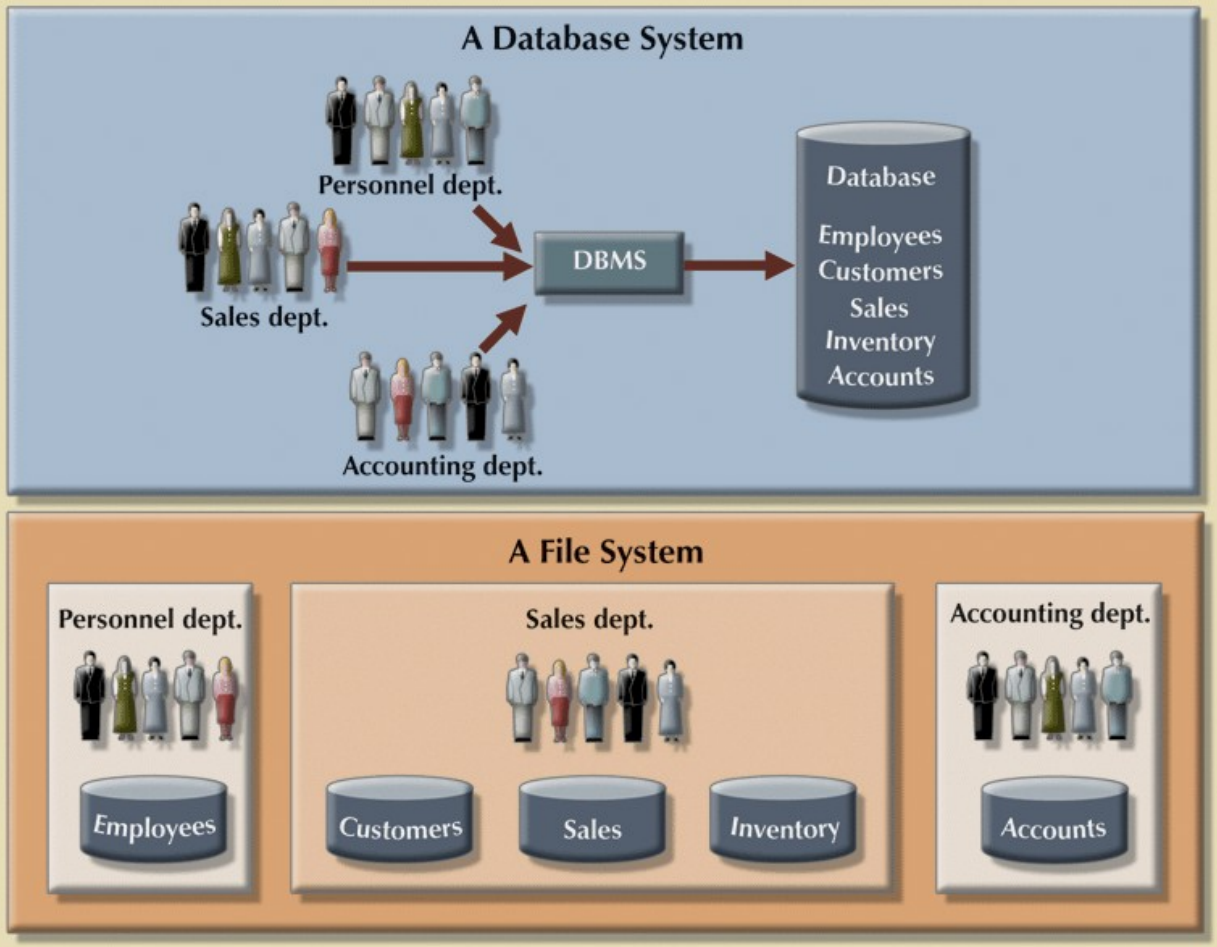
Data Redundancy (continued)

- **Data inconsistency**: different and conflicting versions of same data occur at different places
- **Data anomalies**: abnormalities when all changes in redundant data not made correctly
  - Update anomalies
  - Insertion anomalies
  - Deletion anomalies

Database Systems

- Database system consists of logically related data stored in a single logical data repository
  - May be physically distributed among multiple storage facilities
- **DBMS eliminates most of file system's problems**
- Current generation stores data structures, relationships between structures, access paths
  - Takes care of defining, storing, managing all access paths and components

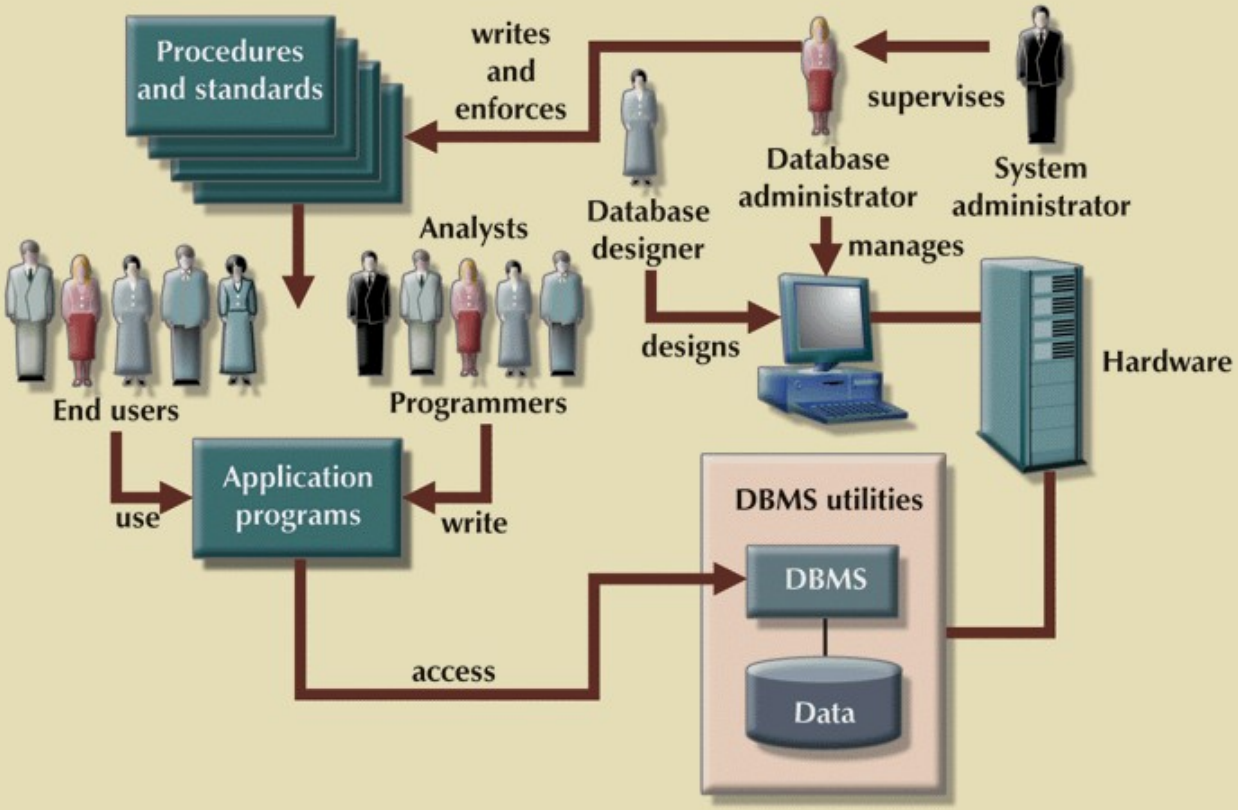
FIGURE 1.6 Contrasting database and file systems



The Database System Environment

- **Database system**: defines and regulates the collection, storage, management, use of data
- Five major parts of a database system:
  - **Hardware**
  - **Software**
  - **People**
  - **Procedures**
  - **Data**

FIGURE 1.7 The database system environment



The Database System Environment (continued)

- **Hardware**: all the system's physical devices
- **Software**: three types of software required:
  - Operating system software
  - DBMS software
  - Application programs and utility software
- **People**: all users of the database system:
  - System and database administrators
  - Database designers
  - Systems analysts and programmers
  - End users

The Database System Environment (continued)

- **Procedures**: instructions and rules that govern the design and use of the database system
- **Data**: the collection of facts stored in the database
- Database systems created and managed at different levels of complexity
- Database solutions must be cost-effective as well as tactically and strategically effective
- Database technology already in use affects selection of a database system

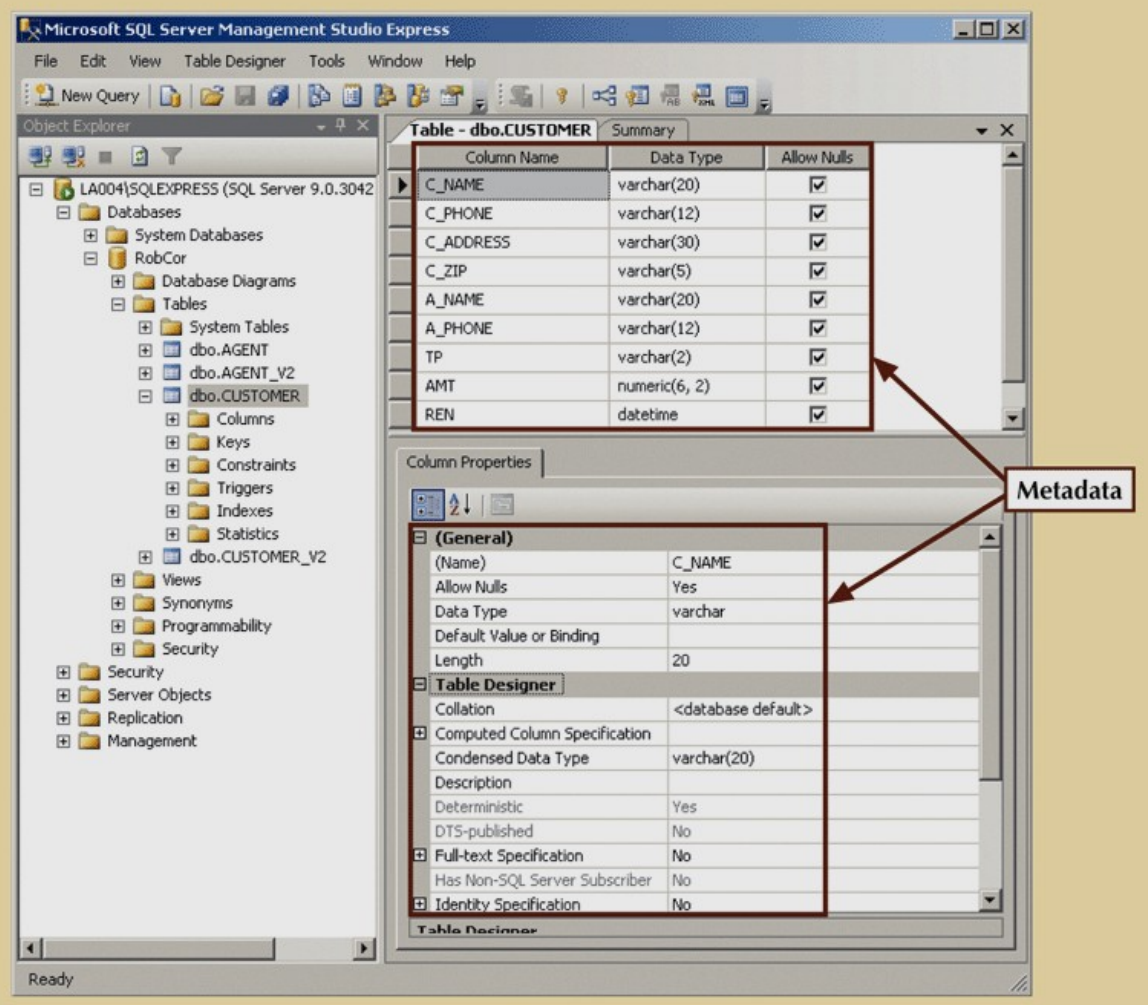
DBMS Functions

- Most functions transparent to end users
  - Can only be achieved through the DBMS
- **Data dictionary** management

ciri ciri kepada sesuatu data

  - DBMS stores definitions of data elements and relationships (metadata) in a **data dictionary**
  - DBMS looks up required data component structures and relationships
  - Changes automatically recorded in the dictionary
  - DBMS provides data abstraction, removes structural and data dependency

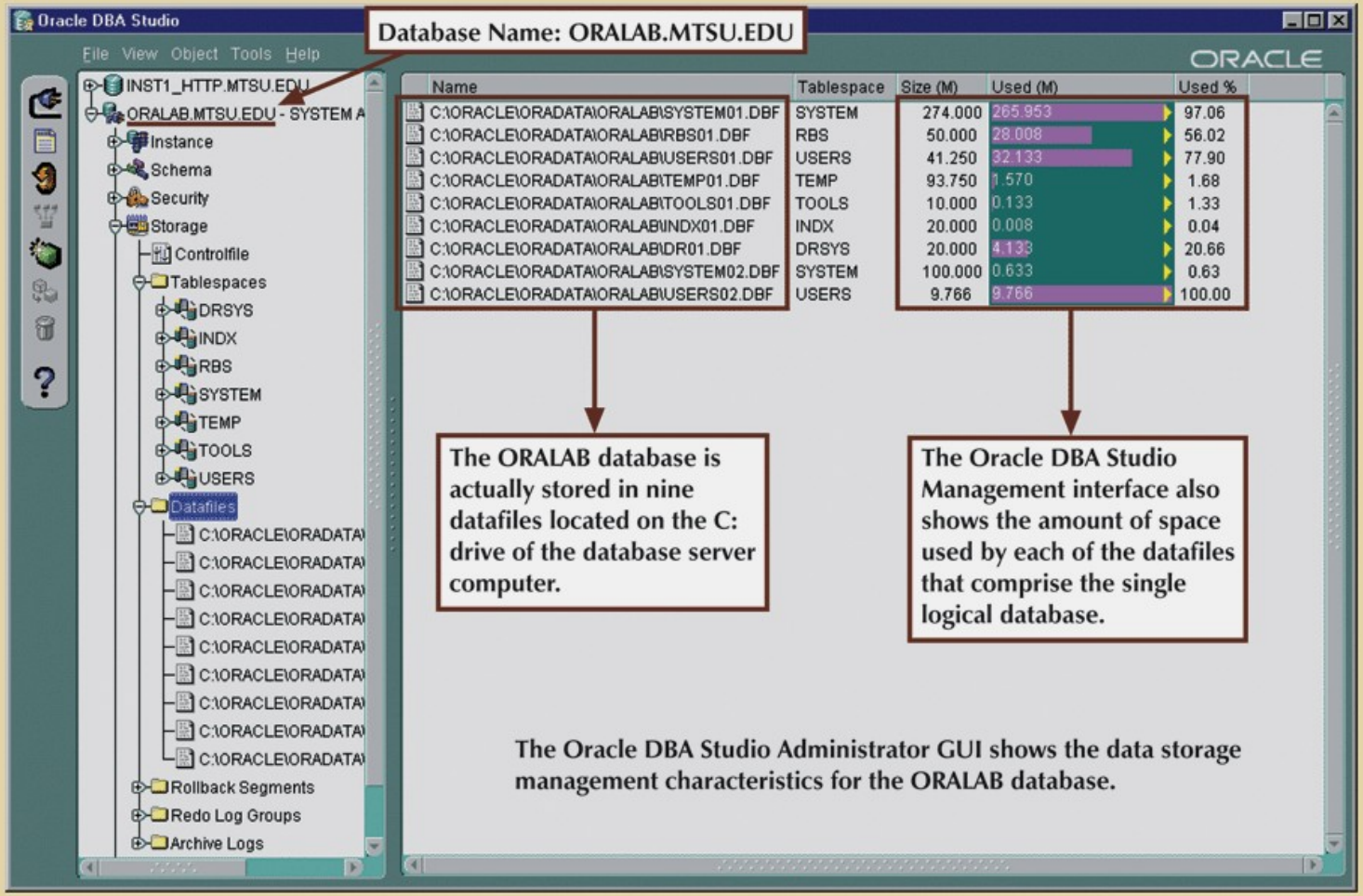
FIGURE 1.8 Illustrating metadata with Microsoft SQL Server Express



DBMS Functions (continued)

- Data storage management
  - DBMS creates and manages complex structures required for data storage
  - Also stores related data entry forms, screen definitions, report definitions, etc.
  - **Performance tuning**: activities that make the database perform more efficiently
  - DBMS stores the database in multiple physical data files

FIGURE 1.9 Illustrating data storage management with Oracle



DBMS Functions (continued)

- Data transformation and presentation
  - DBMS transforms data entered to conform to required data structures
  - DBMS transforms physically retrieved data to conform to user's logical expectations
- Security management
  - DBMS creates a security system that enforces user security and data privacy
  - Security rules determine which users can access the database, which items can be accessed, etc.

DBMS Functions (continued)

- Multiuser access control
  - DBMS uses sophisticated algorithms to ensure concurrent access does not affect integrity
- Backup and recovery management
  - DBMS provides backup and data recovery to ensure data safety and integrity
  - Recovery management deals with recovery of database after a failure
    - Critical to preserving database's integrity

DBMS Functions (continued)

- Data integrity management
  - DBMS promotes and enforces integrity rules
    - Minimizes redundancy
    - Maximizes consistency
  - Data relationships stored in data dictionary used to enforce data integrity
  - Integrity especially important in transaction-oriented database systems

DBMS Functions (continued)

- Database access languages and application programming interfaces
  - DBMS provides access through a query language
  - **Query language** is a nonprocedural language
  - **Structured Query Language (SQL)** is the de facto query language
    - Standard supported by majority of DBMS vendors

DBMS Functions (continued)

- Database communication interfaces
  - Current DBMSs accept end-user requests via multiple different network environments
  - Communications accomplished in several ways:
    - End users generate answers to queries by filling in screen forms through Web browser
    - DBMS automatically publishes predefined reports on a Web site
    - DBMS connects to third-party systems to distribute information via e-mail

Managing the Database System: A Shift in Focus

- Database system provides a framework in which strict procedures and standards enforced
  - Role of human changes from programming to managing organization's resources
- Database system enables more sophisticated use of the data
- Data structures created within the database and their relationships determine effectiveness

Managing the Database System: A Shift in Focus (continued)

- Disadvantages of database systems:
  - Increased costs
  - Management complexity
  - Maintaining currency
  - Vendor dependence
  - Frequent upgrade/replacement cycles

Summary

- Data are raw facts
- Information is the result of processing data to reveal its meaning
- Accurate, relevant, timely information is the key to good decision making
- Data usually stored in a database
- DBMS implements a database and manages its contents

Summary (continued)

- Metadata is data about data
- Database design defines the database structure
  - Well-designed database facilitates data management, generates valuable information
  - Poorly-designed database leads to bad decision making, organizational failure
- Databases evolved from manual and computerized file systems
  - In a file system, data stored in independent files
    - Each requires its own management program

Summary (continued)

- Some limitations of file system data management:
  - Requires extensive programming
  - System administration complex and difficult
  - Changing existing structures difficult
  - Security features likely inadequate
  - Independent files tend to contain redundant data
    - Structural and data dependency problems

Summary (continued)

- Database management systems developed to address file system's inherent weaknesses
- DBMS present database to end user as single repository
  - Promotes data sharing
  - Eliminates islands of information
- DBMS enforces data integrity, eliminates redundancy, promotes security