Concepts of Database Management
Seventh Edition

Chapter 9
Database Management Approaches
Objectives

• Describe distributed database management systems (DDBMSs)
• Discuss client/server systems
• Examine the ways databases are accessed on the Web
• Discuss XML and related document specification standards
Objectives (continued)

• Define data warehouses and explain their structure and access
• Discuss the general concepts of object-oriented DBMSs
Distributed Databases

- Computers at various sites
- Connected with *communications network* or *network*
- **Distributed database**: single logical database physically divided among networked computers
- **Distributed database management system (DDBMS)**: supports and manipulates distributed databases
Distributed Databases (continued)

FIGURE 9-1: Communications network
Distributed Databases (continued)

- Computers in a network communicate through **messages**
- **Access delay** required for every message
  - Fixed amount of time
- Communication time = access delay + (data volume / transmission rate)
Characteristics of Distributed DBMSs

• **Homogeneous DDBMS**: same local DBMS at each site

• **Heterogeneous DDBMS**: at least two sites at which local DBMSs are different

• Shared characteristics of DDBMSs
  – Location transparency
  – Replication transparency
  – Fragmentation transparency
Location Transparency

- **Remote site**: site other than one where user is
- **Local site**: site where user is
- **Location transparency**: users do not need to be aware of location of data in a distributed database
Replication Transparency

• Data replication creates update problems that can lead to data inconsistencies

• Replication transparency: users unaware of steps taken by DDBMS to update various copies of data
Fragmentation Transparency

- **Data fragmentation**: DDBMS can divide and manage a logical object among various locations under its control
  - Data placed at the location where it is most often accessed
- **Fragmentation transparency**: users unaware of fragmentation
Fragmentation Transparency (continued)

<table>
<thead>
<tr>
<th>PartNum</th>
<th>Description</th>
<th>OnHand</th>
<th>Class</th>
<th>Warehouse</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT94</td>
<td>Iron</td>
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<td>HW</td>
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<td>$24.95</td>
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<td>45</td>
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<td>HW</td>
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<td>Treadmill</td>
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<td>SG</td>
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<td>$1,390.00</td>
</tr>
</tbody>
</table>

**FIGURE 9-2: Premiere Products Part table data**
Fragmentation Transparency (continued)

**Fragment Part 1**

<table>
<thead>
<tr>
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</table>

**Fragment Part 2**

<table>
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<th>PartNum</th>
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<tbody>
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</tbody>
</table>

**Fragment Part 3**

<table>
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<tr>
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**FIGURE 9-3:** Fragmentation of Part table data by warehouse
Advantages of Distributed Databases

• Local control of data
• Increased database capability
• System availability
• Improved performance
Disadvantages of Distributed Databases

• Update of replicated data
  – Primary copy
• More complex query processing
• More complex treatment of concurrent update
  – Local deadlock: occurs at a single site in a distributed database
  – Global deadlock: involves more than one site
• More complex recovery measures
  – Two-phase commit: one site acts as coordinator
Disadvantages of Distributed Databases (continued)

- More difficult management of data dictionary
- More complex database design
- More complicated security and backup requirements
Rules for Distributed Databases
(C.J. Date)

• Local autonomy
• No reliance on a central site
• Continuous operation
• Location transparency
• Fragmentation transparency
• Replication transparency
Rules for Distributed Databases (continued)

- Distributed query processing
- Distributed transaction management
- Hardware independence
- Operating system independence
- Network independence
- DBMS independence
Client/Server Systems

- File server architecture
  - **File server**: stores user files on the network

- **Client/server** architecture
  - **Server**: computer providing data to clients
    - **Back-end processor** or **back-end machine**
  - **Clients**: computers connected to a network and used by users to access data
    - **Front-end processor** or **front-end machine**
Client/Server Systems (continued)

FIGURE 9-4: File server architecture
Client/Server Systems (continued)

FIGURE 9-5: Two-tier client/server architecture
Client/Server Systems (continued)

• **Two-tier architecture**
  – Server performs database functions
  – Clients perform presentation functions
    • Fat client
    • Thin client

• **Three-tier architecture**
  – Clients perform presentation functions
  – **Database server** performs database functions
  – **Application servers** perform business functions and interface between clients and database server
Client/Server Systems (continued)

**FIGURE 9-6: Three-tier client/server architecture**
Advantages of Client/Server Systems

- Lower network traffic
- Improved processing distribution
- Thinner clients
- Greater processing transparency
- Increased network, hardware, and software transparency
- Improved security
- Decreased costs
- Increased scalability
Web Access to Databases

- **Internet** and **World Wide Web** (or the **Web**)
- **Web page**: digital document on the Web
- **Web server**: stores Web pages
- **Web client**: computer requesting a Web page
- Each Web page has a **Uniform Resource Locator (URL)**
- **Hypertext Transfer Protocol (HTTP)**: data communication method used to exchange data on the Internet
Web Access to Databases (continued)

- **Web browser**: computer program that retrieves a Web page from a Web client
- **Transmission Control Protocol/Internet Protocol (TCP/IP)**: standard protocol for communication on the Internet
- Web pages usually created using **Hypertext Markup Language (HTML)**
Web Access to Databases (continued)

FIGURE 9-7: Retrieving a Web page on the Internet
Web Access to Databases (continued)

• Static vs. dynamic Web pages
  – **Static Web pages**: same content for all Web clients
  – **Dynamic Web pages**: content changes in response to inputs and choices from Web clients

• **Server-side extensions** or **server-side scripts**

• **Client-side extensions** or **client-side scripts**

• Three-tier Web-based architecture
  – Web clients
  – Web server
  – Database server
Web Access to Databases (continued)

FIGURE 9-8: Three-tier Web-based architecture
XML

• **HTML**
  – Describes content and appearance of Web pages
  – Does not describe structure and meaning of data

• **Extensible Markup Language (XML)**
  – Tags can define meaning and structure of data
  – An XML document should begin with an **XML declaration**
XML (continued)

• Extensible Hypertext Markup Language (XHTML)
  – Markup language based on XML
  – Stricter version of HTML

• Defining structure, characteristics, and relationships of data
  – Document Type Definition (DTD)
  – XML schema

• Presentation of data
  – Stylesheet
FIGURE 9-10: XML schema for the Rate element from the Rep table
FIGURE 9-11: Interaction among XML and related languages
Data Warehouses

• **Online transaction processing (OLTP) systems**
  – Users use transactions when interacting with an RDBMS

• **Data warehouse**
  – Subject-oriented, integrated, time-variant, nonvolatile collection of data in support of management’s decision-making process
  – Used for analysis of existing data
  – Resolves performance issues suffered by operational RDBMSs and OLTPs
FIGURE 9-12: Data warehouse architecture
Data Warehouse Structure and Access

• **Star schema**
  – Fact table
  – Dimension table

• **Online analytical processing (OLAP) software**:
  for access to a data warehouse

• **Data cube**: a shape for visualizing a data warehouse as a multidimensional database

• **Data mining**: uncovering new knowledge, patterns, trends, and rules from data in a data warehouse
Data Warehouse Structure and Access (continued)

FIGURE 9-13: A star schema with four dimension tables and a central fact table
Data Warehouse Structure and Access (continued)

FIGURE 9-14: A data cube representation of the Part, Customer, and Time dimensions.

Each cell contains unit sales and dollar sales data.
Rules for OLAP Systems
(E.F. Codd)

- Multidimensional conceptual view
- Transparency
- Accessibility
- Consistent reporting performance
- Client/server architecture
- Generic dimensionality
Rules for OLAP Systems (continued)

• Dynamic sparse matrix handling
• Multiuser support
• Unrestricted, cross-dimensional operations
• Intuitive data manipulation
• Flexible reporting
• Unlimited dimensions and aggregation levels
Object-Oriented DBMSs

• Complex objects: graphics, drawings, photographs, video, sound, voice mail, spreadsheets, etc.
• RDBMSs store complex objects using special data types
  – Binary large objects (BLOBs)
• Object-oriented DBMSs used with applications whose focus is on complex objects
What Is an Object-Oriented DBMS?

- **Object**: set of related attributes along with associated actions

- **Object-oriented database management system (OODBMS)**: database management system in which data and associated actions are **encapsulated** into objects
Objects and Classes

• Represent each entity as an *object* rather than a relation
• List attributes vertically below object names
  – Follow each attribute by name of *domain*
• Objects can contain other objects
• An object can contain a portion of another object
Methods and Messages

- **Methods**: actions defined for a class
- Defined during data definition process
- Executed when user sends a message to the object
Methods and Messages (continued)

Add Order (WOrders)
Add row to Orders table
OrderNum = WOrderNum
OrderDate = WOrderDate
CustomerNum = WCustomerNum
For each order line record in WOrders DO
Add row to OrderLine table
OrderNum = WOrderNum
PartNum = WPartNum
NumOrdered = WNumOrdered
QuotedPrice = WQuotedPrice
Update Part table (WHERE PartNum = WPartNum)
Allocated = Allocated + WNumOrdered

Delete Order (WOrderNum)
Delete row from Orders table (WHERE OrderNum = WOrderNum)
For each OrderLine record (WHERE OrderNum = WOrderNum) DO
Delete row from OrderLine table
Update Part table (WHERE Part.PartNum = OrderLine.PartNum)
Allocated = Allocated – NumOrdered

FIGURE 9-22: Two methods for the Premiere Products object-oriented database
Inheritance

• **Subclass**
  – Every occurrence of subclass is considered an occurrence of the class
  – Subclass *inherits* structure and methods of the class
Unified Modeling Language (UML)

• Used to model all aspects of software development for object-oriented systems
  – Includes a way to represent database designs
• **Class diagram**: most relevant diagram type for database design
  – Rectangles represent classes
  – Lines joining classes represent relationships; called **associations**
  – **Visibility symbol** indicates whether other classes can view or update value in attribute
Unified Modeling Language (UML) (continued)

FIGURE 9-24: Class diagram for the Premiere Products database
Unified Modeling Language (UML) (continued)

- **Multiplicity**: number of objects that can be related to an individual object
- Constraints
- **Superclass**
- **Generalization**: relationship between a superclass and a subclass
Unified Modeling Language (UML) (continued)

FIGURE 9-26: Class diagram with a generalization and a constraint
Rules for OODBMSs

• Complex objects
• Object identity
• Encapsulation
• Information hiding
• Types of classes
• Inheritance
• Late binding
Rules for OODBMSs (continued)

- Computational completeness
- Extensibility
- Persistence
- Performance
- Concurrent update support
- Recovery support
- Query facility
Summary

• Distributed database: single logical database physically divided among computers at several sites on a network
• Location transparency, replication transparency, and fragmentation transparency are important characteristics of DDBMSs
• Two-tier client/server architecture: DBMS runs on file server and server sends only the requested data to the clients
Summary (continued)

- Web servers interact with Web clients using HTTP and TCP/IP to display HTML Web pages.
- Dynamic Web pages, not static Web pages, are used in e-commerce.
- XML was developed because of need for data exchange between organizations and inability of HTML to specify structure and meaning of data.
Summary (continued)

- **XHTML**: markup language based on XML; stricter version of HTML
- **Data warehouse**: subject-oriented, integrated, time-variant, nonvolatile collection of data in support of management’s decision-making process
- **Users perceive data in a data warehouse as a multidimensional database in data cube shape**
- **Data mining**: uncovering new knowledge, patterns, trends, and rules from data stored in a data warehouse
Summary (continued)

• Object-oriented DBMSs deal with data as objects
  – Object: set of related attributes and actions associated with the attributes
  – OODBMS: database management system in which data and actions that operate on the data are encapsulated into objects

• UML: an approach to model all aspects of software development for object-oriented systems