CIS 412
DATABASE MANAGEMENT SYSTEMS

Chapter 9

Database Management Approaches

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)

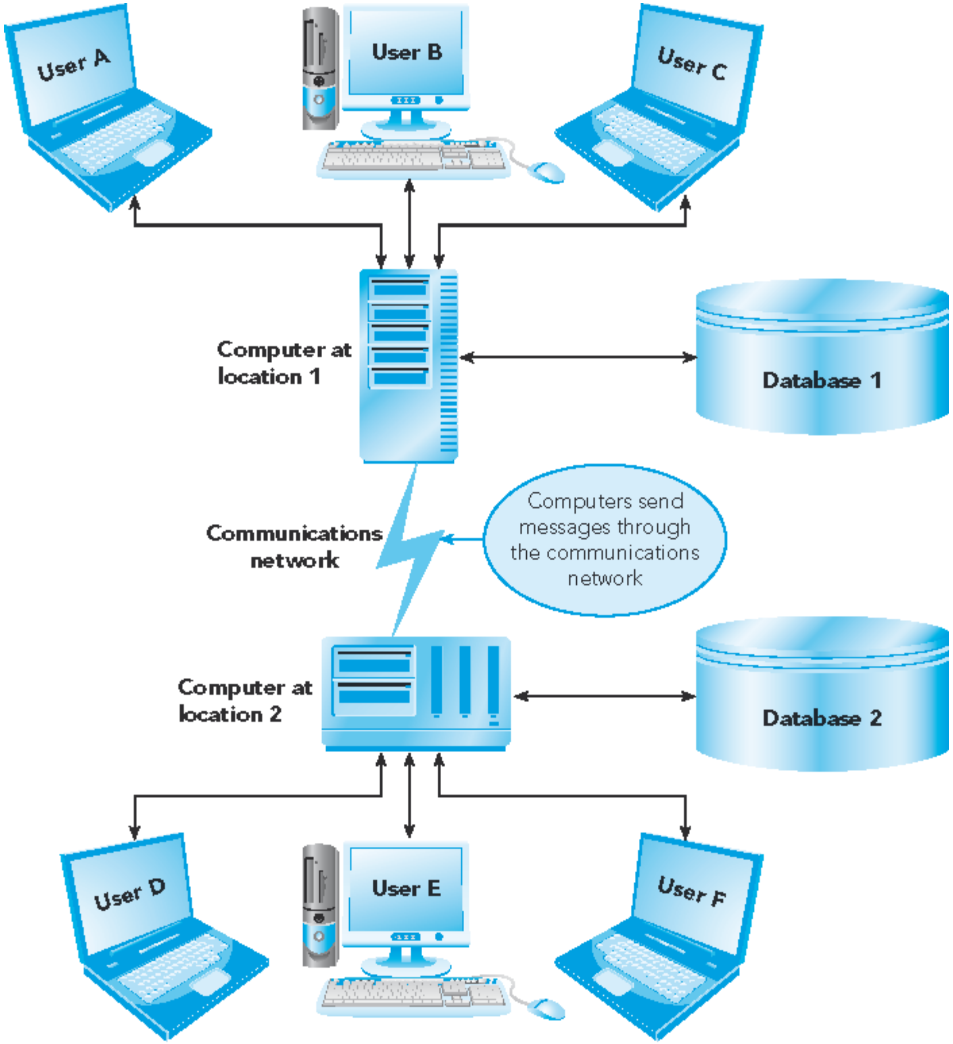


FIGURE 9-1: Communications network

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

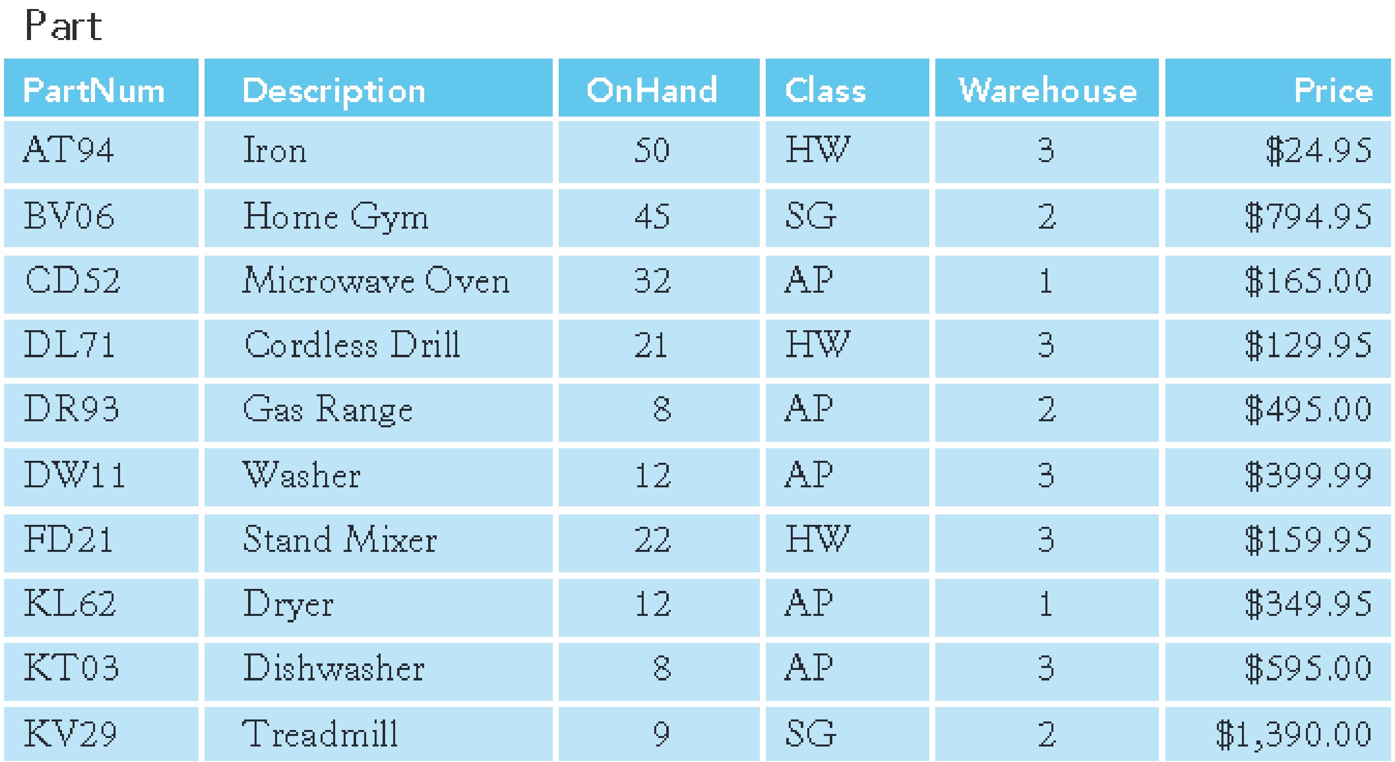
Replication Transparency

- 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)

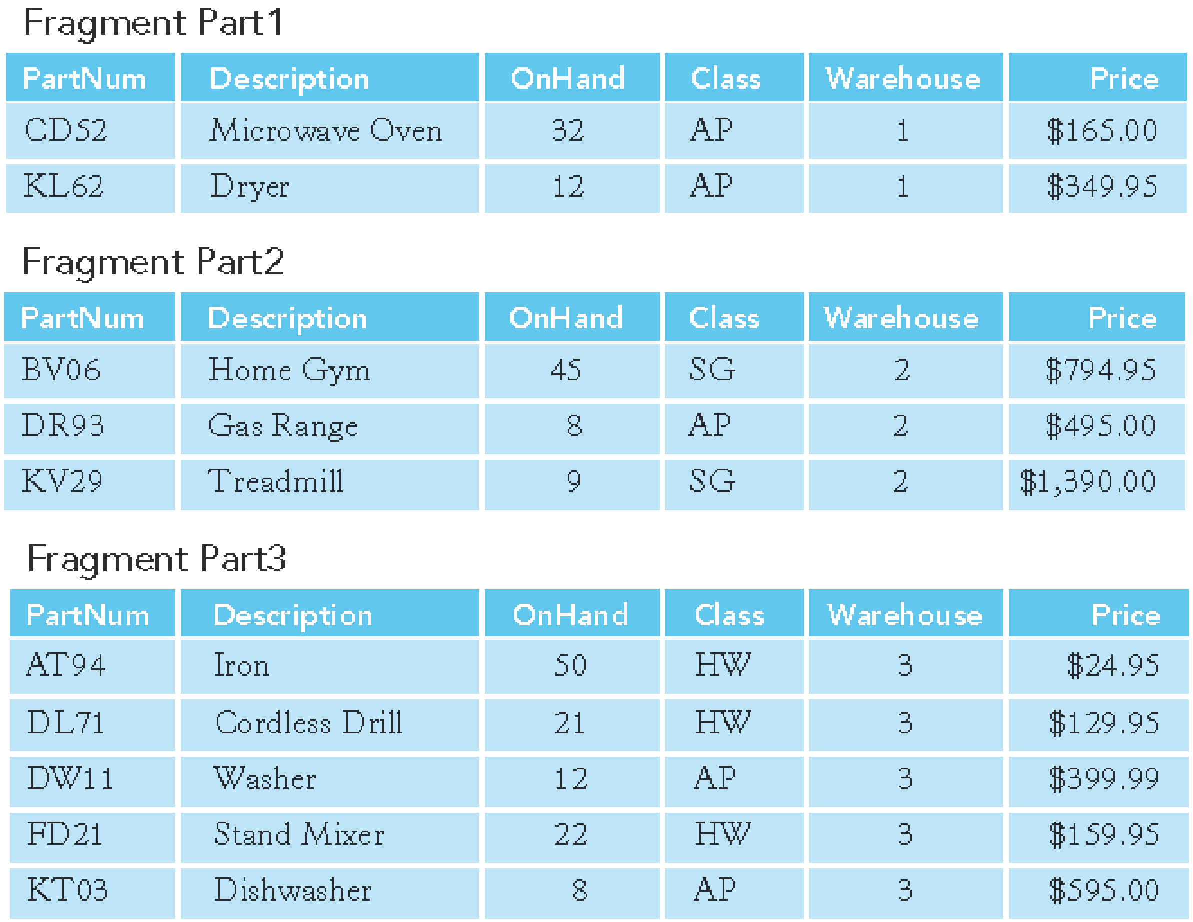


Part

PartNum	Description	OnHand	Class	Warehouse	Price
AT94	Iron	50	HW	3	$24.95
BV06	Home Gym	45	SG	2	$794.95
CD52	Microwave Oven	32	AP	1	$165.00
DL71	Cordless Drill	21	HW	3	$129.95
DR93	Gas Range	8	AP	2	$495.00
DW11	Washer	12	AP	3	$399.99
FD21	Stand Mixer	22	HW	3	$159.95
KL62	Dryer	12	AP	1	$349.95
KT03	Dishwasher	8	AP	3	$595.00
KV29	Treadmill	9	SG	2	$1,390.00

FIGURE 9-2: Premiere Products Part table data

Fragmentation Transparency (continued)



Fragment Part1

PartNum	Description	OnHand	Class	Warehouse	Price
CD52	Microwave Oven	32	AP	1	$165.00
KL62	Dryer	12	AP	1	$349.95

Fragment Part2

PartNum	Description	OnHand	Class	Warehouse	Price
BV06	Home Gym	45	SG	2	$794.95
DR93	Gas Range	8	AP	2	$495.00
KV29	Treadmill	9	SG	2	$1,390.00

Fragment Part3

PartNum	Description	OnHand	Class	Warehouse	Price
AT94	Iron	50	HW	3	$24.95
DL71	Cordless Drill	21	HW	3	$129.95
DW11	Washer	12	AP	3	$399.99
FD21	Stand Mixer	22	HW	3	$159.95
KT03	Dishwasher	8	AP	3	$595.00

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)

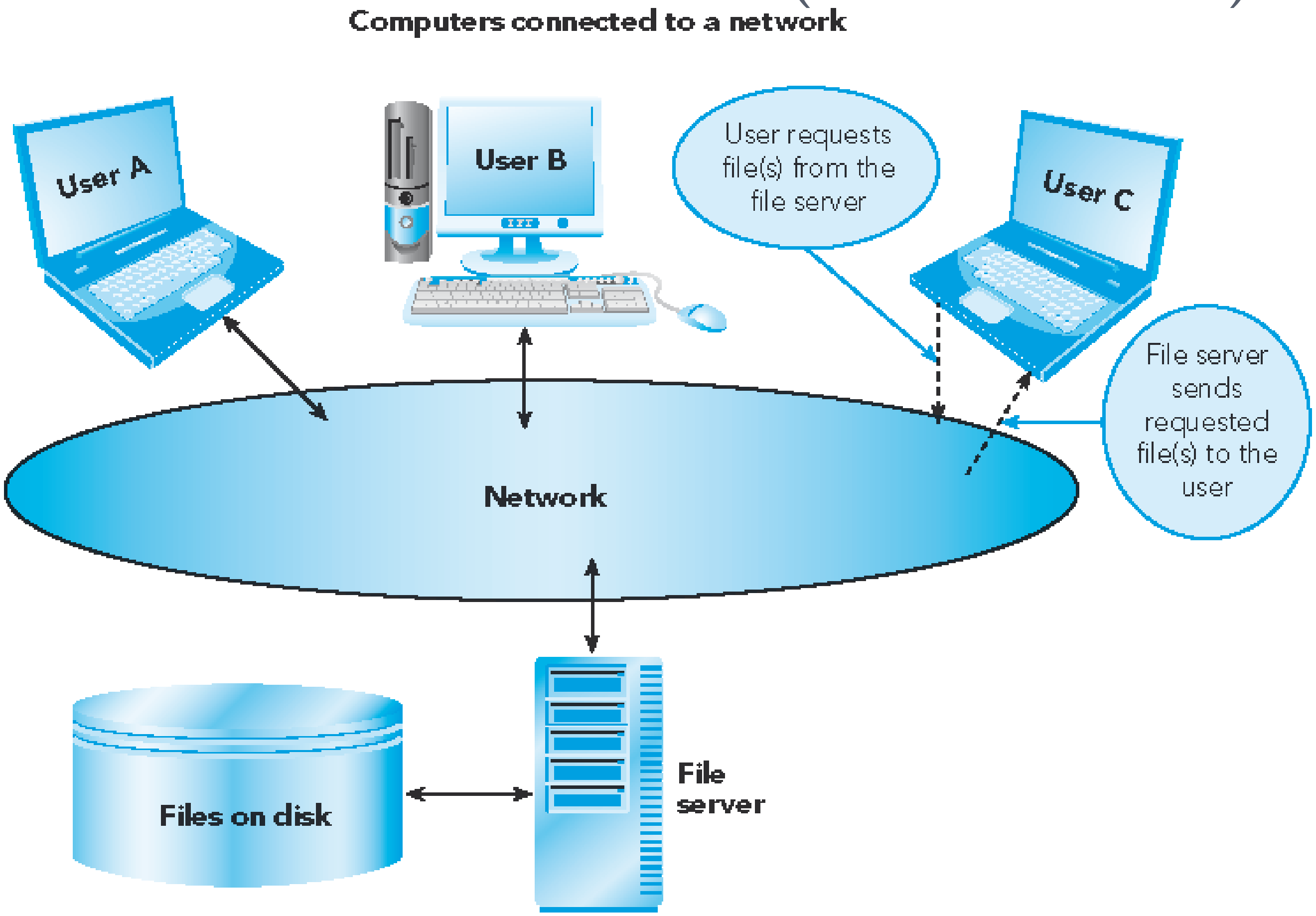

Computers connected to a network
User A
User B
User requests file(s) from the file server
User C
File server sends requested file(s) to the user
Network
Files on disk
File server

FIGURE 9-4: File server architecture

Client/Server Systems (continued)

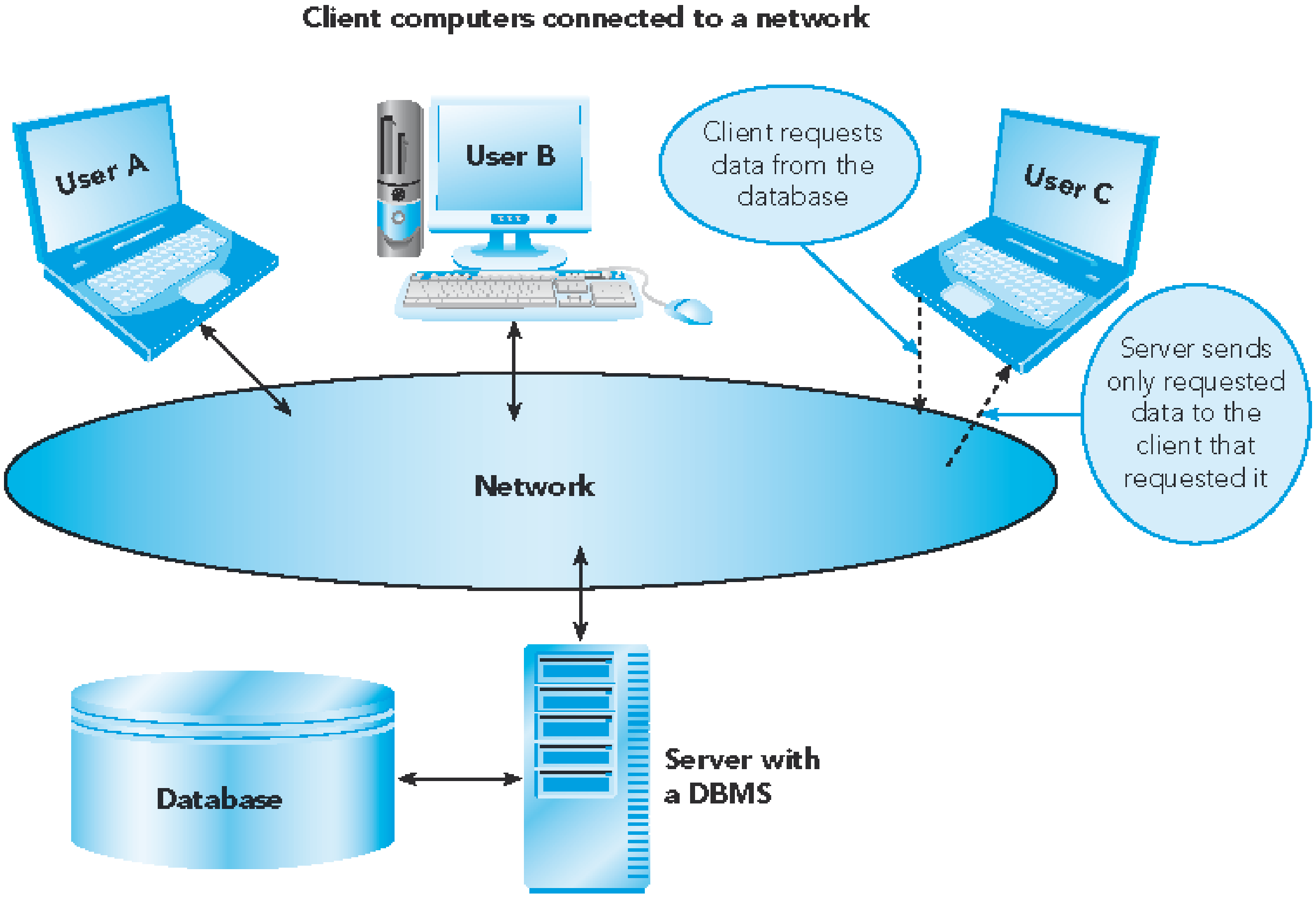

Client computers connected to a network
User A
User B
Client requests data from the database
User C
Server sends only requested data to the client that requested it
Network
Database
Server with a DBMS

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)

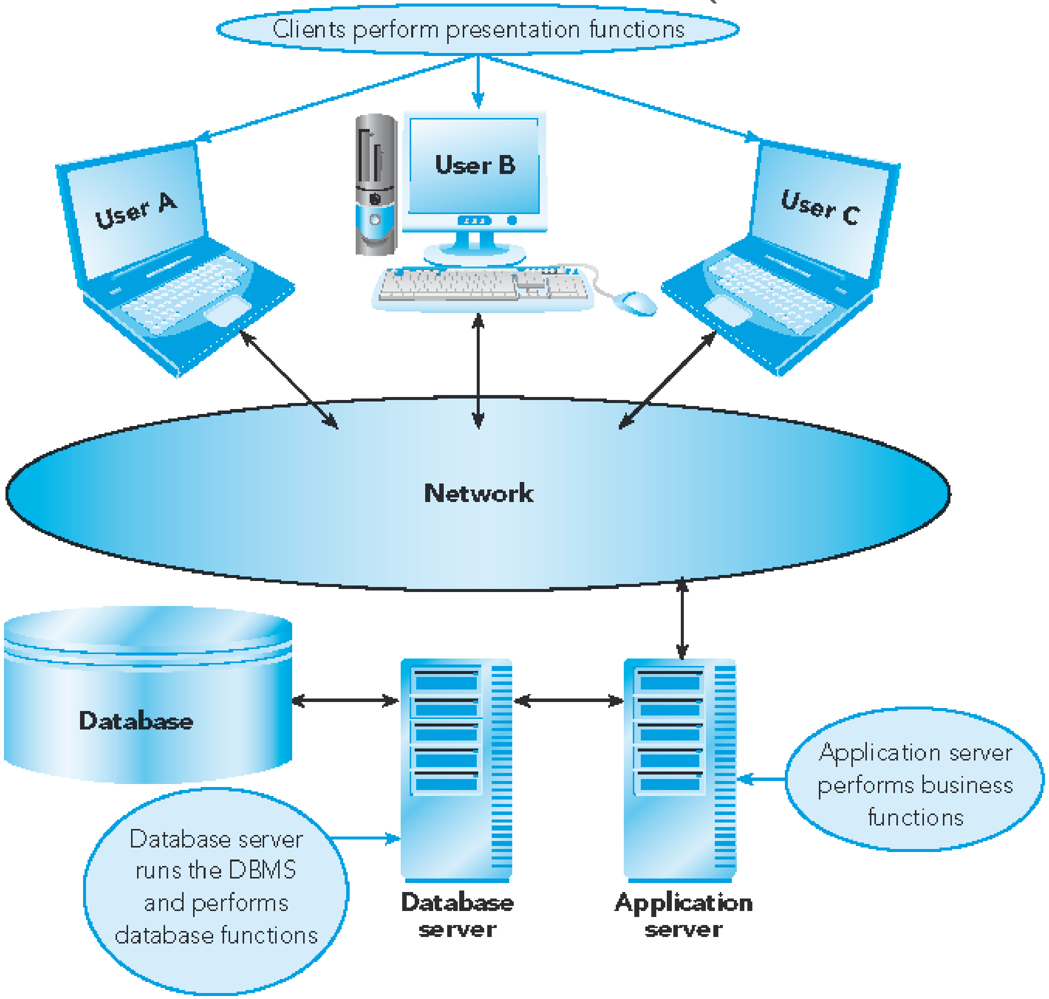

Clients perform presentation functions
User A
User B
User C
Network
Database
Database server runs the DBMS and performs database functions
Database server
Application server
Application server performs business functions

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)

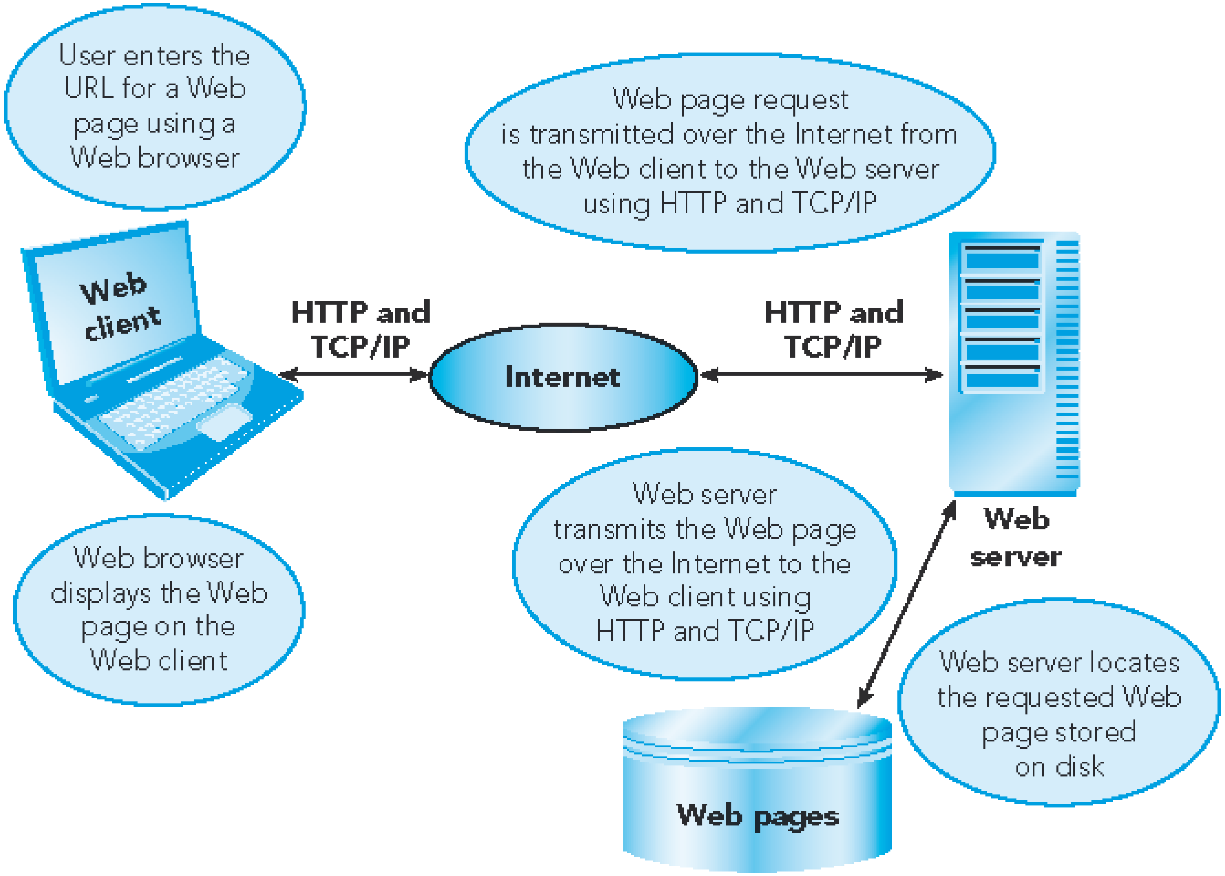

User enters the URL for a Web page using a Web browser
Web page request is transmitted over the Internet from the Web client to the Web server using HTTP and TCP/IP
Web client
HTTP and TCP/IP
Internet
HTTP and TCP/IP
Web server
Web browser displays the Web page on the Web client
Web server transmits the Web page over the Internet to the Web client using HTTP and TCP/IP
Web server locates the requested Web page stored on disk
Web pages

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)

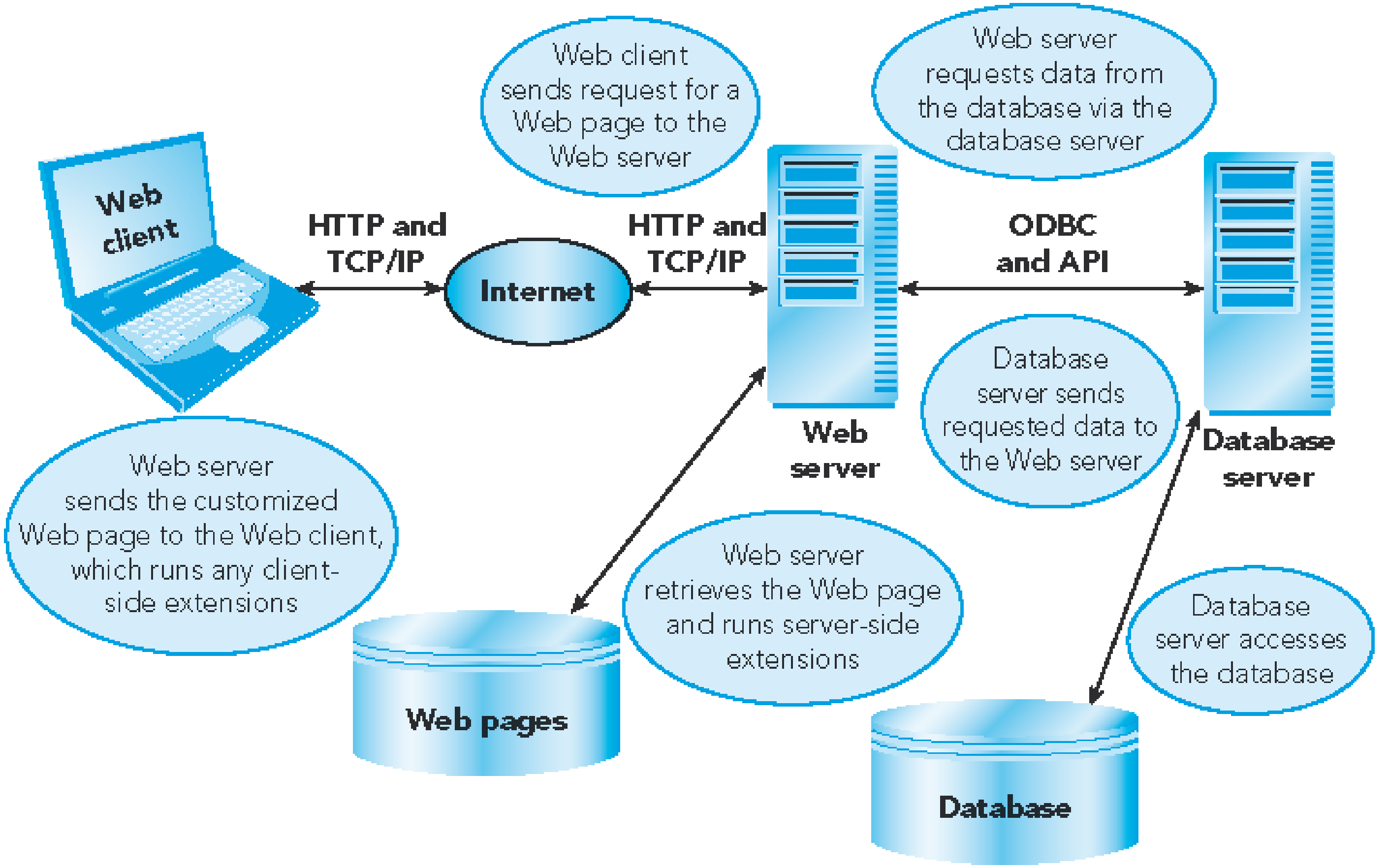


FIGURE 9-8: Three-tier Web-based architecture

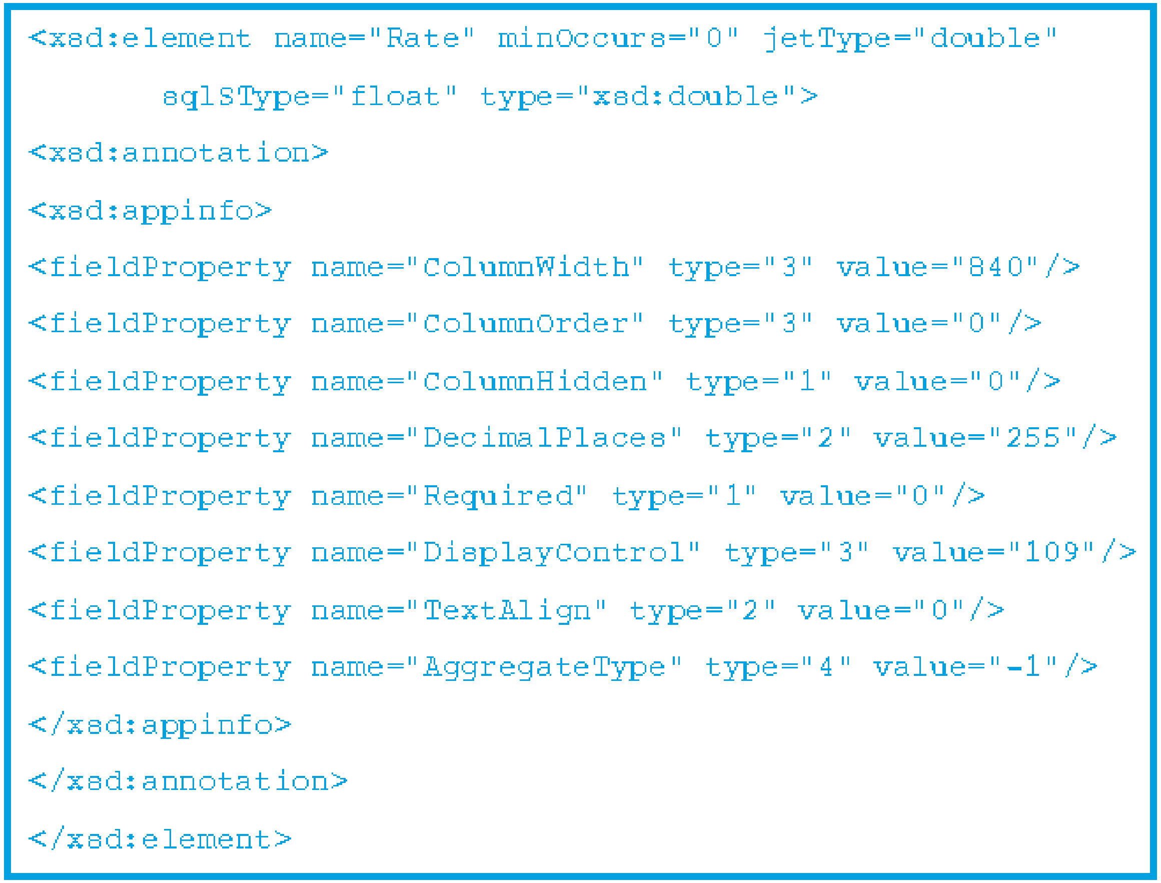
XML

- 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**

XML (CONTINUED)



```
<xsd:element name="Rate" minOccurs="0" jetType="double"
       sqlSType="float" type="xsd:double">
<xsd:annotation>
<xsd:appinfo>
<fieldProperty name="ColumnWidth" type="3" value="840"/>
<fieldProperty name="ColumnOrder" type="3" value="0"/>
<fieldProperty name="ColumnHidden" type="1" value="0"/>
<fieldProperty name="DecimalPlaces" type="2" value="255"/>
<fieldProperty name="Required" type="1" value="0"/>
<fieldProperty name="DisplayControl" type="3" value="109"/>
<fieldProperty name="TextAlign" type="2" value="0"/>
<fieldProperty name="AggregateType" type="4" value="-1"/>
</xsd:appinfo>
</xsd:annotation>
</xsd:element>
```

FIGURE 9-10: XML schema for the Rate element from the Rep table

XML (CONTINUED)

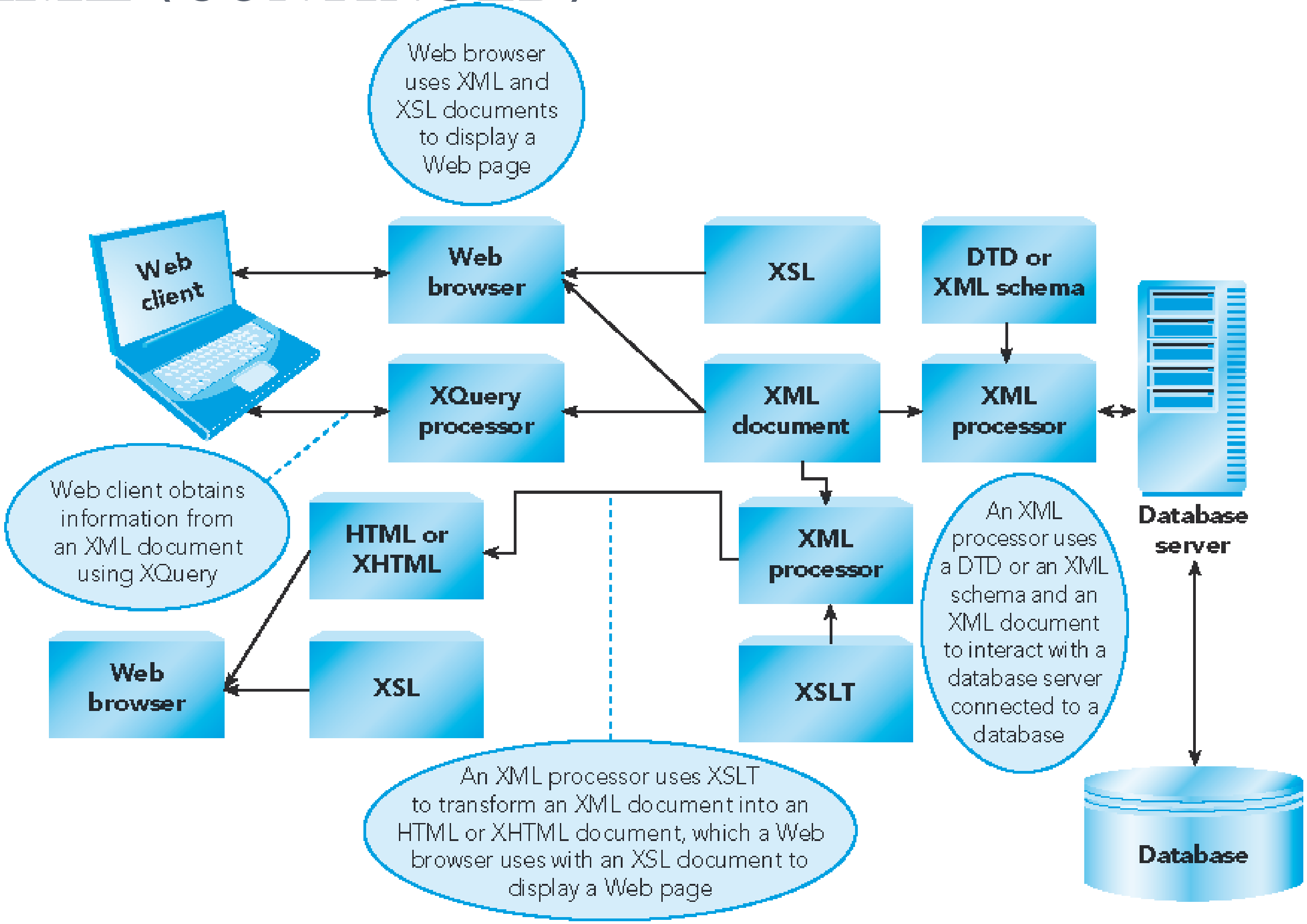

Web browser uses XML and XSL documents to display a Web page
Web client
Web browser
XSL
DTD or XML schema
XQuery processor
XML document
XML processor
Database server
Web client obtains information from an XML document using XQuery
HTML or XHTML
XML processor
An XML processor uses a DTD or an XML schema and an XML document to interact with a database server connected to a database
Web browser
XSL
XSLT
An XML processor uses XSLT to transform an XML document into an HTML or XHTML document, which a Web browser uses with an XSL document to display a Web page
Database

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

Data Warehouses (continued)

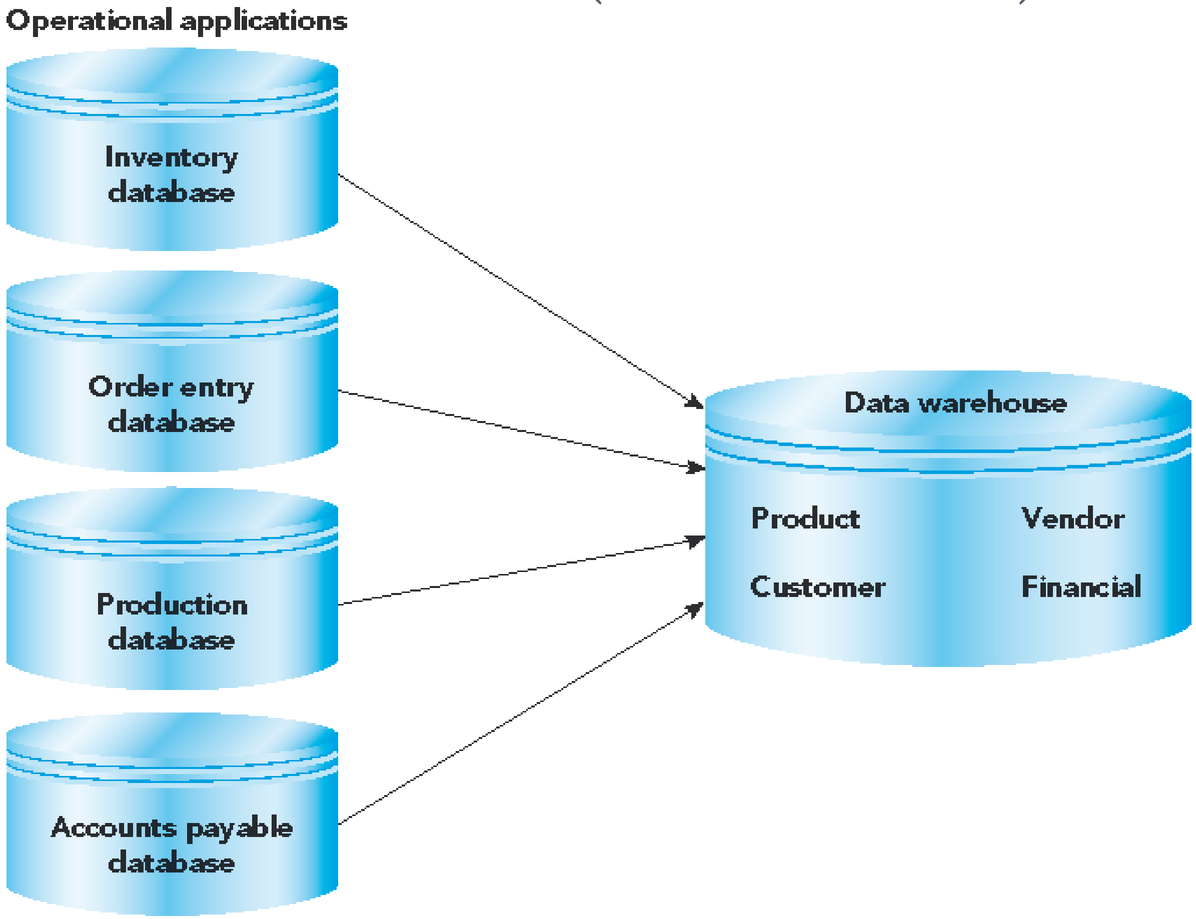
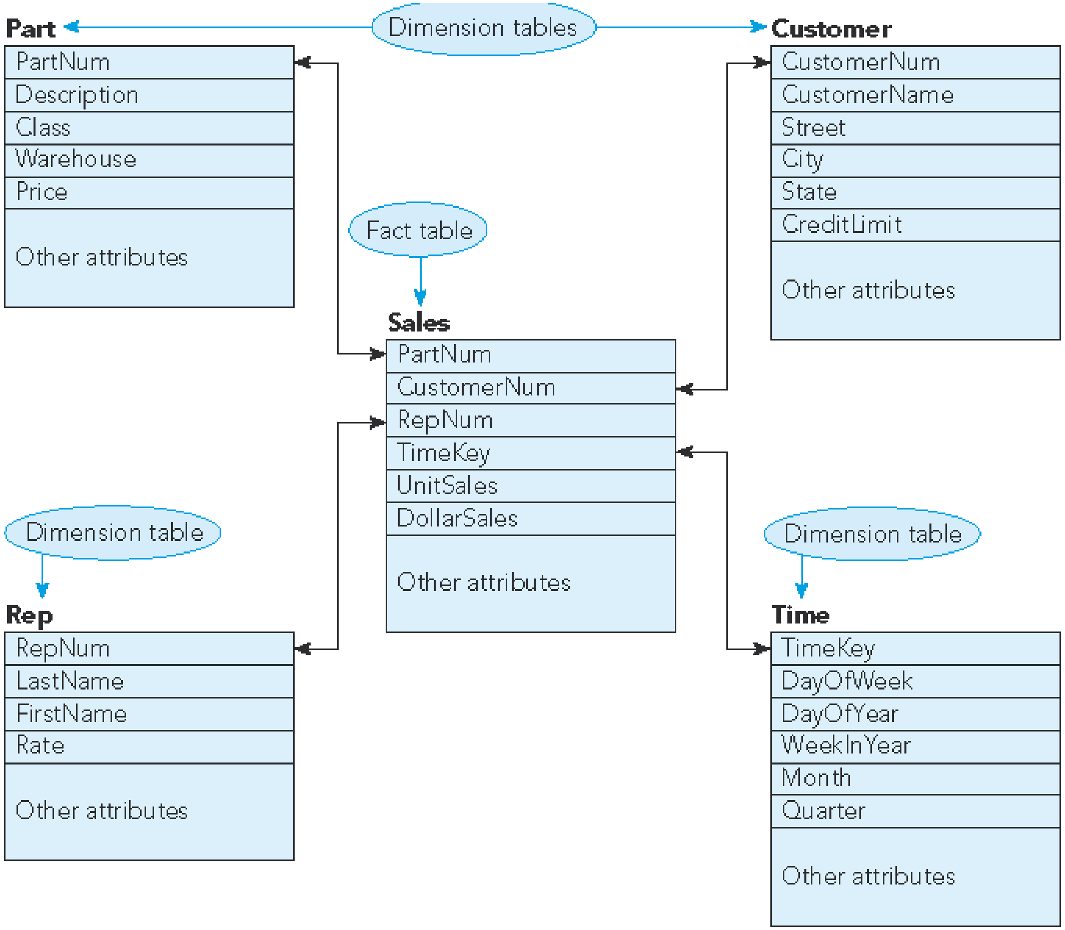


FIGURE 9-12: Data warehouse architecture

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)



Dimension tables

Part

- PartNum
- Description
- Class
- Warehouse
- Price
- Other attributes

Customer

- CustomerNum
- CustomerName
- Street
- City
- State
- CreditLimit
- Other attributes

Fact table

Sales

- PartNum
- CustomerNum
- RepNum
- TimeKey
- UnitSales
- DollarSales
- Other attributes

Dimension table

Rep

- RepNum
- LastName
- FirstName
- Rate
- Other attributes

Dimension table

Time

- TimeKey
- DayOfWeek
- DayOfYear
- WeekInYear
- Month
- Quarter
- Other attributes

FIGURE 9-13: A star schema with four dimension tables and a central fact table

DATA WAREHOUSE STRUCTURE AND ACCESS (CONTINUED)

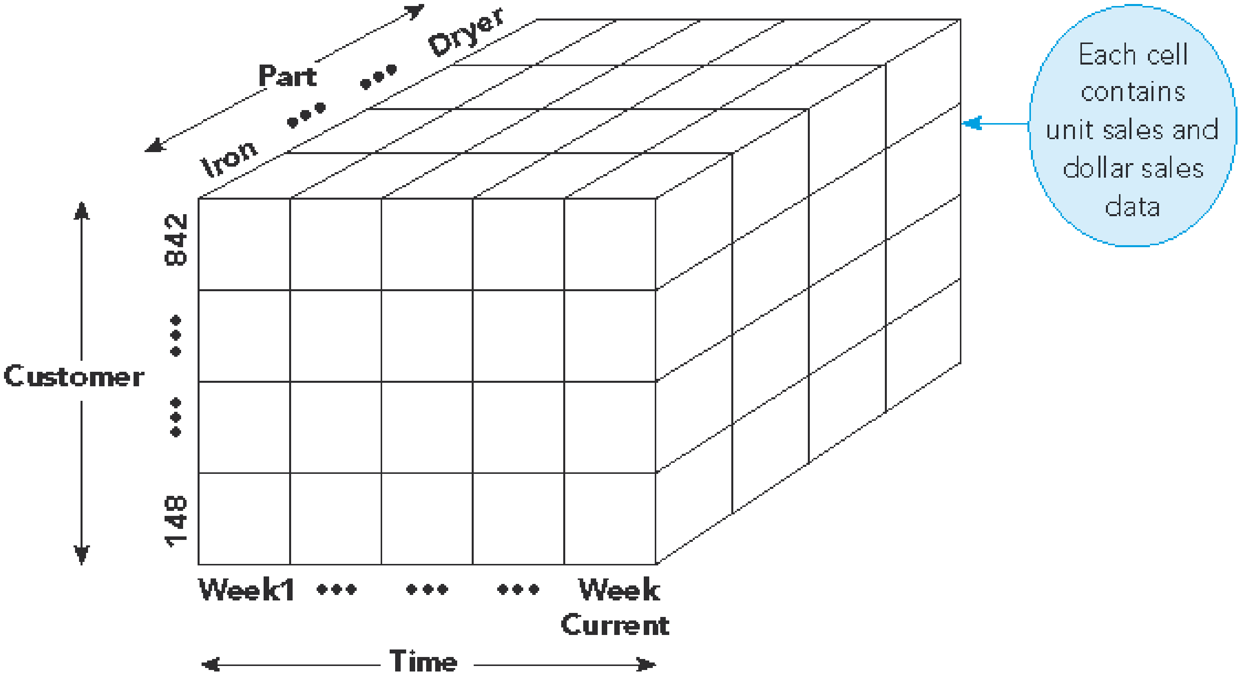


FIGURE 9-14: A data cube representation of the Part, Customer, and Time dimensions

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

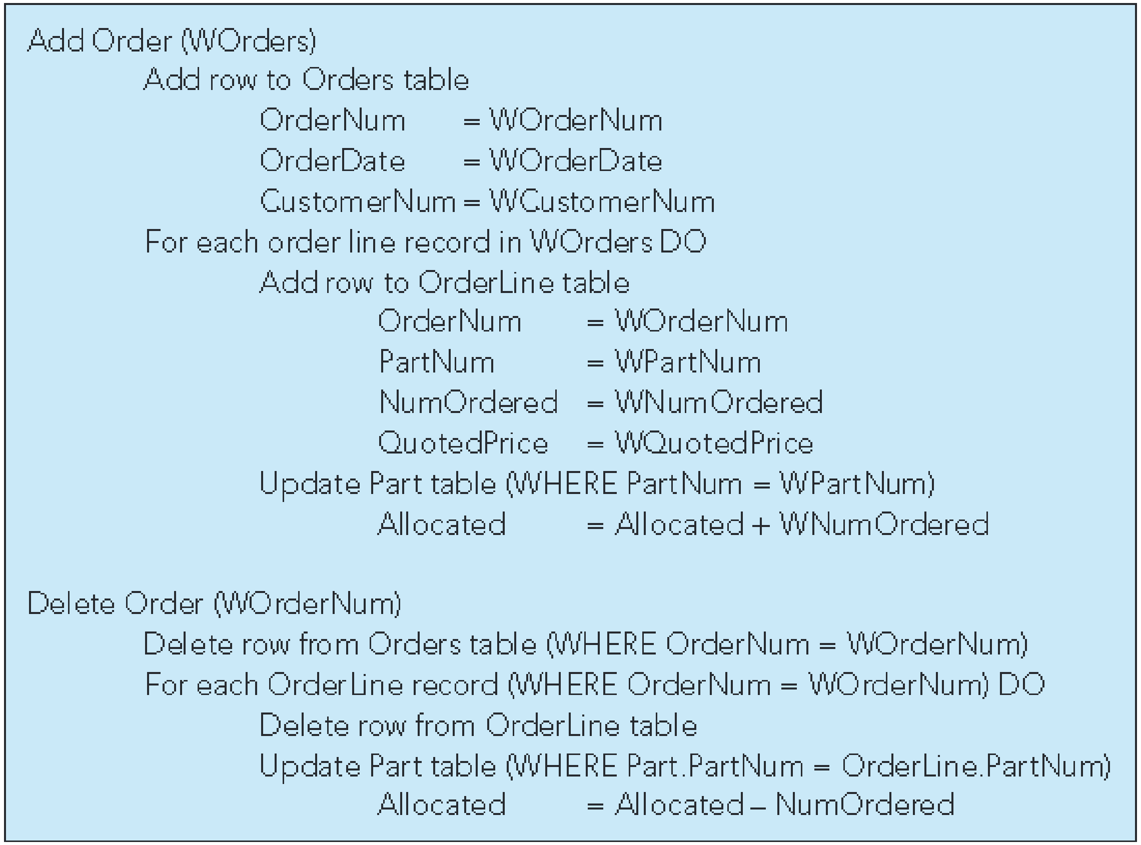
Objects and Classes

- 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

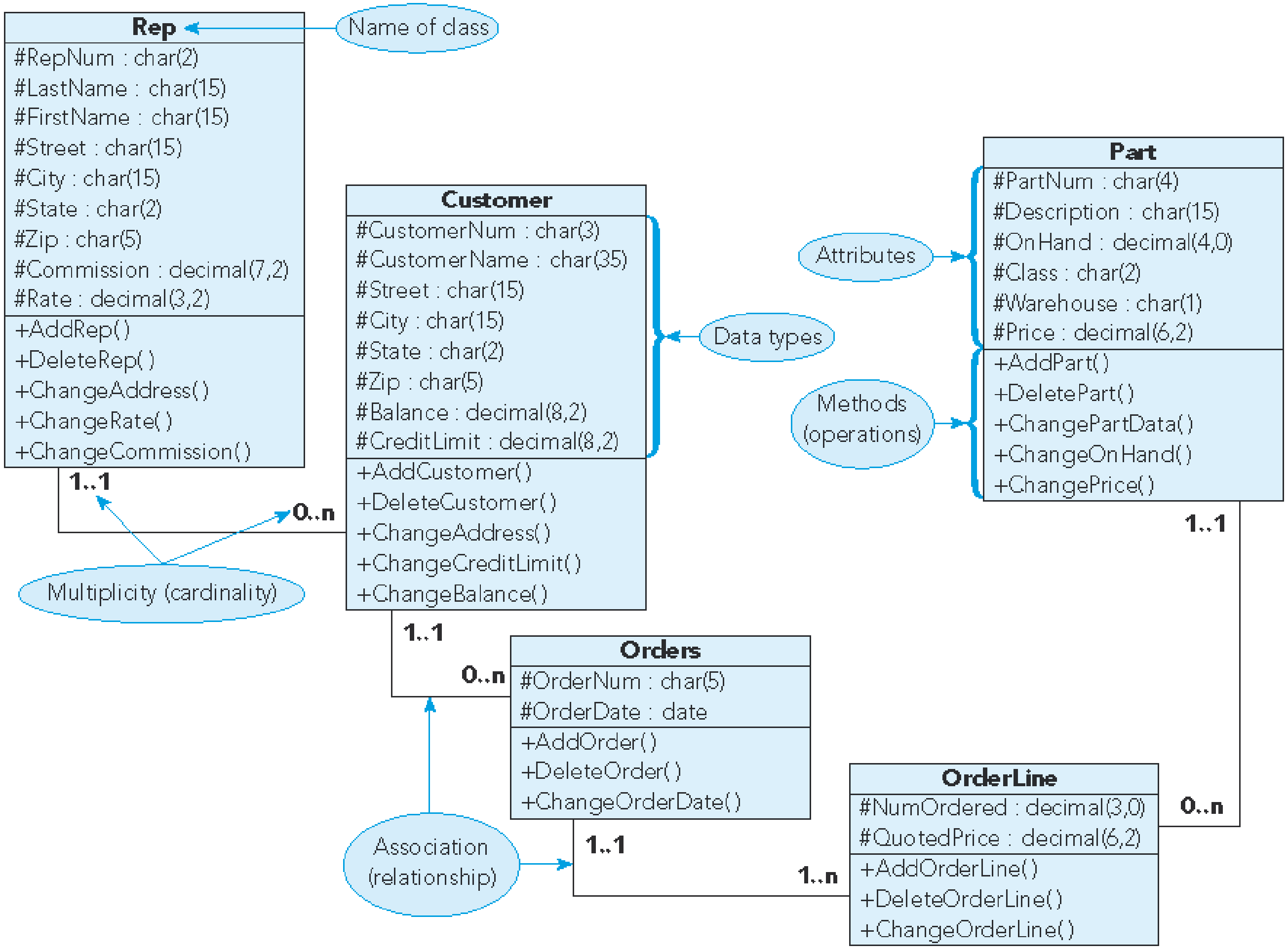
Inheritance

- **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)



Rep

#RepNum : char(2)
#LastName : char(15)
#FirstName : char(15)
#Street : char(15)
#City : char(15)
#State : char(2)
#Zip : char(5)
#Commission : decimal(7,2)
#Rate : decimal(3,2)

+AddRep( )
+DeleteRep( )
+ChangeAddress( )
+ChangeRate( )
+ChangeCommission( )

Customer

#CustomerNum : char(3)
#CustomerName : char(35)
#Street : char(15)
#City : char(15)
#State : char(2)
#Zip : char(5)
#Balance : decimal(8,2)
#CreditLimit : decimal(8,2)

+AddCustomer( )
+DeleteCustomer( )
+ChangeAddress( )
+ChangeCreditLimit( )
+ChangeBalance( )

Part

#PartNum : char(4)
#Description : char(15)
#OnHand : decimal(4,0)
#Class : char(2)
#Warehouse : char(1)
#Price : decimal(6,2)

+AddPart( )
+DeletePart( )
+ChangePartData( )
+ChangeOnHand( )
+ChangePrice( )

Orders

#OrderNum : char(5)
#OrderDate : date

+AddOrder( )
+DeleteOrder( )
+ChangeOrderDate( )

OrderLine

#NumOrdered : decimal(3,0)
#QuotedPrice : decimal(6,2)

+AddOrderLine( )
+DeleteOrderLine( )
+ChangeOrderLine( )

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)

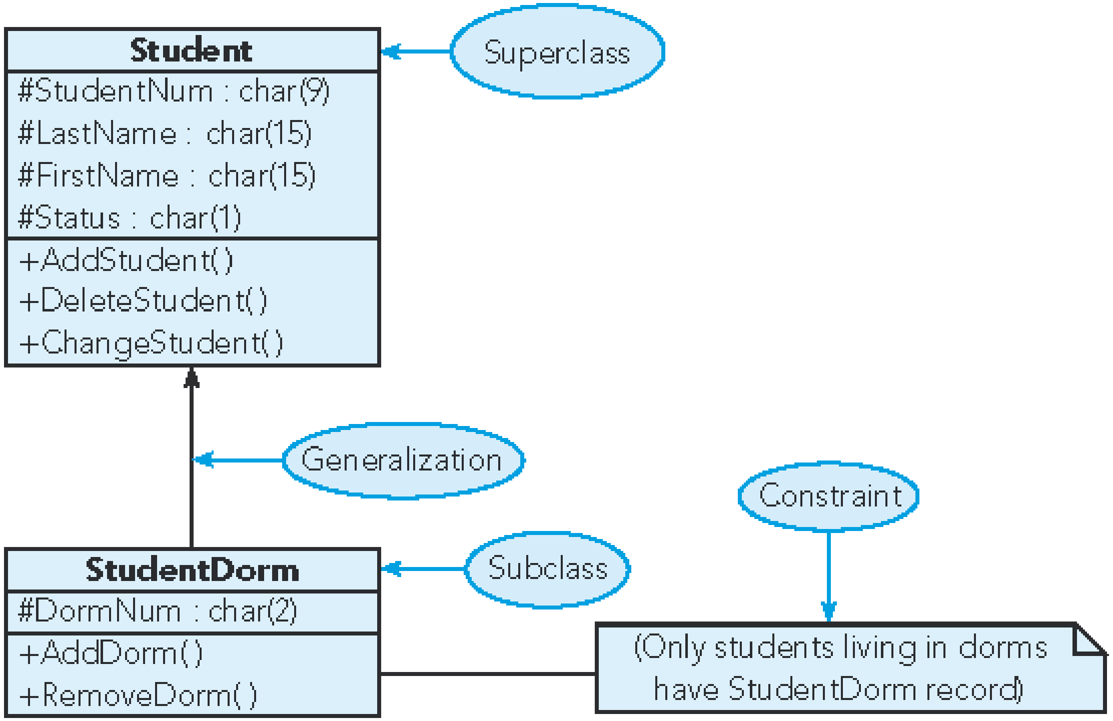


FIGURE 9-26: Class diagram with a generalization and a constraint

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)

- Three-tier client/server architecture: clients perform presentation functions, database servers perform database functions, and application servers perform business functions
- 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