Database Principles: Fundamentals of Design, Implementation, and Management

Tenth Edition

Chapter 11

Interacting with Databases Through the Web

Objectives

In this chapter, you will learn:

- About various database connectivity technologies
- How Web-to-database middleware is used to integrate databases with the Internet
- About Web browser plug-ins and extensions
- What services are provided by Web application servers

Objectives (cont’d.)

- What Extensible Markup Language (XML) is and why it is important for Web database development
- About cloud computing and how it enables the database-as-a-service model

Database Connectivity

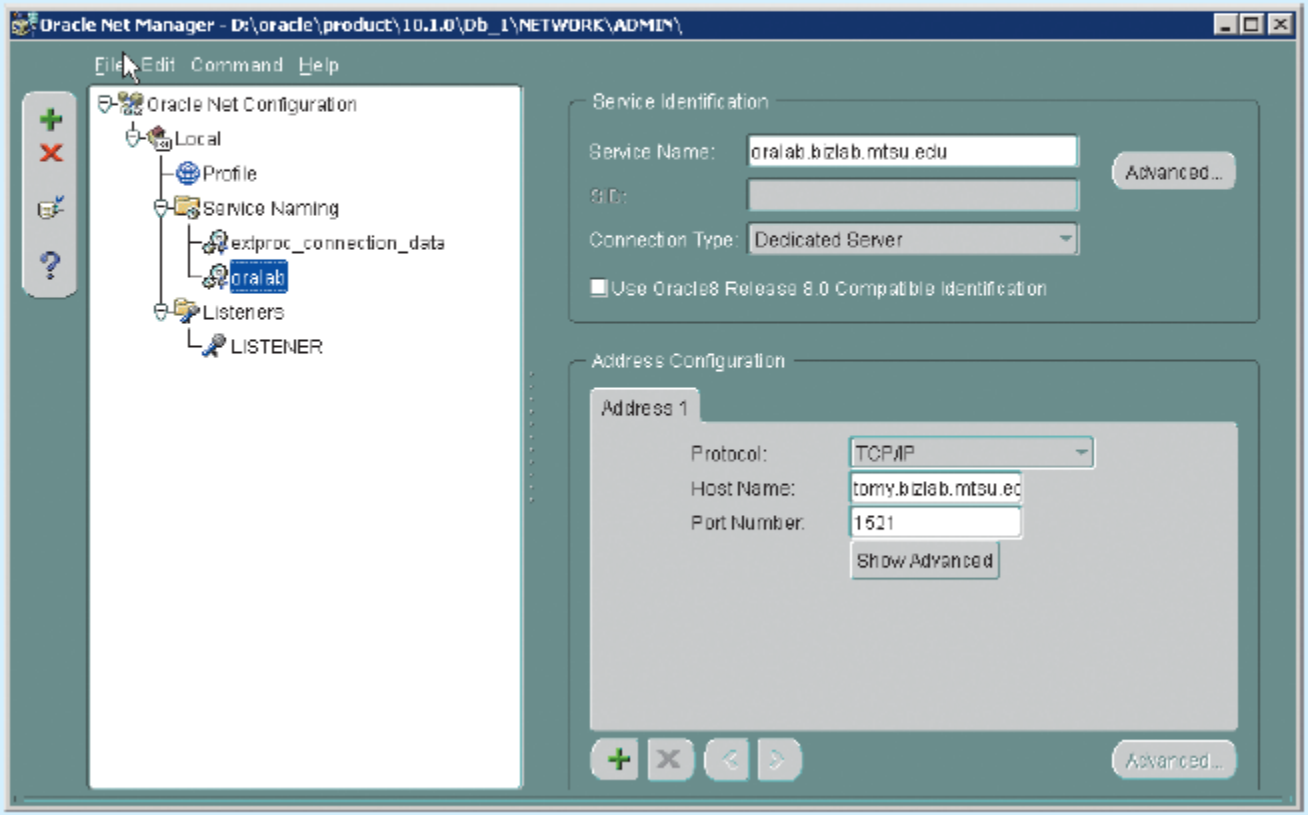
- Mechanisms by which application programs connect and communicate with data sources
  - Also known as database middleware
- Data repository:
  - Also known as a data source
  - Represents the data management application
    - Used to store data generated by an application program
- ODBC, OLE-DB, ADO.NET: the backbone of MS Universal Data Access (UDA) architecture

Native SQL Connectivity

- Connection interface provided by database vendors
  - Unique to each vendor
- Example: Oracle RDBMS
  - Must install and configure Oracle's SQL*Net interface in client computer
- Interfaces optimized for particular vendor's DBMS
  - Maintenance is a burden for the programmer

FIGURE 11.1

Oracle native connectivity



SOURCE: Course Technology/Cengage Learning

ODBC, DAO, and RDO

- Open Database Connectivity (ODBC)
  - Microsoft's implementation of a superset of SQL Access Group Call Level Interface (CLI)
  - Widely supported database connectivity interface
  - Any Windows application can access relational data sources
  - Uses SQL via standard application programming interface (API)

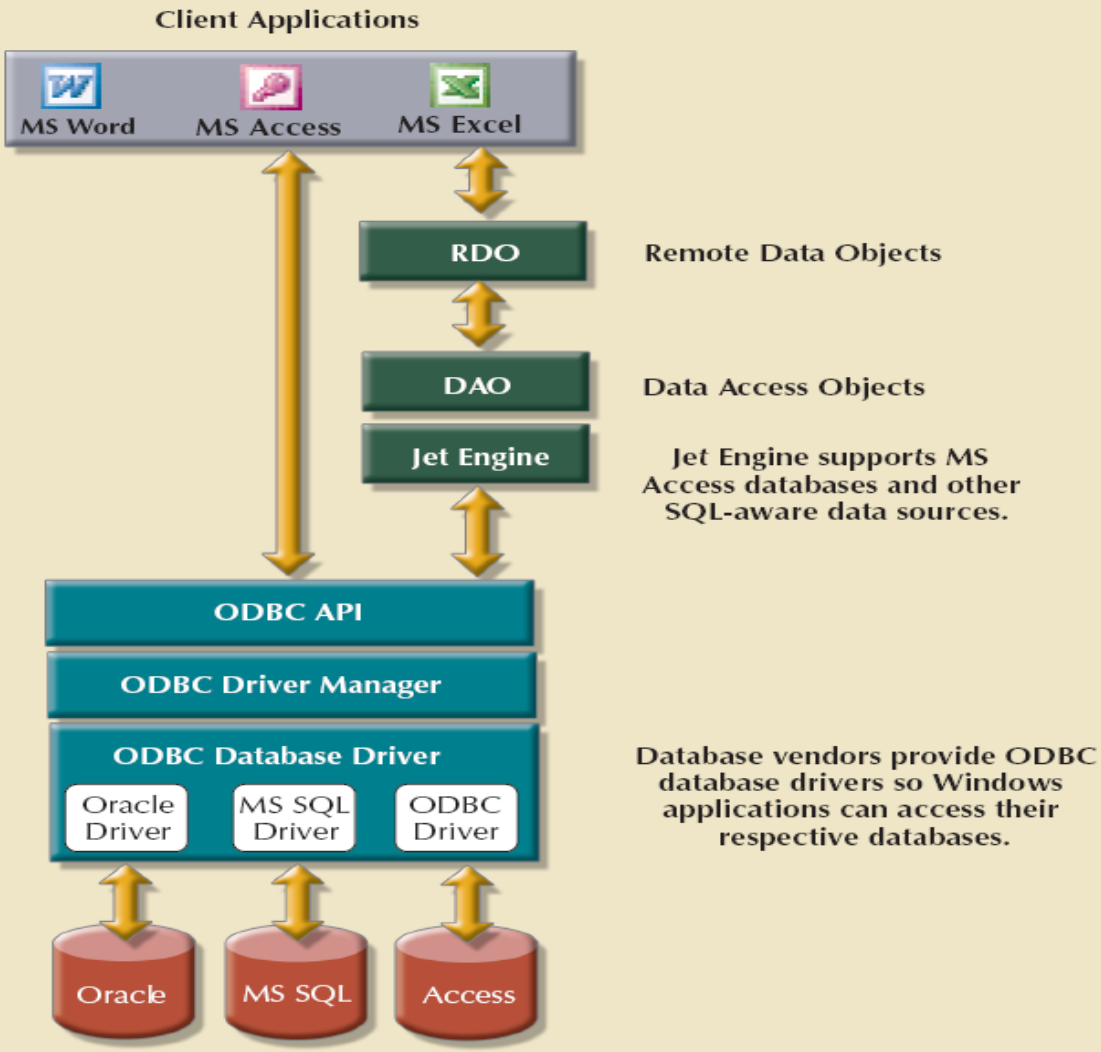
ODBC, DAO, and RDO (cont'd.)

- Data Access Objects (DAO)
  - Object-oriented API
    - Accesses MS Access, MS FoxPro, and dBase databases from Visual Basic programs
  - Provided an optimized interface that exposed functionality of Jet data engine to programmers
  - DAO interface can also be used to access other relational style data sources

ODBC, DAO, and RDO (cont'd.)

- Remote Data Objects (RDO)
  - Higher-level object-oriented application interface used to access remote database servers
  - Uses lower-level DAO and ODBC for direct access to databases
  - Optimized to deal with server-based databases, such as MS SQL Server, Oracle, and DB2
- Implemented as shared code dynamically linked to Windows via dynamic-link libraries

FIGURE 11.2 Using ODBC, DAO, and RDO to access databases

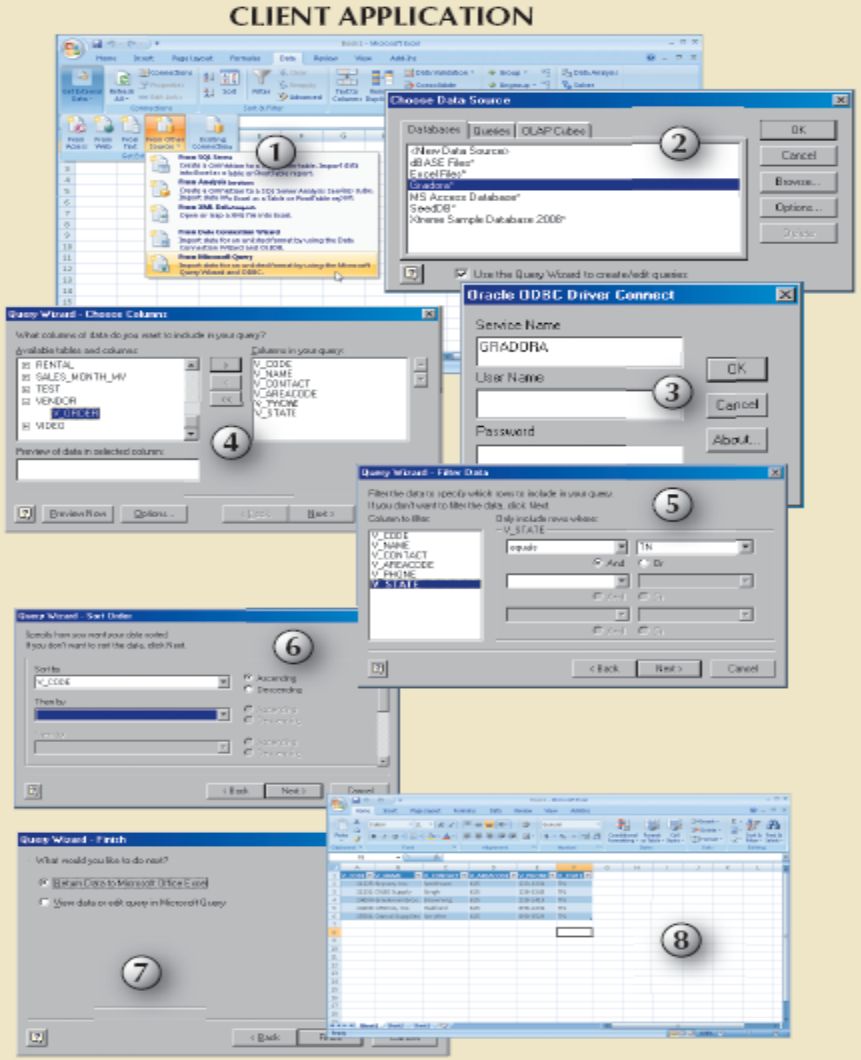


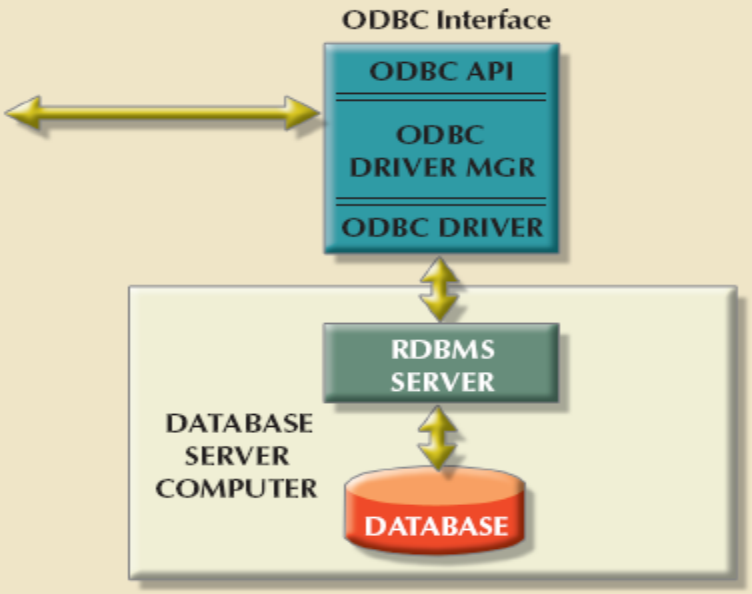
SOURCE: Course Technology/Cengage Learning

ODBC, DAO, and RDO (cont'd.)

- Basic ODBC architecture has three main components:
  - High-level ODBC API through which application programs access ODBC functionality
  - Driver manager that is in charge of managing all database connections
  - ODBC driver that communicates directly to DBMS

FIGURE 11.4 MS Excel uses ODBC to connect to an Oracle database





1. From Excel, select Get External Data, From Other Sources and From Microsoft Query options to retrieve data from an Oracle RDBMS.
2. Select the Gradora ODBC data source.
3. Enter the authentication parameters. ODBC uses the connection parameters to connect to the data source.
4. Select the table and columns to use in the query.
5. Select filtering options to restrict the rows returned.
6. Select sorting options to order the rows.
7. Select Return Data to Microsoft Office Excel.
8. Excel uses the ODBC API to pass the SQL request down to the database. Oracle executes the request and generates a result set. Excel issues calls to the ODBC API to retrieve the result set and populate the spreadsheet.

SOURCE: Course Technology/Cengage Learning

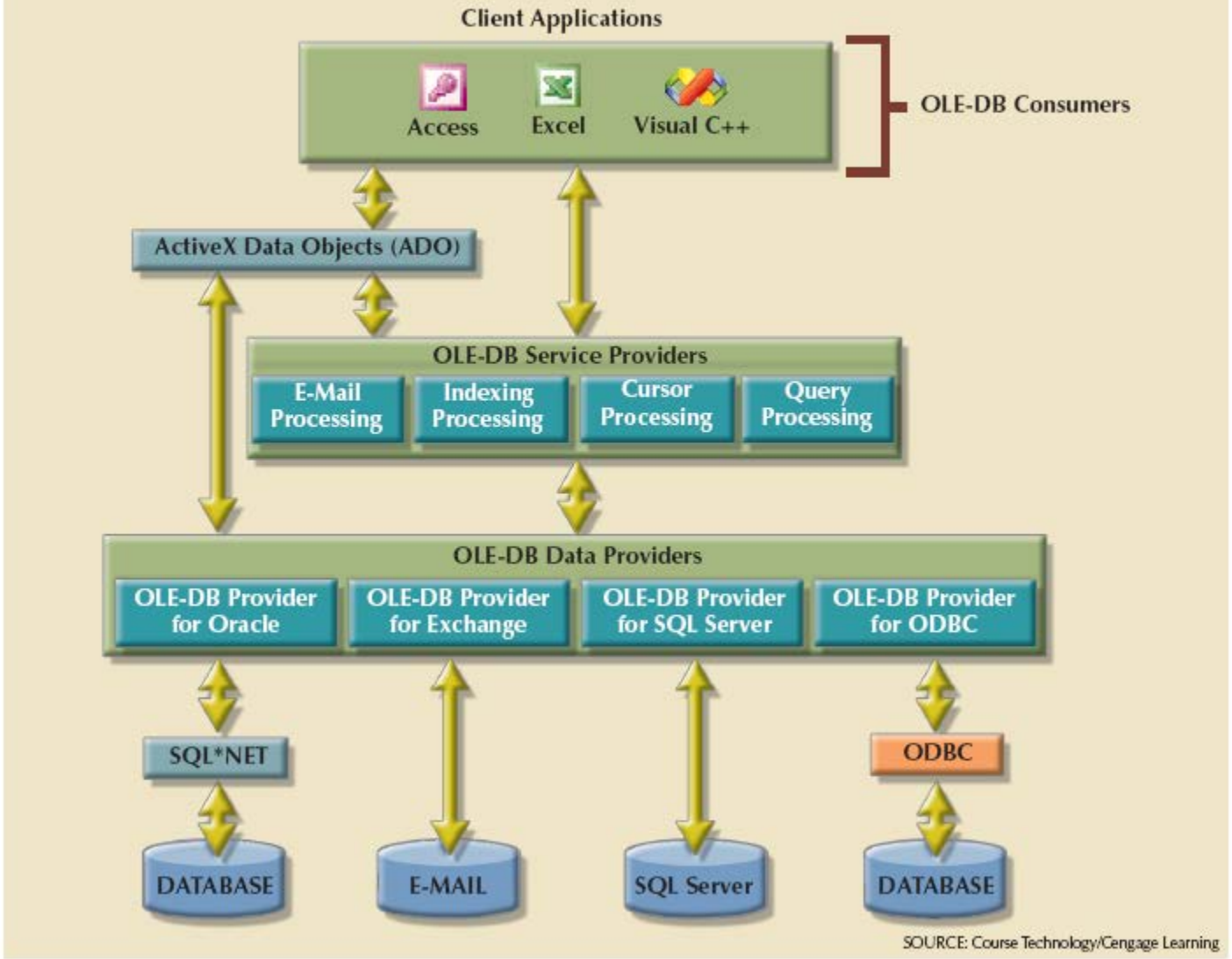
OLE-DB

- Object Linking and Embedding for Database
- Database middleware that adds object-oriented functionality for access to data
- Series of COM objects provides low-level database connectivity for applications
- Functionality divided into two types of objects:
  - Consumers
  - Providers

OLE-DB (cont'd.)

- OLE-DB did not provide support for scripting languages
- ActiveX Data Objects (ADO) provides high-level application-oriented interface to interact with OLE-DB, DAO, and RDO
- ADO provides unified interface to access data from any programming language that uses the underlying OLE-DB objects

FIGURE 11.5 OLE-DB architecture

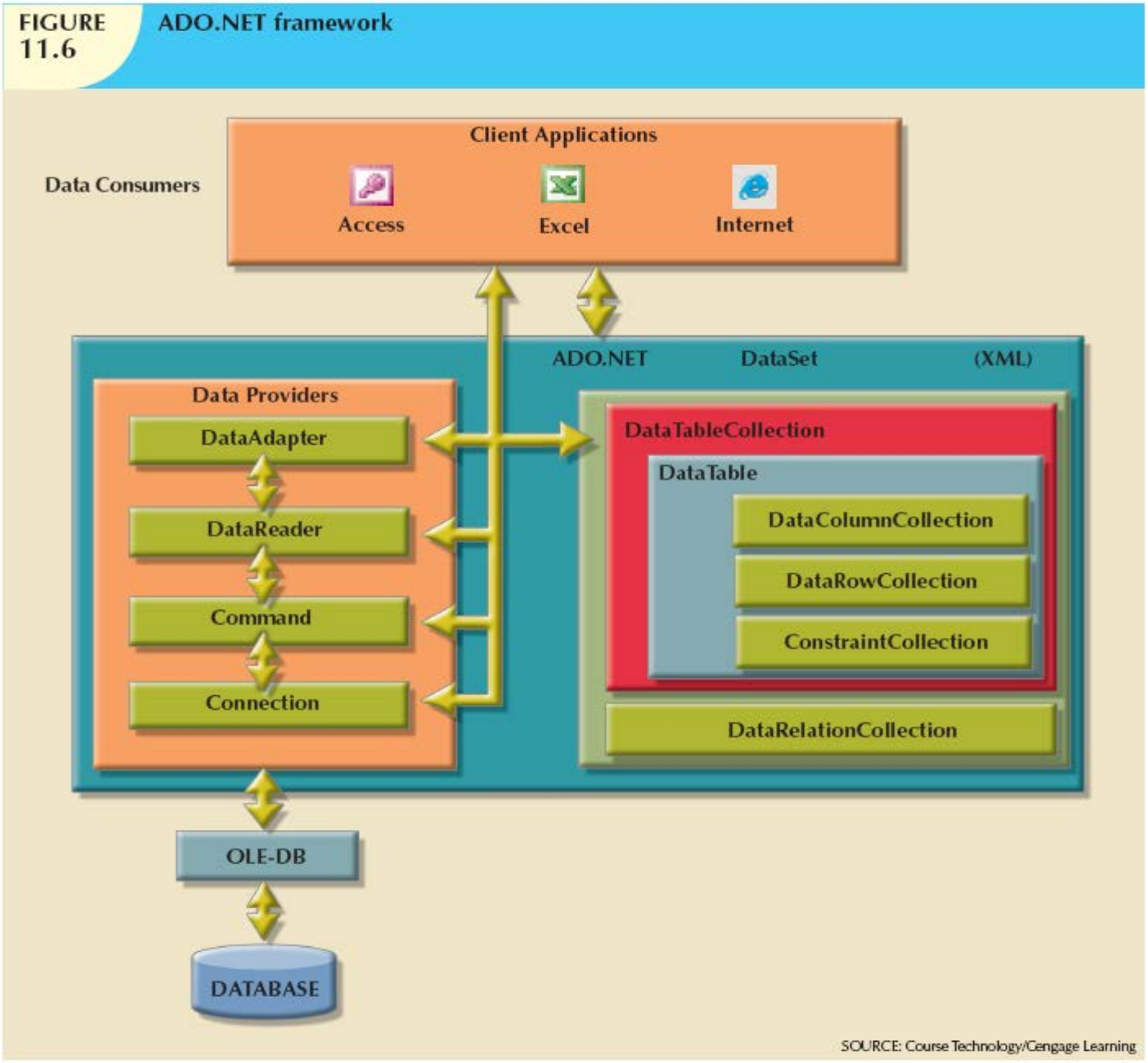


SOURCE: Course Technology/Cengage Learning

ADO.NET

- Data access component of Microsoft's .NET application development framework
- Two new features for development of distributed applications:
  - DataSet is disconnected memory-resident representation of database
  - DataSet is internally stored in XML format
    - Data in DataSet made persistent as XML documents

FIGURE 11.6 ADO.NET framework



SOURCE: Course Technology/Cengage Learning

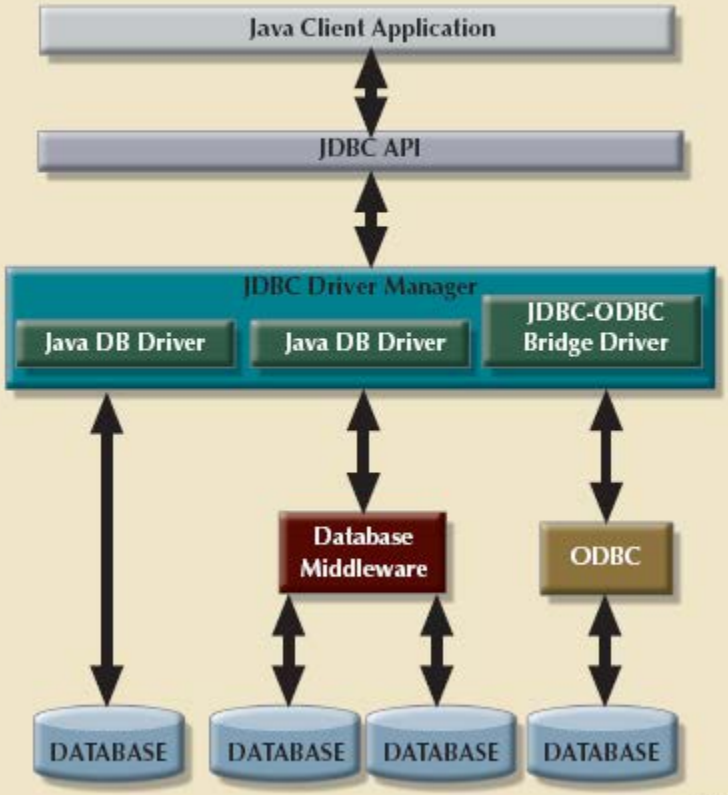
ADO.NET (cont'd.)

- Specific objects manipulate data in data source
  - Connection
  - Command
  - DataReader
  - DataAdapter
  - DataSet
  - DataTable

Java Database Connectivity (JDBC)

- Java is an object-oriented programming language
  - Runs on top of Web browser software
- Advantages of JDBC:
  - Company can leverage existing technology and personnel training
  - Allows direct access to database server or access via database middleware
  - Provides a way to connect to databases through an ODBC driver

FIGURE 11.7 JDBC architecture



SOURCE: Course Technology/Cengage Learning

Database Internet Connectivity

- Web database connectivity allows new innovative services that:
  - Permit rapid response by bringing new services and products to market quickly
  - Increase customer satisfaction through creation of Web-based support services
  - Allow anywhere, anytime data access using mobile smart devices via the Internet
  - Yield fast and effective information dissemination through universal access

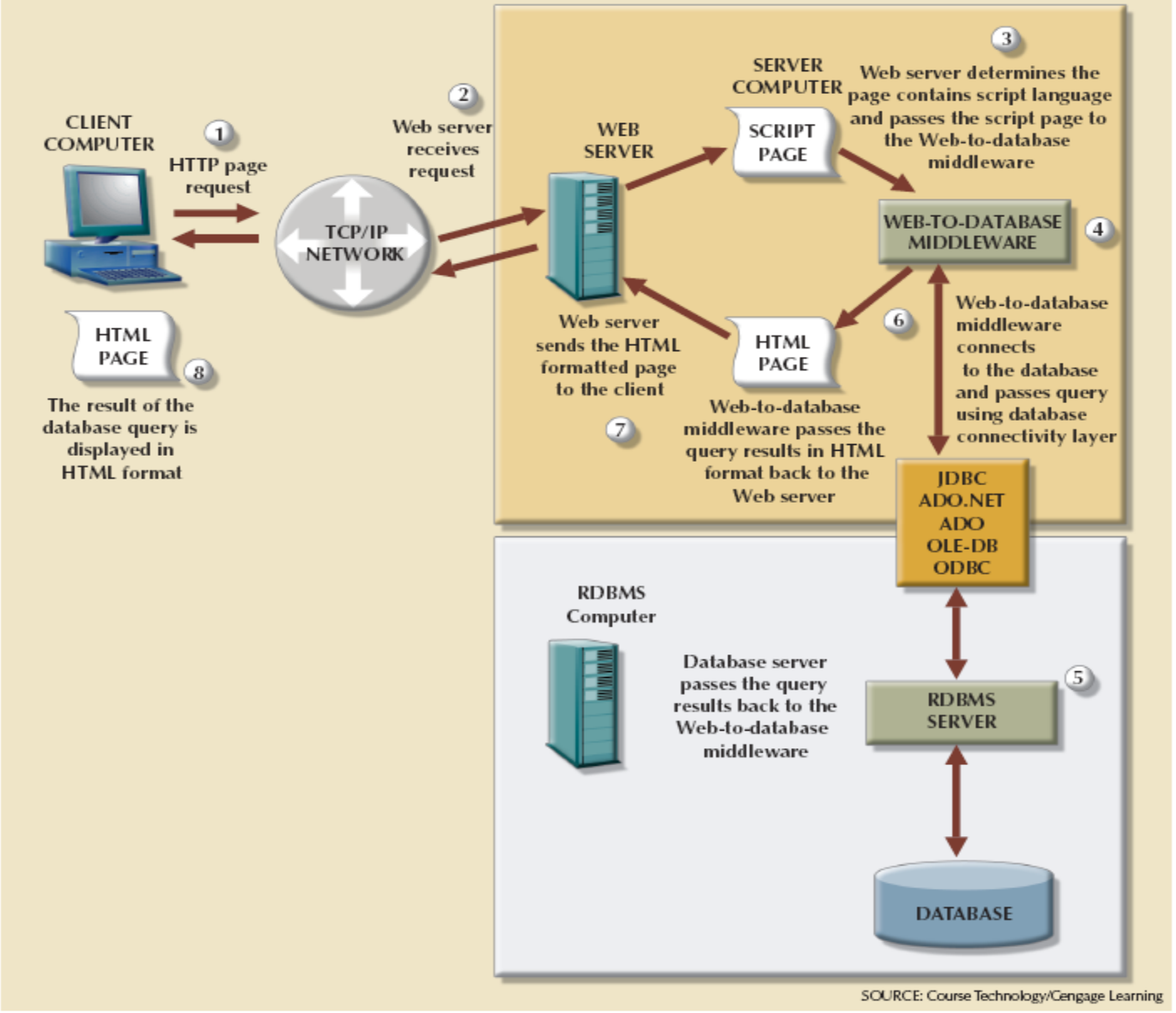
TABLE 11.3 Characteristics and Benefits of Internet Technologies

INTERNET CHARACTERISTIC	BENEFIT
Hardware and software independence	Savings in equipment and software acquisition Ability to run on most existing equipment Platform independence and portability No need for multiple platform development
Common and simple user interface	Reduced training time and cost Reduced end-user support cost No need for multiple platform development
Location independence	Global access through Internet infrastructure and mobile smart devices Reduced requirements (and costs!) for dedicated connections
Rapid development at manageable costs	Availability of multiple development tools Plug-and-play development tools (open standards) More interactive development Reduced development times Relatively inexpensive tools Free client access tools (Web browsers) Low entry costs; frequent availability of free Web servers Reduced costs of maintaining private networks Distributed processing and scalability using multiple servers

Web-to-Database Middleware: Server-Side Extensions

- Web server is the main hub through which Internet services are accessed
- Dynamic Web pages are at the heart of current generation Web sites
- Server-side extension: a program that interacts directly with the Web server
  - Also known as Web-to-database middleware
- Middleware must be well integrated

FIGURE 11.8 Web-to-database middleware

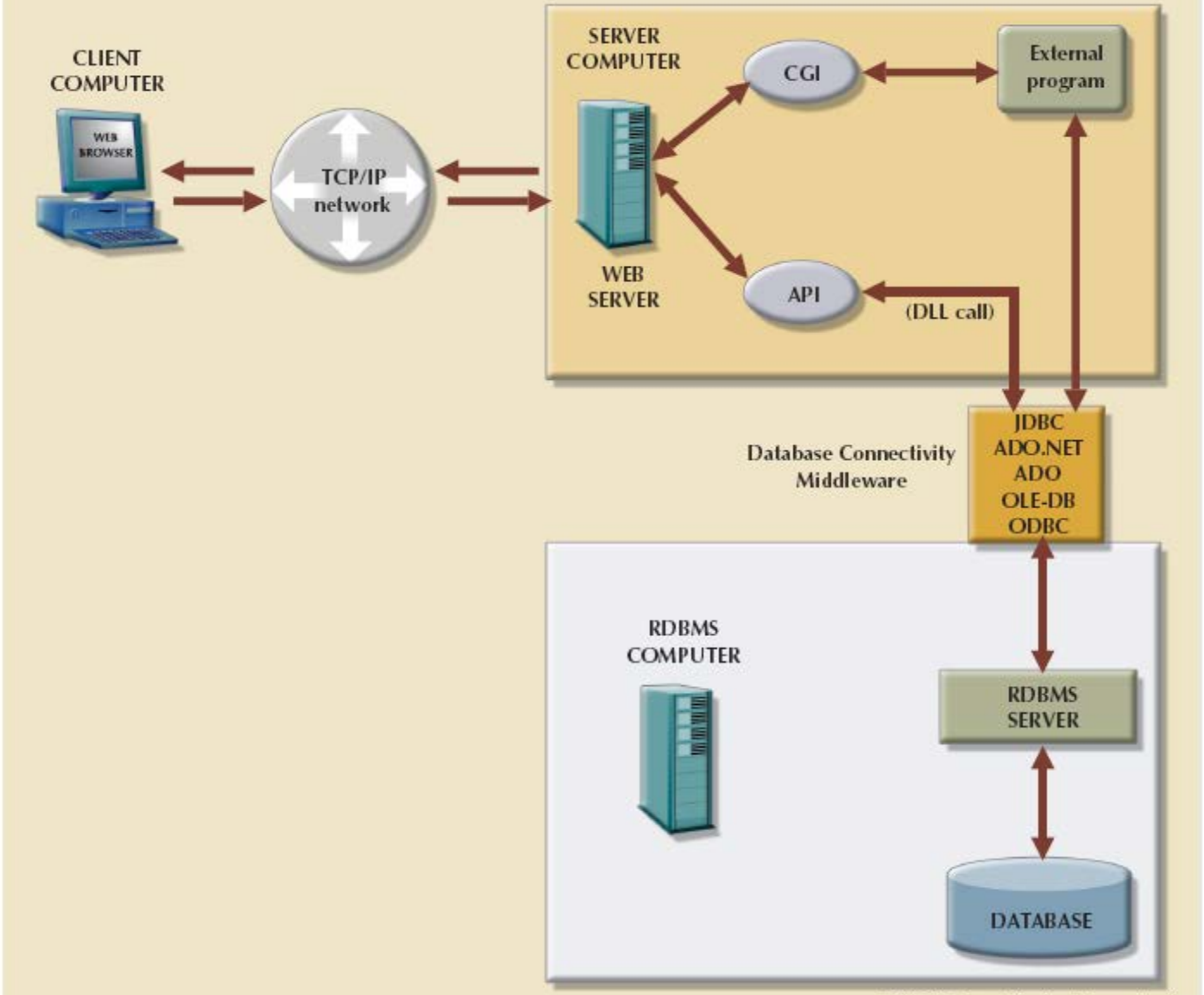


SOURCE: Course Technology/Cengage Learning

Web Server Interfaces

- Two well-defined Web server interfaces:
  - Common Gateway Interface (CGI)
  - Application Programming Interface (API)
- Disadvantage of CGI scripts:
  - Loading external script decreases system performance
  - Language and method used to create script also decrease performance
- API is more efficient than CGI
  - API is treated as part of Web server program

FIGURE 11.9 Web server CGI and API interfaces



SOURCE: Course Technology/Cengage Learning

The Web Browser

- Software that lets users navigate the Web
- Located in client computer
- Interprets HTML code received from Web server
- Presents different page components in standard way
- Web is a stateless system: Web server does not know the status of any clients

Client-Side Extensions

- Add functionality to Web browser
- Three general types:
  - Plug-ins
  - Java and JavaScript
  - ActiveX and VBScript

Client-Side Extensions (cont'd.)

- Plug-in: an external application automatically invoked by the browser when needed
- Java and JavaScript: embedded in Web page
  - Downloaded with the Web page and activated by an event
- ActiveX and VBScript: embedded in Web page
  - Downloaded with page and activated by event
  - Oriented to Windows applications

Web Application Servers

- Middleware application that expands the functionality of Web servers
  - Links them to a wide range of services
- Some uses of Web application servers:
  - Connect to and query database from Web page
  - Create dynamic Web search pages
  - Enforce referential integrity
- Some features of Web application servers:
  - Security and user authentication
  - Access to multiple services

Web Database Development

- Process of interfacing databases with the Web browser
- Code examples
  - ColdFusion
  - PHP

FIGURE 11.11 ColdFusion code to query the VENDOR table

```
<HTML>
<HEAD>
<TITLE>Rob & Coronel -  ColdFusion Examples</TITLE>
<CFQUERY NAME="venlist" DATASOURCE="RobCor">
    SELECT * FROM VENDOR ORDER BY VEN_CODE
</CFQUERY>
</HEAD>
<BODY BGCOLOR="LIGHTBLUE">
<H1>
<CENTER><B>Simple Query using CFQUERY and CFOUTPUT</B></CENTER>
<CENTER><B>(Vertical Output)</B></CENTER>
</H1>
<BR>
<HR>
<CFOUTPUT>
    Your query returned #venlist.RecordCount# records
</CFOUTPUT>
<CFOUTPUT QUERY="venlist">
<PRE><B>
 VENDOR CODE:        #VEN_CODE#
 VENDOR NAME:        #VEN_NAME#
 CONTACT PERSON:     #VEN_CONTACT_NAME#
 ADDRESS:            #VEN_ADDRESS#
 CITY:               #VEN_CITY#
 STATE:              #VEN_STATE#
 ZIP:                #VEN_ZIP#
 PHONE:              #VEN_PH#
 FAX:                #VEN_FAX#
 E-MAIL:             #VEN_EMAIL#
 CUSTOMER ID:        #VEN_CUS_ID#
 SUPPORT ID:         #VEN_SUPPORT_ID#
 SUPPORT PHONE:      #VEN_SUPPORT_PH#
 VENDOR WEB PAGE:    #VEN_WEB_PAGE#
<HR></B></PRE>
</CFOUTPUT>
</FORM>
</BODY>
</HTML>
```

SOURCE: Course Technology/Cengage Learning

FIGURE 11.12 PHP code to query the VENDOR table

```
<HTML>
<HEAD>
<TITLE>Rob & Coronel -  PHP Example</TITLE>
</HEAD>
<BODY BGCOLOR="LIGHTBLUE">
<H1><CENTER><B>Simple Query using PHP and ODBC functions</B></CENTER>
<CENTER><B>(Vertical Output)</B></CENTER></H1>
<BR>
<HR>
<?php
$dbc = odbc_connect("RobCor","","");
$sql = "SELECT * FROM VENDOR ORDER BY VEN_CODE";
$rs  = odbc_exec( $dbc, $sql );

while (odbc_fetch_row( $rs ))
{
$VEN_CODE         = odbc_result($rs,"VEN_CODE");
$VEN_NAME         = odbc_result($rs,"VEN_NAME");
$VEN_CONTACT_NAME = odbc_result($rs,"VEN_CONTACT_NAME");
$VEN_ADDRESS      = odbc_result($rs,"VEN_ADDRESS");
$VEN_CITY         = odbc_result($rs,"VEN_CITY");
$VEN_STATE        = odbc_result($rs,"VEN_STATE");
$VEN_ZIP          = odbc_result($rs,"VEN_ZIP");
$VEN_PH           = odbc_result($rs,"VEN_PH");
$VEN_FAX          = odbc_result($rs,"VEN_FAX");
$VEN_EMAIL        = odbc_result($rs,"VEN_EMAIL");
$VEN_CUS_ID       = odbc_result($rs,"VEN_CUS_ID");
$VEN_SUPPORT_ID   = odbc_result($rs,"VEN_SUPPORT_ID");
$VEN_SUPPORT_PH   = odbc_result($rs,"VEN_SUPPORT_PH");
$VEN_WEB_PAGE     = odbc_result($rs,"VEN_WEB_PAGE");

echo "<BR>";
echo "VENDOR CODE:     ". $VEN_CODE . "<BR>";
echo "VENDOR NAME:     ". $VEN_NAME . "<BR>";
echo "CONTACT PERSON:  ". $VEN_CONTACT_NAME . "<BR>";
echo "ADDRESS:         ". $VEN_ADDRESS . "<BR>";
echo "CITY:            ". $VEN_CITY . "<BR>";
echo "STATE:           ". $VEN_STATE . "<BR>";
echo "ZIP:             ". $VEN_ZIP . "<BR>";
echo "PHONE:           ". $VEN_PH . "<BR>";
echo "FAX:             ". $VEN_FAX . "<BR>";
echo "E-MAIL:          ". $VEN_EMAIL . "<BR>";
echo "CUSTOMER ID:     ". $VEN_CUS_ID . "<BR>";
echo "SUPPORT ID:      ". $VEN_SUPPORT_ID . "<BR>";
echo "SUPPORT PHONE:   ". $VEN_SUPPORT_PH . "<BR>";
echo "VENDOR WEB PAGE:". $VEN_WEB_PAGE . "<BR>";
echo "<HR>";
}
odbc_close($dbc);
?>
</BODY>
</HTML>
```

SOURCE: Course Technology/Cengage Learning

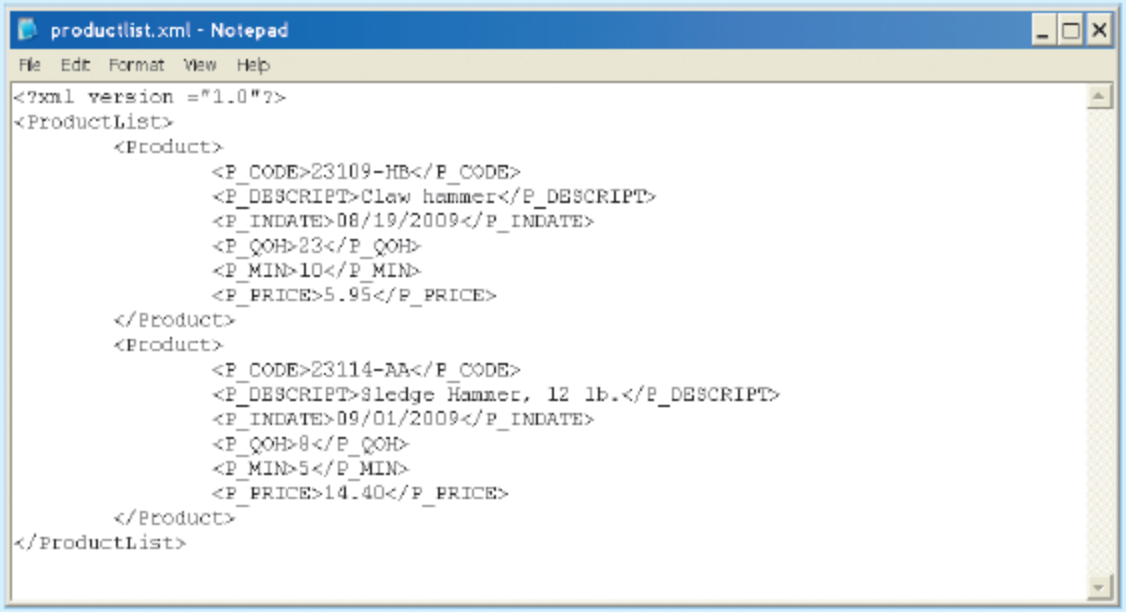
Extensible Markup Language (XML)

- Companies use Internet to create new systems that integrate their data
  - Increase efficiency and reduce costs
- Electronic commerce enables organizations to market to millions of users
- Most e-commerce transactions take place between businesses
- HTML Web pages display in the browser
  - Tags describe how something looks on the page

Extensible Markup Language (XML) (cont'd.)

- Extensible Markup Language (XML)
  - Metalanguage to represent and manipulate data elements
  - Facilitates exchange of structured documents over the Web
  - Allows definition of new tags
    - Case sensitive
    - Must be well-formed and properly nested
    - Comments indicated with <- and ->
    - XML and xml prefixes reserved for XML tags only

FIGURE 11.13 Contents of the productlist.xml document



SOURCE: Course Technology/Cengage Learning

Document Type Definitions (DTD) and XML Schemas

- Document Type Definition (DTD)
  - File with .dtd extension that describes elements
  - Provides composition of database's logical model
  - Defines the syntax rules or valid tags for each type of XML document
- Companies engaging in e-commerce transaction must develop and share DTDs
- DTD referenced from inside XML document

FIGURE 11.16 DTD and XML documents for order data

OrderData.dtd

OrderData.dtd - Notepad

File Edit Format View Help

```
<!ELEMENT OrderData (ORD_ID,ORD_DATE,CUS_NAME,ORD_SHIPTO,ORD_PRODS*,ORD_TOT)>
<!ELEMENT ORD_ID          (#PCDATA )>
<!ELEMENT ORD_DATE        (#PCDATA )>
<!ELEMENT CUS_NAME        (#PCDATA )>
<!ELEMENT ORD_SHIPTO      (#PCDATA )>
<!ELEMENT ORD_PRODS (P_CODE, P_DESCRIPT, P_QOH, P_PRICE)+>
<!ELEMENT P_CODE          (#PCDATA )>
<!ELEMENT P_DESCRIPT      (#PCDATA )>
<!ELEMENT P_QOH           (#PCDATA )>
<!ELEMENT P_PRICE         (#PCDATA )>
<!ELEMENT ORD_TOT         (#PCDATA )>
```

"+" sign indicates one or more ORD_PRODS elements

OrderData.xml

OrderData.xml - Notepad

File Edit Format View Help

```
<?xml version = "1.0"?>
<!DOCTYPE OrderData SYSTEM "OrderData.dtd">
<OrderData>
   <ORD_ID>34583</ORD_ID>
   <ORD_DATE>12/08/2009</ORD_DATE>
   <CUS_NAME>Jill Atkins</CUS_NAME>
   <ORD_SHIPTO>1234 Crown Rd, Chicago, IL34564</ORD_SHIPTO>
   <ORD_PRODS>
      <P_CODE>2309-HB</P_CODE>
      <P_DESCRIPT>Claw Hammer</P_DESCRIPT>
      <P_QOH>2</P_QOH>
      <P_PRICE>5.95</P_PRICE>
   </ORD_PRODS>
   <ORD_PRODS>
      <P_CODE>23114-AA</P_CODE>
      <P_DESCRIPT>Sledge Hammer, 12 lb.</P_DESCRIPT>
      <P_QOH>1</P_QOH>
      <P_PRICE>14.40</P_PRICE>
   </ORD_PRODS>
   <ORD_TOT>26.30</ORD_TOT>
</OrderData>
```

Two ORD_PRODS elements in XML document

SOURCE: Course Technology/Cengage Learning

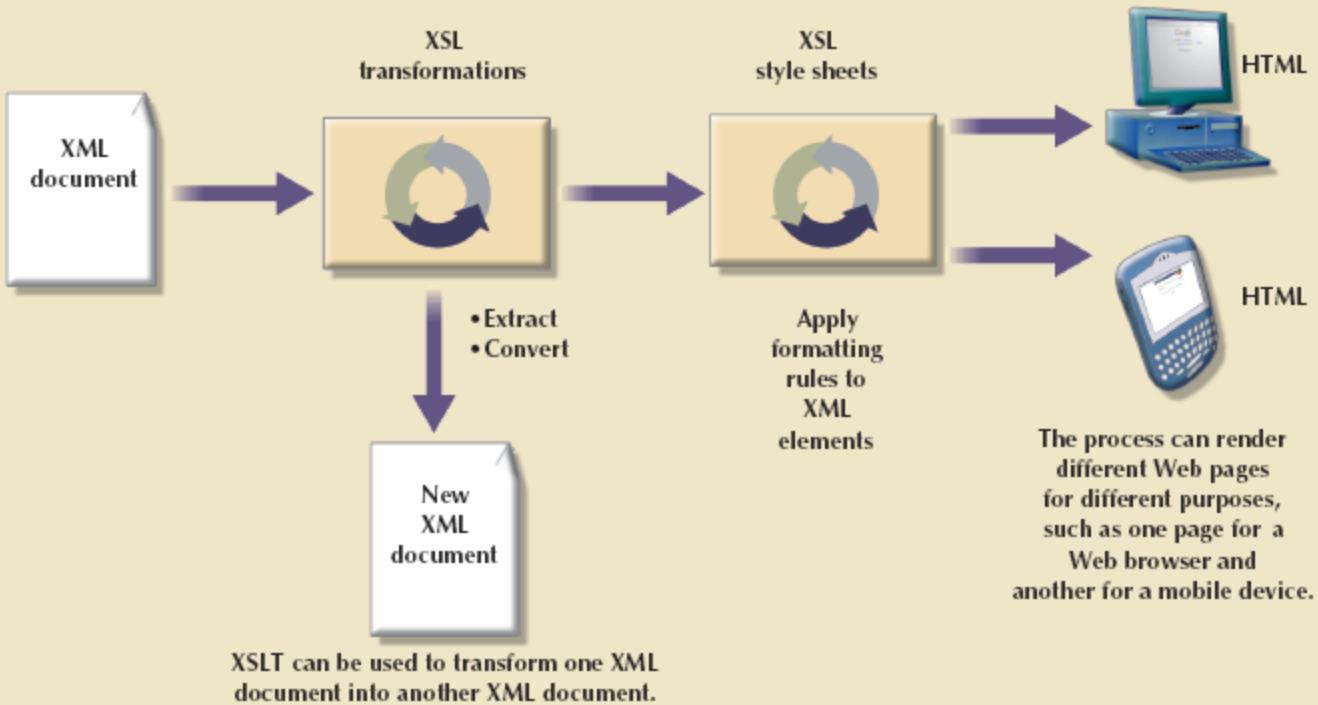
Document Type Definitions (DTD) and XML Schemas (cont'd.)

- XML schema
  - Advanced data definition language
  - Describes the structure of XML data documents
- Advantage of XML schema:
  - More closely maps to database terminology and features
- XML schema definition (XSD) file uses syntax similar to XML document

XML Presentation

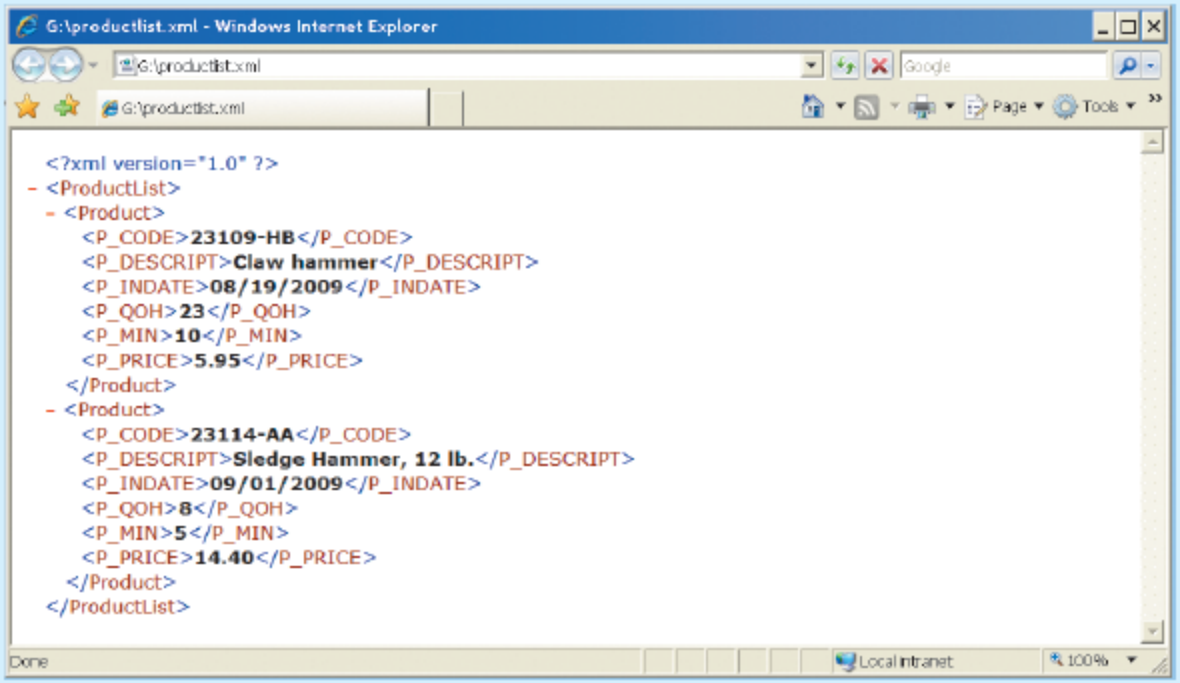
- XML separates data structure from presentation and processing
- Extensible Style Language (XSL) displays XML data
  - Defines the rules by which XML data are formatted and displayed
  - Two parts:
    - Extensible Style Language Transformations (XSLT)
    - XSL style sheets

FIGURE 11.18 Framework for XML transformations



SOURCE: Course Technology/Cengage Learning

FIGURE 11.19 Displaying XML documents



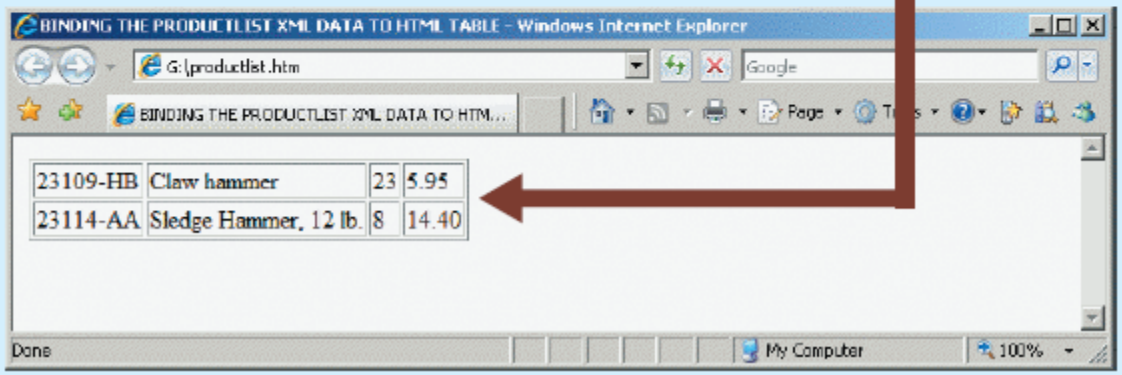
SOURCE: Course Technology/Cengage Learning

FIGURE 11.20 XML data binding

productlist.htm - Notepad

File Edit Format View Help

```
<HTML>
<HEAD>
<TITLE>BINDING THE PRODUCTLIST XML DATA TO HTML TABLE</TITLE>
</HEAD>

<BODY>

<XML ID="PRODLIST" SRC="PRODUCTLIST.XML"></XML>

<TABLE BORDER="1" DATASRC="#PRODLIST">
        <TR>
        <TD><SPAN DATAFLD="P_CODE"></SPAN></TD>
        <TD><SPAN DATAFLD="P_DESCRIPT"></SPAN></TD>
        <TD><SPAN DATAFLD="P_QOH"></SPAN></TD>
        <TD><SPAN DATAFLD="P_PRICE"></SPAN></TD>
        </TR>

</TABLE>

</BODY>
</HTML>
```



SOURCE: Course Technology/Cengage Learning

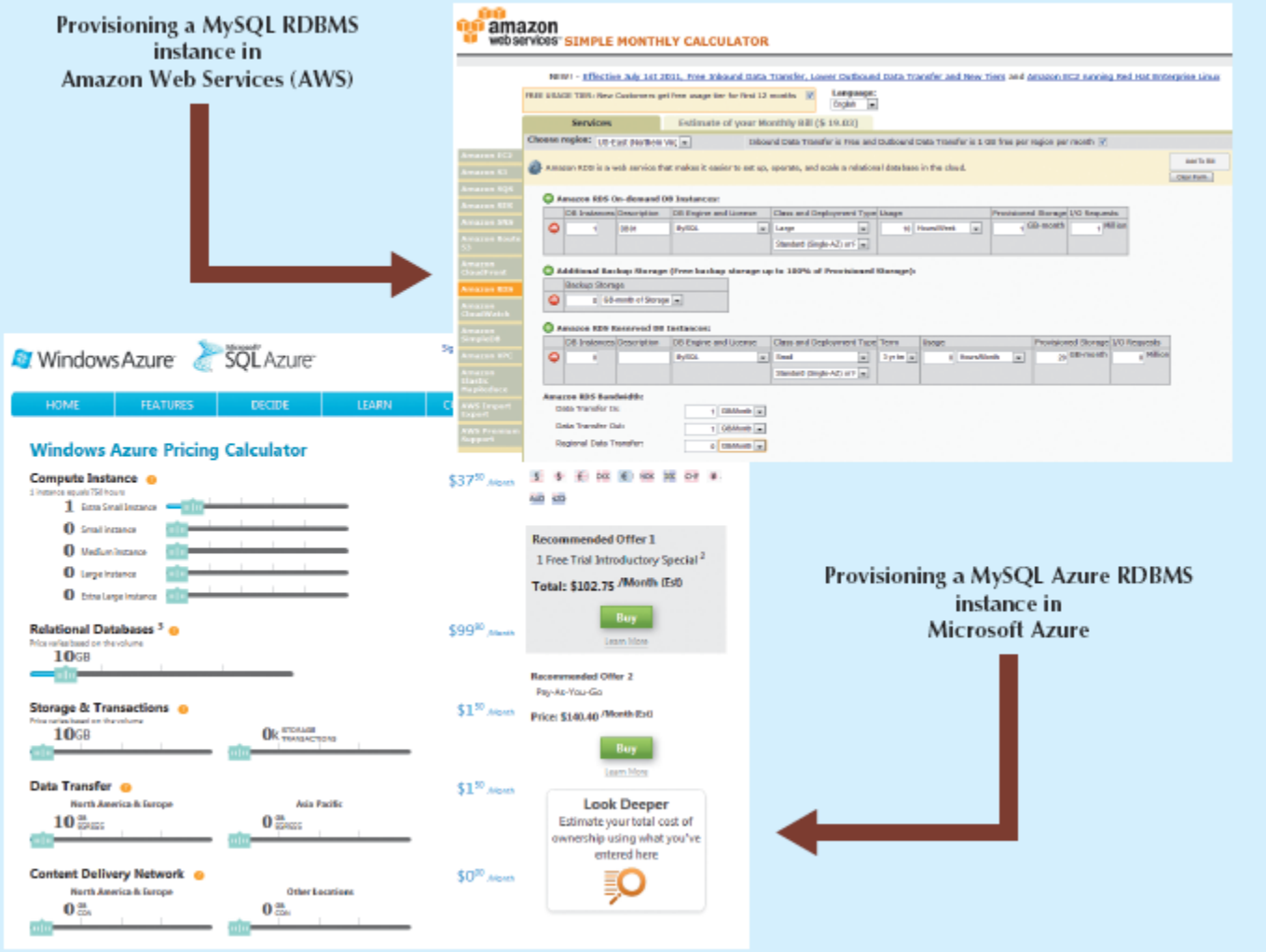
XML Applications

- B2B exchanges
- Legacy systems integration
- Web page development
- Database support
- Database meta-dictionaries
- XML databases
- XML services

Cloud Computing Services

- Cloud computing
  - "A computing model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computer resources that can be rapidly provisioned and released with minimal management effort or service provider interaction."
  - Potential to become a "game changer"

FIGURE 11.22 Provisioning an RDBMS in the cloud



SOURCE: Course Technology/Cengage Learning

Cloud Implementation Types

- Public cloud
- Private cloud
- Community cloud

Characteristics of Cloud Services

- Ubiquitous access via Internet technologies.
- Shared infrastructure
- Lower costs and variable pricing
- Flexible and scalable services
- Dynamic provisioning
- Service orientation
- Managed operations

Types of Cloud Services

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

Cloud Services: Advantages and Disadvantages

TABLE 11.4 Advantages and Disadvantages of Cloud Computing

ADVANTAGE	DISADVANTAGE
Low initial cost of entry. Cloud computing has lower costs of entry when compared with the alternative of building in house.	*Issues of security, privacy, and compliance*. Trusting sensitive company data to external entities is difficult for most data-cautious organizations.
Scalability/elasticity. It is easy to add and remove resources on demand.	*Hidden costs of implementation and operation*. It is hard to estimate bandwidth and data migration costs.
Support for mobile computing. Cloud computing providers support multiple types of mobile computing devices.	*Data migration is a difficult and lengthy process*. Migrating large amounts of data to and from the cloud infrastructure can be difficult and time-consuming.
Ubiquitous access. Consumers can access the cloud resources from anywhere at any time, as long as they have Internet access.	*Complex licensing schemes*. Organizations that implement cloud services are faced with complex licensing schemes and complicated service-level agreements.
High reliability and performance. Cloud providers build solid infrastructures that otherwise are difficult for the average organization to leverage.	*Loss of ownership and control*. Companies that use cloud services are no longer in complete control of their data. What is the responsibility of the cloud provider if data are breached? Can the vendor use your data without your consent?
Fast provisioning. Resources can be provisioned on demand in a matter of minutes with minimal effort.	*Organization culture*. End users tend to be resistant to change. Do the savings justify being dependent on a single provider? Will the cloud provider be around in 10 years?
Managed infrastructure. Most cloud implementations are managed by dedicated internal or external staff. This allows the organization's IT staff to focus on other areas.	*Difficult integration with internal IT system*. Configuring the cloud services to integrate transparently with internal authentication and other internal services could be a daunting task.

SQL Data Services

- Cloud computing data management service
- Provides relational data management to companies of any size
- Avoids high cost of personnel/maintenance
- Leverages Internet to provide:
  - Hosted data management
  - Standard protocols
  - A common programming interface
- Could assist businesses with limited information technology resources

Summary

- Database connectivity:
  - Ways in which programs connect and communicate with data repositories
- Database connectivity software known as database middleware
- Database repository also known as data source
  - Represents data management application used to store data generated by the program
- Microsoft interfaces are dominant players
  - ODBC, OLE-DB, ADO.NET

Summary (cont'd.)

- Microsoft's Universal Data Access (UDA) architecture
  - Collection of technologies to access any type of data source using common interface
- Native database connectivity: interface provided by database vendor
  - ODBC is Microsoft's implementation of SQL Access Group Call Level Interface
    - Allows any Windows application to access relational data sources using SQL

Summary (cont'd.)

- OLE-DB adds object-oriented functionality for access to data
- ActiveX Data Objects provide interface with OLE-DB, DAO, and RDO
- ADO.NET is data access component of Microsoft .NET framework
- Java Database Connectivity (JDBC) interfaces with Java applications with data sources

Summary (cont'd.)

- Database access through the Web uses middleware
- On client side of Web browser, use plug-ins, Java and JavaScript, ActiveX, and VBScript
- On server side, middleware expands functionality of Web servers
  - Links them to wide range of services
- XML provides semantics to share structured documents across the Web
  - Produces description and representation of data

Summary (cont'd.)

- Cloud computing
  - Computing model that provides ubiquitous, on-demand access to a shared pool of configurable resources that can be rapidly provisioned
- SQL data services (SDS)
  - Cloud computing-based data management service that provides relational data storage, ubiquitous access, and local management to companies of all sizes