

If the presence of electricity can be made visible in any part of a circuit, I see no reason why intelligence may not be transmitted instantaneously by electricity.

—Samuel F. B. Morse

Protocol is everything.

—Francois Giuliani

What networks of railroads, highways and canals were in another age, the networks of telecommunications, information and computerization ... are today.

—Bruno Kreisky

The port is near, the bells I hear, the people all exulting.

—Walt Whitman

27

Networking

Objectives

In this Chapter you'll learn:

- To understand Java networking with URLs, sockets and datagrams.
- To implement Java networking applications by using sockets and datagrams.
- To understand how to implement Java clients and servers that communicate with one another.
- To understand how to implement network-based collaborative applications.
- To construct a multithreaded server.

Self-Review Exercises

27.1 Fill in the blanks in each of the following statements:

- a) Exception _____ occurs when an input/output error occurs when closing a socket.
ANS: IOException.
- b) Exception _____ occurs when a hostname indicated by a client cannot be resolved to an address.
ANS: UnknownHostException.
- c) If a DatagramSocket constructor fails to set up a DatagramSocket properly, an exception of type _____ occurs.
ANS: SocketException.
- d) Many of Java's networking classes are contained in package _____.
ANS: java.net.
- e) Class _____ binds the application to a port for datagram transmission.
ANS: DatagramSocket.
- f) An object of class _____ contains an IP address.
ANS: InetAddress.
- g) The two types of sockets we discussed in this chapter are _____ and _____.
ANS: stream sockets, datagram sockets.
- h) The acronym URL stands for _____.
ANS: Uniform Resource Locator.
- i) The acronym URI stands for _____.
ANS: Uniform Resource Identifier.
- j) The key protocol that forms the basis of the World Wide Web is _____.
ANS: HTTP.
- k) AppletContext method _____ receives a URL object as an argument and displays in a browser the World Wide Web resource associated with that URL.
ANS: showDocument.
- l) Method getLocalHost returns a(n) _____ object containing the local IP address of the computer on which the program is executing.
ANS: InetAddress.
- m) The URL constructor determines whether its String argument is a valid URL. If so, the URL object is initialized with that location. If not, a(n) _____ exception occurs.
ANS: MalformedURLException.

27.2 State whether each of the following is *true* or *false*. If *false*, explain why.

- a) UDP is a connection-oriented protocol.
ANS: False; UDP is a connectionless protocol and TCP is a connection-oriented protocol.
- b) With stream sockets a process establishes a connection to another process.
ANS: True.
- c) A server waits at a port for connections from a client.
ANS: True.
- d) Datagram packet transmission over a network is reliable—packets are guaranteed to arrive in sequence.
ANS: False; packets can be lost, arrive out of order or be duplicated.

Exercises

NOTE: Solutions to the programming exercises are located in the `ch27solutions` folder. Each exercise has its own folder named `ex27_##` where `##` is a two-digit number representing the exercise number. For example, exercise 27.13's solution is located in the folder `ex26_13`.

- 27.3** Distinguish between connection-oriented and connectionless network services.
ANS: Connection-oriented services maintain a connection while data is being transferred. Connectionless services do not maintain a connection. Connection-oriented services are generally slower but more reliable.
- 27.4** How does a client determine the hostname of the client computer?
ANS: `InetAddress.getLocalHost().getHostName()`.
- 27.5** Under what circumstances would a `SocketException` be thrown?
ANS: If a socket operation fails due to a problem in the underlying protocol. For example, if a `DatagramSocket` cannot bind to the specified port.
- 27.6** How can a client get a line of text from a server?
ANS: After connecting, the client can get data from the server using the stream object returned by the `Socket`'s `getInputStream` method. The code required to get a single line of text can be simplified by wrapping the `InputStream` in a `Scanner` or `ObjectInputStream`. Alternatively, the server can send the text by wrapping it in a `DatagramPacket` and using `send` method of class `DatagramSocket`.
- 27.7** Describe how a client connects to a server.
ANS: A server listens for a connection on a specific address and port using the `ServerSocket` class. A client can then connect to the server by giving the address and port to the `Socket` constructor. Once the connect operation completes, the server and client can send data back and forth between each other.
- 27.8** Describe how a server sends data to a client.
ANS: For stream-based sockets, the client connects to the server by creating a socket using the `Socket` class constructor. The name of the server and the port to connect to are passed to the `Socket` constructor. Information can be exchanged between the client and server using the socket's `InputStream` and `OutputStream`. For datagram-based sockets, the server can send a `DatagramPacket` to the client using the `send` method of class `DatagramSocket`.
- 27.9** Describe how to prepare a server to receive a stream-based connection request from a single client.
ANS: First a `ServerSocket` object must be created and associated with a port on the server computer. If the `ServerSocket` is created properly, a call to the `accept` method can be issued on the `ServerSocket` object. This call will wait for a client to connect. When a client connects, a `Socket` object is returned from the `accept` call. The `Socket` object is used to get the `InputStream` and `OutputStream` objects for communication with the client.
- 27.10** How does a server listen for streams-based socket connections at a port?
ANS: The `ServerSocket` `accept` method is used.
- 27.11** What determines how many connect requests from clients can wait in a queue to connect to a server?
ANS: When the `ServerSocket` object is created on the server, the second argument to the `ServerSocket` constructor specifies the "queue length" (the number of clients that can wait to be processed by the server).
- 27.12** As described in the text, what reasons might cause a server to refuse a connection request from a client?
ANS: A server usually has a capacity of the number of clients that can wait for a connection and be processed by the server. If the queue of clients is full, client connections are refused.

