

PART I

Introduction to Networking and Internet Applications

Chapter 1 - Introduction And Overview

1.1 Search the Web to identify reasons for Internet growth in recent years.

1.2 List ten industries that depend on computer networking.

1.3 According to the text, is it possible to develop Internet applications without understanding the architecture of the Internet and the technologies? Support your answer.

Answer: Yes, it is possible to write code that communicates over a network, without understanding the hardware and software technologies that are used to transfer data from one application to another. However, knowledge of the underlying network system allows a programmer to write better code.

1.4 To what aspects of networking does data communications refer?

Answer: Data communications refers to the study of low-level mechanisms and technologies used to send information across a physical communication medium, such as a wire, radio wave, or light beam.

1.5 What is packet-switching, and why is packet switching relevant to the Internet?

Answer: Packet switching divides data into small blocks, called packets, and includes an identification of the intended recipient in each packet. Packet switching changed networking in a fundamental way, and provided the basis for the modern Internet. Packet switching allows multiple senders to transmit data over a shared network.

1.6 Provide a brief history of the Internet describing when and how it was started.

1.7 What is interoperability, and why is it especially important in the Internet?

1.8 What is a communication protocol? Conceptually, what two aspects of communication does a protocol specify?

Answer: A communication protocol refers to a specification for network communication. Major aspects of a protocol are syntax (format) and semantics (meaning).

1.9 What is a protocol suite, and what is the advantage of a suite?

Answer: Protocols are designed in complete, cooperative sets called suites or families, instead of creating each protocol in isolation. Each protocol in a suite handles one aspect of

communication; together, the protocols in a suite cover all aspects of communication. The entire suite is designed to allow the protocols to work together efficiently.

1.10 Describe the TCP/IP layering model, and explain how it was derived.

1.11 List the layers in the TCP/IP model, and give a brief explanation of each.

Answer: The TCP/IP consists of 5 layers. The layers and their short explanation are as follows:

- ***Layer 1: Physical: Protocols in the Physical layer specify details about the underlying transmission medium and the associated hardware.***
- ***Layer 2: Network Interface Protocols in the Network Interface layer specify details about communication between higher layers of protocols and the underlying network.***
- ***Layer 3: Internet: Protocols in the Internet layer form the fundamental basis for the Internet. Layer 3 protocols specify communication between two computers across the Internet.***
- ***Layer 4: Transport: Protocols in the Transport layer provide for communication from an application program on one computer to an application program on another.***
- ***Layer 5: Application: Protocols in the top layer of the TCP/IP stack specify how a pair of applications interact when they communicate.***

1.12 Explain how headers are added and removed as data passes through a layered protocol stack.

Answer: each layer on the sending computer prepends extra information onto the packet; the corresponding protocol layer on the receiving computer removes and uses the extra information.

1.13 List major standardization organizations that create standards for data communications and computer networking.

Answer: Various national and international organizations are involved in standardization of communications and networking services. To list few:

- ***International Organization for Standardization (ISO)***
- ***International Telecommunications Union, Telecommunication Standardization Sector (ITU-T)***
- ***Institute of Electrical and Electronics Engineers (IEEE)***
 - ***Internet Engineering Task Force (IETF)***

Chapter - 2 Internet Trends

2.1 Why was sharing of computational resources important in the 1960s?

2.2 The plot in Figure 2.1 shows that Internet growth did not start until after 1995. Why is the figure misleading?

Answer: Researchers computers working for the Advanced Research Projects Agency (ARPA) of US Department of Defense (DoD) needed powerful and computers were incredibly expensive. The ARPA budget was insufficient to fund many computers. The ARPA planned to interconnect all computers with a data network and devise software that would allow a researcher to use whichever computer was best suited to perform a given task.

2.3 Assume that one hundred million new computers are added to the Internet each year. If computers are added at a uniform rate, how much time elapses between two successive additions?

2.4 Extend the plot in Figure 2.2, and estimate how many computers will be connected to the Internet by 2020.

2.5 What shift in Internet use occurred when the World Wide Web first appeared?

2.6 List the steps in the transition in graphics presentation from the early Internet to the current Internet.

**Answer: The trend in the graphic presentation has been as follows:
Text → Graphic Images → Video Clips → Full-Motion Video**

2.7 Describe the evolution in audio that has occurred in the Internet.

**Answer: The trend in audio processing has been as follows:
Alert Sounds → Human Voice → Audio Clips → High-Fidelity Audio**

2.8 What impact is Internet technology having on the cable television industry?

2.9 What Internet technology is the telephone system using?

Answer: Some current telephone systems uses Voice-Over IP technology. Reader is encouraged to refer to later chapters for details.

2.10 Why is the switch from wired Internet access to wireless Internet access significant?

2.11 List four new Internet applications, and tell the groups for which each is important.

2.12 Describe Internet applications that you use regularly that were not available to your parents when they were your age.

2.13 Why would individuals who do not have a technical background be drawn to cloud computing?

2.14 Search the Web to find three companies that offer cloud services.

Chapter 3 - Internet Applications And Network Programming

3.1 What are the two basic communication paradigms used in the Internet?

Answer: There are various approaches, but according to textbook, we can specify them as Stream Paradigm and Message Paradigm.

3.2 Give six characteristics of Internet stream communication.

Answer: Characteristics of Internet stream communication can be listed as follows:

- ***Connection-oriented***
- ***1-to-1 communication***
- ***Sequence of individual bytes***
- ***Arbitrary length transfer***
- ***Used for multimedia applications***
- ***Built on UDP protocol***

3.3 Give six characteristics of Internet message communication.

Answer: Characteristics of Internet message communication can be listed as follows:

- ***Connectionless***
- ***Many-to-many communication***
- ***Sequence of individual messages***
- ***Each message limited to 64 Kbytes***
- ***Used by most applications***
- ***Built on TCP protocol***

3.4 If a sender uses the stream paradigm and always sends 1024 bytes at a time, what size blocks can the Internet deliver to a receiver?

Answer: Stream paradigm does not provide any guarantees for block sizes, so it all depends on individual transfer.

3.5 If a sender wants to have copies of each data block being sent to three recipients, which paradigm should the sender choose?

Answer: The message paradigm is suitable for such transfer, since it allows many-to-many communication

3.6 What are the four surprising aspects of the Internet's message delivery semantics?

Answer: The Internet's message delivery has the following undesirable characteristics:

- ***Messages can be lost***
- ***Messages can be duplicated***
- ***Messages can be delayed***

- *Messages can be delivered out-of-order*

3.7 Give the general algorithm that a connection-oriented system uses.

Answer: *The interaction between two connection-oriented parties can be summarized as:*

- *Setting-up connection between two parties*
- *Exchange information*
- *Terminate the connection*

3.8 When two applications communicate over the Internet, which one is the server?

Answer: *The application that waits for some other applications to contact is called server, and the application that contact other one is called client.*

3.9 Compare and contrast a client and server application by summarizing characteristics of each.

3.10 What is the difference between a server and a server-class computer?

Answer: *The server term refers to a program that waits passively for communication, and not to the computer on which it executes. However, when a computer is dedicated to running one or more server programs, the computer itself is sometimes called a server. Hardware vendors contribute to the confusion because they classify computers that have fast CPUs, large memories, and powerful operating systems as server machines.*

3.11 Can data flow from a client to a server? Explain.

Answer: *Yes, data may flow in both directions (client → server and server → client).*

3.12 List the possible combinations of clients and servers a given computer can run.

3.13 Can all computers run multiple services effectively? Why or why not?

3.14 What two identifiers are used to specify a particular server?

Answer: *A particular server is identified by the following identifiers:*

- *An identifier for the computer on which a server runs (IP Address)*
- *An identifier for a particular service on the computer (Port Number)*

3.15 List the steps a client uses to contact a server after a user specifies a domain name for the server.

Answer: *The steps that a client uses to contact a server can be summarized as follows:*

- *Start after server is already running*
- *Obtain server name from user*
- *Use DNS to translate name to IP address*
- *Specify that the service uses port N*

Contact server and interact

- 3.16 What basic operating system feature does a concurrent server use to handle request from multiple clients simultaneously?
- 3.17 What performance problem motivates peer-to-peer communication?
- 3.18 Name two operating systems that offer the socket API.
- 3.19 Once a socket is created, how does an application reference the socket?
- 3.20 What are the main functions in the socket API?
- 3.21 Give a typical sequence of socket calls used by a client and a typical sequence used by a server.
- 3.22 Does a client ever use *bind*? Explain.
- 3.24 Why is symbolic constant `INADDR_ANY` used?
- 3.25 Is *sendto* used with a stream or message paradigm?
- 3.26 Suppose a socket is open and a new thread is created. Will the new thread be able to use the socket?
- 3.27 Examine the web server in Appendix 1, and build an equivalent server using the socket API.
- 3.28 Implement the simplified API in Appendix 1 using socket functions.

Chapter 4 - Traditional Internet Applications

4.1 What details does an application protocol specify?

Answer: *An application protocol may specify the following details:*

- *The syntax and semantics of messages that can be exchanged*
- *Whether the client or server initiates interaction*
- *Which actions to take if an error arises*
- *How the two sides know when to terminate communication*

4.2 Why is a protocol for a standardized service documented independent of an implementation?

4.3 What are the two key aspects of application protocols, and what does each include?

Answer: *Application-layer protocols specify two aspects of interaction which are given below:*

- *Data Representation: Syntax of data items that are exchanged, specific form used during transfer, translation of integers, characters, and files between computers*
- *Data Transfer: Interaction between client and server, message syntax and semantics, valid and invalid exchange error handling, termination of interaction*

4.4 Give examples of web protocols that illustrate each of the two aspects of an application protocol.

4.5 Summarize the characteristics of HTML.

Answer: *HTML has the following general characteristics:*

- *Uses a textual representation*
- *Describes pages that contain multimedia*
- *Follows a declarative rather than procedural paradigm*
- *Provides markup specifications instead of formatting*
- *Permits a hyperlink to be embedded in an arbitrary object*
- *Allows a document to include metadata*

4.6 What are the four parts of a URL, and what punctuation is used to separate the parts?

Answer: *The URL breaks down into four components: a protocol, a computer name, a document name, and parameters. The computer name and protocol port are used to form a connection to the server on which the page resides. And the document name and parameters are used to request a specific page.*

4.7 What are the four HTTP request types, and when is each used?

Answer: *The four common HTTP request types and their usage can be given as follows:*

- *GET: Requests a document; server responds by sending status information followed by a copy of the document*

- **HEAD:** Requests status information; server responds by sending status information, but does not send a copy of the document
- **POST:** Sends data to a server; the server appends the data to a specified item
- **PUT:** Sends data to a server; the server uses the data to completely replace the specified item

4.8 How does a browser know whether an HTTP request is syntactically incorrect or whether the referenced item does not exist?

4.9 What does a browser cache, and why is caching used?

Answer: A browser saves the Last-Modified date information along with the cached copy. Caching provides an important optimization for web access because users tend to visit the same web sites repeatedly.

4.10 Describe the steps a browser takes to determine whether to use an item from its cache.

Answer: A browser saves the Last-Modified date information along with the cached copy. Before it uses a document from the local cache, a browser makes a HEAD request to the server and compares the Last-Modified date of the server's copy to the Last-Modified date on the cached copy. If the cached version is stale, the browser downloads the new version. Algorithm 4.1 summarizes caching.

4.11 Can a browser use transfer protocols other than HTTP? Explain.

4.12 When a user requests an FTP directory listing, how many TCP connections are formed? Explain.

Answer: FTP uses two types of connections to perform its functionality, namely

- A control connection is reserved for commands. Each time the server needs to download or upload a file, the server opens a new connection.
- A data connection is used to transfer files.

4.13 True or false: when a user runs an FTP application, the application acts as both a client and server. Explain your answer.

Answer: True, An FTP may invert the client-server relationship for data connections. That is, when opening a data connection, the client acts like a server (i.e., waits for the data connection) and the server acts like a client (i.e., initiates the data connection).

4.14 How does an FTP server know the port number to use for a data connection?

Answer: Before making a request to the server, a client allocates a protocol port on its local operating system and sends the port number to the server. The client binds to the port to await a connection, and then transmits a PORT command over the control connection to inform the server about the port number being used.

4.15 According to the original email paradigm, could a user receive email if the user's computer did not run an email server? Explain.

4.16 List the three types of protocols used with email, and describe each.

Answer: Three major types of protocols being used with email are:

- **Transfer: used to move a copy of an email message from one computer to another**
- **Access: allows a user to access their mailbox and to view or send email messages**
- **Representation specifies the format of an email message when stored on disk**

4.17 What are the characteristics of SMTP?

Answer: The following can be given as major characteristics of SMTP

- **Follows a stream paradigm**
- **Uses textual control messages**
- **Only transfers text messages**
- **Allows a sender to specify recipients' names and check each name**
- **Sends one copy of a given message**

4.18 Can SMTP transfer an email message that contains a period on a line by itself? Why or why not?

4.19 Where is an email access protocol used?

Answer: An email access protocol is used for users to access their mailboxes, either to send or to receive email messages.

4.20 What are the two main email access protocols?

Answer: Two major email access protocols are:

- **Post Office Protocol (POP)**
- **Internet Mail Access Protocol (IMAP)**

4.21 Why was MIME invented?

Answer: Multi-purpose Internet Mail Extensions (MIME) standard allows the transfer of non-text data in a message. MIME specifies how a binary file can be encoded into printable characters, included in a message, and decoded by the receiver.

4.22 What is the overall purpose of the Domain Name System?

Answer: The overall purpose of Domain Name System (DNS) is to provide a service that maps human-readable symbolic names to computer addresses.

4.23 Assuming ISO has assigned N country codes, how many top-level domains exist?

4.24 True or false: a web server must have a domain name that begins with www. Explain.

Answer: False. An arbitrary computer can run a web server, even if the computer's domain name does not contain www. Furthermore, a computer that has a domain name beginning with www is not required to run a web server. Using the first label in a domain name to denote a service (e.g., www) is merely a convention to help humans.

4.25 True or false: a multi-national company can choose to divide its domain name hierarchy in such a way that the company has a domain name server in Europe, one in Asia, and one in North America.

Answer: One of the main features of the Domain Name System (DNS) is autonomy. The DNS is designed to allow each organization to assign names to computers or to change those names without informing a central authority. Each organization is free to choose the details of its servers. A large organization that runs its own server can choose to place all names for the organization in a single physical server, or can choose to divide its names among multiple servers.

4.26 When does a domain name server send a request to an authoritative server and when does it answer the request without sending to the authoritative server?

4.27 True or false: if a company moves its web server from computer x to computer y, the names of the two computers must change. Explain.

4.28 True or false: a DNS server can return a different IP address for a given name, depending on whether the lookup specifies email or web service. Explain.

Answer: Yes, a corporation may decide to use the name corporation.com for both web and email services. With the DNS, it is possible for the corporation to divide the workload between separate computers by mapping type A lookups to one computer and type MX lookups to another.

4.29 Does the IDNA standard require changes in DNS servers? in DNS clients? Explain.

Answer: No, instead of modifying the underlying DNS, IDNA uses ASCII to store all names. That is, when given a domain name that contains a non-ASCII character, IDNA translates the name into a sequence of ASCII characters, and stores the result in the DNS. For the clients (the latest versions of the widely-used browsers, Firefox and Internet Explorer) can accept and display non-ASCII domain names because they each implement IDNA.

4.30 Search the web to find out about iterative DNS lookup. Under what circumstances is iterative lookup used?

4.31 How does XML allow an application to specify fields such as a name and address?

Answer: XML does not assign any meaning to tags, tag names can be created as needed. In particular, tag names can be selected to make data easy to parse or access. If two companies

agree to exchange corporate telephone directories, they can define an XML format that has data items such as an employee's name, phone number, and office.