1. Consider an HTTP client that wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application-layer protocols besides HTTP are needed in this scenario?

2. Obtain the HTTP/1.1 specification (RFC 2616). Answer the following questions:

   (a) What encryption services are provided by HTTP?

   (b) Explain the mechanism used for signalling between the client and server to indicate that a persistent connection is being closed.

   (c) Can the client, the server, or both signal the close of a connection?

   (d) Can a client open three or more simultaneous connections with a given server?

3. Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur a RTT of $\text{RTT}_1, \ldots, \text{RTT}_n$. Further suppose the web page contains exactly two objects. Let RTT_0 denote the RTT between the local host and the server containing the object. Assume transmission time for each object i is T_i.

   (a) How much time elapses from when the client clicks on the link until the client receives the objects using persistent HTTP?

   (b) How much time elapses from when the client clicks on the link until the client receives the objects using non-persistent HTTP?

   (c) How much time elapses from when the client clicks on the link until the client receives the objects using non-persistent HTTP with parallel connections?

4. Consider a short 10 meter link, over which a sender can transmit at a rate of 128 bits/sec in both directions. Suppose that packets containing the data are 96,000 bits long, and packets containing only control (ACK, handshaking) are 240 bits long. Assume that N parallel connections get $1/N$ of the link bandwidth. Now consider HTTP where each object is 96,000 bits long, and the initial downloaded object references 10 additional objects from the same sender.

   (a) Would parallel downloads via parallel instances of non-persistent HTTP make sense in this case?

   (b) Now consider persistent HTTP. Are there significant gains over the non-persistent case?

5. What is the difference from `MAIL FROM:` in SMTP and `From:` in the mail message itself?

6. (a) How does SMTP mark the end of a message body? Explain.

   (b) How about HTTP? Explain.

   (c) Can HTTP use the same method as SMTP to mark the end of a message body? Explain.

7. Describe at least 3 differences between the POP3 and IMAP protocols.

8. Suppose that your department has a local DNS server for all computers in the department. You are an ordinary user (i.e., not a network/system administrator). Can you come up with a way to determine if an external Web site was very likely accessed from a computer in your department a couple of seconds ago? Explain

9. Read RFC 959 for FTP. List all of the client commands that are supported by the RFC.